TX v. NM # 141
New Mexico Exhibit
NM_EX-006

No. 141, Original

IN THE
SUPREME COURT OF THE UNITED STATES

◆

STATE OF TEXAS,
Plaintiff
v.

STATE OF NEW MEXICO and
STATE OF COLORADO,
Defendants

◆

SECOND DECLARATION OF MARGARET BARROLL, PH.D.

◆

I, Dr. Margaret (Peggy) Barroll, pursuant to 28 U.S. C. § 1746, hereby declare as follows:

1. I am over 18 years of age and have personal knowledge of the facts stated herein.
2. I am the same Dr. Margaret Barroll who authored an Expert Report dated October 31, 2019 (NM-EX 100),[1] a Rebuttal Expert Report dated June 15, 2020 (NM-EX 101), a Supplemental Rebuttal Expert Report dated July 15, 2020 (NM-EX 102), a Supplemental Rebuttal Expert Report (2nd Edition) dated September 15, 2020 (NM-EX 103), and a Declaration dated November 4, 2020 (NM-EX 001) in this case.
3. My curriculum vitae and list of publications from the last 10 years can be found in my October 31, 2019 Expert Report at 106-111, NM-EX 100.

Background

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[1] All exhibits designated ("NM-EX") in this Declaration are contained in the State of New Mexico's Exhibit Compendium filed with New Mexico's Partial Summary Judgment Motions on November 5, 2020, and additional exhibits in the State of New Mexico's Supplemental Exhibit Compendium dated December 22, 2020. Exhibits used by the United States and Texas in their motions for partial summary judgment are cited as in those briefs.

4. In this Declaration, I refer to the New Mexico water district, Elephant Butte Irrigation District as “EBID,” and the Texas water district, El Paso County Water Improvement District No. 1, as “EPCWID.” I refer to EBID and EPCWID collectively, as the “Districts.” I refer to the Rio Grande Compact of 1938 as the “Compact.” I refer to the area between Elephant Butte Dam, New Mexico, and the New Mexico state line, which contains the Rio Grande Project (“Project”) as the “LRG.” I refer to that portion of Texas below the Rio Grande gage at El Paso, and above the gage at Fort Quitman, that contains Project lands, as the El Paso valley.

5. I have been asked by Counsel for New Mexico to summarize technical data and findings related to the following topics:

   - Groundwater pumping data in New Mexico and Texas within and in the vicinity of the Project;
   - The impacts of groundwater pumping on the Project and on Project deliveries to Texas;
   - The use and interception of Project Return flows;
   - The distribution of Project Supply between New Mexico and Texas;
   - The 2008 Operating Agreement and its effects; and
   - New Mexico water administration in the LRG.

6. I have been informed by Counsel for New Mexico that I should focus my summary on these issues as they relate and respond to the Motions for Partial Summary Judgment filed by Texas and the United States on November 5, 2020.

The Project and Reclamation

7. The Project is operated by the U.S. Bureau of Reclamation ("Reclamation"). As relevant to this Declaration, the operations of the Project include the allocation and delivery of Project water stored in Elephant Butte and Caballo reservoirs to EBID, EPCWID and to Mexico. *See e.g.* NM-EX 529, Bureau of Reclamation Final Environmental Impact Statement (Sep. 30, 2016) ("FEIS") at 3-4.

Project Supply and Allocation

8. The Compact defines "Project Storage" as "the combined capacity of Elephant Butte Reservoir and all other reservoirs actually available for the storage of usable water below Elephant Butte and above the first diversion to lands of the Rio Grande Project …"; and "Usable Water" as "all water exclusive of credit water, which is in project storage and which is available for release in accordance with irrigation demands, including deliveries to Mexico." NM-EX 330, Compact, at Art. I (k), (*l*).[2]

9. Water for Project Storage derives from inflows from the Rio Grande watershed upstream of Elephant Butte, and local inflows of surface water. The Compact provides limits and constraints on upstream storage that are initiated when Project Storage. Reclamation releases Usable Water from Project Storage for delivery to Project beneficiaries and to Mexico as part of the operations of the Rio Grande Project. Releases are made in response to orders by the Districts, and in accordance with each year's schedule of deliveries to Mexico. NM-EX 529, FEIS at 3-5.

10. The term "Project Supply" refers to the Usable Water released from Caballo Dam, plus Project return flows and inflows occurring below Caballo Dam, that can be allocated and

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[2] In later years the term "Usable Water" was amended to also exclude San Juan-Chama project water.

delivered to the beneficiaries of the Project, namely the citizens of New Mexico and Texas, and to Mexico. NM-EX 529, FEIS at 3-4; NM-EX 100, Barroll Rep. at 26-30. Not all of the water delivered into Elephant Butte can be delivered to Project Beneficiaries. Some of this water is lost to evaporation or seepage before it is delivered to Project beneficiaries. A small amount of the water released from Project storage is used by pre-Compact water rights such as those associated with the Bonita Lateral.

11. Project allocations are the amount of Project Supply each District (EBID and EPCWID) is entitled to order (take) each year from the Project, and the amount Mexico is entitled to receive by Treaty. *See e.g.*, NM-EX 529, FEIS at 4; NM-EX 307, *Convention between the United States and Mexico - Equitable Distribution of the Waters of the Rio Grande* (May 21, 1906). Project allocations are determined before the beginning of each irrigation season and updated as necessary throughout the season.

12. During each irrigation season (approximately March through October), each District may order surface water from the Project to be delivered at its canal headings as long as the District has not expended its allocation. Deliveries by Reclamation to the Districts are measured by gages and converted into what are known as "Charged Diversions" (or "Allocation Charges") which are then subtracted from each District's allocation account as the irrigation season progresses. *See e.g.*, NM-EX 510, 2008 Operating Agreement at 9-11; NM-EX 529, FEIS at 12, 18, 24, Appendix B.

13. During the course of the irrigation season, Reclamation receives orders from the Districts, and adjusts the gates of Caballo Dam to control the release of water so that these orders are delivered to the Districts' canal headings. *See* NM-EX 531, Rio Grande Project Operations Manual, at 4-5 (2018) ("Operations Manual"). Reclamation sets the Caballo release rate

taking into account the losses and gains between Caballo Dam and the canal headings to which it is delivering water, so that regardless of what losses or gains may occur, the amount ordered will reach the canal heading for which the order is being made. NM-EX 531, Operations Manual at 4-8. If the delivery to EPCWID falls short of the order for any reason, there is a procedure by which water is released from EBID's works to temporarily mitigate the shortfall until adjustment of the Caballo release resolves the problem. NM-EX 529, FEIS at 4, 24; NM-EX 531, Operations Manual at 8. Historically, Reclamation has always been able to fulfill the orders made by the Districts. Stream depletions occurring upstream of EPCWID's canal headings do not prevent Reclamation from delivering the water that EPCWID has ordered. *See e.g.*, NM-EX 210, Dr. Ian M. Ferguson Dep., Vol. 2 (Feb, 20, 2020) (Ferguson Dep.) at 260:6-7 ("I'm not aware of any records that suggest EPCWID ordered water that it did not receive."); NM-EX 231, Robert Rios Dep. (Aug 26, 2020) at 56:21-24; NM-EX 230, Gary Esslinger Dep. Vol. 1 (August 17, 2020) at 121:18 – 122:3; NM-EX 228, Filiberto Cortez 30(b)(6) Dep. (August 20, 2020) at 20:22 – 22:15.

Irrigation Well Pumping in the LRG

14. Before the creation of the Project, farmers in the LRG used wells to supplement undependable surface water supplies, and other water users relied on wells for drinking water and other uses. NM-EX 342, Slichter 1905[3] at 31-35; NM-EX 336, Lee 1907[4] at 41-47. Once the Project began to supply surface water, the need for supplemental groundwater was reduced. By the 1940's, after decades of Project operation, "very few" of the early

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[3] NM-EX 342, Charles S. Slichter, *Observations on the Ground Waters of Rio Grande Valley*, U.S. Geological Survey Water-Supply and Irrigation Paper No. 141, Washington, D.C.: Government Printing Office (1905) (Slichter 1905).

[4] NM-EX 336, Willis T. Lee, *Water Resources of the Rio Grande Valley in New Mexico* (Lee 1907).

irrigation wells remained in operation. NM-EX 343, Conover 1947[5] at 9; NM-EX 424, Conover 1954[6] at 9, 103-105, 107. Declarations[7] on file at the New Mexico Office of the State Engineer indicate that some irrigation wells were drilled during the 1920s and 1930s, which suggests that there were some active irrigation wells in New Mexico at the time the Compact was enacted.

15. The Rio Grande basin and the entire Southwest region was hit by a serious drought that began in 1946, accelerated in the winter of 1946-1947, and lasted through most of the 1950s. NM-EX 112, Jennifer Stevens, Ph.D. Expert Report (October 28, 2019) (Stevens Rep.) at 91. During the late 1940s Reclamation warned farmers of impending low-supply conditions (NM-EX 334, 1946-1950 Rio Grande Project Histories,[8] "Water Announcements,") and many farmers in both Districts began to drill irrigation wells. Reclamation recognized that groundwater pumping would be necessary to sustain the Project: in the 1950 RGP History Reclamation states: "Providing the present drought conditions continue, a study will have to be undertaken to determine means of irrigating the Rio Grande Project, with no available runoff from the upper watershed. At present, pumping from wells appears to be the most feasible for a short time." NM-EX 335, 1950 RGP Histories, "Future Work" at 43-44.

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[5] NM-EX 343, C.S. Conover, *Preliminary Memorandum on Groundwater Supplies for Elephant Butte Irrigation District, New Mexico* (September 1947) (Conover 1947).

[6] NM-EX 424, C.S. Conover, *Ground-Water Conditions in the Rincon and Mesilla Valleys and Adjacent Areas in New Mexico*. Geological Survey Water-Supply Paper 1230 (prepared in cooperation with the Elephant Butte Irrigation District, 1954) (Conover 1954).

[7] "Declarations" as used in New Mexico water administration are formal statements filed by groundwater rights claimants with the Office of the State Engineer.

[8] Rio Grande Project Histories, or "RGP Histories" were annual reports produced by Reclamation dealing with all aspects of Project operations.

16. At that time, in the late 1940s, the connection between groundwater and surface water within the Project was understood and had been documented by USGS study. NM-EX 343, Conover 1947 at 1, 12-15.

17. In 1951 there was insufficient Usable Water in Project Storage to supply the Project, and the final allotment to farmers was only 1.75 AF/A (as compared with a full-supply allotment of 3.024 AF/A). NM-EX 419, 1951 RGP Histories 1951, "Water Announcements." As the 1950s progressed, and water-short conditions continued and deepened, more irrigation wells were drilled within the Project, and groundwater became an integral part of the water supply to Project farmers in both Texas and in New Mexico. This is evidenced by the Water Announcements and Operations and Maintenance Reports contained in RGP Histories from 1951 – 1957. NM-EX 417, 1951-1957 RGP Histories, "Water Announcements"; NM-EX 420, 1951-1957 RGP Histories, "Operations and Maintenance." Starting in 1951, Reclamation encouraged farmers with good wells "to transfer a part of their unused allotment water to those who are in need of additional water." NM-EX 419, 1951 RGP Histories, "Water Announcement" (August). In 1954 Reclamation requested farmers with wells to use them "to the greatest extent possible" NM-EX 417, 1954 RGP Histories, "Water Announcement" (March).

18. Reclamation staff worked with Project farmers during the 1950s to distribute pumped groundwater through Project conveyances. NM-EX 420, 1951 RGP Histories, "Operations and Maintenance."

19. The use of groundwater pumped from farmers' wells in both New Mexico and in Texas allowed the Project to operate successfully during the drought years of the 1950s, and allowed Project farmers to produce crops of good yield despite extremely low surface water

supplies in a number of years. NM-EX 420, 1951-1957 RGP Histories, “Operation and Maintenance.”

20. The drought years of the 1950s, and later low-supply years in the 1960s were a difficult time for Project farmers as evidenced by a number of contracts for the Deferment of Construction Charges that are contained in Rio Grande Project Histories for this period. These Contracts refer to “severe losses in recent years as a result of unprecedented drought conditions.” NM-EX 421, “Supplemental Contract[s] Providing for the Deferment of Construction Charges Payable in Calendar Year [X].” A similar contract is included in the 1964 Project Histories. *Id.*

21. During the 1970s Reclamation worked with Districts on the development of District-owned irrigation supply wells. The 1978 Rio Grande Project Histories contains a contract related to the drilling of four District irrigation wells in EPCWID. NM-EX 422, 1978 RGP Histories, “License Agreement with El Paso County Water Improvement District No. 1 for Installation of 4 Water Wells.” During the 1970s EBID drilled a number of District irrigation wells that were used briefly. NM-EX 415, Memorandum Opinion, *Mestas v. Elephant Butte Irrigation District*, CIV NO 78-138-B, D.N.M. (5/11/1979).

22. Irrigation well pumping in the LRG portions of New Mexico has been fully metered since 2008. Metering data from the period of record (2009 – 2019), combined with surface water delivery data, indicates that New Mexico farmers are applying an average of 4.0 AF of combined surface and groundwater to each irrigated acre. By comparison, EPCWID allots 4.0 AF per acre of surface water to its farmers in full-supply years, plus unknown amounts of groundwater. NM-EX 423, 2001 Rio Grande Project Third Party Implementing Contract Among the U.S., EPCIWD, and the City of El Paso at 49, 59.

23. The cropping pattern in the Project has changed throughout the history of the Project. At the time the Compact was signed, cotton comprised about 50% of the crop mix in both EBID and EPCWID, and the full Project acreage (155,000 acres) was not yet in irrigation. By the 1950's the percentage of cotton had risen to approximately 80%. Forage crops including alfalfa and pasturage comprised the majority of the rest of the crop mix. At the time of the Compact, Reclamation cropping reports indicate that both Districts contained a few 10's of acres of pecan trees. Pecan acreage in both states expanded rapidly during the 1980s and thereafter. Currently, Pecan acreage comprises approximately 40% of irrigated acreage in the Project in both New Mexico and in Texas. Sullivan and Welsh, 2nd Ed. Original Rep. (7-15-2020) at 24 – 32; NM-EX 122, NM-EX 101, Barroll Reb. Rep. at 5.

24. The total amount of irrigated acreage in New Mexico has decreased over recent decades, from a high of over 90,000 acres during the 1950s to approximately 75,000 acres today, as illustrated in Figure 1 of this Declaration. When the total amount of irrigation water applied in the LRG is averaged over the entire EBID authorized acreage of 90,640, the result is 3.4 AF per acre of assessed or authorized Project acreage. NM-EX 101, Barroll Reb. Rep. at Table 1 and Figure 10. This value is consistent with the irrigation demand per acre (3.5 AF per acre) used by Gunaji in his 1961 analysis[9] of water use during the 1950's drought, and the estimate of 3.3 AF per acre made by Conover in 1947, and so the total application of irrigation water in New Mexico has not increased since that time. NM-EX

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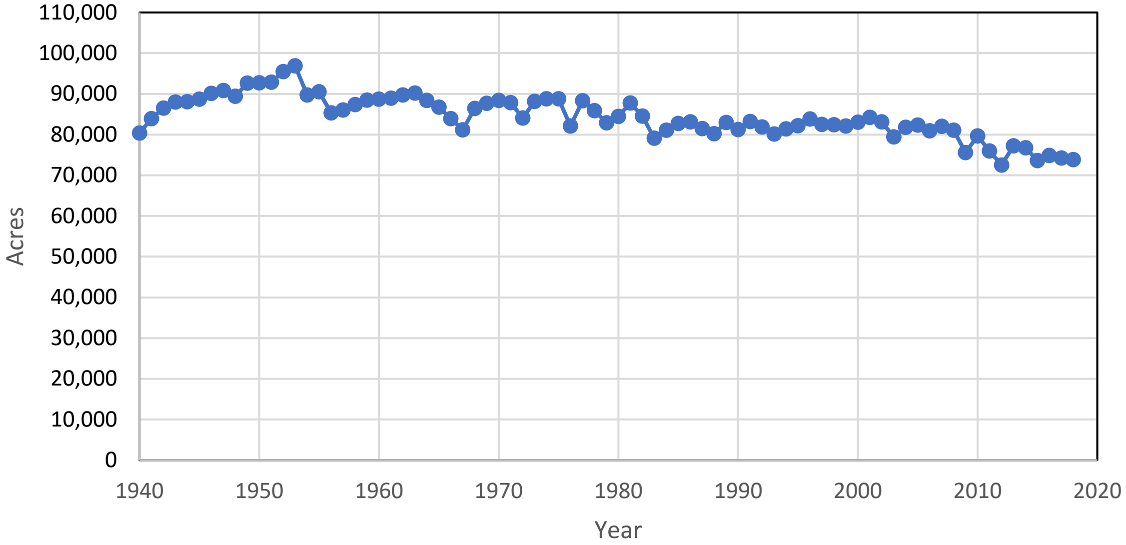
[9] NM-EX 432, N. Gunaji, *Groundwater Conditions in the Elephant Butte Irrigation District* (1961) (Gunaji 1961).

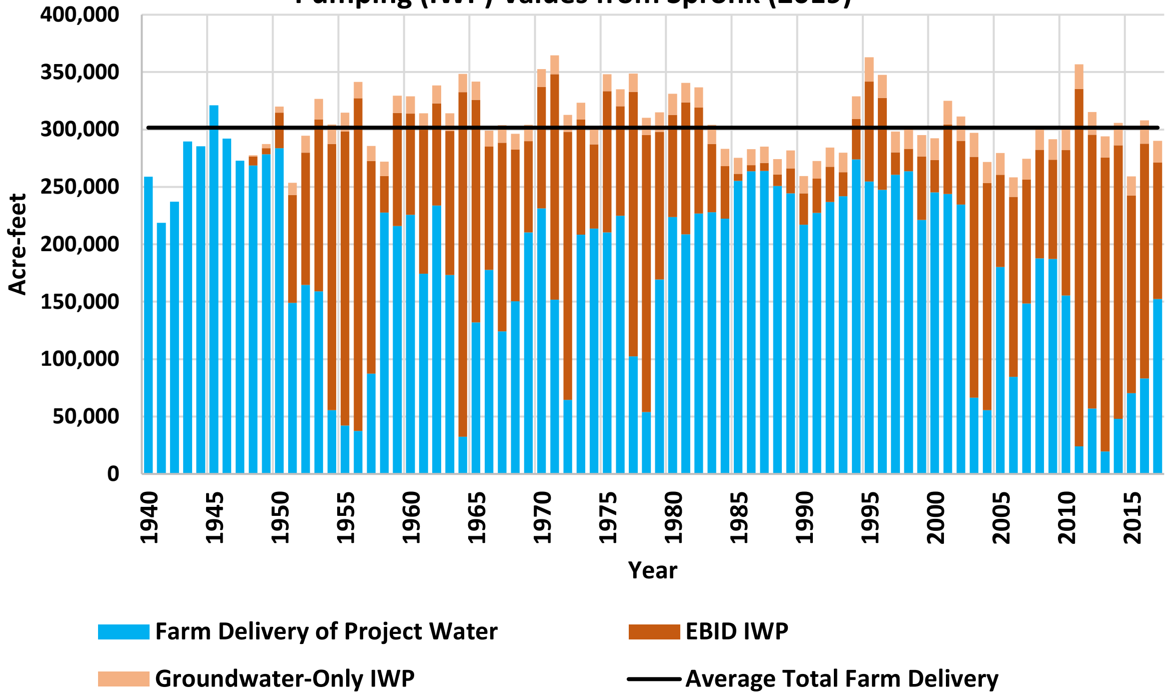
432, Gunaji 1961 at 3, 19; NM-EX 343, Conover 1947 at 6.

Figure 1. (Figure 6. from NM-EX 101, Barroll Reb. Rep.)
Irrigated Acreage in New Mexico LRG



25. The available evidence suggests that the total application of irrigation water in New Mexico, including both surface water and groundwater sources, has not increased since the 1950s, as illustrated in Figure 2 of this Declaration. Data and analysis suggest that the depletions associated with irrigation within New Mexico have not increased since the 1950s. NM-EX 101, Barroll Reb. Rep. at Figures 9 and 10.

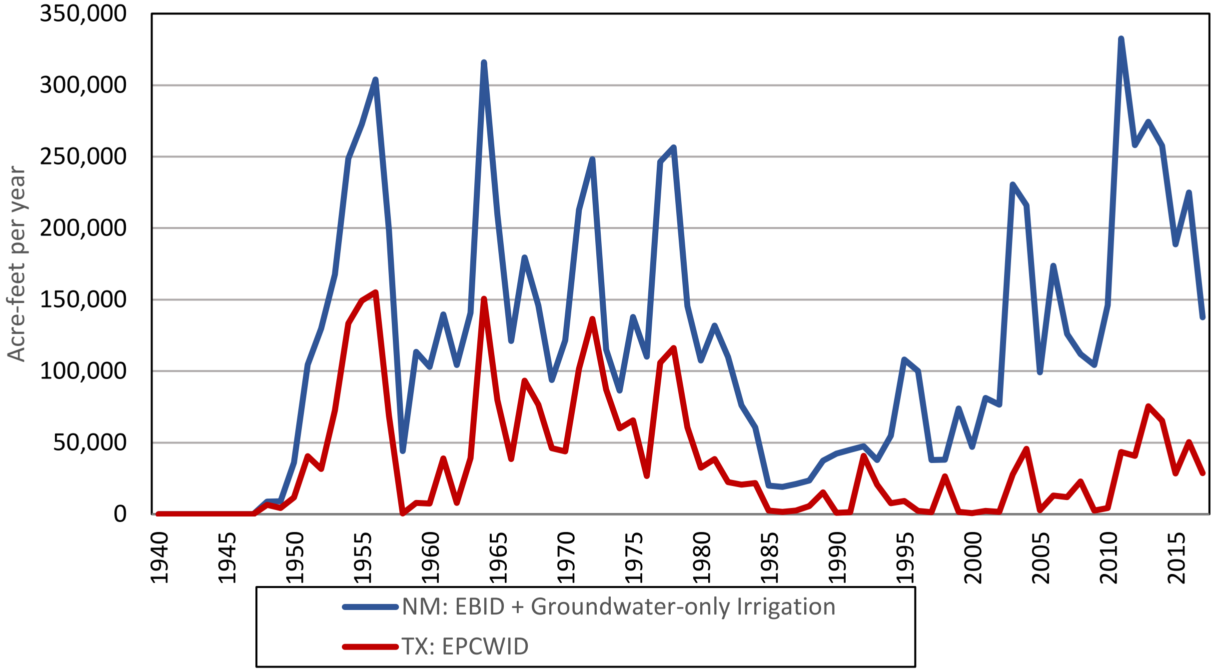
Figure 2. (Figure 9. from NM-EX 101, Barroll Reb. Rep.)
New Mexico LRG: Total Farm Delivery Project Water and Irrigation Well Pumping (IWP) Values from Spronk (2019)



26. Current irrigation well pumping levels in New Mexico in recent years are consistent with the irrigation well pumping estimated during the 1950s' drought, as shown by Figure 3 of this Declaration, and comparison with historical estimates NM-EX 432, Gunaji 1961; NM-EX 100, Barroll Rep. at 19-20. Current levels of irrigation well pumping in New Mexico are in part due to drought conditions, but since 2006 are also due to the large reduction in EBID's surface water caused by the 2008 Operating Agreement. NM-EX 101, Barroll Reb. Rep. at 9 and §12; NM-EX 100, Barroll Rep. at § 8. In years in which the Project has a full supply available to it, the 2008 Operating Agreement has reduced EBID's allocation by more than one-third (1/3). NM-EX 100, Barroll Rep. at Figure 8.2. Analysis of recent well meter data shows that irrigation well pumping in the New Mexico part of the LRG is directly proportional to EBID's surface water shortage, so that the greater the reduction in EBID's allocation, the greater the total irrigation well pumping in the New Mexico. NM-EX 101,

Barroll Reb. Rep. at Figure 7. Despite the reduction in EBID's allocation caused by the 2008 Operating Agreement, irrigation well pumping in New Mexico in recent low-supply years are consistent with those from the drought of the 1950s, and as described above, the total amount of water applied to irrigated lands in New Mexico has not increased.

Figure 3. Annual Irrigation Pumping (AF/yr)



Source: Expert Report of Gregory K. Sullivan and Heidi M. Welsh (Second Edition) (July

27. There is no evidence that Texas requires metering of irrigation wells, and no meter data is available for these wells. Furthermore, there is no evidence that Texas places any limits on how much these wells can pump. In addition to farm wells, EPCWID has drilled over 60 District water wells, which it has used to pump groundwater into EPCWID conveyances for use by Texas Project beneficiaries.[10]

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[10] NM-EX 532, Reyes, J. (EPCWID General Manager), *Water Conservation and Management Projects in El Paso County Water Improvement District* (PPT also at http://www.twdb.texas.gov/waterplanning/rwp/climate/doc/13-Reyes.pdf), Symposium: Far West Texas Climate Change, June 17, 2008.

28. Throughout the history of the Project, and especially during periods of low surface-water supply, farmers throughout the Project have relied on groundwater supplies, and are entitled to do so. NM-EX 107, Expert Report of Estevan Lopez (October 31, 2019) (Lopez Rep.) at 42. (P 7, 8). The Project operates in an arid climate, and there will continue to be years when surface water supplies are very low due to normal variations in climate, plus a potentially drier future due to climate change. The 1950s drought shows that in a prolonged, multi-year drought, the Project was able to successfully operate only because farmers pumped groundwater. During droughts today, it is likely farmers will go out of business if they are unable to pump groundwater as they have been able to do since the 1950s. Also, cities and towns in the Lower Rio Grande have grown over the decades in their reliance on groundwater supplies. Without the groundwater supplies towns and cities would be left without water for the citizens. Similarly, domestic wells throughout the Lower Rio Grande supply water to individual homes and these families do not have access to surface water supplies.

Non-Irrigation Well Pumping in the LRG

29. Within New Mexico, the City of Las Cruces currently pumps approximately 15,000 AF/yr from wells in the Mesilla basin. NM-EX 013, Lee Wilson, Ph.D., Decl. at ¶ 6. Las Cruces has pumped groundwater since at least the early years of the 20th century, gradually increasing their diversions as the population of the city increased. *Id.* at ¶ 4. Las Cruces also pumps between approximately 4,000 AF/yr from wells in the Jornada del Muerto, an adjoining but hydrologically disconnected basin. *Id.* at ¶ 6. Return flow from both sources of water, in the form of treated effluent, returns to the Rio Grande below Las Cruces, and is available for diversion as part of Project Supply at Mesilla Dam. *Id.* at ¶ 6. Diversion of

this water is accounted as Project Supply. Assorted other New Mexico municipal and commercial groundwater users pump an additional approximately 20,000 AF/yr in Rincon and Mesilla basins. Some percentage of this water also returns to the Rio Grande as treated effluent. NM-EX 116, Expert Report of Gilbert R. Barth, Ph.D. (3nd Edition September 15, 2020) (Barth Rep.) at 5-19.

30. In New Mexico, in the LRG, irrigation wells pumping comprises 80% to 90% of total groundwater pumping, and municipal and industrial pumping comprise the other 10 to 20%. In Texas, municipal groundwater pumping comprises far more than half of the total pumping, although a lack of meter data makes it difficult to ascertain the exact percentage.
31. Texas pumps groundwater for municipal and other non-irrigation purposes from its part of the Mesilla basin. The largest Texas diversions in the Mesilla basin are from the Canutillo well field, which pumps approximately 24,000 AF/yr based on data by the El Paso Water Utility, for El Paso municipal use. A portion of the water pumped from the Canutillo well field returns to the Rio Grande below the Rio Grande at El Paso (or Courchesne) gage. Diversion of this return flow is accounted as Project Supply. NM-EX 100, Barroll Rep. at 30.
32. Other than the Canutillo well field, there is no recent meter data is available for Texas groundwater pumping (either for irrigation or other non-irrigation uses) in the Mesilla Basin.
33. In the Hueco bolson, the City of El Paso in Texas and Ciudad Juarez in Mexico, have historically pumped large amounts of groundwater, creating a cone of depression more than 100 feet deep, as illustrated in NM-EX 117, LRG Wells and Goundwater Level Declines. The rate of pumping increased substantially since 1938, increasing from only a few

thousand AF/yr in 1938 up to a maximum of approximately 75,000 AF/yr around 1990. NM-EX 121, Charles P. Spalding and Daniel J. Morrissey Reb. Report (July 15, 2020) at Figure 5.4.

Impacts of Groundwater Pumping

34. When water is pumped from a stream-connected aquifer, that pumping eventually depletes water from the stream system but the ***timing*** of the depletion, the ***location*** where that depletion occurs, and the ***amount*** of depletion depends on a variety of hydrologic conditions, and the location and construction of the pumping wells. Stream depletions generally consist of reduction of gains to streams and to irrigation drains, and increases in the seepage loss from natural streams and irrigation conveyances.

35. The Rio Grande within the LRG and El Paso valley has historically had both gaining and losing reaches. During times of low Project Supply and high groundwater pumping, the losses from the Rio Grande are higher than in high-Project-supply years with low groundwater pumping. Groundwater pumping in both New Mexico and in the Texas Mesilla impact the gains and losses from the Rio Grande in the Mesilla Valley. Groundwater pumping in both Texas and Mexico impact the gains and losses from the Rio Grande in the El Paso Valley. NM-EX 122, Sullivan and Welsh, 2nd Ed. Original Rep. (7-15-2020) at 92-98; Spaulding and Morrissey, 2nd Ed. Original Rep. (7-15-2020) at Figure 9.3.

36. Stream depletion by groundwater pumping does not necessarily equate to impairment of other water rights, even in a fully appropriated stream system. The impact of stream depletion upon other water users depends on a number of factors, including hydrologic conditions and river operations. In the case of the Project, stream depletions that occur during years of adequate supply do not impact downstream deliveries. Instead, as a function

of normal operations of the Project, Reclamation adjusts releases from Caballo as necessary, taking into account the gains and losses occurring between Caballo dam and the points of delivery, to ensure that all the water that has been ordered is in fact delivered. NM-EX 100, Barroll Rep. at § 2.2 and Appx. B.

37. Groundwater pumping in both New Mexico and Texas (and Mexico as well) may cause stream depletions. These stream depletions may cause Reclamation to release more water from Project Storage in order to deliver water to Project beneficiaries than otherwise. NM-EX 103, Barroll Suppl. Reb. Rep. (2nd Ed.) at 4; NM-EX 122, Sullivan and Welsh, 2nd Ed. Original Rep. (7-15-2020) at 92-93.

38. Prior to 2006, stream depletions occurring in Project full-supply years would have no effect on either the water allocated to the Districts or the water delivered to the Districts in those full-supply years. Furthermore, if Project Supplies remained adequate until the next spill of the Project reservoirs, then the Project beneficiaries would not experience any later reduction in deliveries resulting from those stream depletions. NM-EX 103, Barroll Suppl. Reb. Rep. (2nd Ed.) at 3-9.

39. However, stream depletions that occurred in the years leading up to a shortage could reduce the Project allocations in the subsequent water-short years. The amount by which allocations are reduced would not be equal to the stream depletions. Stream depletions occurring outside of the Caballo release season would not reduce Project allocation or deliveries, which are accounted only during the Caballo release season. Stream depletions occurring during the irrigation season could result in extra releases from Project storage, reducing the Usable Water available in subsequent short-supply years. Prior to 2006, this would result in reduced allocations to both Districts in the subsequent low-supply years.

However, the reductions to Usable Water in storage that accumulated during the years leading up the shortage would also have reduced reservoir evaporation. This difference in evaporation would lessen the change in allocation caused by those stream depletions. NM-EX 103, Barroll Suppl. Reb. Rep. (2nd Ed.) at 4; NM-EX 122, Sullivan and Welsh, 2nd Ed. Original Rep. (7-15-2020) at 71-72.

40. Texas claims damages from New Mexico pumping for the years 1985 – 2016. Of these years, 1985 - 2002 were full-supply years for the Project. Texas (EPCWID) was allocated a full supply in these year and was not entitled to any additional water in these years., In most of those years, EPCWID could have ordered more water than it did, if such water was in any way necessary. NM-EX 001, Barroll 1st Decl. at ¶¶ 24, 28-31. Normal Project operations ensured that Texas received the water it did order. NM-EX 100, Barroll Rep. at 8 – 13.

41. From 2006 to the present, since the advent of D3 Allocation, any impacts of groundwater pumping and stream depletion on the Project, regardless of their cause, now reduce EBID's Project Allocation and the supply of Project water available in New Mexico. Texas now receives far more than the 43% share of the Project Supply to which it is entitled. New Mexico's share of Project Supply has been reduced and increasing amounts of irrigation well pumping are now needed to supply its irrigated acreage in the LRG. NM-EX 100, Barroll Rep. at 31, Appx. A at A25; NM-EX 101, Barroll Reb. Rep. at 9-10, 43-47; NM-EX 103, Barroll Suppl. Reb. Rep. (2nd Ed.) at 14-19.

42. Pumping in the Hueco bolson by Texas and Mexico has lowered groundwater levels in some parts of the El Paso Valley by over 100 feet, as illustrated in NM-EX 117, LRG Wells and Groundwater Level Declines). This pumping has intercepted irrigation return flows, dried

up drains, and increased seepage losses from the Rio Grande, impacting the entire Project. In fact, these drawdowns may have disconnected the stream system from the aquifer in the El Paso area, maximizing the seepage losses in this area. NM-EX 101, Barroll Reb. Rep. at 18.

43. New Mexico has long understood the impacts of groundwater pumping on surface water systems, and as related to New Mexico's Compact obligations. New Mexico declared the Rio Grande Underground Water Basin upstream of Elephant Butte reservoir in 1956, for the express purpose of protecting the flows of the Rio Grande. This would have the effect of protecting New Mexico's Compact deliveries to Elephant Butte reservoir.[11] *See* NM-EX 007, D'Antonio 2nd Decl. at ¶¶ 15, 17, 21.

44. Prior to 2006, groundwater levels in the Rincon and Mesilla valleys were relatively high and fluctuated from season to season due to the application of irrigation water from the Rio Grande on Project lands resulting in seepage of surface water into the groundwater system. Groundwater levels also fluctuated from year to year based on Project Supply levels: in low supply years groundwater levels declined, and in subsequent full-supply years groundwater levels recovered. Following the adoption of D3 Allocation in 2006 and the 2008 Operating Agreement, groundwater levels in the Rincon and Mesilla valleys have declined in years of low Project supply, but have not recovered in any substantive way in subsequent full-supply years. NM-EX 100, Barroll Rep. at 73 - 77.

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[11] NM-EX 416, S. E. Reynolds & Philip B. Mutz, Water Deliveries under the Rio Grande Compact, 14 Nat. Resources J. 201 (1974). "There can be no doubt that the November 29, 1956 Order of the New Mexico State Engineer assuming jurisdiction over the drilling of wells and the appropriation of groundwater in the Rio Grande Basin above Elephant Butte Reservoir contributed to the liquidation of the New Mexico debit by preventing new ground water appropriations that would have diminished the flow of Rio Grande above Elephant Butte Reservoir and thus delayed the realization of credit status for New Mexico."

45. Over the past 50 years, groundwater levels in parts of the Hueco bolson and El Paso valley have declined by over 100 feet due to municipal groundwater pumping by the City of El Paso and Ciudad Juarez. There has been no recovery in these groundwater levels. *See* NM-EX 117, LRG Wells and Groundwater Levels Decline, which is a snapshot of the much larger interactive exhibit submitted in the full Gilbert Barth Rebuttal Expert Report (2nd Ed.).

Project Return Flow: Use and Interception

46. Project return flows form part of Project Supply. NM-EX 100, Barroll Rep. at 26-30; TX_MSJ_000132, Rio Grande Joint Investigation (RGJI) at 100.

47. Project return flows associated with irrigation largely return through drains and Project wasteways. The quantity of irrigation return flow varies from year to year, depending on supply conditions, with larger amounts of return flow occurring in years of higher Project Supply; meaning, the more surface water that is applied for irrigation purposes, the more return flow is created. The amounts of irrigation return flow also vary within a year, increasing as the irrigation season progresses and more water is applied to crops. NM-EX 100, Barroll Rep. at 26-29, NM-EX 122, Sullivan and Welsh, 2nd Ed. Original Rep. (7-15-2020) at 24 – 32; NM-EX 424, Conover 1954 at 45- 50.

48. The Rio Grande Joint Investigation Report ("RGJI") states that "total measured return flows, represented by the total of measured drain flows averaged for the years 1930 -1936, was 50 percent of the average of total net diversions in the same period." TX-MSJ-00022, RGJI at 13. This does not mean that return flows (drain flows) ***comprise*** 50% of Project net diversions[12] but rather that the amount of total annual drain flow, throughout the Project

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[12] Net diversions exclude Project water rediverted as part of planned bypass operations.

and throughout the calendar year, is equal to approximately 50% of the amount of water diverted at Project headings. Some of these Project drain flows were not and could not be diverted by the Project, such as drain flows generated in the lowermost parts of EPWID below the Tornillo heading. In fact, drain flows comprised 17.2% of total Project diversions on average during the years 1930 – 1936 as shown in RGJI Table 90. TX_MSJ_000045, TX_MSJ_000132, RGJI at 13, 100. The percentages in RGJI Table 90 for the El Paso Valley are not representative of present conditions due to the re-plumbing of the Project diversion and conveyance system in the El Paso Valley that eliminated the river diversions at the Riverside Dam and the Hansen, Guadalupe, and Tornillo heading that served lands in EPCWID, as well as the cessation of use of irrigation return flows arising within the El Paso Valley portion of EPCWID. NM-EX 100, Barroll Rep. at 14-15 and Appx. C, at C4-C8).

49. Project return flows available for use within the Project were historically generated within the Rincon valley in New Mexico, the Mesilla valley in New Mexico and Texas, and within the El Paso valley above the Tornillo heading in Texas. NM-EX 100, Barroll Rep. at 26 – 29.

50. Historically, in addition to EPCWID's first diversion from the Rio Grande in the El Paso valley (located initially at the International Dam, and later at the American Dam), EPCWID also had several river diversion headings further downstream, including the Riverside, Tornillo, Hanson and Guadalupe canal headings. These additional headings diverted return flows generated in the upper part of the El Paso valley as well as municipal effluent generated by the City of El Paso, and any other Project waters available at these locations which might include water released from storage and return flows from the Rincon and Mesilla valleys. NM-EX-100, Barroll Rep. at 14, Appx. C at C8; NM-EX-101, Barroll Reb.

Rep. at 25. The data in Table 90 of the RGJI (TX_MSJ_000132, *see also* Figure 6 of Texas Motion for Partial Summary Judgment at TX_MSJ_000131 and 001579) reflects the diversion of return flows arising in the El Paso valley. This table reports that EPCWID diversions in the Upper El Paso Valley, at Franklin, were composed of 35.1% drain flow and seepage, whereas in the Lower El Paso Valley the water diverted by EPCWID at Tornillo canal were composed of 57.7% return flow. The difference in the percentage of "Drain flow and seepage" between the Franklin and Tornillo diversions is a result of return flows generated in the Upper El Paso being diverted into the Tornillo canal. The percentages of return flows shown throughout Table 90 of the RGJI reflect the return flows occurring during the 1930 – 1936 period, and show that at the time of the negotiation of the Compact, the return flows generated within the El Paso Valley were an integral part of Project Supply. The fact that the El Paso Valley return flows are no longer accounted as Project Supply is a significant change that has substantial impacts on New Mexico's allocation and delivery of Project water. TX_MSJ_000132, RGJI at 100; NM-EX 100, Barroll Rep. at Appx. C.; NM-EX 101, Barroll Reb. Rep. at 24 – 36; NM-EX 103 Barroll Suppl. Reb. Rep. (2nd Edition) at 21-30. EPCWID should make use of return flows generated within the El Paso Valley (whether from drains or from municipal wastewater discharges) and the use of this water should be properly accounted for.

51. The rectification of the Rio Grande in the El Paso valley in 1938[13] separated the Rio Grande from the Tornillo, Hanson and Guadalupe canal headings. Following the rectification of the Rio Grande and until approximately 1980, water was diverted from EPCWID drains in the El Paso Valley into the Tornillo canal for use by EPCWID farmers. Since approximately

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[13] For an explanation of the rectification of the Rio Grande, see NM-EX 100, Barroll Rep., Appx. at C10 – C12.

1980, there is no evidence that EPCWID makes any use of drain flow or other irrigation return flow arising within the El Paso Valley. NM-EX 100, Barroll Rep. Appx. C, at C21-C28.

52. Groundwater pumping by both Texas and New Mexico intercepts return flows associated with Project irrigation and reduces the flow in Project drains.
53. From 1950 through 2005, the Project allocated 57% of Project Supply to EBID (New Mexico) and 43% to EPCWID (Texas), without any explicit accounting for interception of Project return flows.
54. The City of El Paso diverts a considerable amount of Project Water for municipal purposes in the El Paso Valley. Much of this municipal use has replaced Project irrigation in Texas. NM-EX 423, Third Party Implementing Contract at 48 of 74. Some of these municipal diversions for the City of El Paso take place as a result of contractual agreements allowing for the exchange of Project Supply for municipal effluent, that is then considered to be "District Supply" for EPCWID, and not "Project Supply." Some of the municipal diversions for the City of El Paso take place as a result of contractual agreements related to a Project accounting credit related to the American Canal Extension. NM-EX 423, Third Party Implementing Contract at 6-7 and 57-62 of 74
55. Municipal effluent and return flows associated with the municipal use of Project Water in the El Paso Valley were originally accounted as part of Project Supply. NM-EX 100, Barroll Rep. at 30; NM-EX 425, Cortez 1999 Summary of June 25, 1999, Meeting to Discuss Water Accounting etc. These municipal Project return flows have now been intercepted by Texas, by diverting them directly into EPCWID conveyances, and this water is no longer accounted as Project Supply. NM-EX 100, Barroll Rep. at 30, 49-50; Barroll Reb. Rep. at 24-36. The

reduction in irrigation return flows in Texas, as well as the fact that Reclamation no longer charges EPCWID for the use of any such return flows, means that a greater portion of EPCWID's charged diversions consist of reservoir releases than occurred previously, which may increase EPCWID's draw on the reservoir, reducing the amount of water available for allocation to both New Mexico and Texas. The treatment of municipal effluent in the El Paso Valley stands in stark contrast to the treatment of municipal effluent in New Mexico. Municipal effluent from the City of Las Cruces is available for diversion at Mesilla Dam and at Project diversion heading farther downstream, and the diversion of that effluent is accounted as Project Supply.

Current Inequitable Distribution of Project Water (2006 to Present)

56. From the early years of the Project through 1978, the Project was operated as one unit, and each acre of Project land was equally entitled to the same amount of Project Water. NM-EX 506, Affidavit of Filiberto Cortez (April 20, 2007) at 8; NM-EX 119, Expert Reb. Rep. of Dr. Ian Ferguson at 7. Since authorized Project acreage was distributed 88/155 (approximately 57%) in New Mexico and 67/155 (approximately 43%) in Texas, the entitlement to Project water during this time was 57% to New Mexico and 43% to Texas.

57. From 1979 through 2005 Reclamation allocated water to the Districts for their delivery to individual Project beneficiaries, and explicitly allocated 57% of Project Supply to EBID and 43% to EPCWID. NM-EX 100, Barroll Rep. at 34-38; NM-EX 400, Reclamation Water Supply Allocation Procedures (WSAP) at 5-6. This distribution was consistent with the 1938 Downstream Contract. The allocation method employed during that time used the D1 and D2 Curves, which are Project performance relations based on data from 1951 through 1978, a time when farmers in both Districts, as well as the City of El Paso, pumped large

amounts of groundwater. When developing the D1 and D2 Curve, Reclamation made "[s]tatistical evaluations of operational records for the period 1951 through 1978," and "provided graphs, equations, and data" which Reclamation intended to use "to ensure that future allocations to Mexico and the allocations to the U.S. maintain the historical relationship between the delivery of water to U.S. farms and Mexico." NM-EX 400, WSAP at 9. Under the D1/D2 Allocation Method, Mexico's share of Project Supply was calculated using the D1 Curve. The total Project Supply was calculated using the D2 Curve, and Project Supply remaining beyond Mexico's share was split 57% to EBID and 43% to EPCWID. NM-EX 100, Barroll Rep. at 33-37, Appx. A at A13-A17.

58. Starting in 2006, the Project allocation method changed, and Reclamation substantially reduced allocations and deliveries to EBID, while increasing EPCWID's allocation of Project Water. NM-EX 100, Barroll Rep. at 8-10, 44, and Appx. A at A25-A30. The Project allocation method that was applied starting in 2006 is referred to as the D3 Allocation method. The D3 Allocation method reduces EBID's allocation by the total of all real or apparent discrepancies in Project performance relative to the 1951 - 1978 period. As a result, all increases in system losses that have occurred since the 1951 – 1978 period result in reductions to EBID's allocation. Similarly, all reductions in accounted deliveries that have occurred as a result of changes in Project accounting cause reductions to EBID's allocation. NM-EX 100, Barroll Rep. at 40 - 44. For example, the fact that municipal effluent from the City of El Paso in the El Paso valley is no longer accounted as Project Supply, even though this effluent now comprises the majority of Project return flow in that valley, results in a reduction to EBID's allocation. NM-EX 425, Cortez 1999 Summary of

June 25, 1999, Meeting to Discuss Water Accounting, NM-EX 100, Barroll Rep. at 30, 49-50 and Appx. D at D25 – D28; NM-EX 101, Barroll Reb. Rep. at 24-36.

59. New Mexico's analysis shows that changes in Project accounting are responsible for up to 74,000 AF of the apparent reduction in Project deliveries or Project performance since the 1951-1978 period. D3 Allocation reduces EBID's allocation for all reductions in Project performance compared with the 1951-1978 period. Therefore, up to 74,000 AF of reduction in EBID's allocation are not a result of groundwater pumping in New Mexico, but are caused by changes in Project accounting. NM-EX 100, Barroll Rep. at 60.

60. Also, starting in approximately 2006, Reclamation initiated individual "carryover accounts" for the Districts. Thereafter during the allocation process, the amounts in the Carryover account, plus extra water needed to ensure delivery of those accounts, has been deducted from Project Storage before the D3 Allocation for the next year is calculated. Because of the contemporaneous reduction in its allocation, EBID has not been able to take much advantage of Carryover. EPCWID has carried over large amounts of allocation in many years. The mechanics of how these Carryover accounts are implemented means that large amounts of EPCWID Carryover have reduced the water available for allocation to EBID. NM-EX 100, Barroll Rep. at 48-49 and Appx. D at D21-D23; NM-EX 101, Barroll Reb. Rep. at 21-24.

61. The 2008 Operating Agreement, under which Reclamation continues to operate the Project and allocate its supply, combines the D3 Allocation method and Carryover as described above. NM-EX 510, 2008 Operating Agreement.

62. For the years 2006 through 2019, EPCWID's percentage share of Project allocation, excluding Carryover, has averaged 56% of the total Districts' allocation, compared with

43% prior to 2006. If Project Supply had been divided 57:43 as it had been historically, EPCWID would have been allocated a total 693,408 AF less during 2006 - 2019, and EBID would have been allocated 693,408 AF more. NM-EX 101, Barroll Reb. Rep. at 44, Table 9. By reducing EBID's surface water allocation, the 2008 Operating Agreement forces EBID members to pump additional groundwater to order to supply their crops.

63. If EBID had been allocated and delivered its 57% share of Project Supply since 2006, EBID and the Project as a whole would have benefitted from an improvement in groundwater conditions in New Mexico that would have reduced stream losses and increased drain flows. This improvement in groundwater conditions would have increased Project delivery efficiency and thereby further increased EBID's allocation and delivery at little cost to EPCWID. NM-EX 103, Barroll Suppl. Reb. Rep. (2nd Ed.) at 18-19.

64. D3 Allocation and the 2008 Operating Agreement starve the upper part of the Project of water, causing reductions in total Project return flows and depleting the groundwater supply in the upper part of the Project. The net result is a reduction in Project delivery efficiency and a reduction in total Project Supply. NM-EX 103, Barroll Suppl. Rep. (2nd Ed.) at 14-20. To use the analogy proposed by Texas, the 2008 Operating Agreement itself "reduces the size of the pizza" that represents Project Supply, upon which the two District rely.

65. United States witnesses have testified and written that the purpose of the change in allocation associated with the 2008 Operating Agreement was to offset depletions caused by New Mexico groundwater pumping and depletions, and to protect the delivery of EPCWID's allocation from the effects of New Mexico pumping. *See, e.g.,* NM-EX 119, Ferguson Reb. Rep. at 5-6. The US did not perform any quantitative analysis of the impacts of New Mexico pumping at the time the 2008 Operating Agreement was adopted.

66. Prior to adoption of D3 Allocation in 2006 and the 2008 Operating Agreement, groundwater levels in New Mexico responded resiliently; that is, groundwater levels dropped by 5-10 feet during years of low supply and then recovered in subsequent full-supply years. This reactive behavior changed after 2006, and since that time groundwater levels in the Mesilla basin have declined during years of drought but have failed to recover in subsequent full-supply years due to the lack of surface water supply in the New Mexico portion of the Project as effected by D3 Allocation. As a result, the groundwater system in the Mesilla basin in New Mexico has changed from a sustainable system to a mined groundwater system. NM-EX 100, Barroll Rep. at 73-77.

67. Now that less surface water is allocated to southern New Mexico, EBID farmers must pump more groundwater to supply their crops, which depletes New Mexico's groundwater reserves, and impacts Project performance and Project Supply. The operations of D3 Allocation then further reduce EBID's allocation in subsequent years, which exacerbates and perpetuates this unsustainable cycle. This cycle is illustrated in NM-EX 118, Effect of 2008 OA on New Mexico: A Vicious Cycle.

Quantitative Analysis of Project Allocation

68. Analysis by New Mexico's experts using the New Mexico Integrated Lower Rio Grande Model (ILRGM) calculates that the impact of New Mexico pumping on Texas is much smaller than the reallocation of Project water away from New Mexico under D3 Allocation and the 2008 Operating Agreement. NM-EX 103, Barroll Suppl. Reb. Rep. (2nd Ed.) at vi-vii, 9, 20.

69. Results from the New Mexico ILRGM show that if New Mexico had been allocated 57% percent of Project Supply from 2006 through 2017, the combined effects of that allocation

increase, and the resulting improved groundwater conditions and Project performance, would have resulted in New Mexico being allocated a total of 1,053,393 AF more than under D3 Allocation, or on average, 94,000 AF more per year from 2006 through 2017. In effect, the D3 Allocation and the 2008 Operating Agreement have reduced New Mexico surface water allocation by 88,000 AF/yr on average since 2006. NM-EX 103, Barroll Suppl. Reb. Rep. (2nd Ed.) at 15-16.

70. New Mexico's ILRGM calculates that if New Mexico had been allocated 57% of Project Supply, the resulting improved groundwater conditions and associated reduction in river seepage and increased drain flow would have resulted in a total increase in Project Supply deliveries of 863,730 AF in the years 2006 through 2017, or an average of 72,000 AF/year. NM-EX 103, Barroll Suppl. Reb. Rep. (2nd Ed.) at 18.

71. Reclamation's implementation of the D3 Allocation method and the 2008 Operating Agreement have reduced the delivery efficiency and performance of the Rio Grande Project as a whole. NM-EX 100, Barroll Rep. at 77-78; NM-EX 103, Barroll Suppl. Reb. Rep. (2nd Ed.) at 18-19.

72. Reclamation's implementation of the D3 Allocation method and the 2008 Operating Agreement have harmed New Mexico by substantially reducing its surface water supply in the LRG, and negatively impacting the water balance of groundwater systems of the Rincon and Mesilla basins. NM-EX 100, Barroll Rep. at 71-77. EPCWID and Texas have benefitted by gaining a disproportionate share of surface water.

73. The United States is incorrect in stating at its USMF 65: "Between 2003 and 2005, when the Project allocations to the Districts were less than 50% of a normal allocation (equivalent to 1.37 af/ac in 2003, 1.01 af/ac in 2004, and 1.13 af/ac in 2005)." The United States

provides no basis for these allocation estimates ***except for my reports, and my reports do not contain these numbers.*** EBID set an allotment to individual constituents of 0.67 acre-feet per acre (AF/A) in both 2003 and 2004. NM-EX 100, Barroll Rep. at Appx. A, Table A.7 at A20.

74. The United States is incorrect in stating at USMF 65: "Had all groundwater pumping in New Mexico below Elephant Butte been "turned off" between 2003 and 2005, EBID and EPCWID could have received a full allocation from the Project." The United States has misinterpreted the result from the ILRGM and the text, figures and table from my own Supplemental Reports (NM-EX 102 and 103). No model run has been done that simulates the conditions described, and it is my opinion that such a model run would not show that result. In fact, the model runs New Mexico has performed show that even when all New Mexico LRG pumping is turned off from 1940 forward, there still would not have been a full supply of water to the Project in 2004. NM-EX 103, Barroll Suppl. Reb. Rep. (2nd Ed.) at 4-6.

New Mexico Water Administration in the LRG

75. New Mexico considers the Rio Grande to be fully appropriated, and has considered this to be so since 1908. NM-EX 007, D'Antonio 2nd Decl. at ¶ 16. New Mexico does not permit new appropriation of the surface waters of the Lower Rio Grande, and enforces against illegal diversion of those waters. NM-EX 007, D'Antonio 2nd Decl. at ¶¶ 16, 24; NM-EX 010, Declaration of Ryan Serrano, Lower Rio Grande Water Master, at ¶¶ 22-27.

76. Water rights associated with the Project comprise the largest surface water rights in the LRG. In addition to Project water rights, there are a few pre-Project surface water rights in the New Mexico part of the LRG, including water rights associated with the Bonita Lateral,

and a few pre-Project rights that obtain water directly from the Rio Grande. New Mexico water laws and regulation protect the senior water rights of the Rio Grande Project. NM-EX 007, D'Antonio 2nd Decl. at ¶ 1, 16, 17, 21-24, 34, 37, 38, 40, 43, 53; NM-EX 010, Serrano Decl. at ¶¶ 5-30.

77. New Mexico recognizes its responsibility to ensure that New Mexico's legal and regulatory framework allows Reclamation to deliver Project and Compact waters. New Mexico recognizes its responsibility to work in good faith with Reclamation to assist in the delivery of surface water by the Project, and address problems in Project operations that occur in New Mexico. NM-EX 007, D'Antonio 2nd Decl. at ¶¶ 38, 52, 54, 55, 57, 58, 59; NM-EX 002, D'Antonio 1st Decl. at ¶¶ 10, 11, 12; NM-EX 009, Schmidt-Petersen 2nd Decl. at ¶¶ 4-22.

78. As described in the Declaration of State Engineer John D'Antonio, New Mexico rigorously and consistently manages its water systems, including the groundwater use in the LRG. *See* NM-EX 007, D'Antonio 2nd Decl. at ¶¶ 1-59.) The OSE assures vigorous enforcements of its statutory obligations, rules, regulation, and State Engineer and court orders. *Id*.; NM-EX 010, Serrano Decl. at ¶¶ 4-34, 37.

79. Groundwater rights for irrigation in the LRG were fully developed prior to 1980, during drought periods during the 1950s, 1960s and 1970s, in cooperation with Reclamation as described above. During that time, it is likely that almost every acre of land in EBID was irrigated by groundwater.

80. As I have proved throughout my expert reports and declarations, New Mexico's analysis of the impacts of groundwater pumping, and the impacts of the change in Project Allocation that started in 2006 with D3 Allocation, demonstrates that impacts to Texas by groundwater

pumping in New Mexico are far exceeded by the amount of Project Supply allocated away from EBID to EPCWID since 2006. At present, Reclamation allocates far more water to EPCWID than its 43% share and all evidence is that EPCWID is allocated and receives more than sufficient Project Supply to satisfy its demands. Therefore, Texas cannot complain of any shortage caused by New Mexico groundwater pumping. Absent any claim by Texas that it is being shorted Project Supply there is no need for water right curtailment in New Mexico to provide Texas with additional supply.

81. As I have proved throughout my expert reports and declarations, groundwater levels in the Rincon and Mesilla basins have been negatively impacted since 2006 by the effects of drought and of New Mexico's reduced share of Project Supply caused by D3 Allocation and the 2008 Operating Agreement. New Mexico is developing mechanisms to address these groundwater issues, and is currently implementing a Pilot Project to reduce groundwater depletions in the LRG.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on December 21, 2020

Margaret Barroll

Dr. Margaret (Peggy) Barroll, Ph.D.

TX v. NM #141
New Mexico Exhibit
NM_EX-007

No. 141, Original

IN THE
SUPREME COURT OF THE UNITED STATES

♦

STATE OF TEXAS,
Plaintiff
v.

STATE OF NEW MEXICO and
STATE OF COLORADO,
Defendants

♦

SECOND DECLARATION OF JOHN R. D'ANTONIO, JR.

♦

I, John R. D'Antonio, Jr., P.E., pursuant to 28 U.S.C. § 1746, hereby declare as follows:

1.A) I am over 18 years of age and have personal knowledge of the facts stated herein.

2.A) I am the same John R. D'Antonio, P.E. who submitted a declaration in support of New Mexico's November 5, 2020 motions for partial summary judgment. My credentials and background are discussed therein. NM-EX 002, Declaration of John R. D'Antonio, Jr. (D'Antonio 1st Decl.) at ¶¶ 2-8.[1]

3.A) Texas and the United States demonstrate misunderstandings relating to New Mexico water administration history, authority, and practice in their motions for partial summary judgment, as well as provide erroneous statements of fact. I have been asked to address those. In this declaration I have provided a broad overview of New Mexico authority and practice both in the state-wide, comprehensive context, as well as to specific issues relevant to this litigation.

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[1] All exhibits designated "NM-EX" in this Declaration are contained in the State of New Mexico's Exhibit Compendium filed with New Mexico's Partial Summary Judgment Motions on November 5, 2020, and additional exhibits in the State of New Mexico's Supplemental Exhibit Compendium dated December 22, 2020 filed with New Mexico's responses to Texas and the United States motions for partial summary judgment. Exhibits used by the United States and Texas in their motions for partial summary judgment are cited as in those briefs.

New Mexico has a Comprehensive Water Administration System

1) Under the New Mexico Constitution and statutory law, water in New Mexico belongs to the public. This provision was part of the New Mexico Constitution from before the Rio Grande Compact (Compact) was negotiated. Private rights to the use of New Mexico's unappropriated public waters may be established by the appropriation of water for beneficial use. Beneficial use is the basis, measure and limit of a right to the use of water. Priority of appropriation gives the better right. New Mexico Constitution, Art. XVI, §§ 2, 3; NMSA 1978 §§ 72-1-1, -2.

2) These provisions regarding beneficial use and priority of appropriation were first formally adopted into New Mexico law in the 1907 Water Code, NMSA 1978 Title 72 (1907 Water Code). The 1907 Water Code was based on a Model Water Code drafted by an employee of the predecessor to the United States Bureau of Reclamation, Morris Bien, and was enacted in anticipation of the building of the Rio Grande Project (Project) in the Lower Rio Grande (LRG—the area of New Mexico from the Elephant Butte Dam to the Texas state line (A1)).[2] The 1907 Water Code has as its most "striking feature" a centralization of authority in a State [then-Territorial] Engineer. NM-EX 434, Ira Clark, *Water in New Mexico: A History of its Management and Use* (University of New Mexico Press 1987) at 118-119.

3) The New Mexico State Engineer is a New Mexico cabinet-level position.

4) Since 1907 the (Territorial, then) State Engineer has actively exercised "broad powers" to administer waters throughout the State in an "exclusive and comprehensive" administrative system. *Tri-State Generation & Transmission Ass'n v. D'Antonio*, 2012-NMSC-039, ¶24, 289 P.3d 1232, *construing* NMSA 1978 §72-2-1 (the State Engineer has "general supervision of waters of the state and of the measurement, appropriation, distribution thereof and such other duties as required").

5) For example, among many other duties:

    a) Since 1907, a permit from the State Engineer is required to develop a water right for surface water use. The application proceeding for such a permit requires analysis by the Office of the State Engineer (OSE) of detailed information submitted by the applicant, followed by publication of the application, opportunity for protests, and, if warranted, hearings before the State Engineer. NMSA 1978 §72-5-1 through 7.

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[2] This is the New Mexico use of the term "LRG." However, in Rio Grande Compact terminology the area from Elephant Butte Reservoir, New Mexico down to Fort Quitman, Texas is also referred to as the Lower Rio Grande. For purposes of this declaration, I am only using "LRG" to mean Elephant Butte Dam to the Texas state line.

b) Since 1931, an almost identical process has been required for the development of a water right to the use of groundwater once a groundwater basin has been "declared" by the State Engineer--that is, determined to have "reasonably ascertainable boundaries." NMSA 1978 §72-12-1, *et seq.* After a groundwater basin is declared, a State Engineer permit is required to establish a groundwater right within that basin. *State ex rel. Bliss v. Dority,* 1950-NMSC-066, 55 N.M. 12, 225 P.2d 1007 (the State Engineer has the authority to extend his jurisdiction by declaring the boundaries of an underground body of water). As of 2005, all groundwater basins in New Mexico have been declared and are under the State Engineer's permitting jurisdiction. http://www.ose.state.nm.us/RulesRegs/ground-water-regs/GroundWaterRegs-Article7.pdf (showing all groundwater basins in New Mexico, and documenting when they were declared or extended). New Mexico's Lower Rio Grande Underground Water Basin, as discussed in detail below, was declared in 1980 and extended in 1982.

c) The State Engineer produces and maintains the hydrographic surveys that support the adjudication of water rights throughout the State. NMSA 1978 § 72-4-16. The State Engineer works closely with the adjudication courts to assist in these massive cases.

d) The State Engineer administers water rights, enforces water right permit conditions and prevents excessive or illegal uses of water. NMSA 1978 §§72-2-18; 72-5-39.

e) The State Engineer, pursuant to the responsibility for the measurement of the State's waters, may require metering of all groundwater uses and the reporting of metering data to the State Engineer. NMSA 1978 §72-12-27; *e.g.* NM-EX-533, State Engineer Supplemental Order #180 (03/21/2007) (Final Metering Order).

f) By statute, the regulations, codes, and orders issued by the State Engineer are "presumed to be in proper implementation of the provisions of the water laws administered by [the State Engineer]." NMSA 1978 §72-2-8 (H).

g) The State Engineer serves as the Secretary to New Mexico's Interstate Stream Commission (ISC), which oversees New Mexico's compact obligations, expending significant resources to ensure compliance with the Rio Grande Compact and seven (7) other interstate compacts. The declaration of Rolf Schmidt-Petersen contains a detailed discussion of the many responsibilities and significant undertakings by the ISC to assure compact compliance across the state. See NM-EX 009, Rolf Schmidt-Petersen 2nd Decl., ¶¶ 4-22.

h) Both OSE and ISC have dedicated technical staff charged with monitoring and managing all issues impacting New Mexico's stream systems.

   i) The State Engineer also serves as New Mexico's Rio Grande Compact Commissioner.

6) The State Engineer has established seven District Offices across the State. The LRG is administered by District IV in Las Cruces, where unique issues arise relating to the Elephant Butte Irrigation District (EBID) and the Project, as well as the complex hydrology of the area.

7) While the United States Bureau of Reclamation (Reclamation) and EBID control delivery of Project water, the State Engineer retains authority over and ensures compliance with all water rights and river diversions of New Mexico water, including the use of New Mexico water outside the state.

New Mexico's Comprehensive Administration Scheme Has Been Applied to Ensure Compliance with the Rio Grande Compact

8) Using the broad authority over water matters in New Mexico delegated to the State Engineer, the State Engineer has administered water from a centralized perspective that has allowed the State Engineer to address Compact compliance and administrative issues together. The most famous example of this convergence of State Engineer duties specifically involved the interconnections between surface and groundwater on the Rio Grande. In *City of Albuquerque v. Reynolds*, 1962-NMSC-173, 71 N.M. 428, 379 P.2d 73, the New Mexico Supreme Court upheld State Engineer Steve Reynolds' 1956 decision to publish guidelines for the Middle Rio Grande groundwater basin that required those seeking to appropriate groundwater to offset the new impacts on surface water caused by their diversions of groundwater. By this administrative action, State Engineer Reynolds pioneered the principle of conjunctive management of surface and groundwater. Following State Engineer Reynolds' lead, many other prior appropriation states have adopted conjunctive management principles in water administration. The New Mexico State Engineer's responsible, science-based approach to compliance with the Rio Grande Compact has had national effects. Any suggestion that the New Mexico State Engineer ignored or failed to understand the science of conjunctive management cannot be supported in the light of New Mexico's general history of comprehensive water administration, as well as New Mexico's specific history of taking strong action to ensure compliance with the Rio Grande Compact.

9) As he explained at an April, 1968 conference on "International Water Law Along the Mexican-American Border," State Engineer Reynolds imposed this hydrologic realism regarding conjunctive management in part because of New Mexico's Compact obligations, as it was imperative under the Rio Grande Compact that water flowing through the Middle Rio Grande above Elephant Butte be protected from depletions in order to meet New Mexico's delivery

obligations at Elephant Butte reservoir.[3] State Engineer Reynolds also observed in that same conference that the Compact was designed so that New Mexico has an incentive to comply with the Compact, as the farmers below Elephant Butte Reservoir are New Mexico citizens, so some of the water is intended for New Mexico lands.[4]

10) The fact that New Mexico has both a legal obligation and a political incentive to comply fully with the Compact was, and still is, the background for the State Engineer's rigorous, science-based and practical administration on the Rio Grande, which has successfully achieved the goal of compliance. State Engineer Reynolds' decisions are a good example of this. He fought hard to initiate conjunctive management principles in the Middle Rio Grande because the Compact required that New Mexico make deliveries to Elephant Butte Reservoir, in part to serve New Mexico lands. State Engineer Reynolds' different approach to groundwater in the LRG reflected the very different circumstances there, described in the following paragraphs ¶¶ 12-15.

11) New Mexico's centralized, comprehensive scheme, together with the work of the local District Offices, has allowed the State Engineer to tailor administration to particular conditions. For example, while State Engineer Reynolds' establishment of the principle of conjunctive management applied to all of New Mexico, State groundwater permitting administration was not required in the LRG during the early life of the Project because of the particular hydrologic and historical conditions of the LRG. The State Engineer continued to have general administrative authority over the LRG as over all of the waters of New Mexico. NMSA 1978 § 72-2-1.

12) Up until 1980, the Project was run by Reclamation as a single unit that delivered surface water to farm headgates on a basis of equal amounts of water for each acre throughout the Project. *See* NM-EX 506, Affidavit of Filiberto Cortez (4-20-2007) (Cortez Aff.) at ¶8. In the earlier days of the Project, the system was hydrologically self-regulating so that groundwater pumping had no lasting effects on Project Supply. In drought years farmers in both Texas and New Mexico, with the encouragement of Reclamation, pumped groundwater to supplement the surface supply delivered by the Project. In wetter years, the groundwater table throughout the Project rebounded quickly from the effects of that pumping. The state line was irrelevant. New Mexico groundwater permitting administration would not have been helpful under these conditions. NM-EX 100, Expert Report of Margaret Barroll, Ph.D. ("Barroll Rep.") at §§2.1, 2.2.

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[3] TX_MSJ_005776-5783, S.E. Reynolds, State Engineer, The Rio Grande Compact (April 29, 1968; and TX_MSJ_005741-5754, S.E. Reynolds, State Engineer, State of New Mexico, "The Rio Grande Compact," in Clark S. Knowlton, ed., International Water Law Along the Mexican-American Border, Contribution No. 11 of The Committee on Desert and Arid Zones Research, Southwestern and Rocky Mountain Division, A.A.A.S. (El Paso: University of Texas, 1968) at 58-59.

[4] TX_MSJ_005776-5783 and TX_MSJ_005741-5754.

13) By 1980 the debts owed to the United States by Elephant Butte Irrigation District and El Paso District No. 1 were paid off. In accordance with Reclamation law, title to much of the infrastructure of the Project was then handed over to the two districts ("Title Transfer"). This led to changes in how the Project was run. Reclamation retained administrative control over releases from Elephant Butte Reservoir but, rather than delivering water to farm headgates on the basis of equal amounts of water for each acre throughout the Project, Reclamation changed its practice to deliver instead to the two districts at the major Project diversions. The districts then took over the duty to distribute the water within each district. NM-EX 100, Barroll Rep. at §§2.2, 6.2; NM-EX 506, Cortez Aff. at ¶ 8-9. This change meant that the Project was no longer administered as one project in disregard of the state line. It was unclear at that time what the effect of this change would be.

14) At approximately the same time, the City of El Paso, Texas expressed its intent to appropriate a hundred-year supply of groundwater in New Mexico, a circumstance that raised the possibility of drastically affecting the balance of the Compact. New Mexico's concern for that possibility was ultimately rejected in *El Paso by Pub. Serv. Bd. v. Reynolds*, 563 F. Supp. 379 (D.N.M. 1983) (because the Compact does not apportion groundwater, El Paso's appropriation of groundwater would not violate it). At the time of El Paso's original expression of interest in appropriating groundwater in New Mexico, however, it was unclear what the effect would be on the Compact.[5]

15) The uncertainties that these two developments (¶¶ 13-14) created suggested that there was an increased need for State participation in the administration of groundwater in the LRG. Accordingly, State Engineer Steve Reynolds in September of 1980 defined the boundaries and "declared" the LRG Underground Water Basin as to the Mesilla Valley under State Engineer Order #126 (NM-EX 427, State Engineer Order #126), in accordance with his powers under the New Mexico groundwater statutes at NMSA 1978 §72-12-1 *et seq.* In 1982 State Engineer Reynolds expanded the boundaries of the LRG Underground Water Basin to include the

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[5] In ¶61 of his declaration (TX_MSJ_001618-001619), Dr. Miltenberger states that a document purporting to summarize the results of a streamflow study that was retrieved from the files of former IBWC Commissioner Joseph F. Friedkin was created and circulated by the OSE. *See id.,* fn 106. I am not aware of this document and after diligent investigation the document is not within OSE files and no OSE personnel are familiar with the document. As stated in New Mexico's Responses to Texas's First Requests for Admission (RFA No. 57) New Mexico does not believe the document was authored by New Mexico. NM-EX 603, New Mexico Responses to Texas RFAs (9-2-20). It is not and has never been OSE practice to circulate or adopt the position of unsigned, unattributed documents. I have no reason to believe this document or the conclusions therein were created or endorsed by the OSE.

Rincon valley by State Engineer Order #135 (NM-EX 428, State Engineer Order #135) (collectively, the LRG Groundwater Basin). Under New Mexico law, by declaring a groundwater basin the State Engineer asserts administrative control over the groundwaters of the basin.

16) The State's administration of water in the LRG is premised on the fact that the surface water of the Rio Grande has been fully appropriated since 1908, after the United States filed notices to appropriate all unappropriated surface water of the Rio Grande and its tributaries for the Project. Since 1908, no new appropriation of surface waters has been permitted in the LRG.

17) The fact that the surface water was fully appropriated meant that, following the declaration of the LRG Groundwater Basin and under the principles of conjunctive management established by State Engineer Reynolds, no permit to use groundwater would be issued after 1980 unless surface water was protected from any new depletion caused by the groundwater pumping.

18) There were numerous existing wells in the LRG at the time of the declaration of the LRG Groundwater Basin. Groundwater wells had been drilled for irrigation from at least the early 1900, if not before. A significant number of irrigation wells were drilled during the 1950s through 1970s, with the encouragement of Reclamation. NM-EX 112, Expert Report of Jennifer Stevens, Ph.D. ("Stevens Report") at 91; NM-EX 113, Jennifer Stevens Reb. Rep. at 5-6; NM-EX 100, Expert Report of Margaret Barroll, Ph.D. ("Barroll Rep.") at 4.1.[6]

19) Under NMSA 1978 §72-12-5, water rights users who claim a priority date earlier than the September 1980 LRG Groundwater Basin declaration could file with the State Engineer individual "declarations" describing their claimed existing rights and were encouraged to do so by the State Engineer.[7] The vast majority of these declarations reflect that the subject wells were drilled during the droughts of the 1950s and 1970s, often in cooperation or with the encouragement of Reclamation. NM-EX 100, Barroll Rep. at 4.1. The State Engineer now directs all claims, including proposed declarations, to the adjudication court.

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[6] In addition to individual EBID farmers' groundwater rights, in 1977 EBID itself began pumping groundwater from five (5) wells it had drilled to make groundwater available to supplement the surface water during dry years. *See Mestas v. Elephant Butte Irrigation District*, Civ. No. 78-138-B D.N.M (1979) at 6-7. EBID drilled those wells on Reclamation land, based on sites chosen by Reclamation. *Id.* The pumped water was distributed to EBID constituents. *Id.* EBID has claimed a water right in these five wells in New Mexico's LRG Adjudication.

[7] Once an adjudication is initiated, claimants for groundwater rights may no longer file declaration but must, instead, present their evidence in the adjudication and specifically to the hydrographic survey team for its investigation of the proffered proofs.

20) Following Title Transfer to the districts, Reclamation incorporated pre-1980 groundwater uses in both Texas and New Mexico into the calculations that resulted in the D2 Curve. NM-EX 100, Barroll Rep. at Appx. E.

21) Since 1980, an application must be filed with the State Engineer and a permit must be issued before any changes to a groundwater use can be made in the LRG. Changes may include replacement wells, supplemental wells, or changes to the point of diversion or place or purpose of use. Notice of the application must be published, affording the public the opportunity to protest the changes proposed in the application. Thereafter the OSE rigorously evaluates the application to determine if the proposed change will impair existing rights or will cause new depletions to surface water, in addition to considering whether the proposed change is contrary to conservation within New Mexico or detrimental to the public welfare. *See* NMSA 1978 §72-12-3. If the application is found to impair other water rights or to cause depletions to the stream, the permit may be denied, or the amount of water requested reduced, or the permit may be issued with conditions to address the impairment or depletion, which may include a requirement that any resulting depletions of surface water be offset. The permitting process ensures that no new depletions to the stream system are allowed.[8]

22) In 1999, the State Engineer published the primary guidelines for water rights evaluations in the LRG: the Mesilla Valley Administrative Area Guidelines (MVAA). The MVAA provides that the "criteria apply to applications for new appropriations, applications for supplemental wells, and applications to change point of diversion, and/or place and/or purpose of use." *See* MVAA Guidelines, TX_MSJ_001243-1266. In practice, with trivial exceptions, no permits for new appropriation in the Mesilla or Rincon basins have been granted since 1980.[9] *See, e.g.*, NM-EX 233, Thacker Dep. (4-18-19) at 22:9-23:4.

23) Since the LRG Groundwater Basin was declared in 1980, no State Engineer groundwater permits have been granted without conditions to ensure that no new depletions would be caused to the surface waters of the Rio Grande. All applications are subject to a rigorous and thorough investigation. *See* NM-EX 233, Thacker Dep. (4-18-19) at 15:17-26:2, 37:15-21, 37:15-48:25, 58:7-59:10, 74:1-12, 77:13-78:6-22, 98:3-99:4.

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[8] Analysis of hydrologic conditions and the implications of groundwater use in the Project area are fully addressed in the expert reports filed by Dr. Margaret Barroll (NM-EX 100, 101, 102 and 103) and her declarations filed with New Mexico's dispositive motion briefing (NM-EX 001 and 006), as well as the hydrologic and modeling information prepared by New Mexico's experts as referred to in the Barroll Supplemental and Amended Supplemental reports (NM-EX 102 and 103).

[9] OSE extensively researched this statement. We found three (3) minor exceptions to this statement which are more fully explained in NM-EX 010, Serrano Decl. at ¶ 21: LRG file numbers 1232, 5406, and 17587. The total diversions of these three permitted groundwater diversions is 13.865 AF/yr.

24) If over-diversions occur, they must be repaid to the stream system. New Mexico's LRG Water Master enforcement assures reconciliation. These concepts are more fully explained in the declaration of New Mexico's LRG Water Master Ryan Serrano, NM-EX 010 at ¶¶ 22-27 (Serrano Decl.), filed simultaneously.

Specific Compliance and Enforcement Issues in the LRG

25) District IV, situated in Las Cruces, New Mexico, is the OSE district charged with implementing State Engineer administration in the LRG. In addition, the New Mexico LRG Water Master manages from this office. District IV conducts the on-the-ground administration, compliance, and enforcement activities of the OSE in the LRG. Those issues that cannot be resolved by District IV are referred to appropriate divisions within the OSE, including the Administrative Litigation Unit (ALU). *See* NM-EX 010, Serrano Decl. at ¶¶ 10, 13, 14, 23, 28.

26) The District IV Manager is Andrea Mendoza. Ryan Serrano, the New Mexico LRG Water Master, reports to Ms. Mendoza. Ms. Mendoza has a staff of water management specialists. Among their duties, they receive and evaluate every application for water rights permits for compliance with all water rights rules, regulations, and guidelines. NM-EX-233, Thacker Dep. (4-18-19) at 15:17-26:2, 37:15-21, 37:15-48:25, 58:7-59:10, 74:1-12, 77:13-78:6-22, 98:3-99:4. Based upon the analysis of an application, which includes analysis of impacts on the stream system and other water rights owners, the OSE, through District IV, denies, imposes conditions, or approves each application as appropriate. NM-EX-233, Thacker Dep. (4-18-19) at 15:17-26:2.

27) OSE staff inputs all water rights information into the OSE's water management software known internally as WATERS. All information input into WATERS is publicly available through the public interface version of the system, the New Mexico Water Rights Reporting System (NMWRRS) at http://nmwrrs.ose.state.nm.us/nmwrrs/index.html.

28) A detailed explanation of the work of New Mexico's day-to-day administration and enforcement of water rights in the LRG is provided in Water Master Ryan Serrano's declaration. NM-EX 010, Serrano Decl. at ¶¶ 4-37.

Adjudicating New Mexico Water Rights and New Mexico's LRG Adjudication

29) The 1907 Water Code requires that the State Engineer perform a hydrographic survey of New Mexico stream systems. NMSA 1978 §72-4-13. The State Engineer may then request that the New Mexico Attorney General bring an adjudication lawsuit on behalf of the State. NMSA 1978 §72-4-15. If an adjudication lawsuit has been filed by a private party, as happened in the LRG, the State Engineer may recommend that the Attorney General intervene on behalf of the State if in the State Engineer's opinion the public interest warrants intervention. If an

adjudication is initiated by either New Mexico or a private party, hydrographic surveys performed by the State Engineer or filed with the State Engineer are considered as evidence in the adjudication lawsuit. NMSA 1978 §72-4-16.

30) The State Engineer devotes significant agency resources to support adjudication work in New Mexico. There are 11 active adjudication cases in New Mexico. More than 50% of New Mexico has adjudications in progress. *See* https://www.ose.state.nm.us/Legal/adjudications.php

31) Many New Mexico stream system adjudications address complex legal and factual challenges that take time and expertise to resolve, involving Native American water rights dating "from time immemorial" (New Mexico is home to 19 Native American Pueblos, the Mescalero Apache Tribe and the Jicarilla and Navajo Nations), Spanish and Mexican land and water rights dating from the pre-1600s and the more newly-established American water rights from 1848, all competing for the very limited water resources in arid New Mexico.

32) A lawsuit for the adjudication of water rights was commenced in the LRG by EBID and the State intervened in 1996. *State of New Mexico ex rel. State Engineer v. Elephant Butte Irrigation District et al.,* No. D-307-CV-96-888 (the "LRG Adjudication"). The LRG Adjudication has unique and complex legal challenges relating to the Project and to other matters specific to the area.

33) The hydrographic survey prepared for the LRG Adjudication divided the stream system into five sections: Nutt-Hockett, Rincon, Northern Mesilla, Southern Mesilla and Outlying Areas. Surveys for each of these sections have been filed with the LRG Adjudication court. The hydrographic survey includes all information available from State Engineer and county records relating to claimed water rights, as well as in-person surveys, historic crop and water use information, and aerial photography.

34) The LRG Adjudication court divided the work of determining individual water rights in the LRG adjudication into the five sections of the hydrographic survey. Within each section, the State Engineer evaluates the information for each claimed water right and the result is provided to the individual water right claimant in an "Offer of Judgment" within a "subfile" to the adjudication. The claimant has the option to accept the Offer of Judgment or to provide new information for consideration. The State Engineer and the claimant may either agree on the Offer of Judgment, mediate a different result or try the case to the court. The result of those processes then becomes a "Subfile Order" entered by the court.

35) The State Engineer's most recent status report in the LRG Adjudication reflects that there are presently approximately 14,050 subfiles in the adjudication, which encompass 18,546 water

right claimants. Approximately 66% of these subfiles have been sent Offers of Judgment and 50% have been adjudicated.

36) There is another phase to the adjudication process that will follow the completion of all Subfile Orders. Once each water right claimant within a section has a final Subfile Order, there will follow an "*inter se*" process by which every claimant within that section has the opportunity to contest the water rights of others. When the *inter se* phase is completed, the Adjudication Court will enter a final order as to the water rights in that unit. This order is final as to the statutory elements of a water right: "the priority, amount, purpose, periods and place of use, and as to water used for irrigation, except as otherwise provided in this article, the specific tracts of land to which it shall be appurtenant, together with such other conditions as may be necessary to define the right and its priority." NMSA 1978 §72-4-19.

37) Apart from individual subfiles, there are issues common to many parties to an adjudication. In the mid-2000s, the LRG Adjudication court determined that there were several overarching issues impacting the LRG which should be addressed separately. These were termed "Stream System Issues" and "Expedited *Inter Se* Proceedings" and were or will be litigated and tried apart from the individual water rights claims. Of import to this litigation are the following:

   a) ***Stream System 101 (SS101 LRG Adjudication Order):*** In August 2011 the LRG Adjudication court entered a Final Judgment in Stream System 101, specifically addressing the consumptive irrigation requirement (CIR) and farm delivery requirements (FDR) throughout the LRG, thereby setting the limits on groundwater and surface water use affecting all LRG claimants. NM-EX 541, SS101 Final Judgment (August 22, 2011) (SS101 LRG Adjudication Order). The SS101 LRG Adjudication Order adopted a settlement of these issues among the major parties to the adjudication, was not appealed. The SS101 LRG Adjudication Order is binding on all participating parties in the LRG adjudication, including the United States. Its limits on irrigation water use apply to all LRG water rights owners, including all EBID (*i.e.* Project) constituents[10] in New Mexico as well as owners of pre-Project rights.

   In relevant part the SS101 LRG Adjudication Order:

   - Sets the annual FDR for the LRG at 4.5 AF/acre unless a claimant is able to prove beneficial use of up to 5.5 AF/acre.[11] Surface water and groundwater use combined

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[10] In the LRG, the vast majority of surface water rights belong to EBID constituents.

[11] Out of over 18,000 claimants in the LRG Adjudication, there were 956 Notices of Intent to file proof of beneficial use of up to 5.5 AF/yr filed by the December 2012 deadline. The opportunity to provide evidence supporting those claims of beneficial use closed in 2013. (Note that in his deposition testimony cited by the United States, Ryan Serrano mistakenly testified that over 1000 Notices of Intent had been filed; we have since verified the number as 956.) (US 84)

cannot exceed this total, ***and surface water available must be exhausted before groundwater may be used.*** *See id.* at §§ II(D), V(B). Consistent with historic Project operations, the maximum FDR for surface water was set at 3.024 AF/acre per year. The FDR AF/acre numbers were approved by experts in the litigation and supported by historic use.

  - The OSE enforces these water rights limits based on "actually irrigated acreage," as identified by the hydrographic survey. "Actually irrigated acreage" is often less than the acreage assessed by EBID for surface water delivery, which may include buildings, roads, etc., in the EBID-assessed tract, which is subtracted to obtain the OSE-permitted acreage.

- Establishes that combined surface and groundwater rights cannot be separately transferred.
- Establishes that transfers of irrigation water rights to a non-irrigation purpose of use may only transfer a CIR of 2.6 AF/yr. This provision takes into account that in irrigation use a large portion of the FDR returns to the stream system as return flow.

b) ***Stream System 103 (SS103)*** addresses domestic wells and is currently on hold. Throughout the Basin, domestic wells and stock well use is approximately 2-3,000 AF/yr. and represents less than 1% of total surface water – groundwater use in the Mesilla and Rincon basins. Domestic well and stock well water use has a negligible effect on the issues in this case.[12]

c) ***Stream System 104 / Expedited Inter Se Proceeding (SS104):*** This Stream System issue addressed "the interests of the United States deriving from the establishment of the Rio Grande Project" for determination in the LRG Adjudication.[13] NM-EX-534, Order Designating Stream System Issue/Expedited *Inter Se* Proceeding No. 104 (1-8-2010).

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[12] The United States mistakenly places great importance on domestic well use. (US 59) Under the 2006 Domestic Well rules, new domestic wells for single-family use require meters and are permitted for 1 AF/yr; if livestock is included the permit may be for 2 AF/yr. These uses are monitored represent less than 1% of the total combined use of surface and groundwater in the LRG. Of the several thousand domestic use wells drilled through the decades in the LRG, many are plugged and many are no longer used because residences now have municipal water. In any event, the small amount of domestic and stock water use in the LRG has no appreciable impact on surface water supplies.

[13] The United States had previously attempted to get its claim that groundwater is part of the Project litigated in federal court, side-stepping the LRG Adjudication. In 1997 the United States brought suit in New Mexico federal court to quiet title to its Project water rights, including groundwater in its claim to Project water. The federal district court dismissed the suit in favor of allowing the LRG Adjudication court to determine the issues. *See United States v. City of Las Cruces*, 289 F.3d 1170 (10th Cir. 2002).

- By Order dated August 16, 2012 the LRG Adjudication court ruled on summary judgment that the United States had no interests in groundwater. It found that groundwater and surface water are separate sources of water, the United States had not appropriated groundwater for the Project, and that groundwater is not Project water. NM-EX-535, Order on Summary Judgment. This Order is subject to appeal when final. Should the United States ultimately prevail against New Mexico I believe that the United States will cite such a New Mexico state judgment in other venues to argue that hydrologically connected groundwater belongs to the United States in all Reclamation projects. That has never been the rule in New Mexico or, to my knowledge, in any other Western state. The August 16, 2012 Order did recognize, however, the right of the United States to use return flows to the Rio Grande or to Project conveyances.

- SS 104 went to trial in summer 2016 on the sole issue of the priority date of Project surface water, all other issues having been resolved. The LRG Adjudication court entered its Findings of Fact and Conclusions of Law (2017 Findings) on April 17, 2017 (NM-EX-536, Findings of Fact and Conclusions of Law) holding the Project has a surface water priority date of March 1, 1903. No final order has been issued on these Findings.[14]

- With a (non-final) priority date of March 1, 1903, the United States' Project water rights are senior to most of the groundwater rights in the LRG. One exception is New Mexico State University's groundwater right, which has a priority date of 1890. Should there ever be a need for priority administration in the LRG, these relative priority dates would be significant.

Active Water Resources Management – the Statute and the Practice

38) Adjudications can be complex and time-consuming, while the need for the actual administration of water can be urgent, especially in times of increasing population and increasing drought related to climate change. The State Engineer has the authority to address those urgencies regardless of the progress of adjudications. The New Mexico legislature recognized this explicitly in 2003 when it enacted NMSA 1978 §72-2-9.1, known as the Active Water Resource Management statute (AWRM Statute), which directed the State Engineer to promulgate regulations governing how priority administration of water rights would be done whether or not an adjudication had been completed. NMSA 1978 §72-2-9.1 states:

> The legislature recognizes that the adjudication process is slow, the need for water administration is urgent, compliance with interstate compacts is imperative and the

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[14] The SS 104 trial took place and the court's 2017 Findings were filed well into this litigation. Periodically New Mexico and the United States appear before the LRG Adjudication court to request that the court stay the entry of a final order in SS 104.

state engineer has authority to administer water allocations in accordance with the water right priorities recorded with or declared or otherwise available to the state engineer.

39) In 2004, in compliance with the legislative mandate to issue regulations for how priority administration would be done if necessary, the State Engineer created and promulgated Active Water Resources Management regulations (AWRM Framework Rules). 19.25.13 NMAC. The AWRM Framework Rules provide rules of statewide applicability and allow for the adoption of specific rules that could be promulgated separately for individual Water Master Districts. A central provision of the AWRM Framework Rules defines types of priority administration to be used as circumstances dictate, including Alternative Administration based on water sharing agreements among affected water rights, if those agreements are acceptable to the State Engineer. 19.25.13.7(C) 1-4.

40) Alternative Administration is a part of the AWRM Framework Rules of which I am particularly proud. It provides an opportunity for water rights owners to agree upon an alternative to strict adherence to priority administration, which cuts off junior water rights completely until senior water rights get all of the water to which they are entitled. The AWRM Framework Rules' identification of the possibility of Alternative Administration allows the State Engineer to support water right owners' creation of agreements that share shortages among themselves. Although New Mexico is a prior appropriation state, water sharing is a part of New Mexico's unique cultural history. New Mexico's Native American Pueblos and Spanish-settled communities have a 400-year old history of water sharing in times of shortage, which is statutorily specified, for instance, in those portions of the 1907 Water Code governing acequia associations. NMSA 1978 § 73-2-1 *et seq*. Throughout New Mexico I have frequently observed a cultural preference for working out water shortage situations rather than for enforcement of a strict priority call completely cutting off certain water rights.[15] The LRG Groundwater Conservation Pilot Program, funded by the New Mexico legislature and currently being implemented by the OSE and ISC, was strongly supported by the major groundwater users in the LRG as a means to develop data and information that could support future proposals for Alternative Administration.

41) Other key provisions of the AWRM Framework Rules address:
    a) The creation of Water Master Districts, 19.25.13.12 NMAC
    b) The appointment of Water Masters and staff, 19.25.13.15 NMAC
    c) The measurement of water use, 19.25.13.19 NMAC
    d) The formalization of what had previously been an informal hierarchy of evidence of priority in administering water use or rights:

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[15] "Priority administrations where we make a call on the river and shut a whole bunch of water rights down" might be considered a "nuclear option." NM-EX-229, Thacker 30(b)(6) Dep. at 76:14-19.

i) Final decree from adjudication
ii) Subfile order from an adjudication
iii) Offer of judgment from an adjudication
iv) Hydrographic survey
v) License issued by the State Engineer
vi) Permit issued by the State Engineer
vii) Determination by the State Engineer using the best evidence of historic, beneficial use. NMAC 19.25.13.27

42) Shortly after the promulgation of the AWRM Framework Rules, on December 30, 2004, an electric power cooperative holding water rights filed a district court action challenging the AWRM Framework Rules' constitutionality. While the case worked through the court system, the State Engineer refrained from implementing some of the provisions being challenged, while working toward accomplishment of the goals and intent of the AWRM Framework Rules. On November 1, 2012, the New Mexico Supreme Court upheld the State Engineer's position and found the AWRM Framework Rules constitutional in their entirety. *Tri-State Generation & Transmission Ass'n v. D'Antonio*, 2012-NMSC-039, 289 P.3d 1232.

43) In accordance with the structure of water administration outlined in the AWRM Framework Rules and relying on long-standing statutes that underlie those rules, the State Engineer established several Water Master Districts throughout the state, including the LRG Water Master District. NM-EX-429, State Engineer LRG Water Master District Order #169. *See* NMSA 1978 §72-3-1, *et seq.*

44) Simultaneously with the creation of the LRG Water Master District, the State Engineer issued a metering order in the LRG, requiring that all groundwater wells[16] in the LRG be metered by March 1, 2006. NM-EX-430, State Engineer Order #168 (12-3-2004). *See* NMSA §72-12-27 (the State Engineer has the authority to require the metering of wells). This order was immediately contested by EBID, resulting in legal action.[17] The State Engineer worked in many ways with EBID on its complaints about the order and variations of it, including providing a state-backed re-loan program for purchase of meters. These negotiations cannot properly be construed as a "grace period" as characterized by the United States; (US 77) rather, it was time spent in legal action and negotiations ultimately resulting in settlement and the March 28, 2007 final order on metering. NM-EX-533, Final Metering Order; *see also* NM-EX-229, Dorman Dep. at 71:18-25 (discussing the State Engineer providing a low interest loan

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[16] Excepting single family domestic wells and stock wells.

[17] EBID immediately fought the metering order and I engaged in discussions with EBID representatives, resulting in the December 2005 First Amended Metering Order #172. EBID was not content with the concessions in Order #172 and it, along with one of the EBID farming enterprises, filed a "Motion to Set Aside State Engineer's Metering Order and For Injunctive Relief" in the LRG Adjudication court in February 2006. I again engaged in discussions with EBID attempting to resolve their complaints about OSE-required meters and measuring. We reached settlement on the metering issues, and I issued Order #180 on March 28, 2007. NM-EX-533, Final Metering Order.

program). By 2008 all irrigation, commercial, multi-family domestic, and municipal wells in the LRG were metered.

45) Pursuant to the AWRM Framework Rules, and despite the pending litigation, the State Engineer made a list of priority water districts that would be first in line for District Specific Rules ("DSRs"). A group of specialists comprising hydrologic, legal, and water administration professionals was assigned to each such district to consider the unique conditions that would affect water rights administration in each individual district.

46) The State Engineer's group dedicated to developing the LRG DSRs released a draft for public comment on June 28, 2006. NM-EX-538, Proposed Rules and Regulations Providing for Active Water Resources Administration of the Waters of the Lower Rio Grande Water Master District - First Public Draft. Although the State Engineer did extensive outreach, these draft regulations received negative response from New Mexico stakeholders, including EBID. The State Engineer continued to revise and refine these draft rules, with inputs from stakeholders, for some months. A revised draft was released on November 14, 2006. NM-EX-539, Proposed Rules and Regulations Providing for Active Water Resources Administration of the Waters of the Lower Rio Grande Water Master District - Second Public Draft. However, further development of the DSRs was interrupted by other events occurring from mid-2006.

47) In 2006, Reclamation adopted the D3 method for the allocation of Project water and also began allowing carryover of water at Elephant Butte reservoir, changes in Project operations which were adopted into the 2008 Operating Agreement. These were dramatic modifications to the way the Project had been operated for decades and violate Compact apportionment to New Mexico's detriment. Reclamation's actions were taken without evaluation or approval by either the State Engineer or the Rio Grande Compact Commission. NM-EX 100, Barroll Rep. at §6.3; NM-EX 002, D'Antonio 1st Decl. at ¶10.

48) Reclamation's dramatic, unilateral changes to Project operations halted the progress on the LRG DSR drafts. No further productive work or public comment on any LRG DSRs could be done until significant issues relating to Reclamation's changes in Project operations and allocation were studied and addressed. Attention turned instead to study of these Project changes and discussions with Reclamation and EBID relating the new Project operations. *See* NM-EX 002, D'Antonio 1st Decl. at ¶¶11-12.

49) When the 2008 Operating Agreement was made public, I cautioned that the impacts needed to be evaluated. NM-EX 002, D'Antonio 1st Decl. at ¶11. By late 2009 and early 2010, my office's evaluation of the effects of the 2008 Operating Agreement demonstrated that Texas was now receiving far more than the 43% share of Project Supply to which Texas is entitled, while New Mexico was receiving far less than its 57% and less than New Mexico crops required. New Mexico farmers were forced to increase their groundwater use steeply in order to maintain their crops. Drawdowns to the aquifer accelerated and the aquifer fell to unprecedentedly low levels. *See e.g.*, NM-EX 100, Barroll Rep. at §§6.3, 6.4, 9.3, 9.4, 9.5.

These issues were repeatedly discussed by myself and other OSE personnel with Texas, Reclamation and EBID, all of which continued to maintain, incorrectly, that the 2008 Operating Agreement was beneficial to EBID. NM-EX 002, D'Antonio 1st Decl. at ¶¶10-12.

50) Under New Mexico law, an application must be filed with the State Engineer to obtain a permit for the transportation of waters outside of New Mexico. NMSA 1978 §72-12B-1. I have acted under this statute. *See, e.g.*, NM-EX 545, Permit to City of Eunice, NM to Transport Water for Use Outside the State of New Mexico. The LRG Water Master has also enforced compliance with this statute. *See* NM-EX 010, Serrano Decl. at ¶ 17. Under the 2008 Operating Agreement, Reclamation delivers New Mexico's surface water to Texas without the required permit from the State Engineer.

51) Reclamation's transport of New Mexico surface water to Texas also interferes with the conjunctive management principles and underlying goals and assumptions that formed the basis for the SS101 LRG Adjudication Order, which mandated that surface water be exhausted before groundwater may be used. *See* ¶ 37(a) above.

52) Because of the excess amounts of water allocated to Texas under the 2008 Operating Agreement, the draft LRG DSR provisions aimed at protecting Compact deliveries to Texas were no longer necessary and any alleged need for curtailment of water rights in New Mexico to get water to Texas became moot. New Mexico sued Reclamation in August 2011 after New Mexico's concerns about the adverse effects of the 2008 Operating Agreement fell on deaf ears.[18] NM-EX 002, D'Antonio 1st Decl. at ¶12. In retaliation, in 2013, Texas sued New Mexico in this Original Action No. 141. Further work on LRG DSRs cannot move forward until significant issues are resolved in this litigation.

53) There has never been a priority call in the LRG. No LRG water user has requested the State Engineer investigate a water shortage or initiate priority administration. No priority call has been made to the Rio Grande Compact Commission. Should any water rights owner in the LRG request of the State Engineer a priority call due to water shortage, the State Engineer would promptly take the following actions:

a) Investigate the validity and cause of the claimed shortage, and
b) Determine appropriate short-term and long-term actions.

Any response to a priority call is necessarily dependent upon the cause of the shortage and must take into consideration such things as the public health issues of essential drinking water and sanitation uses. Potential responses include, but are not limited to, release of storage water, curtailment of junior surface water diversions, curtailment of junior groundwater rights, and

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[18] New Mexico's lawsuit also raised the issue of Reclamation's 2011 unilateral release of New Mexico credit water in violation of Compact provisions and the resolutions of the Rio Grande Compact Commission.

the possibility of a range of agreed-upon alternatives to strict priority administration.[19] The required analysis, decision on response, and implementation of response could take place in a matter of days for a short-term response to a matter of weeks or months to address long-term or systemic response. *See, e.g.,* NM-EX-226, Barroll 30(b)(6) Dep. at 37:5-22 (errata).

54) Both before and after declaring the LRG Groundwater Basin, the State Engineer had and continues to have administrative jurisdiction and responsibilities regarding the surface waters of the Rio Grande as part of the State Engineer's "general supervision" of the waters of the State. NMSA 1978 §72-2-1. For example, the State Engineer has authority over-diversions of surface water from the Rio Grande. EBID, in turn, has the authority delegated to it by the New Mexico legislature to distribute among its members the surface water diverted. NMSA 1978 §§ 73-10-16, -24. The legislature reaffirmed this division of authority between the State Engineer and irrigation districts when in 2003 it enacted a law allowing the establishment of a "special water users' association" to allow the leasing of water from members of an irrigation district with the approval of the State Engineer and the affected irrigation district. NMSA 1978 § 73-10-48. This statute recognizes the existing authority of the State Engineer to permit changes to surface water rights by directing the State Engineer to adopt specific rules governing "changes in place or purpose of use or point of diversion of annual allotments of project water…." [20]

55) The State Engineer's comprehensive administrative authority in the LRG has been exercised appropriately based on changing circumstances. While the Project was administered by Reclamation as one unit the State Engineer did not need to exercise groundwater permitting jurisdiction. After the transfer of title to the districts, EBID and its counterpart in Texas assumed many Project responsibilities that had formerly been performed by Reclamation, while Reclamation retained the responsibility for releases of Project water from the reservoirs and delivery to the districts' major diversion points. NM-EX 100, Barroll Rep. at §§2.2, 6.2. The State Engineer, in response to these changed circumstances, acted responsibly by declaring the LRG Groundwater Basin and ensuring that any change to groundwater use would not result in new depletions. Since that time, the State Engineer has continued New Mexico's rigorous, hydrology-based approach to administration in the LRG by providing technical expertise and significant agency resources to support the LRG adjudication and by issuing and acting under the AWRM regulations.

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[19] The United States repeatedly confuses the idea of "curtailment" under priority administration with State Engineer actions to ensure compliance with permits. For instance, the State Engineer has not had to *curtail* water use through priority administration because, as set forth herein, there has never been a need for priority administration in the LRG. *Compare* USMF 68. However, the State Engineer regularly enforces groundwater use limits and over-diversions throughout New Mexico and in the LRG, as more fully explained in the New Mexico's LRG Water Master's declaration. NM-EX 010, Serrano Decl. (US 68)

[20] However, the obligation to actually deliver water to the members of an irrigation water district such as EBID rests with the district. *See, e.g.,* NMSA 1978 § 73-10-16, -24, and -48.

56) I am aware that Texas water authorities have not made similar efforts to control groundwater use in Texas, despite the detrimental effects of Texas' extensive groundwater use on historical Project Supply. *See* NM-EX 606, Comparison of Select New Mexico and Texas water administration facts.

57) Under the comprehensive compliance and enforcement processes diligently pursued by the OSE as described in this declaration, it is incorrect and disingenuous to claim that "groundwater pumping in New Mexico continued unabated" or that New Mexico does not regulate its groundwater pumping and use. Groundwater pumping is closely monitored by the OSE and water rights strictly enforced. This is in stark contrast to the complete lack of Texas groundwater administration.

58) Under the comprehensive compliance, enforcement, and cooperation processes diligently pursued by the OSE as described in this declaration, and of the ISC as described in the declaration of ISC Director Rolf Schmidt-Petersen (NM-EX 009, Schmidt-Petersen 2nd Decl.), it is incorrect and disingenuous to assert that New Mexico in any sense fails in its water administration responsibilities or Compact obligations.

59) As described in this declaration, the Second Declaration of Mr. Schmidt-Peterson (NM-EX 009) and the Declaration of Mr. Serrano (NM-EX 010), the State of New Mexico has a robust and comprehensive system for water administration and enforcement in the LRG. New Mexico has successfully employed this system to ensure compliance the Compact and stands ready to utilize that system to vigorously enforce the orders of the Court in this case, whatever those orders may be.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on December 21, 2020

John R. D'Antonio, Jr., P.E.

TX v. NM # 141
New Mexico Exhibit
NM_EX-008

No. 141, Original

IN THE
SUPREME COURT OF THE UNITED STATES

◆

STATE OF TEXAS,

Plaintiff

v.

STATE OF NEW MEXICO and
STATE OF COLORADO,

Defendants

◆

SECOND DECLARATION OF ESTEVAN R. LOPEZ, P.E., IN SUPPORT OF

Comes now Estevan R. Lopez, P.E., pursuant to 28 U.S.C. § 1746, and states as follows:

1. I am over 18 years of age and have personal knowledge of the facts stated herein.

2. I am the same Estevan Lopez who authored the following reports in this case: an Expert Report dated October 31, 2019 (NM-EX 107),[1] a Rebuttal Expert Report dated June 15, 2020 (NM-EX 108), a Supplemental Rebuttal Expert Report dated July 15, 2020 (NM-EX 109), and a Supplemental Rebuttal Expert Report (2nd Ed.) dated September 15, 2020 (NM-EX 110). I also submitted a declaration in support of New Mexico's motions for partial summary judgment on November 5, 2020 (NM-EX 003). My credentials and background are discussed in my first declaration filed in this case on November 5, 2020. NM-EX 003 at ¶¶ 3-10.

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[1] All exhibits designated "NM-EX __" in this Declaration are contained within the State of New Mexico's Exhibit Compendium filed with New Mexico's Partial Summary Judgment Motions on November 5, 2020 and in the State of New Mexico's Supplemental Exhibit Compendium dated December 22, 2020 filed with New Mexico's responses to Texas and United States motions for partial summary judgment. Exhibits used by the United States and Texas in their motions for partial summary judgment are cited as in those briefs.

3. I have been asked by Counsel for New Mexico to provide this declaration based on my knowledge, experience, and research relating to the Rio Grande Compact (the "Compact"), the Rio Grande Compact Commission ("RGCC"), the relationship between the Compact and the Rio Grande Project ("Project"), and their operations specifically in reference to the motions for partial summary judgment filed by the United States and Texas on November 5, 2020. Most of my statements are summaries of detailed information in my expert reports.

The Rio Grande Compact, the Rio Grande Compact Commission, and Apportionment

4. Texas in particular makes several incorrect and incomplete statements and assumptions about articles in the Compact that are not factually supported. For example, Texas states that the references to Project Storage in the Compact's definitions Articles I(k)-(q) are "the only direct references to the Rio Grande Reclamation Project in the Compact" and "are intended to ensure that deliveries into the Reservoir and Texas's apportionment are protected from upstream post-1938 depletions." In fact, Article I(k) of the Compact defines "Project Storage" as "the combined capacity of Elephant Butte reservoir and all other reservoirs actually available for the storage of water below Elephant Butte and above the first diversion to lands of the Rio Grande project, but not more than a total of 2,638,860 acre-feet." There are direct references to "Project Storage" not only in the definitions of Compact Article I(l)-(q), but also in Articles VI, VII and VIII. Further, Articles VI, VII an VIII have numerous additional indirect references to "Project Storage" by virtue of the use of defined terms from Articles I(l)-(q) whose definitions reference "Project Storage" directly. These numerous direct and indirect references to Project Storage in various parts of the Compact simply underscore the fact the Project and the Compact are inextricably intertwined. The Project relies on the Compact to secure its water supply and the Compact relies on the Project to distribute the water. Finally, the definitions referenced by

Texas (Articles I(k)-(q)) do not support its assertion that they "are intended to ensure that deliveries … are protected from upstream post-1938 depletions." NM-EX 330, Compact; NM-EX 107, Lopez Rep. at 15-25.

5. Contrary to Texas' assertion that Article I(c) of the Compact specifies the "scope of the apportionment", Article I(c) only specifies the *geographic* scope within which the Compact is operative. An example of why this specificity is important is that the scope of the Compact does not extend to apportionment of groundwater. NM-EX 330, Compact; NM-EX 107, Lopez Rep. at 10-12; NM-EX 237, Lopez 30(b)(6) Dep. (September 18, 2020) at 49:19-21.

6. Article II of the Compact specifies Compact gaging requirements at specified locations including below reservoirs constructed after 1929 "for the securing of records required for the carrying out the Compact", and ***not*** "[d]ue to concern about post-1938 depletions" as asserted by Texas. There is no reference to any such concern in the Compact nor in the historical record. NM-EX 330, Compact; NM-EX 107, Lopez Rep. at 18-19.

7. Article III of the Compact adopted two delivery schedules for Colorado: one for the Conejos River and one for the Rio Grande exclusive of the Conejos River. Article IV adopted a delivery schedule for New Mexico's deliveries at San Marcial. This Article IV schedule and the San Marcial delivery point were changed by a resolution of the Rio Grande Compact Commission in 1948. There is no schedule similar to those in Articles III and IV for deliveries to Texas at the state line, although quite clearly the Compact drafters could have done so if that was their intent. Rather, deliveries to Texas and its apportionment are effectuated through the operation of the Rio Grande Project as a single unit that makes Project Supply available equally (i.e., on an acre-foot per annum/acre basis) to all authorized Project lands,

whether in New Mexico or in Texas. NM-EX 330, Compact; NM-EX 107, Lopez Rep. at 19-22 and 26-27.

8. The schedules in Articles III and IV of the Compact were derived from streamflow data that was available in 1938. This assured that existing uses as of 1938 in Colorado, in New Mexico above Elephant Butte Reservoir and in the Rio Grande Project area below Elephant Butte were all protected while allowing Compact operation in variable hydrology. Further, both Colorado and New Mexico were allowed to develop additional water resources after 1938 subject to certain constraints that are specified in Articles VI, VII and VIII. Notably, those constraints do not preclude additional depletions but do constrain operations of post-1929 upstream reservoirs depending on the conditions at Elephant Butte Reservoir. To the extent that those Articles protect Project Supply during relatively dry periods, those protections benefit New Mexico below Elephant Butte, Texas and Mexico. NM-EX 330, Compact; NM-EX 107, Lopez Rep. at 22-23 and 24-26.

9. Unlike the temporary 1929 Rio Grande Compact, the 1938 Compact did not freeze or preserve the status quo of water uses on the Rio Grande even though the 1929 Compact provided a ready example of how that could be accomplished if that had been the intent of the drafters. Rather, the 1938 Compact contains provisions (e.g., Articles III, IV, VI, VII and VIII) that constrain post-Compact operations particularly during times when supply is limited but allows a broader array of operations in times of abundance so long as delivery schedules are complied with. NM-EX 344, 1929 Temporary Compact; NM-EX 330, Compact.

10. While the Compact contains numerous provisions articulating post-1937 constraints applicable to Colorado and post-1929 constraints to New Mexico above Elephant Butte that help assure deliveries to Elephant Butte, there are no such constraints articulated for

the operation of the Project below Elephant Butte. Clearly, if the Compact negotiators intended to so constrain the operation of the Project, they knew how to do so. Yet they chose not to. Instead, for the Compact section below Elephant Butte the drafters relied on the operation of the Project as a single unit with equal water rights to authorized Project acreage to effectuate the apportionment and assure that New Mexico below Elephant Butte and Texas would be treated equitably. NM-EX 330, Compact; NM-EX 107, Lopez Rep. at 33-43; NM-EX 108 Lopez Rebuttal Rep. at 4-9 and Appx. 1 (Letter from Frank Clayton to Sawnie Smith dated October 4, 1938).

11. Contrary to Texas's assertion that "Colorado and New Mexico benefit and are protected from upstream depletions that exceed the depletions that occurred in 1938, but Texas has no such protections", Colorado gets no benefit from the post-1937 constraints on its uses and New Mexico above Elephant Butte gets benefits from the constraints on Colorado but gets no benefits from the post-1929 constraints on its own uses. Rather, the Project is the primary beneficiary of the post-1937 constraints on Colorado and the post-1929 constraints on New Mexico above Elephant Butte. This benefit to the Project then flows to New Mexico below Elephant Butte, Texas and Mexico. NM-EX 330, Compact; NM-EX 107, Lopez Rep. at 19-27 and 32.

12. Article IV of the Compact (as modified by the 1948 Rio Grande Compact Commission resolution) defines New Mexico's delivery obligations to Elephant Butte Reservoir. Such deliveries are for the Project as a whole and benefit New Mexico, Texas and Mexico. NM-EX 330, Compact; NM-EX 107, Lopez Rep. at 8, 20-22 and 26-27.

13. Texas' assertion that "[t]here are two types of debits: 'Annual Debits' and 'Accrued Debits,' and two types of credits: 'Annual Credits' and 'Accrued Credits'" is incorrect.

Actually, Annual Debits and Accrued Debits are the same type of debits and Annual Credits and Accrued Credits are the same type of credits. The difference between Annual and Accrued debits is simply the timeframe during which those debits are accounted. Similarly, the difference between Annual and Accrued credits is simply the timeframe during which those credits are accounted. NM-EX 330, Compact; NM-EX 107, Lopez Rep. at 16-17.

14. Article VII of the Compact precludes Colorado and New Mexico from storing water in post-1929 reservoirs upstream of Elephant Butte whenever Usable Water in Project Storage is less than 400,000 acre-feet unless Colorado or New Mexico has relinquished Accrued Credits. In which case, the state that has so relinquished has a right to store a like amount of water in the upstream post-1929 reservoirs. NM-EX 330, Compact; NM-EX 107, Lopez Rep. at 23.

15. Under Article VII of the Compact, Texas has sole authority to accept relinquishment of Accrued Credits. However, neither Colorado nor New Mexico is obligated to offer such relinquishment. In other words, Texas cannot compel such relinquishment. This division of responsibilities under the Compact (i.e., "…Colorado or New Mexico, or both, may relinquish accrued credits at any time, and Texas may accept such relinquished water…") makes sense for at least three very practical reasons. First, Texas's sole apportionment under the Compact is entirely below Elephant Butte (43% of Project Supply), whereas New Mexico has apportionments under the Compact both above and below Elephant Butte. Second, Texas is the only Compact party that cannot accrue Credits under the Compact that it could relinquish. And third, Texas has no post 1929 reservoirs upstream of Elephant Butte within which it could store water equal to the amount relinquished. NM-EX 330, Compact; NM-EX 107, Lopez Rep. at 23.

16. Under Article VIII of the Compact, the Rio Grande Compact "[C]ommissioner for Texas may demand of Colorado and New Mexico, and the [C]ommissioner for New Mexico may demand of Colorado, the release of water from storage reservoirs constructed after 1929 to the amount of accrued debit of Colorado and New Mexico, respectively." To the extent that New Mexico wishes to exercise such a demand upon Colorado, it may do so independently from any similar Texas demand upon New Mexico. Such a demand by New Mexico is intended to increase Usable Water in Project Storage, reflecting New Mexico's apportionment interest below Elephant Butte. NM-EX 330, Compact; NM-EX 107, Lopez Rep. at 24-27.

17. Contrary to Texas's assertion that "authority [to protect the volume of water that is 'delivered' in Elephant Butte Reservoir] is vested solely in the Texas Rio Grande Commissioner", neither the Compact, Project ownership, nor historic practice vests such authority in the Texas Commissioner. NM-EX 330, Compact.

18. Similarly, Texas's contention that "it was Texas, in Articles VII and VIII, that was granted the Compact right to ensure that depletions upstream of Elephant Butte Reservoir were protected from post-1938 depletions in Colorado or New Mexico" is also incorrect. First, post-1929 reservoir operations above Elephant Butte are constrained in certain circumstances (see ¶¶ 9, 14 and 16 above) by the Compact, which can indirectly constrain post-1938 depletions but does not preclude them. Second, to the extent that post-1938 depletions are constrained by Articles VII and VIII, it is the Compact itself that sets those constraints. All three Compact states have roles in managing those constraints as specified in Articles VII and VIII. Finally, to the extent that contention is meant to imply that Texas alone has an interest in assuring adequate Usable Water for Project uses, Texas has done very little to assure adequate Usable Water; whereas New Mexico over the last two decades has invested tens of millions of dollars to assure

its Compact compliance and build Credits and has relinquished a total of 380,000 acre-feet for use by the Project. NM-EX 330, Compact; NM-EX 107, Lopez Rep. at 23-26; NM-EX 009, Schmidt-Petersen 2nd Declaration at ¶¶ 14, 15 and 16.

19. Article VIII of the Compact describes a "normal release of 790,000 acre-feet … from Project Storage in [a] year." This amount was negotiated among the Compact states and reflects the amount of water then thought to be needed for Project irrigation purposes in a given year, including an unspecified allowance for flushing salts. In this negotiation, Texas was negotiating for its interests below Elephant Butte Reservoir, whereas New Mexico was negotiating to balance its interests above and below Elephant Butte Reservoir. Since 1938, the release has been less than 790,000 acre-feet/year in all but 13 years and several of the years with releases greater than 790,000 acre-feet were spill years. NM-EX 330, Compact; NM-EX 112, Expert Report of Dr. Jennifer Stevens (October 28, 2019) at 65-70; NM-EX 122, 2nd Ed. Original Expert Report of Gregory K Sullivan, P.E. and Heidi M. Welsh (July 15, 2020), at 41 and 180.

20. Texas states that it "did not anticipate that Project return flows, which were anticipated to comprise a significant portion of the 790,000 acre feet (sic) of Texas's entitlement, would be intercepted by New Mexico groundwater pumping." There are several implications in this statement that are incorrect. First, the 790,000 acre-feet/year release of Usable Water from Project Storage agreed to by the states and described in Article VIII of the Compact is not a Texas entitlement. Instead, it is a negotiated "normal release from Project Storage"; that is, a release from Caballo reservoir, that the Compact negotiators believed would be sufficient to meet Project irrigation needs including deliveries to Mexico under the 1906 Treaty. Second, Project return flows do not comprise any portion of the 790,000 acre-feet/year normal release. Project return flows occur entirely below the Rio Grande below the Caballo Reservoir gage where

releases from Project Storage are measured. Third, the Compact does not require the Actual Release in a given year to be 790,000 acre-feet/year. Whatever volume the Actual Release volume is (whether less than, equal to or greater than 790,000 acre-feet/year), that released water is simply the primary component of Project Supply[2] which benefits Mexico, New Mexico below Elephant Butte and Texas: part of which comprises the Texas Compact apportionment or entitlement. NM-EX 330, Compact; NM-EX 107, Lopez Rep. at 8, 17, 18 and 26-27.

21. To the extent that either Texas or New Mexico or both demand the release of Accrued Debits stored in reservoirs constructed after 1929 pursuant to Article VIII of the Compact (¶ 16 above), such releases are intended to increase the Usable Water in Project Storage early in the year in anticipation of the irrigation season "*to the end that a normal release* of 790,000 acre-feet *may be made* from Project Storage in that year" (emphasis added). However, there is no guarantee that such a release will actually result in sufficient Usable Water in Project Storage to allow a normal release of 790,000 acre-feet. In fact, such a release from post-1929 upstream reservoirs is limited to the amount of the Accrued Debits so stored, if any. In other words, this provision of the Compact cannot protect Project Storage to allow for 'a normal release' [of 790,000 acre-feet] from the Project" in all circumstances. The provisions in Articles VI and VII also protect inflows to Elephant Butte Reservoir and Project Storage, but still there is no guarantee that 790,000 acre-feet of Usable Water will be available for a normal release. NM-EX 330, Compact; NM-EX 107, Lopez Rep. at 22-25.

22. Groundwater use at the time of the Compact negotiation was minimal as compared to current use. Nevertheless, there was already a nascent understanding of groundwater interactions with surface flow. Although that interaction was not yet well

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[2] Project water supply is comprised of releases of Usable Water, inflow below Elephant Butte and return/drain flows. NM-EX 107, Lopez Rep. at 6 and 42.

understood, investigation of groundwater use and interaction with surface flows by the Rio Grande Joint Investigation published in February 1938 ("RGJI") was largely limited to areas above Elephant Butte and focused primarily on the San Luis Valley in Colorado and the Middle Valley in New Mexico. The RGJI observes that "extensive development of ground water for irrigation would add no new water to the Upper Rio Grande Basin and that recharge of the ground-water basins would necessarily involve a draft on surface supplies which are now utilized otherwise." TX_MSJ 000090, RGJI at 56. In spite of this understanding the Compact negotiators chose not to address groundwater at all. NM-EX 112, Stevens Rep. at 65-70; TX_MSJ_ - TX_MSJ_00096, 000090, RGJI at 55-62.

23. The Rio Grande Compact does not apportion nor even make any mention of groundwater. Nevertheless, for the two upstream sections of the Compact, the inflow-outflow schedules in Compact Articles III and IV require the administration of groundwater use in order to meet delivery obligations. TX_MSJ 005776, S.E. Reynolds, *The Rio Grande Compact* (April 29, 1968) *cited by* Dr. Miltenberger at TX_MSJ_001617. For the lowest Compact section between Elephant Butte reservoir and Ft. Quitman, Texas, however, the different apportionment mechanism (i.e., the operation of the Project as a single unit that makes available an equal amount of water for each authorized Project acre) does not necessitate the same actions if the groundwater use is associated with conjunctive use of groundwater for Project irrigation purposes. NM-EX 237, Lopez 30(b)(6) Dep. at 34 :2-5. This is an important consideration given that one of the purposes of the Compact is to protect the continued viability of the Project. NM-EX 237, Lopez 30(b)(6) Dep. at 33 :6-11; NM-EX 005, Stevens Decl. at ¶ 10. In fact, water users in both states have made extensive use of their respective groundwater resources with full knowledge and even encouragement from Reclamation since the early 1950s. NM-EX 107,

Lopez Rep. at 10-12, 26-27 and 41-42; NM-EX 100, Expert Report of Margaret Barroll, Ph.D. (October 31, 2019) at 19-25.

24. Neither Article IV nor any other part of the Compact requires that New Mexico deliver a certain amount of water to the New Mexico-Texas state line, nor does the Compact refer to any 1938 condition that must be maintained in the Compact section below Elephant Butte.[3] Rather, apportionment of Project water supply between New Mexico below Elephant Butte and Texas can be inferred by reading the Compact together with the contemporaneous Downstream Contracts.[4] With regard to the Project and its operation, the Compact makes no distinction as to Project lands in New Mexico and Project lands in Texas. Rather, it simply describes operation of the Project and how that operation relates to other geographic sections of the Compact. As described by the Compact negotiators,[5] it is apparent that the Project was intended to be operated as a single unit. Meanwhile, the two 1937 Downstream Contracts between the United States and the individual Districts have virtually identical provisions except for assigning Project cost recovery responsibility to the individual Districts in proportion to their authorized Project acreage. The 1938 Downstream contract between the two Districts specifies the Project acreage in each District and also specifies that in times of shortage the available water

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[3] This is in stark contrast to the Pecos River Compact, which at Article III(a) states explicitly "New Mexico shall not deplete by man's activities the flow of the Pecos River at the New Mexico-Texas state line below an amount which will give to Texas a quantity of water equivalent to that available to Texas under the 1947 condition." Further, Article II(e) defines the term "deplete by man's activities" and Article II(g) defines the term "1947 condition" in significant detail. Thus, the Pecos River Compact demonstrates how both a state line delivery requirement and a specific condition are specified in an interstate stream Compact. Pecos River Compact, NMSA 1978 § 72-15-19.

[4] In my Expert Report dated October 31, 2019 (NM-EX 107) I identified three specific contracts as the "Downstream Contracts". Those are: 1) the contract between the United States and Elephant Butte Irrigation District ("EBID") dated Nov. 9, 1937 (NM-EX 320); 2) the contract between the United States and El Paso County Water Improvement District No. 1 ("EPCWD") dated Nov. 10, 1937 (NM-EX 321); and 3) the contract between Elephant Butte Irrigation District of New Mexico and El Paso County Water Improvement District No. 1 of Texas dated Feb. 16, 1938 and approved by the United States on April 11, 1938 (NM-EX 324).

[5] NM-EX 327, J.H. Bliss, "Provisions of the Rio Grande Compact" (State Engineer's Office, April 2, 1938) at 1; NM-EX 328, Letter from Frank B. Clayton to Sawnie Smith (October 4, 1938).

will be shared in proportion to the Districts' authorized Project acreage; that is, approximately 57% to EBID farmers and approximately 43% to EPCWID farmers. In fact, this 57/43 split is the basis of Project allocation at all times, not just in shortage. Thus, under the Compact, the apportionment of Project Supply remaining after first providing water to Mexico under the 1906 Treaty[6] is 57% to New Mexico and 43% to Texas. NM-EX 330, Compact; NM-EX 107, Lopez Rep. at 8, 26-27 and 41-43, NM-EX 108, Lopez Rebuttal Rep. at 6-9 and Appx. 1 (Frank Clayton letter to Sawnie Smith (Oct. 4, 1938).

25. Texas's contention that "[t]here is no question that these elements associated with the total volume of water to which the Districts are entitled pursuant to the Downstream Contracts, and that these figures mirror the conditions that were contemplated in 1938" is flawed for several reasons. First, as noted in the preceding paragraph, the Compact does not refer to any 1938 condition for the section below Elephant Butte. Second, the Downstream Contracts similarly do not refer to any 1938 condition. Third, the Downstream Contracts do not refer to or define any "total volume of water to which the Districts are entitled." Instead, as described in the preceding paragraph, the 57/43 apportionment to New Mexico and Texas, respectively, is understood by reading the Compact together with the Downstream Contracts. That 57/43 apportionment does not refer to a volume of water but rather to how the available water will be shared, regardless of the volume. NM-EX 330, Compact; NM-EX 107, Lopez Rep. at 8, 26-27 and 41-43, NM-EX 108, Lopez Rebuttal Rep. at 6-9.

26. New Mexico's overall apportionment under the Rio Grande Compact is comprised of:

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[6] NM-EX 307, Convention for the Equitable Distribution of the Waters of the Rio Grande, U.S – Mex., May 21, 1906 ("1906 Treaty").

a. apportionment above Elephant Butte: Colorado's required deliveries under Compact Article III plus inflows between the Colorado-New Mexico state line and Elephant Butte Reservoir *less* New Mexico's delivery obligation to Elephant Butte under Article IV based on the flow at Otowi gage; and

b. apportionment below Elephant Butte: 57% of the Project Supply that remains after first having provided for Mexico's allocation under the 1906 Treaty.

NM-EX 330, Compact; NM-EX 107, Lopez Rep. at 8, 19-22 and 26-27.

27. Pursuant to the Downstream Contracts, Project Supply may be used for irrigation purposes on authorized Project lands. NM-EX 320, Contract between the United States and EBID; NM-EX 321, Contract between the United States and EPCWID. However, both the purpose of use and the place of use are subject to modification through execution of Miscellaneous Purposes contracts under the Sale of Water for Miscellaneous Purposes Act of 1920, 41 Stat. 451; 43 USC 521.

28. Texas's assertion that "[t]he [Downstream] contracts only deal with the available Project supply and cannot address depletions in New Mexico that reduce the volume of that supply" is correct. However, it is important to note that those contracts similarly cannot address depletions in Texas or Mexico that reduce the volume of the Project supply either. NM-EX 320, Contract between the United States and EBID; NM-EX 321, Contract between the United States and EPCWID.

29. While the Downstream Contract between EBID and EPCWID was signed in February 1938 and approved by the United States in April 1938, Texas is incorrect in its characterization of this contract as the "repayment contract." In fact, this contract does not address repayment of Project costs at all. Repayment is addressed in the two contracts between

the United States and the Districts entered in November 1937. Compare NM-EX 320, Contract between the United States and EBID and NM-EX 321, Contract between the United States and EPCWID with NM-EX 324, 1938 Downstream Contract.

30. In my 30(b)(6) deposition I agreed with the questioner that the 1937 EBID/United States contract is the sole means for New Mexico to get its apportionment. However, later in the same deposition I clarify that there are certain pre-Compact rights (e.g., Bonita Lateral rights) that are protected under the Compact and are not part of the EBID contract. I also note that while the apportionment is based on the 1937 EBID/United States contract, it is nevertheless an apportionment to New Mexico (i.e., not to EBID) which would continue even if EBID ceased to exist. NM-EX 237, Lopez 30(b)(6) Dep. at 23 and 83-85.

31. The Rio Grande Compact and the Rio Grande Project are inextricably intertwined. During their annual review of Compact operations, the Engineer Advisers to the Rio Grande Compact Commission receive a report of Project accounting from Reclamation. Given that up until 2006 Project operation had been the mechanism for effectuating the Compact apportionment below the Elephant Butte Reservoir, that Project accounting amounted to Compact accounting for New Mexico (EBID) and Texas (EPCWID). Since the changes to Project accounting that began in 2006 and continue under the 2008 Operating Agreement are contrary to the Compact apportionment, Project accounting since 2006 simply provides a record of the deviation from the apportionment. NM-EX 107, Lopez Rep. at 24, 30, 32 and 44-48.

32. It is true that "the Compact accounting data includes '*deliveries by New Mexico to Texas at Elephant Butte.*'" However, that statement is incomplete because that same Compact accounting data (i.e., Article IV deliveries to Elephant Butte Reservoir) also includes deliveries

by New Mexico to southern New Mexico below Elephant Butte and to Mexico. NM-EX 330, Compact; NM-EX 107, Lopez Rep. at Appx. 5 at 15-16 and 29.

33. Contrary to Texas's assertion that "the Compact protects the Project and its operations under the conditions that existed in 1938, and relies on the Project, as it operated in 1938, as the means to provide Compact apportionments", the Compact does not require maintenance of any 1938 conditions for the Project. In fact, very little about the Project has remained static since 1938. Major changes to the Project include but are not limited to: completion of the Rectification and Canalization projects, proliferation of groundwater wells in both states and in Mexico, Project acreage buildout then reduction in irrigated acreage, changes in on-farm irrigation efficiencies, changes in crop mix, urbanization of Project area, growth of municipal water demands with significant amounts of that demand being supplied by the Project, significant Project accounting changes, infrastructure changes (e.g., construction of the American Canal and its Extension), designation of wastewater treatment plant treated effluent as non-Project water, transfer of ownership and operation of Project infrastructure from Reclamation to the Districts, and significantly modified Project operations under the 2008 Operating Agreement. NM-EX 107, Lopez Rep. at 12-13, 33, 35, 43-48 and 62-65; NM-EX 100, Barroll Rep. at 53-60 and Appendix C.

34. Texas mistakenly asserts that the Compact Article IV requires adjustment to the scheduled amounts based on depletion of tributary runoff between Otowi Bridge and San Marcial during July, August and September by works constructed after 1937. While the original Article IV did contain a provision that required such adjustment, Texas fails to note that that particular provision was eliminated in 1948 when the Rio Grande Compact Commission changed the delivery schedule and the San Marcial delivery point to Elephant Butte Reservoir and by

unanimously adopted resolution of the RGCC. NM-EX 330, Compact; NM-EX 107, Lopez Rep. at Appx. 3 at 17-18.

35. Contrary to Texas's assertion, New Mexico is not required to limit groundwater pumping for Project irrigation conjunctive use below Elephant Butte Reservoir as long as the 57/43 apportionment of Project Supply to New Mexico and Texas, respectively, is maintained. In fact, if there were any such Compact obligation, it would apply equally to Texas. Yet as noted in ¶ 33 above, numerous changes within the Project have altered depletion conditions within the Project, and Texas has benefited from most if not all of those, often to New Mexico's detriment. While Texas claims that "the parties, including New Mexico, understood the 1938 Condition as the foundation for Compact formation", Texas itself has never demonstrated an inclination to preserve a "1938 Condition" for the Project if doing otherwise would benefit it. The United States has similarly participated in post-1938 activities that have changed Project conditions and impacted Project depletions. Examples include but are not limited to:

a. Texas water users have made extensive use of groundwater for both Project and non-Project uses (with United States knowledge);

b. Texas and EPCWID have availed themselves of the benefits of the United States' Rectification and Canalization projects;

c. Texas farmers have improved irrigation efficiencies and changed their crop mix to higher water-use crops;

d. EPCWID has transferred the purpose of use of a significant portion of its Project Supply from irrigation to municipal supply through Miscellaneous Purposes contracts with Reclamation but without properly accounting for return flows;

e. EPCWID, working with Reclamation but without review by other Compact parties, has negotiated the American Canal Extension credit for its benefit and to the detriment of EBID;

f. Similarly, EPCWID, working with Reclamation but without review by other Compact parties, has deemed treated wastewater effluent as "non-Project" water – retaining its use but without being charged under its Project allocation;

g. EPCWID has opted to forego use of available drain flows, instead calling for additional water out of Project Storage;

h. EPCWID has sold Project water to Hudspeth County Conservation and Reclamation District No. 1[7]; and

i. EPCWID, working with EBID, Reclamation and Texas but without the other Compact parties, negotiated the 2008 Operating Agreement which effectively changed Project operation and allocation contrary to the Compact to New Mexico's detriment.

NM-EX 100, Barroll Rep. at 20,22,31-52, Appx. C and Appx. D; NM-EX 107, Lopez Rep. at 26, 43-66.

36. Texas states that "depletions existing in 1938 describe the relationship between Reservoir releases and the volume of water that Texas anticipated would reach the Texas state line." As described in ¶¶ 33 and 35 above, there is no 1938 condition for the Compact section below Elephant Butte. And, as explained in ¶ 24, there is no required delivery to the Texas state line. Importantly, Article II of the Compact specifies the gages necessary for Compact

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[7] NM-EX 248, Chavez Dep. (July 22,2020) at 69:5.

operations and also requires that "[s]imilar gaging stations shall be maintained and operated … at such other points as may be necessary for securing of records required for the carrying out the of the [C]ompact." The lowest required gage is "on the Rio Grande below Caballo [R]eservoir," approximately 100 miles north of the Texas state line. Further, to the best of my knowledge, Texas has never requested that the Rio Grande Compact Commission consider requiring additional Compact gages at the state line or any other locations downstream of the below Caballo Reservoir gage. NM-EX 330, Compact.

37. The total Project water supply available for diversions by EBID, EPCWID and Mexico are comprised of releases of Usable Water, inflow below Elephant Butte Reservoir and return/drain flows throughout the length of the Project in New Mexico and Texas. Historically, this supply has included treated wastewater inflow as either a return/drain flow or an inflow below Elephant Butte. NM-EX 107, Lopez Rep. at 6, 41-43 and 63; NM-EX 100, Barroll Rep. at 30.

38. The United States assertion that "[t]he effect of the 2008 Operating Agreement is that EBID voluntarily cedes some of its surface water allocation to EPCWID to compensate for surface water depletion caused by groundwater pumping in New Mexico, including by water users outside of EBID" is problematic for a number of reasons. First, the parties to the Operating Agreement did not quantify or conduct any comprehensive technical analysis of the depletions due to groundwater pumping within New Mexico or of other factors that might be affecting Project deliveries. Second, conjunctive use of groundwater for Project irrigation has been allowed throughout the Project since the Compact was signed. Third, while EBID is the Project beneficiary under its 1937 Downstream Contract with the United States, the water is apportioned to the State of New Mexico. It is not permissible for EBID to negotiate away any part on New

Mexico's apportionment. Finally, the citation to my 30(b)(6) deposition does not support the United States' assertion. Instead, the language cited states: *"[since 2008 with a new] operating agreement where, in essence, all – all of the project inefficiencies are assessed, in essence, to EBID, I think that is inconsistent with the – with the Compact."* NM-EX 107, Lopez Rep. at 44; NM-EX 108 Lopez Rebuttal Rep. at 13-17; NM-EX 237, Lopez 30(b)(6) Dep. (September 18, 2020) Tr. at 67:4-7.

39. Prior to the Texas and United States complaints in this Original Action, neither Texas nor the United States had ever formally requested that New Mexico do anything to curtail groundwater pumping in New Mexico below Elephant Butte. NM-EX 002, John D. Antonio Decl. at ¶¶ 18-19. While they now claim that this lawsuit should serve as appropriate notice, this lawsuit was in direct response to New Mexico's complaint in New Mexico Federal District Court. NM-EX 212, Gordon Dep. (Vol. II) (July 15, 2020) 109:2-13; NM-EX 224, Schmidt-Petersen Dep. (Vol. I) (June 29, 2020) 40:19-41:12. In that 2011 lawsuit, New Mexico sued Reclamation claiming that under the terms of the 2008 Operating Agreement Texas has been receiving more water than it is entitled to under the Compact, and that Reclamation injured New Mexico through its unilateral 2011 release of New Mexico's Compact Credit water.[8] To date, neither Texas nor the United States has demonstrated through expert reports or witness testimony that Texas is not getting enough water or that New Mexico's groundwater pumping is preventing Texas from getting its apportionment. NM-EX 107, Lopez Rep. at 33-34 and 66-67.

40. Texas's statement that "[t]he Project, in turn, is the means by which the water apportioned to Texas by the Compact is stored in Elephant Butte Reservoir and subsequently delivered to Texas, subject to deliveries to EBID pursuant to its contract with the United States,

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[8] NM-EX 520, Complaint for Declaratory and Injunctive Relief, *New Mexico v. United States*, No. 1:11-cv-00691 (D.N.M. Aug. 8, 2011).

and to Mexico pursuant to the 1906 Treaty" is wrong. As described in ¶¶ 12, 14 and 17 above, the Compact protects deliveries into Elephant Butte Reservoir for use by the Project. The Project in turn releases Usable Water which together with inflows below Elephant Butte Reservoir and return/drain flows comprise the available Project Supply. Mexico gets its entitlement pursuant to the 1906 Treaty and the remaining Project Supply is shared by EBID (New Mexico) and EPCWID (Texas) in proportion to the authorized project acreage in each District or 57/43, respectively, (¶ 24 above). That historic division (consistent with the Downstream Contracts) is the basis of the Compact's apportionment of the water below Elephant Butte Reservoir to New Mexico and Texas. NM-EX 330, Compact; NM-EX 107, Lopez Rep. at 8, 22-27 and 41-43.

41. Texas's citation to the 1968 article by New Mexico State Engineer Steve Reynolds is incomplete and misleading. Texas states: "New Mexico State Engineer Reynolds opined that the delivery schedules upon which the Compact relied "makes the control of ground water appropriations in the upstream states essential" as otherwise the states could not adhere to their "compact commitments." In fact, what Reynolds wrote was: "The Rio Grande Compact makes no specific reference to ground water. However, the inflow-outflow mechanism for determining delivery obligations makes the control of groundwater appropriations in the upstream states essential for the protection of existing surface water rights in those states and the preservation of their ability to meet the compact commitments." Reynolds goes on to explain that he is specifically talking about the Middle Rio Grande area above Elephant Butte to "protect the existing water rights in New Mexico and to preserve the state's ability to meet its compact obligations." Reynolds was talking about New Mexico's Article IV delivery obligation, with its specific inflow-outflow schedules, hence the need to control groundwater depletions makes sense. As described in ¶ 24 above, the Compact section below Elephant Butte Reservoir is

different. There is no inflow-outflow schedule for deliveries to the New Mexico-Texas state line, there is no 1938 condition and there is no prohibition of groundwater use. Instead, the Compact relies on the operation of the Project as a single unit pursuant to the Downstream Contracts as the basis for apportioning the water below Elephant Butte between New Mexico and Texas after having fulfilled the obligation to Mexico under the 1906 Treaty. TX_MSJ 005776, S.E. Reynolds, *The Rio Grande Compact* (April 29, 1968) at 20-21; NM-EX 330, Compact; NM-EX 107, Lopez Rep. at 8, 26-27 and 41-43.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on December 21, 2020

Estevan R. Lopez, P.E.

TX v. NM # 141
New Mexico Exhibit
NM_EX-009

No. 141, Original

IN THE
SUPREME COURT OF THE UNITED STATES

◆

STATE OF TEXAS,
Plaintiff
v.

STATE OF NEW MEXICO and
STATE OF COLORADO,
Defendants

◆

SECOND DECLARATION OF ROLF I. SCHMIDT-PETERSEN

◆

I, Rolf I. Schmidt-Petersen, pursuant to 28 U.S.C. § 1746, hereby declare as follows:

1) I am over 18 years of age and have personal knowledge of the facts stated herein.

2) I submitted a declaration in support of New Mexico's Motions for Partial Summary Judgment on November 5, 2020 and my qualifications are described in that declaration. NM-EX 004, Schmidt-Petersen 1st Decl. at ¶¶2-9.[1]

3) Texas and the United States demonstrate misunderstandings relating to New Mexico actions and authority related to compact compliance and water administration in their motions for partial summary judgment, as well as provide erroneous statements of fact. I have been asked to address those.

4) The New Mexico Interstate Stream Commission (ISC), of which I am the current Director, was created by statute in 1935. NMSA 1978§ 72-14-3. Recognizing the complex nature of the interstate agreements then being negotiated, the Legislature created the ISC as a permanent body to negotiate interstate compacts rather than relying on individually appointed

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[1] All exhibits designated "NM-EX" in this Declaration are contained in the State of New Mexico's Exhibit Compendium filed with New Mexico's Partial Summary Judgment Motions on November 5, 2020, and additional exhibits in the State of New Mexico's Supplemental Exhibit Compendium dated December 22, 2020 filed with New Mexico's responses to the Texas and United States motions for partial summary judgment. Exhibits used by the United States and Texas in their motions for partial summary judgment are cited as in those briefs.

gubernatorial appointees as negotiators[2]. The ISC has broad powers to investigate, protect, conserve and develop New Mexico's waters, including both interstate and intrastate stream systems. The Commission itself consists of eight non-salaried members appointed by the Governor who must be representative of major irrigation districts or sections in the state, and at least one must be a member of a New Mexico Indian tribe or pueblo. The ninth member is the State Engineer, who is the Secretary of the Commission.

5) The ISC's statutory authority, and a primary objective, is managing the state's interstate stream compact obligations and entitlements. New Mexico is a party to eight interstate stream compacts: the Colorado River, Upper Colorado River Basin, La Plata River, Animas-La Plata Project, Rio Grande, Costilla Creek, Pecos River, and Canadian River compacts. All of the interstate stream compacts to which New Mexico is a party are both state and federal law.

6) In addition to the compacts, the ISC is responsible for ensuring compliance with provisions of United States Supreme Court Decrees governing water allocations on the Pecos, Canadian and Gila rivers and negotiating controversies that arise related to the compacts and court decrees.

7) The ISC is also authorized by statute to investigate and develop the water supplies of the state and institute legal proceedings in the name of the state for planning, conservation, protection, and development of public waters. The ISC promotes the development of regional water plans and is responsible for statewide water planning.

8) The ISC also administers the strategic water reserve, which was established under §72-14-3.3 to assist in complying with interstate stream compacts and court decrees, or in endangered species water management efforts in the state.

9) I serve as the Director of the ISC's authorized staff of 43 employees, largely comprised of hydrologists, engineers, water management professionals and attorneys. The ISC staff are a program of the Office of the State Engineer (OSE). To assure compact compliance, ISC staff analyze stream flow, reservoir levels, and other data on New Mexico's interstate streams and implement programs and projects both within and outside of New Mexico.

10) ISC staff review water right applications filed with the OSE in the OSE Districts, including OSE District IV (the OSE District encompassing the Rio Grande Project), and file protests when necessary to protect New Mexico's interests and obligations under its compacts. For instance, ISC filed protests to:

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[2] *See* NM-EX 434, Ira Clark, *Water in New Mexico*, University of New Mexico Press 1987 at 232.

a) An application to the OSE to move pre-1929 storage rights on the Rio Chama[3] because of its potential impact on administration of the Rio Grande Compact (Horse Lake);
b) An application to the OSE to begin using water at a specific location in the middle Rio Grande basin because of the potential future impact on the Rio Grande, which was settled with the conditions that the applicant would offset any impacts to the Rio Grande and that the water rights cannot be transferred into another part of the basin (Cat Mountain Ranch);
c) An application to the OSE to move and lease water rights for a long unused potash mine on the Pecos River, potentially impacting Pecos River Compact obligations (Intrepid Potash);[4]
d) An application to the OSE to move 2400 AF/yr of water rights to mining purposes on the Lower Rio Grande because of its potential impacts to Rio Grande water administration and Rio Grande Compact/Project Usable Water in Caballo Reservoir (Copper Flat).

11) ISC staff also provide support in water rights adjudications to protect New Mexico's allocations and obligations under its interstate compacts. For example, ISC staff provided technical expertise to protect the administration of the Rio Grande Compact in the adjudications of the United States' Wild and Scenic Rivers Act water rights on the Rio Chama and the Rio Jemez, were involved in both the Taos and Aamodt Indian water rights settlements, and were central to the negotiation of the Navajo Nation water rights settlement within New Mexico's Colorado River Compact apportionments on the San Juan River.[5]

12) The ISC is a lead agency and member of the executive committee of the Upper Rio Grande Water Operations Model (URGWOM) which was formed in the late 1990's with the Bureau of Reclamation (Reclamation), U.S. Army Corps of Engineers, U.S. Geological Survey (USGS), U.S. Fish and Wildlife Service, Bureau of Indian Affairs (BIA), and the International Boundary and Water Commission (IBWC) to develop a unified water operations model for the Upper Rio Grande Basin from its headwaters in Colorado to Hudspeth County, Texas. URGWOM is a numerical computer model for simulating water storage and delivery operations from Rio Grande reservoirs, river flows, and groundwater interactions that replaces some of the previous more cumbersome methods used to plan, analyze, and evaluate river and reservoir management. A database developed specifically for URGWOM stores the vast amount of data necessary for continued development of and completion of simulations with URGWOM. The URGWOM Riverware-based model is the water operations model used for most reservoir and river planning, operations, and accounting on the Rio Grande upstream of Elephant Butte and has been for years.

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[3] The Rio Chama is a tributary to the Rio Grande.

[4] The ISC is currently a party in the related *inter se* proceeding on Intrepid's water rights claims in the Pecos adjudication, and began trial on December 8, 2020. *State of New Mexico, ex rel. State Engineer, et al. v. L.T. Lewis, et al., and United States of America*, No. CV-WH-3-001240, Fifth Judicial District (Carlsbad Section), State of New Mexico.

[5] The Rio Jemez is a tributary to the Rio Grande

13) The ISC has also undertaken key river and drain maintenance efforts to aid in Rio Grande Compact compliance, including projects that reduce consumption of water and/or improve water delivery through the middle Rio Grande and into Elephant Butte Reservoir. It is critical to maintain the river system infrastructure due to its importance for maintaining drainage, moving/managing sediment, and thus reducing non-human depletions of water, and for delivering water to Elephant Butte Reservoir. If the system infrastructure is not maintained, the natural system can consume large volumes of water and significantly reduce inflows to Elephant Butte Reservoir (i.e., an acre of open water in the area can lose more than 5 AF of water off its surface in a year compared to 3-4 AF per acre per year of riparian bottomland (the bosque) and 2-3 AF per acre per year of farmland. The work includes maintaining the Elephant Butte Reservoir Delta Channel, ongoing river and drain maintenance activities with Reclamation and the Middle Rio Grande Conservancy District (MRGCD), and support for levee reconstruction. State of New Mexico costs for conducting these efforts, a number of which we partner on, range from several hundred thousand dollars a year to several million as described in more detail below.

14) The Delta Channel Project is a major project under the ISC's river and drain maintenance effort. The ISC worked collaboratively with Reclamation to build a river channel from the top of Elephant Butte Reservoir to the reservoir itself in the early 2000's as drought, evaporation, and reservoir releases resulted in significantly lower reservoir levels than any time in the previous twenty years. That channel was built out to over 18 miles in length within a few years as the elevation of Elephant Butte Reservoir dropped nearly 100 feet. The ISC continues to maintain the Delta Channel through the exposed sediment bottom of Elephant Butte Reservoir. This work includes repair of spoil bank levees, sediment excavation, access road realignment, vegetation removal, and other work necessary to maximize conveyance of non-flood flows into Elephant Butte Reservoir. Maintenance of the Delta Channel is critical to ensure flows in the Rio Grande are conveyed into the active reservoir pool instead of spreading out and being depleted by evapotranspiration and evaporation within the upstream end of the exposed reservoir sediment bottom. Two independent technical estimates indicate that the water saved as a result of this action is on the order of 8,000 to 17,000 AF/yr. These activities by the ISC directly contribute to New Mexico's Compact deliveries into the reservoir. The ISC is currently mobilizing amphibious excavators and a crew from Louisiana to New Mexico to conduct maintenance on parts of the delta channel and will spend approximately $1 million on the winter effort. Since its inception, the ISC has spent over $22 million on the Delta Channel.

15) Also under the river and drain maintenance effort, the ISC collaborates with Reclamation and the MRGCDin maintenance of the Low Flow Conveyance Channel (LFCC) and its adjacent levee, running from San Acacia Diversion north of Socorro New Mexico over 50 miles south to the headwaters of Elephant Butte Reservoir, and various features that feed water into it. Additionally, the ISC, MRGCD, and Corps of Engineers partnered over the last ten to fifteen years to replace about eight miles of the spoil levee between the river and the LFCC with an

engineered levee. The ISC contributed almost $9 million to the effort. MRGCD was a sponsor of the Corps project with the ISC, also contributed funds, and is responsible for maintaining that new stretch of levee. Reclamation and the ISC continue to work along the LFCC to remove accumulated debris and sediment to increase flow through the LFCC into the Delta Channel and from there into Elephant Butte Reservoir. It is important to maintain the LFCC infrastructure due to its importance for both maintaining drainage, reducing non-human depletions of water, and delivering water to Elephant Butte Reservoir. The ISC also works with Reclamation to maintain an open river channel from San Acacia Diversion into the Delta Channel. This section of river has a tendency to plug with sediment under certain river flow conditions. The ISC has a standing task order with Reclamation to remove sediment and debris plugs that may form in the Middle Rio Grande related to runoff from burn scars associated with wildfires. This standing task order will allow rapid response to deal with sediment plugs that can exacerbate local flooding and inhibit Compact deliveries and water supply for downstream irrigators. ISC cost for this work varies annually depending on the priority. For instance, the ISC provided the MRGCD $400,000 in the spring of 2019 for flood-fighting support work and issues task orders to Reclamation for drain maintenance work ranging from $10,000 to $250,000 per project.

16) The ISC's work described in ¶¶13, 14, and 15, above, contributed to New Mexico being able to build a large volume of Accrued Credit (Compact Article VI) in Elephant Butte reservoir over the last few decades. That then allowed New Mexico to relinquish approximately 380,000 AF of its Accrued Credit for use by the Project, increasing the Project's Usable Water in storage available for release by that amount.

17) The ISC has provided support to New Mexico water users with infrastructure issues raised by EBID related to Rio Grande Project operations and EBID and others regarding groundwater use in the New Mexico part of the Lower Rio Grande. New Mexico has provided funding and/or loans to upgrade the river and canal gaging system, to install new water control structures and groundwater monitoring wells, and to install groundwater well meters. We also have consistently provided funding and technical support to the USGS Mesilla Valley monitoring program.

18) The ISC collaborated with the States of Colorado and Texas and numerous stakeholders in the Rio Grande Compact Commission's Rio Grande Salinity Management Coalition (Coalition) which was formed in the mid-to-late 2000s. The ISC supported the New Mexico Compact Commissioner and collaborated with the above parties, the Corps of Engineers, and the USGS to evaluate changes in water quality (most specifically salinity) in the Rio Grande from San Acacia, New Mexico to Fort Quitman, Texas. Further, the Coalition addressed water quality

issues raised by Texas and did so with USGS technical experts, local experts, and technical professionals from the Compact states as well as the Rio Grande Compact Commissioners. The Coalition met for several years. The Texas complaints were addressed and resolved, and the Coalition disbanded. No further complaints from Texas about water quality were expressed until the Original Action No. 141 was filed.

19) The ISC also works with Reclamation through a Technical Services Agreement to reduce the non-beneficial consumption of groundwater by invasive phreatophyte vegetation and non-native plants (high-water-use) on close to 11,000 acres of the delta areas at Caballo and Elephant Butte reservoirs. The ISC contributes approximately $75,000 per year toward the vegetation management efforts and Reclamation contributes manpower and equipment.

20) The ISC has also obtained water rights on the Middle Rio Grande for the New Mexico Strategic Water Reserve. For example, in 2011 staff completed an agreement to lease 921.328 AF/yr of pre-1907 Rio Grande surface water rights from the Village of Los Lunas that had been transferred to the Village's permit but were not needed in the near future. The OSE District I office granted the permit to move the water rights into the Reserve in 2012. Since that time, these water rights have been applied to beneficial use for the offset of increased depletions associated with modified operations of storage and release of water from reservoirs upstream of Elephant Butte, for endangered species compliance projects, and for Rio Grande Compact compliance. In that regard, the water rights are not applied to beneficial use at their original location and are left in the river system for delivery to Elephant Butte reservoir.

21) The ISC pays the USGS over $700,000 per year for river gaging, data management, and reporting in New Mexico with over $200,000 of that amount used for Rio Grande river and reservoir gages. It also employs and contracts for technical and water expertise to proactively address issues that might impact New Mexico's comprehensive administration of its Rio Grande Compact delivery obligations.

22) ISC Rio Grande Basin staff communicate with Reclamation Rio Grande Project water operations staff periodically each year to understand Reclamation's planned and actual Project operations. We do so to better understand how those operations may directly impact New Mexico water users at the reservoir and downstream of Elephant Butte Reservoir and indirectly impact upstream reservoir operations (if various Compact Articles VI, VII, or VIII are triggered). This includes but is not limited to assessing and engaging with Reclamation on Compact gage records for the Rio Grande Project reservoirs as well as raising objections on Project operations.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on December 18, 2020

Rolf Schmidt-Petersen

Rolf I. Schmidt-Petersen

TX v. NM # 141
New Mexico Exhibit
NM_EX-010

No. 141, Original

IN THE
SUPREME COURT OF THE UNITED STATES

◆

STATE OF TEXAS,
Plaintiff
v.

STATE OF NEW MEXICO and
STATE OF COLORADO,
Defendants

◆

FIRST DECLARATION OF RYAN J. SERRANO

◆

I, Ryan J. Serrano, pursuant to 28 U.S.C. § 1746, hereby declare as follows:

1) I am over 18 years of age and have personal knowledge of the facts stated herein.

2) The State Engineer promoted me to the position of Water Master for the Lower Rio Grande Water Master District (LRG Water Master District) on May 12, 2012. Prior to that my position was Assistant Lower Rio Grande Water Master with the Office of the State Engineer (OSE), a position I held from June 27, 2009 until my promotion. The LRG Water Master District encompasses a geographic area of 4,224 square miles and is home to one of New Mexico's largest agricultural districts, Elephant Butte Irrigation District (EBID). *See* NM-EX 540, Lower Rio Grande Water Master Annual Report, 2018 Accounting Year, (2018 WM Report) at 1, and map at 4.[1]

3) I earned my Bachelor of Science in Geography, with a minor in Geographic Information Systems (GIS), from New Mexico State University in May 2009.

4) Water Masters appointed by the State Engineer "shall have immediate charge of the apportionment of waters in the water master's district under the general supervision of the

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state engineer, and the water master shall so … regulate and control the waters of the district as will prevent waste." NMSA 1978, § 72-3-2. The LRG Water Master ensures compliance on the local level with the New Mexico Water Code, permits and licenses issued by the State Engineer, orders issued by the LRG adjudication court, and State Engineer orders, regulations, and policy guidance and directives.

5) As the LRG Water Master, I am statutorily charged with the responsibility to regulate and control the waters of the Water Master district, in the best interests of public safety and the water right owners of the district and under the general supervision of the State Engineer. NMSA 1978, §§ 72-3-1, 72-3-2. More specifically, I ensure that water rights in the LRG Water Master District are administered according to New Mexico water administration policy and directives. My duties include but are not limited to:

   a) Controlling illegal diversions (i.e. any diversion without a water right, or in excess of the elements or conditions of a water right);
   b) Measuring and reporting water usage within the District;
   c) Controlling out-of-priority diversions;
   d) Administering water usage according to agreements entered into by the water right owners of the district; and
   e) Coordinating, where indicated, with the United States Bureau of Reclamation (Reclamation) and Elephant Butte Irrigation District (EBID).

   These actions are intended to ensure the appropriate regulation and control of groundwater withdrawals. *See also* the State Engineer's order specifying my duties. NM-EX 429, In the Matter of the Creation of the Lower Rio Grande Water Master District … Order No. 169, (12-3-2004) (Water Master Order #169).

6) As the Water Master I have a staff of four (4) full-time employees who serve as Assistant Water Masters and who assist me in determining whether a water rights owner is in compliance with his or her permit as it relates to all elements of a water right, including diversion limits, place of use or purpose of use, or requirements to retire lands. My Assistant Water Masters also help identify illegal uses of water or over-diversion of water, conduct field investigations and inspections of wells or other points of diversion, conduct flow measurements of both groundwater and surface water points of diversion, and analyze and access aerial photographs and historical records relating to the nature and extent of water rights. These duties facilitate the opening, maintaining and closing of water rights files maintained at the OSE District IV office with respect to all applications, declarations and other matters touching upon water rights which are submitted by different parties to the OSE District IV offices. Water Master staff also assists in enforcement efforts.

7) My Assistant Water Masters and I spend a great deal of time – about 60% of the work week – "in the field", directly dealing with water right owners. We drive all the farm roads, visit water right owners' fields, monitor their meters, advise on issues of compliance with permits and other state requirements, perform visual checks of such compliance, and attend community meetings (including all EBID Board meetings). We are in communication with LRG water right owners on a daily basis.

8) The LRG's agricultural importance to New Mexico is significant. Pecan production in New Mexico is the second highest in the nation and is the State's number one cash crop with a value of $162.3 million in 2018. New Mexico is also ranked 2nd in the nation for chile production, most of that coming from the LRG. New Mexico is ranked 5th in the nation for onion production, and the LRG accounts for the majority of the onion cash crop. NM-EX 540, 2018 WM Report at 1.

9) In their motions for partial summary judgment, Texas and the United States display a number of misunderstandings and also provide erroneous statements of fact relating to New Mexico water administration authority and enforcement in the LRG. I have been asked to address those.

ENFORCEMENT MECHANISMS AND PROCESS

10) Specific statutory authority providing mechanisms for the State Engineer's enforcement of compliance[2] with statutes, court orders, and the State Engineer's regulations, permits, licenses, and orders is at NMSA 1978, § 72-2-18. This provision allows the State Engineer to employ a variety of remedies including issuing Compliance Orders, providing an opportunity for hearing, and filing civil actions against offenders. NMSA 1978, § 72-2-18. For all enforcement issues, I follow this statutory scheme; as an example. The process for any type of violation related to well pumping is:

    a) In the field, Water Master staff will put a "red tag" on non-compliant wells to be followed up by a letter.
    b) By letter I notify an offender of the specific violation/s. Violations include, but are not limited to, inaccurate meters, failure to timely file meter readings, over-diversion, and illegal pumping. The offender is given 30 days to comply. Receipt of the letter usually results in the offender contacting and working directly with Water Master staff to reach compliance.
    c) The offender has 30 days in which to respond to my notice letter, after which I refer the issue to the OSE's Administrative Litigation Unit (ALU) and request that a compliance order issue to the offender. After receipt of the Compliance Order, the offender has 30 days in which to comply.

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[2] The word 'compliance' in this declaration means compliance with State Engineer permits, licenses, orders and regulations, as well as New Mexico law as it relates to the administration of water.

d) If the offender does not comply with the Compliance Order within 30 days, the ALU can file suit in the state district court to enforce the Compliance Order.

See also NM-EX 235, Thacker 30(b)(6) Dep. at 35:18-38:7.

MONITORING COMPLIANCE

11) Every water right in New Mexico must comply with state statutory requirements, State Engineer permits, licenses and orders, OSE policy and guidelines, and applicable court orders.

12) The Mesilla Valley Administrative Area (MVAA) guidelines are the State Engineer's area-specific guidelines applicable to the vast majority of LRG water rights and that are used in assessing applications made to the OSE for changes in use, purpose, or location of a water right, as well as ensuring compliance with other OSE directives. *See, e.g.*, NM-EX 232, Serrano Dep. (2-26-19) at 94:7-96:24.

13) The adjudication court order that most affects my work is the LRG SS101 Adjudication Order (*see* NM-EX 007, D'Antonio 2nd Decl. at ¶37(a). That order establishes the total amount of surface and groundwater that may be used on an acre of land in the LRG. To assure compliance with that order I employ various metrics and mechanisms to monitor water diversions and use, including the following:

   a) As to enforcement of groundwater use, all irrigation wells in the LRG are metered. Meter readings must be submitted to District IV on a quarterly basis. These meter readings are input by OSE staff into WATERS and publicly available at http://nmwrrs.ose.state.nm.us/nmwrrs/index.html. *See* NM-EX 232, Serrano Dep. (2-26-19) at 54:22-55:13 (testifying that all metering information from irrigation, municipal, commercial, industrial, dairy and metered domestic is available to the public).

   b) Before every irrigation season Reclamation calculates allocation of Project water with input from EBID and EPCWID through the Allocation Committee. The allocation determines how much Project water is available for Project lands in New Mexico. Given their Project allocation, EBID then determines the individual allotments to EBID farmers. This may be adjusted based on changes in Project allocation during the season. The LRG Water Master and staff obtain this information from EBID and input it into WATERS as to each EBID member. NM-EX 236, Serrano Dep. (4-17-19) at 183:19-24. In accordance with the SS101 LRG Adjudication Order, the OSE assumes that EBID members use their full allotments, when available, as to surface water diversions and that they use their surface water allotments before using groundwater. NM-EX 541, Final Judgment in SS-97-101 (SS101 LRG Adjudication Order) at ¶ II(D), V(B). This is a conservative assumption because it limits the amount of groundwater available to EBID members. On these assumptions, OSE calculates how much of each water rights owner's 4.5 AF/acre (or 5.5 AF/acre) combined water right may be satisfied by the diversion of groundwater.

This calculation assures compliance with the SS101 LRG Adjudication Order. NM-EX 235, Thacker 30(b)(6) Dep. at 33:12-35:17.

c) OSE does not measure or limit individual EBID farmer diversions of surface water. That is, by statute and EBID procedures, the responsibility of the irrigation district. NMSA 1978, §§ 73-10-16, -24. However, all non-EBID surface water irrigation diversions are monitored through the use of meters and the full panoply of OSE compliance mechanisms.

d) Non-EBID irrigation surface water rights owners in the LRG are required to meter their surface water diversions.[3] The OSE uses these meter readings from surface water and groundwater to track use.

e) All non-irrigation wells in the LRG are metered, excepting single-family domestic and small stock wells. NM-EX 227, Barroll Dep (2-5-20) at 39:21-40:24; NM-EX 533, State Engineer Suppl. Order No. 180 (3-28-2007) (Final Metering Order).

f) Single-family wells and small stock wells are estimated to use approximately 2-3,000 AF/yr total in the LRG. Under the State Engineer's 2006 Domestic Well rules, domestic wells for single-family use do not require meters but are permitted for 1 AF/yr; if livestock is included the permit may be for 2 AF/yr. NM-EX 234, D'Antonio Dep. (6-26-20) at 329:6-331:2. The United States mistakenly confers great importance on domestic well use, which constitutes less than 1% of water use in the LRG.

14) The LRG Water Master staff closely monitors metering in the LRG to assure compliance with the State Engineer's Metering Order (*see* NM-EX 007, D'Antonio 2nd Decl. at ¶¶ 41, 44):

a) There are approximately 2,650 active irrigation wells in the LRG. All are metered.
b) There are approximately 350 active non-irrigation wells in the LRG.[4]
c) There are thus approximately 3,000 active wells in the LRG. I do not know how Texas came up with a figure of 8,000 wells; that is simply wrong by thousands.
d) Meters are regularly checked in the field for accuracy and correct usage. If a meter is non-compliant, it is "red-tagged" and enforcement proceedings begin.
e) Irrigation meter readings are due quarterly. The final quarter includes the last groundwater use of the irrigation season (farmers often irrigate through the end of the year and after surface water allotment deliveries have ceased) and those readings are due on January 10. It would be impractical from administration and cost perspectives to require more frequent meter readings for irrigation wells. *See* ¶ 24, below.

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[3] The water rights of non-EBID surface water rights holders in the LRG pre-date the Project.

[4] Again, not including the domestic use statutory exceptions.

f) Municipal, commercial and industrial (M&I) use meter readings must be provided monthly. NM-EX 232, Serrano Dep. (2-26-19) at 72:25-74:3. The United States confuses domestic wells with M&I wells. As I clearly stated in my deposition, all M&I wells are metered and compliance enforced. *Id.* I did ***not*** testify that "use from these wells was not tracked" until 2012. *See* USMF #59.

g) Contrary to statements by the United States (USMF #59), LRG Water Master staff consistently monitor domestic well issues:

   i) We analyze domestic well meter readings just as we do irrigation meter readings, and

   ii) We regularly make visual checks on domestic wells as to compliance with limitations on their use.

   The United States mischaracterizes the evidence it relies upon when it suggests that the OSE does not perform oversight of domestic wells: the State Engineer testified that he has the authority to monitor domestic wells if necessary, which to date it has not been. NM-EX 234 D'Antonio Dep. (6-26-20) at 331:6-24. He testified he did not know if there has been any enforcement on domestic well use (NM-EX 234, D'Antonio Dep. (6-26-20) at 331:3-6) because that issue is below his level of involvement. *See* (NM-EX 234, D'Antonio Dep. (6-26-20) at 318:17-319:11. Further, of the several thousand domestic wells drilled through the decades in the LRG, many are now plugged and many are no longer used because residences now have municipal water. In any event, the small amount of domestic and stock water use in the LRG has no appreciable impact on surface water supplies.

h) Water Master staff inputs all meter readings into the WATERS database and at that time usage anomalies may be flagged and addressed. For instance, if we receive a meter reading at the July quarterly submission date that reflects higher than expected diversions at that time in the season, we will contact the water right owner and, if warranted, initiate compliance enforcement.

i) My staff is proactive in obtaining meter reading compliance, including sending postcards to water rights owners in advance of the meter reading submission date. *See* NM-EX 540, 2018 WM Report at 11. If a groundwater right owner does not timely submit meter readings, the Water Master staff contacts the water right owner to achieve compliance.

j) If the Water Master staff receives complaints about improper groundwater or surface water diversions, we promptly investigate and/or notify EBID in the case of EBID surface water complaints.

k) If the Water Master and other LRG OSE staff are not able to obtain compliance with water administration issues by working with water rights owners at the local level, we follow the mandates in NMSA 1978, § 72-2-18 and refer the matter to the ALU for legal action.

15) I have read former LRG Water Master Sheldon Dorman's testimony. The United States has misconstrued Mr. Dorman's testimony about domestic wells to the extent the United States implies that Mr. Dorman was describing the present state of administration. First, Mr. Dorman left the LRG in 2011. NM-EX 229, Dorman Dep. at 29:7-11. In his deposition he is discussing the 2007 time period, before final implementation of the Final Metering Order.

He explains that during the implementation of the Metering Order and the comprehensive investigation by the OSE of metering conditions in the LRG, some number of domestic wells were being improperly used to supplement surface water. He goes on to explain that the OSE required that such wells be metered. NM-EX 229, Dorman Dep. at 71:10-25, 72:1-24. All improper uses noted by Mr. Dorman have long since been rectified.

16) During field inspections or through citizen complaints, Water Master staff occasionally discover domestic wells that are non-compliant either because they service more than one household (in which case they must be metered) or because they are being used to irrigate. In those situations we immediately initiate actions to obtain compliance with the limitations on domestic well use.

17) Another statute I enforce is NMSA 1978 §72-12B, "Use of Waters Outside the State." This occurs when New Mexico water right owners pump New Mexico groundwater into Project conveyances for delivery across the Texas state line. NM-EX 548, New Mexico Groundwater Irrigations Wells Pumping Groundwater for Use in Texas (9-11-2018) (EP#1 directed New Mexico farmers to pump New Mexico groundwater into Texas).

WELLS

18) From 2016 through December 14, 2020, the OSE issued permits for 252 wells for M&I use (municipal, commercial, mutual domestic, and industrial; that is, every non-irrigation or non-single-family domestic) in the Mesilla and Rincon basins. This includes exploratory and monitoring wells. Municipal groundwater use in the LRG, including the Jornada basin and unmetered domestic use, is about 40,000 AF/yr. *See, e.g.*, NM-EX 540, 2018 WM Report at 17-18. The OSE subjects every application for municipal or industrial use to the same rigorous and comprehensive analysis as applications for irrigation wells. *See* NM-EX 007, D'Antonio 2nd Decl. at ¶¶ 5 (a-d), 16-17, 19-24. In general, such applications are seeking supplemental or replacement wells and if permitted, are permitted with conditions such that they cause no new depletions to the Rio Grande.

19) Since the LRG Basin was declared in 1980/1982 (*see* NM-EX 007, D'Antonio 2nd Decl. at ¶¶ 13-15), the OSE has permitted approximately 2,678 changes to existing irrigation well water rights. Each one went through the rigorous and comprehensive analysis required by the permitting process.

20) As of 2020 there are approximately 3,000 active irrigation and "M&I" wells in the LRG. See ¶ 14, above.

21) My staff and I have done an extensive search to confirm that the OSE has not permitted any new appropriations of groundwater in the Mesilla or Rincon basins since the LRG Groundwater Basin was declared in September 1980. *See* NM-EX 007, D'Antonio 2nd Decl.

at ¶¶ 13-15. We have discovered three (3) trivial exceptions mostly based on minor inaccuracies or mistakes:

File No.	**Use**	**Total Diversion In AF/acre**	**Official Priority Date**	**Comments**
1232	Comm.	3	12/31/1980	The water right owner filed his declaration in March 1981, claiming a pre-1980 well, but the date is unclear on the declaration. WATERS, as a standard protocol in such situations, applies the last day of the year: 12/31/1980. Thus, although this looks like a new post-Basin right, it is not.
5406	Irr.	7.695	5/16/1985	This was adjudicated a 1985 priority date. However, we have investigated this and it appears the adjudication subfile order (subfile LrN-28-013-0287) was incorrect in that 5/16/1985 was the date the declaration was filed. The declaration claims a priority date of about 1890, with a replacement well drilled in about 1975. Thus, although this looks like a new post-Basin right, it is not.
17587	Irr.	3.17	2/18/1988	This is a "move from/to" application and OSE is awaiting proof of beneficial use which is expected to prove less than 3.17.
TOTAL		**13.865 AF**		**For context, water use in the entire LRG Basin is approximately 350,000 to 375,000 AF annually; these exceptions represent a tiny fraction of a percentage.**

OVER-DIVERSIONS

22) Over-diversion is when a water rights owner takes more water than that to which he/she is entitled. Over-diversion, or a potential for over-diversion, is discovered:

   a) when District IV staff calculates usage in excess of the permitted 4.5 AF/acre (or 5.5 AF/acre) based upon groundwater meter data and the status of the surface water allotment (or surface water meter reading) (see ¶ 13);
   b) when third parties report over-diversion by others; or
   c) at the end-of-season reconciliation of all water use data.

Contrary to the unsupported and incorrect assertions by the United States, ***the Water Master investigates EVERY over-diversion***.

23) If an over-diversion or potential for over-diversion is discovered during the irrigation season, the Water Master contacts the offending water right owner and discusses how to either avoid a potential over-diversion or "repay" an actual over-diversion. If those discussions do not resolve the issue, the matter is sent to the ALU to take appropriate legal action. Over the last ten years, anywhere from 5 to 35 matters per year have been sent to the ALU for resolution; this number includes any type of violation we have not resolved at the local level including, for instance, meter violations. The ALU can, and does, litigate these matters and has obtained court orders and injunctions requiring water right owners to cease groundwater pumping. Any over-diversion of water must also be repaid to the system. NM-EX 235, Thacker 30(b)(6) Dep. at 36:5-38:7.

24) If an over-diversion is discovered at the end of the irrigation season when District IV conducts its reconciliation of all water use data after receipt of the 4th quarter meter readings, our first undertaking is to "true up" the data to account for errors. NM-EX 540, 2018 WM Rep. at 7; NM-EX 226, Barroll 30(b)(6) Dep. at 22:14-25, 23:1-2; NM-EX 235, Thacker 30(b)(6) Dep. at 36:5-25. The reconciliation process can take several weeks as data anomalies are discovered and corrected.

25) Repayment for over-diversions requires a formal, written repayment plan reached in consultation with and acceptable to the LRG Water Master. Repayment plans can be entered into during the season in which they take place, but in any event are entered into before April of the next irrigation season so that the farmer understands payback requirements while making crop decisions for the upcoming season. Due to the nature of water use for seasonal crops, the repayment generally takes the form of abstention from water use, or transfer of water use, in the next season. The Water Master enforces these repayment plans. The procedures for reconciliation and repayment are published every year in my annual Water Master report. *See, for example*, NM-EX 540, 2018 WM Report at 10. The process is extremely effective, as reflected in the graphic showcasing repayment success on page 9 of my 2018 Water Master Report. NM-EX 540, 2018 WM Report.

26) I have read the deposition testimony of Dr. Peggy Barroll with regard to over-diversions. The United States has cited it incompletely. First, many instances of potential for over-diversion are discovered and addressed during the irrigation season. Second, much of the potential for over-diversion is at the end of the irrigation season – in October through December. Meter readings for groundwater use for those months is not due until January 10; thus, over-diversions in those months are addressed after OSE receives the meter readings. While a recent average of over-diversions in a season may reach 200, that includes infractions that are dealt with and resolved immediately at the local level. The number reaches that higher end when surface water supplies are low. As the State Engineer testified, in 2018 we had 133 enforcement actions (not limited to over-diversion) in the LRG, and about 70% were resolved at the local level. The other 30% were referred to ALU. NM-EX 234, D'Antonio Dep. (6-26-20) at 317:4-318:7; NM-EX 540, 2018 WM Rep. at 9. It is important to not

overstate or exaggerate the significance of over-diversions. The LRG stream system has an average of 350,000 to 375,000 AF/yr of diversions; over-diversions are relatively small:

YEAR	NUMBER OF OVER-DIVERSIONS	TOTAL AMOUNT OF OVER-DIVERSION
2019	215	5,173 AF
2018	133	1,769 AF
2017	128	3,992 AF
2016	109	4,161 AF
2015	154	9,563 AF

27) The United States has misstated my testimony with regard to litigation of enforcement actions for over-diversion. As I explained in my deposition, the OSE has an expedited hearing process for over-diversion. I have many times been prepared to testify at such hearings, but to date we have been able to resolve the issues "at [the negotiating] table" before the hearing. In every such resolution the OSE has effected a full repayment of the over-diversion, so the fact that we are able to accomplish compliance without the time and expense of a hearing is a testament to the effectiveness of our compliance process.[5]

"RIVER PUMPERS"

28) There have occasionally been persons who illegally pump Rio Grande surface water for irrigation uses: "river pumpers." Water Master staff investigate and enforce against these illegal uses. The OSE will and has prosecuted these illegal diversions in state court. *See, e.g.,* NM-EX 542, Field Investigation of river pumps/diversions (June 26, 2013); NM-EX 543, Memorandum Opinion, *State of New Mexico ex rel. State Engineer v Faykus,* No. A-1-CA-36848 In the Court of Appeals of the State of New Mexico (April 13, 2020) (affirming the District Court's order that Faykus did not have a water right to pump water from the Rio Grande).

29) Reclamation and the International Boundary Water Commission (IBWC) have themselves improperly pumped surface water for some of IBWC's projects. *See, e.g.,* NM-EX 544, Gary Esslinger letter to Ed Drusina (January 25, 212).

30) There are also a few instances within the LRG where water rights owners are authorized to implement a point of delivery from the Rio Grande main stem. On occasion, Reclamation

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[5] Texas and the United States use the term "curtail" differently than does New Mexico. The OSE uses "curtail" to refer specifically to the mechanism for enforcing a priority call. There has never been a priority call in the LRG. *See* NM-EX 232, Serrano Dep. (Feb 26, 2019) at 55:14-22. In OSE parlance, all other enforcement of water rights, including limits to diversion, is referred to as water right "enforcement."

and/or Texas have complained about these river pumpers, without understanding that they are permitted or otherwise legally entitled to receive their surface water supply in this manner. *See, e.g.*, NM-EX 542, Field Investigation of river pumps/diversions (June 26, 2013), examples at PDF page 39 (Duran surface water pump permitted by the OSE and authorized and assessed by EBID for Project water), pdf page 43 (Holguin surface water pump determined to be a pre-Project right), pdf page 51 (Dulin surface water pump permitted by the OSE and authorized and assessed by EBID for Project water), pdf page 59 (Thurston's Rio Grande river pump adjudicated, and authorized and assessed by EBID for Project water).

OWMAN

31) The SS101 LRG Adjudication Order specifically provides for a mechanism by which water rights owners may exercise surface water rights and groundwater rights to achieve necessary flexibility in irrigation. NM-EX 541, SS101 LRG Adjudication Order at §IV(c). In response, District IV created the "Ownership Management Program" (OwMan). OwMan allows farmers who own or manage lands under more than one water right file number to manage the water rights associated with these lands conjointly so that a higher percentage of groundwater may be used on part of the lands, while a higher percentage of surface water is used on the other part.[6] The combination of water rights used must not exceed the amount of acre-feet per acre per year (AF/A/yr) allowed under the relevant permitted water rights. Applicants for OwMan must formally file statements of intent to enter an OwMan arrangement with co-owners or co-managers by April 30 of each irrigation year (unless they have a pre-existing OwMan statement). *See also* NM-EX 235, Thacker 30(b)(6) Dep. at 42:9-43:9, 44:8-14; NM-EX 540, WM Report at 6.

32) When designing the OwMan program, OSE consulted with LRG water right owners. The LRG water right owners suggested that the OSE use as its model the surface water sharing program used by EBID whereby surface water allotments can be moved from one account to another and surface water use averaged across the assessed acreage. EBID also allows certain flat-raters[7] to combine acreage to achieve farm rate assessments. Further, a liberal mechanism for effecting water sharing such as under the OwMan program is specifically provided to EBID under the statutes governing "Irrigation Districts Cooperating with the United States Under Reclamation Laws; Formation and Management." NMSA 1978, §§ 73-

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[6] OwMan reflects historical water use in the LRG beginning back in the 1950s when Reclamation staff assisted LRG farmers in conjunctive management of groundwater and surface water, sharing of groundwater among farms, and the transfer of surface water from farms with wells to those without wells. For instance, in NM-EX 433, Reclamation Water Announcement of March 1, 1954: "Farmers with good irrigation wells are requested to use them to the greatest extent possible as a source of supply and to make available for transfer their allotment water to those farmers who do not have satisfactory wells." Dr. Barroll discusses the issue of Reclamation encouraging groundwater sharing in her expert report. NM-EX 100, Barroll Rep. at §4.1.

[7] A "flat-rater" is a water rights owner with two acres or less of land and are charged a flat annual rate for their water based on the amount of acreage owned.

10-1 *et seq*. Under those statutes, a district member may "assign the right to the whole or any portion of the water [allocated to him/her by the district] for any one year where practicable, to any other bona fide landowner…" NMSA 1978 § 73-10-16. EBID refers to these transfers as "in-season assignments." Reclamation is apparently supportive of these water sharing arrangements.

33) Texas mischaracterizes OwMan and my testimony about it. OwMan is not a transfer of existing water rights. Instead, it is a sharing of use; there is no transfer of water rights involved. Further, the program is not "informal"; there is in fact a formal process for OwMan applicants and the water usage under an OwMan is monitored for compliance as is all groundwater use in the LRG. *See* NM-EX 232, Serrano Dep. (2-26-19) at 85:17-91:8.

34) In rare cases (less than 5 per year) I will allow the implementation of an OwMan arrangement after the fact when the water rights owners involved can prove that water was shared during the irrigation season due to an unavoidable situation such as a failed pump. I investigate each such request and require proof of such emergencies; if the proof fails, repayment of over-diversion is required.

EFFECTS OF THE 2008 OPERATING AGREEMENT

35) I have had many conversations with water right owners about how the 2008 Operating Agreement has impacted them. One common complaint is that those citizens with surface water only rights have had their surface water allotments severely cut back as a function of the 2008 Operating Agreement, but they cannot make up those losses through use of groundwater. The practical effect is that many water right owners who had, for instance, subsistence gardens and fruit and pecan orchards have lost those crops and property improvements. I have seen many such "dried up" gardens and orchards.

36) Another frequent complaint I hear is that pumping costs have increased as a result of the decrease in surface water allotment since the 2008 Operating Agreement. This is a manifestation of the "vicious cycle" discussed and presented by Dr. Barroll. *See, e.g.,* NM-EX 118, Effect of 2008 OA on New Mexico: A Vicious Cycle (2020).

37) I have described the rigorous and effective compliance and enforcement activities by the OSE in the LRG. Texas's statement that "measuring is all New Mexico has done" is demonstrably false. *See also* NM-EX 100, Barroll Rep. at 22-23, fn 48, describing the New Mexico groundwater administration and noting "Texas has no such mechanisms.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on December 22nd, 2020

Ryan J. Serrano

TX v. NM #141
New Mexico Exhibit
NM_EX-011

No. 141, Original

IN THE
SUPREME COURT OF THE UNITED STATES

◆

STATE OF TEXAS,
Plaintiff
v.

STATE OF NEW MEXICO and
STATE OF COLORADO,
Defendants

◆

SECOND DECLARATION OF JENNIFER STEVENS, PH.D.

◆

I, Dr. Jennifer Stevens, pursuant to 28 U.S. C. § 1746, hereby declare as follows:

1. I am over 18 years of age and have personal knowledge of the facts stated herein.

2. I am the same Dr. Jennifer Stevens who authored expert reports in this litigation (NM-EX 112 and 113) and my first declaration for New Mexico's dispositive motions filed November 5, 2020 (NM-EX 005).[1] My credentials and background are listed in my November 4, 2020 declaration. NM-EX 005 at ¶¶2-7.

3. Texas and the United States make several incorrect and erroneous statements of fact in their Motions for Partial Summary Judgment, and I have been asked to address them.

4. As early as the turn of the 20th century, groundwater was recognized as a potential source of supply for irrigation in the Rio Grande Valley.[2] The New Mexico Agricultural Experiment Station noted in 1903 that Texas irrigators around El Paso had "been compelled to

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[1] All exhibits designated "NM-EX" in this Declaration are contained within the State of New Mexico's Exhibit Compendium filed with New Mexico's Partial Summary Judgment Motions dated November 5, 2020, and additional exhibits in the State of New Mexico's Supplemental Exhibit Compendium dated December 22, 2020 filed with New Mexico's responses to the Texas and United States November 5 motions for partial summary judgment_. Exhibits used by the United States and Texas in their motions for partial summary judgment are cited as in those briefs.

[2] NM-EX 113, Jennifer Stevens, "Rebuttal Report, Prepared for the New Mexico Office of the Attorney General in the Matter of *State of Texas v. State of New Mexico and State of Colorado* No. 141, Original," June 15, 2020 ("Stevens Reb. Rep.") at 6.

turn their attention to other water supplies or else abandon all agricultural work. As a consequence they have demonstrated the fact that crops can be profitably grown by irrigation from wells tapping the underflow in the Rio Grande Valley."[3] New Mexico irrigators in the Mesilla Valley also used groundwater in the years immediately after the turn of the century, before the Rio Grande Project was approved and constructed.[4]

5. Due to Rio Grande Basin-wide needs for a reliable water supply, the U.S. Congress authorized the U.S. Reclamation Service to construct the Rio Grande Project in 1905. Parts of the Project, including the Leasburg Diversion Dam and Canal, were completed in 1908 and watered 25,000 acres in the Mesilla Valley by 1911.[5] Storage water from Elephant Butte dam was delivered to users within the New Mexico and Texas Project districts beginning in 1916.

6. In negotiations related to what became the temporary compact of 1929, each of the three states – Colorado, New Mexico, and Texas – took separate positions, and Texas and New Mexico's positions were closely aligned. New Mexico was unique among the three states in that the two primary water user groups in the state had opposing interests, with its upstream users in Middle Rio Grande Conservancy District (MRGCD) wanting a lesser delivery obligation into Elephant Butte Reservoir and the downstream Project users in EBID demanding a greater delivery of water, thus creating tension between them and putting the state in a tricky position. New Mexico was bound to protect users both above and below the dam, with the city of Albuquerque growing exponentially during these years.[6] Fostering the MRGCD development helped both sets of users, since it permitted development of acreage in the Middle Valley through the drainage of lands; downstream water users in both New Mexico and Texas accepted and agreed with engineering studies showing that MRGCD development would better regulate flows into the Elephant Butte Reservoir as well as augment volumes.[7]

7. During 1920s negotiations, Texas supported New Mexico's MRGCD development, because Texas believed that development of MRGCD would augment and regulate supply into EBR. Texas was not opposed to this development during the 1920s negotiations and supported New Mexico's development of the area.[8] Texas's engineer explained that "the purpose of a compact on the part of New Mexico and Texas with Colorado with regard to the Rio Grande would

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[3] NM-EX 332, John J. Vernon and Francis E. Lester, "Pumping for Irrigation from Wells," Bulletin No. 45 (State College, N.M.: New Mexico College of Agriculture and Mechanic Arts, Agricultural Experiment Station, April 1903) at NM_00151742.

[4] NM-EX 332, Vernon and Lester at NM_00151741.

[5] NM-EX 112, Jennifer Stevens, Ph.D., "The History of Interstate Water Use on the Rio Grande: 1890-1955," Expert Report Prepared for the New Mexico Office of the Attorney General, October 28, 2019 ("Stevens Rep.") at 21.

[6] Albuquerque had 15,157 residents in 1920, 26,570 in 1930, and 35,449 in 1940. (U.S. Census records, New Mexico).

[7] NM-EX 112, Stevens Rep. at 34-35.

[8] NM-EX 112, Stevens Rep. at 34-35, fn 38.

be to assure a continued supply of water to their lands in the Middle Rio Grande Conservancy District, the Rio Grande Project and other irrigated lands, as good as has been enjoyed heretofore." *See* NM-EX-333, Comments on Compact Negotiations (undated, c. 1929) at NM_00101878-886.

8. New Mexico represented two powerful user groups in compact negotiations, user groups whose interests were not aligned. New Mexico's position in the 1920s compact negotiation (as well as the 1930s) was that the Rio Grande Project had "greatly benefitted the section between the dam in New Mexico and Fort Quitman in Texas but above San Marcial the burden of the obligation to Mexico operates as a direct drain during dry cycles upon the resources of the stream in the basin."[9] Therefore, New Mexico's compact delegation aimed to protect the Project as a unit while also protecting the supplies of upstream users in the Middle Valley. Texas and Colorado agreed that the obligation to Mexico through the 1906 Treaty hurt farmers throughout the Rio Grande Basin (hereinafter, "Basin"), and that the United States should fund the construction of infrastructure that would augment supply to the Basin above Elephant Butte, from which Mexico's treaty water was delivered, thereby assuring supply into the reservoir for users in both New Mexico and Texas.

9. To protect its users below the dam, New Mexico aimed, therefore, to protect the Project as a unit, ensuring it received the supply necessary to water all the lands in EBID.[10] Protecting the Project as a unit was the vehicle through which New Mexico protected its users below Elephant Butte in the 1920s as well as the 1930s.[11]

10. Texas and New Mexico even jointly hired an engineer – Osgood – to study Colorado plans in the San Luis Valley and ensure they would not harm Project supplies.[12]

11. Meanwhile, Texas also sought to protect the lower Rio Grande area, including the lands in Hudspeth County, which had rights only to excess Project water through Warren Act contracts, and lands around Fort Quitman, which Texas proposed to serve through six groundwater pumps.[13]

12. Texas's position in the 1920s included its goal to protect future additional developments throughout the Basin, including within its own and New Mexico's borders. Texas's Richard Burges makes this clear in his opposition to one of the proposed compact terms in the

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[9] NM-EX 338, Francis C. Wilson, "Rio Grande Compact Report of Francis C. Wilson, Commissioner for New Mexico" (Interstate River Commission for the State of New Mexico, 1929) at NM_00118544.

[10] NM-EX 112, Stevens Rep. at 34-35.

[11] NM-EX 112, Stevens Rep. at 38-39.

[12] NM-EX 339, J.W. Taylor, President and Manager, to Mr. D.C. Henny, February 7, 1927 at NM_00117911-7912.

[13] NM-EX 340, E.P. Osgood, "Preliminary Report Upon the Use, Control & Disposition of the Rio Grande and Its Tributaries Above Fort Quitman, Texas," March 31, 1928 at NM_00118331-8332.

following passage: "Colorado alleges that over 200,000 acre feet of water on the average are surplus waters. It should be noted that if a compact division of the water is entered into, then New Mexico and Texas are giving up all rights to further appropriation of the alleged surplus, but freeing Colorado, subject to the Compact, to such capture of water as she can effect and to such extension of irrigation as she can accomplish. In other words, Colorado only is the applicant for further and new rights." *See* NM-EX 333, Burges Comments on Compact Negotiations at NM_00101878-886. This interest in and demand to permit future development remained consistent in the 1930s compact negotiations.

13. By 1938, however, Texas's position on other points had changed rather dramatically from its negotiating position in the 1920s, particularly related to MRGCD. In November 1935, Texas filed a complaint against the State of New Mexico in the U.S. Supreme Court,[14] alleging that the infrastructure comprising the Middle Rio Grande project violated provisions of the 1929 Compact and reduced flows into Elephant Butte Reservoir.[15] NM-EX 112, Stevens Rep. at 48-50, 54. Texas was convinced that the MRGCD had increased the amount of acreage the project had originally intended to serve but could not procure any data to prove it.[16] NM-EX 112, Stevens Rep. at 59.

14. Texas gradually recognized the difficulty of proving its case against New Mexico because ***there was no data showing that the MRGCD had caused water deliveries to Elephant Butte Reservoir to decline.*** Therefore, upon a recommendation from Texas's Raymond Hill, the state turned to a new interpretation of a 1929 Compact clause whose language prohibited New Mexico from "impairing" Texas's water supply; Hill's new interpretation depended not on the quantity of water delivered to Elephant Butte, but on the quality of the water Texas used on its lands. According to Hill, "impair" simply meant any change that would "reduce the value of the water supply."[17] NM-EX 112, Stevens at 59, fn 25. This novel interpretation of the 1920s compact clause became the prime concern in the *Texas v. New Mexico* litigation and subsequently, in negotiations over the permanent compact. Concerns over water quality had been non-existent in the 1920s.[18] (C14)

15. New Mexico's positions in the 1930s negotiations remained consistent. New Mexico's compact commissioner Thomas McClure steadfastly represented water users both above and below Elephant Butte Reservoir in the 1930s negotiations, as he had in the 1920s, despite growing tension within New Mexico between water users above and below Elephant Butte Reservoir. New Mexico's delegation had to broker the friction throughout negotiations, and its efforts to protect Project supplies was the means by which it protected its downstream users, while

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[14] *State of Texas v. State of New Mexico*, No. 10 Original, Supreme Court of the United States.

[15] NM-EX 112, Stevens Rep. at 48–50, 54.

[16] NM-EX 112, Stevens Rep. at 59.

[17] NM-EX 112, Stevens Rep. at 59, fn 25.

[18] NM-EX 112, Stevens Rep. at 58-59, fns 25-31 and at 66-67, fn 74.

simultaneously ensuring that the reservoir's agreed-upon "normal release" figure was not higher than was fair for the state's upstream users. *See* TX_MSJ_005303, Appendix 2, McClure to Harper, 1/25/38; TX_MSJ_005311, Appx. 6, March 4, 1938, ¶4; NM-EX-112, Stevens Rep. at 66-69.

16. In late 1937, the Engineering Committee submitted recommended Compact terms to the Compact Commission. Upon review of the December 27, 1937 Engineering Committee report, New Mexico delegate McClure "came to the definite conclusion" that several changes were necessary, particularly the recommended delivery schedule for San Marcial that was based on the relationship between the Otowi index supply and the Elephant Butte usable supply, a relationship which New Mexico felt was "not an accurate or good basis" on which to set up the delivery schedule. *See* TX_MSJ_005258-59, 03-03-1938 Proceedings of the Meeting of the RGCC. Additionally, McClure noted that New Mexico "cannot be satisfied" with the figures in the report representing the "normal release" from Elephant Butte. *See* TX_MSJ_005259, 03-03-1938 Proceedings of the Meeting of the RGCC. These concerns stemmed from McClure's need to balance the demands of both upstream and downstream users.

17. During final negotiations, the parties met again in early March 1938 to discuss and determine whether to adopt the details of the December 1937 Engineering Committee report. Considering New Mexico's objections, the commissioners sent the engineers back to the drawing board to reconsider certain points, at which point former New Mexico Governor Anthony Hannett – serving as one of New Mexico's legal advisers – recommended that MRGCD engineering consultant Mr. H.C. Neuffer be permitted to sit in on the Engineering Committee meetings. *See* TX_MSJ_005273-5276, 03-03-1938 Proceedings of the Meeting of the RGCC. Judge Edwin Mechem, representing EBID, misunderstood the request and objected that he did not want Neuffer *representing* the State of New Mexico. Hannett made clear that New Mexico's formal engineer representative, John H. Bliss, (the only one granted authority to represent the state in the Engineering Committee) represented *all* of that state's water users, and that the request was merely to permit Neuffer to *physically attend* the meetings specifically on behalf of the MRGCD water users, "since that district is the most vitally interested area in New Mexico as to the effect of this compact." *See* TX_MSJ_005273, 03-03-1938 Proceedings of the Meeting of the RGCC. The implied corollary to Hannett's statement was that the Project itself protected the downstream users in EBID. Hannett explained that Neuffer was not to be given a vote or any other formal authority, but that the commission should allow *any* water users' representative to sit in on the engineers' sessions, so that they could ask questions and contribute necessary data in real time. Furthermore, Hannett continued, if any one group (in this scenario, MRGCD) successfully lobbied the New Mexico (or other states') legislature not to ratify the Compact because of their dissatisfaction with its terms, all the negotiations would be pointless; therefore, allowing Neuffer to participate would expedite the process because he would be able to weigh in on the proceedings and obtain and/or

contribute the data he needed. *See* TX_MSJ_005273-5276, 03-03-1938 Proceedings of the Meeting of the RGCC.

18. Neuffer was therefore permitted to attend the engineer advisory committee meetings as an extra attendee, with no formal role, while Bliss remained the neutral New Mexico representative who protected both the Project and the MRGCD. *See* TX_MSJ_005276, 03-03-1938 Proceedings of the Meeting of the RGCC).

19. New Mexico also advocated for the Project by ensuring a clause through which New Mexico could call for water from Colorado to fill Elephant Butte Reservoir. This clause, found in Article VIII, gave New Mexico the authority to protect its own downstream users. New Mexico's John H. Bliss noted that the Compact permitted either "The commissioner from Texas *or* New Mexico" [emphasis added] to "call for the release of Elephant Butte water in upstream reservoirs in amounts sufficient to bring project storage up to 600,000 acre feet by the first of March and to maintain it there until April 30th." NM-EX 327, J.H. Bliss, Provisions of the Rio Grande Compact (April 2, 1938).

20. New Mexico's support of treating the Rio Grande Project as a unit continued until the Compact was signed. New Mexico's own John Bliss stated on April 2, 1938 that "the measurement of the water at San Marcial rather than at the New Mexico-Texas line is necessary because the Elephant Butte Project must be operated as a unit." NM-EX 327, J.H. Bliss, Provisions of the Rio Grande Compact (April 2, 1938).

21. The 1938 Compact in no way "mimics" the 1929 Temporary Compact. The 1929 Compact was overtly temporary and intended only to provide a truce between parties that would last long enough for data about supply in the Basin to be gathered. NM-EX-112, Stevens Rep. at 37.

22. The 1929 Temporary Compact was described by contemporaries as a "six-year cessation of hostilities," and it contained explicit language freezing conditions.[19] The parties intended the document to halt development in Colorado and New Mexico that would deplete downstream flows until a permanent agreement was reached. Language in the temporary compact included Article V, establishing that Colorado "will not cause or suffer the water supply at the Interstate Gauging Station to be impaired by new or increased diversions or storage within the limits of Colorado unless and until such depletion is offset by increase of drainage return."[20] *See* NM-EX 338, Francis C. Wilson, "Rio Grande Compact Report of Francis C. Wilson, Commissioner for New Mexico" (Interstate River Commission for the State of New Mexico, 1929) at NM_00118539.

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[19] NM-EX 112, Stevens Rep. at 37.

[20] NM-EX 338, Francis C. Wilson, "Rio Grande Compact Report of Francis C. Wilson, Commissioner for New Mexico" (Interstate River Commission for the State of New Mexico, 1929) at NM_00118539.

Similar language bound New Mexico in Article XII: "[New Mexico] will not cause or suffer the water supply in the Elephant Butte Reservoir to be impaired by new or increased diversion or storage within the limits of New Mexico unless and until such depletion is offset by increase of drainage return."[21] *See* NM-EX 338, Francis C. Wilson, "Rio Grande Compact Report of Francis C. Wilson, Commissioner for New Mexico" (Interstate River Commission for the State of New Mexico, 1929) at NM_00118540. This temporary "truce" (NM-EX 338, Letter Francis C. Wilson to NM Governor Richard Dillon, at NM_00118541 (1929) came on the heels of federal revocation of the embargo on Rio Grande development and federal approval of a right of way for a new Colorado reservoir. In significant contrast, Articles III and IV of the permanent 1938 Compact is missing any such language, replaced with schedules built in part on the RGJI data and designed to permit maximum possible development of the resource. NM-EX 112, Stevens Rep. at 41, fn 6

23. There is no historical evidence whatever that the 1938 Compact intended to similarly freeze conditions in the Basin. The materials cited by Dr. Miltenberger for this assertion do not actually state what he claims they state. While Article VI contains schedules for deliveries, it does not in any way reference a freeze on existing conditions. It is clear that all parties intended for existing legitimate uses to be protected,[22] and historical documents also state that "usable water supply is no more than sufficient to satisfy such [current] needs." *See* TX_MSJ_005313, 03-03-1938 Proceedings of the Meeting of the RGCC. ***However, protecting "present uses" is not the same as freezing depletions to "present conditions."*** Contrary to Texas's position today, the historical record is replete with documents which make it abundantly clear that none of the three states intended to or believed the Compact would halt their own development. None of the parties – including Texas – would have supported any such freezing, as each state intended to continue developing their supplies within the limits imposed by the protection of existing uses. As noted in my original report, common understanding about the river's behavior was growing and changes to the river's infrastructure were occurring even as the Compact was being negotiated and signed, changes intended to alter the river's flow and improve Project efficiency.[23] Even the Rio Grande Joint Investigation[24] – upon whose data all parties agreed to rely for the 1938 Compact – stated its intent to study "the past, present, and prospective uses of water" in the Rio Grande Basin (TX_MSJ_005338-5339, 03-03-1938 Proceedings of the Meeting of the RGCC; NM-EX 112, Stevens Rep. at 55) and to "determine the basic facts needed in arriving at an accord" among the three states "on an allocation and use of Rio Grande waters in *the future development* of the basin." [Emphasis added.] The RGJI's fundamental premise was to expand development within the limits of the resource.[25] Finally, the Committee of Engineers who reported their recommendations to the compact commissioners in December 1937 explained that the schedules ultimately outlined in

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[21] NM-EX 338, Francis C. Wilson, "Rio Grande Compact Report of Francis C. Wilson, Commissioner for New Mexico" (Interstate River Commission for the State of New Mexico, 1929) at NM_00118540.

[22] NM-EX 112, Stevens Rep. at 56, 68.

[23] NM-EX 112, Stevens Rep. at 77-81.

[24] TX_MSJ_000022, Rio Grande Joint Investigation (RGJI), February 1938.

[25] NM-EX 112, Stevens Rep. at 62, fn 50.

Article VI were intended to "permit the maximum practicable use of the waters of the Rio Grande."[26]

24. The historical record does not provide details on precisely how the schedules in the Compact's Articles III and IV were ultimately derived, nor is it material to the allocation of water represented by the Compact; the schedules speak for themselves. The record tells us that New Mexico objected to the schedules presented in the December 1937 Engineering Committee report, and that New Mexico recommended new schedules based on the relationship between Otowi Bridge and San Marcial, the relationship that was ultimately used in Article IV. Data gathered by and compiled in the RGJI as well as data and records maintained by New Mexico and Colorado informed these schedules. (See, as just one example, reference made to New Mexico submitting curves, tables, and other details of stream flows to the engineering advisors. TX_MSJ_005311, 03-03-1938 Proceedings of the Meeting of the RGCC. In fact, these Articles were arguably the most controversial of the Compact, as they were, in a sense, the basis for the allocation. However, once the compact commissioners directed the engineer advisors to return to the drawing board in March 1938, no records were kept of their discussions. Instead, the language they ultimately recommended merely states that the schedule for Article IV reflects the relationship between Otowi Bridge and San Marcial "for the period prior to 1930," exclusive of July, August, and September. *See* TX_MSJ_005316, 03-03-1938 Proceedings of the Meeting of the RGCC. John Bliss, New Mexico's engineer advisor, recorded his understanding of this particular relationship just two weeks after the Compact was signed, and wrote that the Compact language and the schedule was intended to represent the system prior to the time when "reclamation and drainage in the Middle Rio Grande Conservancy District was started." *See* TX_MSJ_005349, 04-02-1938 Bliss re Provisions of the RG Compact. Note that there is no language restricting development after that time.

25. Much of the Rio Grande Joint Investigation, upon which the Compact was based, had been occupied with investigating methods to augment the existing supply of the river and permit additional development. The Compact wording, which repeatedly accommodated developments on the river *after* 1929 and *after* 1937 also clearly indicated an intent to continue development. Rather than using language that would have limited development below Elephant Butte dam, such as "works constructed at or before 1937," it clearly stated that schedules were intended to accommodate both existing and future works constructed after those dates as well as "trans-mountain diversions into the Rio Grande between Lobatos and San Marcial." *See* TX_MSJ_005317, 03-03-1938 Proceedings of the Meeting of the RGCC. The Compact and the documentation leading up to the Compact demonstrates a clear intent by all to permit continued development and a "living Compact" within the limits posed by existing *legitimate* uses.[27]

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[26] NM-EX 112, Stevens Rep. at 68, fn 86.

[27] NM-EX 112, Stevens Rep. at 69, 72.

26. One of the most controversial issues for the parties to settle in the ultimate Compact language was determining the stated volume of water to be considered "normal" or "actual" release from Elephant Butte Reservoir. The RGJI had recognized the inadequacy of data to account for increased salinity in the lower end of the Project and had thus "arbitrarily" assumed allowances to maintain a salt balance. The arbitrary number arrived at by RGJI authors was 773,000 acre-feet.[28] Like any compromise, none of the parties was completely satisfied with that number. Colorado believed it was too high and demanded an actual release volume no higher than 750,000 acre-feet. Texas continued to push for a volume even higher than the 773,000, advocating 800,000 acre-feet instead, even as Texas engineer Raymond Hill recognized that the actual Project releases in recent years had been closer to 730,000 acre-feet, making it "very difficult to substantiate the 800,000 acre-feet requirement."[29] Still, in late 1937, Texas's Hill expressed his belief that New Mexico was "not unreasonable in their demands" and that New Mexico intended to "continue deliveries into Elephant Butte reservoir, to the extent that water actually entered the reservoir in past years."[30] Again, New Mexico's position reflected its effort to balance the needs of its users above and below the dam, both ensuring that MRGCD was not held to unreasonable standards for delivery and also that EBID users would have ample supplies for existing uses.[31]

27. In trying to land on the right "normal release" volume, New Mexico clearly was balancing the needs of all its users.[32] Since MRGCD's H.C. Neuffer was advocating for a volume no higher than 700,000 acre-feet,[33] New Mexico's ultimate agreement to the 790,000 acre-feet normal release number did not demonstrate an undue influence of MRGCD, but instead New Mexico's delicate balancing act between users, protecting the irrigation needs of New Mexico Project users as well as those in Texas. Although Texas perceived that it was being held overly responsible for protecting the Project, including EBID users, ***this compromise demonstrates New Mexico's balancing of user needs above and below the Elephant Butte Reservoir.*** New Mexico acted accordingly to ensure that neither MRGCD nor EBID users lobbied against Compact ratification.

28. Texas also agreed to the 790,000 acre-feet number and understood that its Project users would receive 43% of actual Project Supply in any given year. There is no evidence in the historical record that Texas believed it controlled all of the water being delivered into Elephant Butte; instead, Texas relied on Reclamation to administer the Project Supply, including return flows, according to contracts signed between the two districts in late 1937 which divided the supply

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[28] NM-EX 112, Stevens Rep. at 65.

[29] NM-EX 112, Stevens Rep. at 67, fn 79.

[30] NM-EX 341, Raymond A. Hill to Mr. Clayton, Memorandum In re Meeting of Committee of Engineers, at Santa Fe, November 22 to 24, 1937, November 26, 1937 at TX_MSJ_00002921-2924.

[31] NM-EX 112, Stevens Rep. at 65-69.

[32] The historical record does not suggest or support an interpretation that the "normal release" volume had any relation to delivery schedules into the reservoir by Colorado and New Mexico.

[33] NM-EX 112, Stevens Rep. at 68.

according to a division of the 155,000 Project acres into 57% for EBID (88,000) and 43% for EPCWID (67,000).[34]

29. Water supply shortages, the Depression, and flooding events which caused the river to move, had caused great variations in irrigated acreage between the 1920s and the 1930s in both Project districts. Therefore, the downstream contracts signed in 1937 between the Project Districts permitted a 3% increase in acreage irrigated over and above the Project's irrigated acreage figures.[35] Furthermore, the RGJI recognized future increase in demand downstream of the dam for both municipal and industrial uses. NM-EX 112, Stevens Rep. at 64, fn 64.

30. Municipalities downstream of Elephant Butte Dam had long relied on groundwater for their supplies,[36] and farmers used wells, too. According to U.S. Geological Survey's Charles S. Slichter writing about groundwater supplies in the Mesilla Valley in 1905, a "number of pumping wells have been installed for the purpose of obtaining ground water for irrigation."[37]

31. However, scientific understanding of the relationship between groundwater and surface water in the Rio Grande Basin was limited at the time that the 1938 Compact was signed, and Texas's delegation fought to keep it that way.[38] The City of El Paso faced a significant municipal water shortage in the mid-1930s. El Paso had been dependent on pumping groundwater for its municipal supply since at least the turn of the twentieth century, and by the mid-1930s, the volume it pumped had increased beyond the existing supplies. The city requested that the U.S. Geological Survey conduct an intensive study of groundwater conditions around the city, which the agency began in July 1935. The agency published the results in 1945. In between those two dates, parties executed the Rio Grande Compact. Texas was well aware of El Paso's predicament and of these studies during Compact negotiations.[39] Thanks to arguments and lobbying by Texas's Raymond Hill, groundwater study of the valleys below Elephant Butte did not figure into the RGJI, nor did it figure into the schedules outlined in the 1938 Compact. Texas's Raymond Hill, in arguing for a limited role for the U.S. Geological Survey in the RGJI, noted in 1936 that "groundwater supplies along the Rio Grande are of little importance in relation to the total supply."[40] And, Hill argued to reduce the role of the federal agency to groundwater studies above Elephant Butte. Therefore, thanks in part to Texas's lobbying for such a limited role, *no* conclusions were drawn related to groundwater below Elephant Butte, either related to additional supply or related to its

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[34] NM-EX 112, Stevens Rep. at 74-77.

[35] NM-EX 112, Stevens Rep. at 74-77.

[36] NM-EX 112, Stevens Rep. at 83-84.

[37] NM-EX 342, Charles S. Slichter, "Observations on the Ground Waters of Rio Grande Valley," U.S. Geological Survey Water-Supply and Irrigation Paper No. 141 (Washington, D.C.: Government Printing Office, 1905) at NM_00166723.

[38] NM-EX 113, Stevens Reb. Rep. at 6-15.

[39] NM-EX 112, Stevens Rep. at 84-85.

[40] NM-EX 112, Stevens Rep. at 57-58, fn 19.

connection to surface water.[41] ***It is a farce to contend that the historical record supports Texas's position that Texas negotiated to prevent groundwater pumping in the Compact when all evidence points to the southernmost state in the talks doing everything it could to limit any such studies.*** Senior geologist for the U.S. Geological Survey on the RGJI called the data on groundwater in the Mesilla Valley "meager."[42]

32. A severe drought began in the late 1940s and continued into the 1950s, causing all parties concern over supplies and spurring new groundwater studies that would finally provide an understanding of the relationship between groundwater basins below Elephant Butte Dam and the surface flow of the Rio Grande.[43] Contrary to Texas's current position, the studies conducted by the U.S. Geological Survey in the 1940s and 1950s presented *new* information that was not available at the time of the Compact signing in 1939. Even C.S. Conover, who in 1954 studied and reported on groundwater conditions in New Mexico's valleys downstream of Elephant Butte Dam called the available data "meager."[44]

I declare under penalty of perjury that the foregoing is true and correct.

Executed on December _21_, 2020

Dr. Jennifer Stevens, Ph.D.

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[41] NM-EX 113, Stevens Reb. Rep. at 12-13.

[42] NM-EX 113, Stevens Reb. Rep. at 14.

[43] NM-EX 113, Stevens Reb. Rep. at 16-21.

[44] NM-EX 113, Stevens Reb. Rep. at 17-18.

TX v. NM # 141
New Mexico Exhibit
NM_EX-012

No. 141, Original

IN THE
SUPREME COURT OF THE UNITED STATES

◆

STATE OF TEXAS,
Plaintiff

v.

STATE OF NEW MEXICO and
STATE OF COLORADO,
Defendants

◆

DECLARATION OF GREGORY SULLIVAN, P.E. IN SUPPORT OF STATE OF NEW MEXICO'S PARTIAL SUMMARY JUDGMENT MOTIONS

◆

I, Gregory K. Sullivan, P.E., hereby declare as follows:

1. I am over 18 years of age and have personal knowledge of the information stated herein.
2. I have authored two expert reports in this case including an Expert Report dated October 31, 2019 (revised July 15, 2020) (NM-EX 122)[1] and a Rebuttal Expert Report dated July 15, 2020 (revised September 15, 2020) (NM-EX 123).
3. I was also deposed three (3) times in this case in conjunction with the opinions I expressed in those expert reports.
4. I have a Bachelor's Degree in Civil Engineering from Colorado State University (1985), and a Master's Degree in Civil Engineering from the University of Colorado, Denver (1990).
5. From 1985 until 1990, I was employed as a water resources engineer by J.W. Patterson and Associates in Denver, Colorado.
6. From December 1990 to the present, I have been employed by Spronk Water Engineers, Inc. ("SWE") in Denver, Colorado. My current position at SWE is President and Senior Water Resources Engineer. Throughout my career with SWE, I have served as a primary consultant to numerous water providers in areas of water supply planning and water rights engineering. In that role, I have been responsible for technical analyses supporting changes of water rights, exchanges, augmentation plans, and other water right matters. I have led the development of

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[1] All Exhibits ("NM-EX") identified in this Declaration are part of the State of New Mexico's Exhibit Compendium dated November 5, 2020 filed with New Mexico's Partial Summary Judgment Motions dated November 5, 2020.

complex surface water operations models that simulate municipal water demands and how those demands may be met by available water supplies and water rights. On behalf of the State of Kansas, I operated and maintained the Hydrologic-Institutional Model of the Arkansas River Basin that supported Kansas' successful original action lawsuit in Kansas v. Colorado in the U.S. Supreme Court (No. 105 Original), and I provided expert testimony in that role before the Special Master in that case. Since 1996, I have served on the Eastern Snake Hydrologic Modeling Committee that guides the development and use of a regional ground water model of the Eastern Snake River Plain Aquifer in Idaho.

7. I have been accepted by various courts as an expert in water resources engineering, water rights engineering, hydrologic modeling, groundwater modeling, hydrology, water measurement, evaluation of beneficial use, and/or data analysis. In my role as an expert, I have authored numerous expert reports and provided expert deposition and trial testimony in cases before the U.S. Supreme Court, the Colorado Water Courts, the Snake River Basin Adjudication Court (Idaho), and in administrative hearings before the Idaho Department of Water Resources.

8. My professional involvement with Lower Rio Grande issues in New Mexico and Texas began in 1999 and my work has involved, among other things:

   - Compilation and review of hydrologic and water use data in the Lower Rio Grande area.
   - Development of a surface water database that supports New Mexico's technical analyses and hydrologic modeling.
   - Development of canal and farm budget models of the irrigation systems of the Rio Grande Project ("Project"), the Hudspeth County Conservation and Reclamation District No. 1 ("HCCRD"), and the Juarez Irrigation District ("JID) in Mexico.
   - Review and analysis of the 2008 Operating Agreement ("2008 OA") for the Project.
   - Review and analysis of historical Project operations.
   - Development of the Integrated Lower Rio Grande Model ("ILRG Model").
   - Use of the ILRG Model to analyze the claims and counterclaims of the parties to this case.
   - Review of technical analyses and modeling submitted by experts for the State of Texas and the United States.
   - Litigation support for New Mexico Counsel.

9. My curriculum vitae, list of expert reports during the past four years and list of expert reports during the past five years can be found in my October 31, 2019 Expert Report at 326-334, NM-EX 122.

Background

10. In this Declaration, I refer to the New Mexico water district, Elephant Butte Irrigation District as "EBID," and the Texas water district, El Paso County Water Improvement District No. 1,

as "EPCWID." I refer to EBID and EPCWID collectively, as the "Districts." I refer to the United States Bureau of Reclamation as "Reclamation."

11. I have been asked by Counsel for New Mexico to review the statements of facts in the motions for partial summary judgment filed by the United States and Texas, and to assess whether they are accurate from my perspective as an expert in this case, and to provide information in response.

12. I have determined that a number of the alleged facts listed by the United States and Texas in their motions for summary judgment are inaccurate, disputed, incomplete, and/or are opinions rather than facts.

United States of America's Memorandum in Support of Motion for Partial Summary Judgment

13. In the United States' Statement of Material Facts, Fact No. 6 states, "Groundwater pumping in New Mexico below Elephant Butte interferes with Project deliveries because it depletes the surface water flows in the river, canals, and drains, and the Project must release additional water from the reservoir to compensate for the depletions instead of storing that water for use in future years."

    The extent of interference with Project deliveries caused by groundwater pumping in New Mexico is a matter of expert opinion rather than fact. The United States exaggerates the effects of New Mexico pumping, implying that it has caused continuous and unrelenting impacts. This is incorrect for several reasons: First, as shown in **Figure 1**, pumping in New Mexico has varied substantially since it developed in the early 1950s, with higher amounts of pumping in low Project supply years and lower amounts of pumping in full supply years. NM-EX 122 Expert Report of Gregory K. Sullivan and Heidi M. Welsh (Second Edition) (July 15, 2020) ("Spronk Report") at 194 and 318. Second, in full supply years, the Districts received all water they ordered, up to their total allocations. Id. Even if Reclamation had to release additional water in these years to make Project deliveries, this did not impact deliveries in those years. NM-EX 123 Gregory K. Sullivan and Heidi M. Welsh, Expert Rebuttal Report (Second Edition) (Sept. 15, 2020) ("Spronk Rebuttal") at 58-59. Third, this statement ignores the seasonality of Project deliveries, and that some of the river depletions from pumping occur during the winter when the Project is not making deliveries. Id. at 351-352. Fourth, this statement ignores that the amount and timing of Rio Grande depletions from pumping depends on many factors, including the locations and depth of the wells, the timing and amount of pumping, aquifer characteristics, the interaction of ground water and surface water, Project and reservoir operations, including spills, and many other factors. Further, this statement ignores the impacts that pumping in Texas has on Project deliveries. Id. at 373-374.

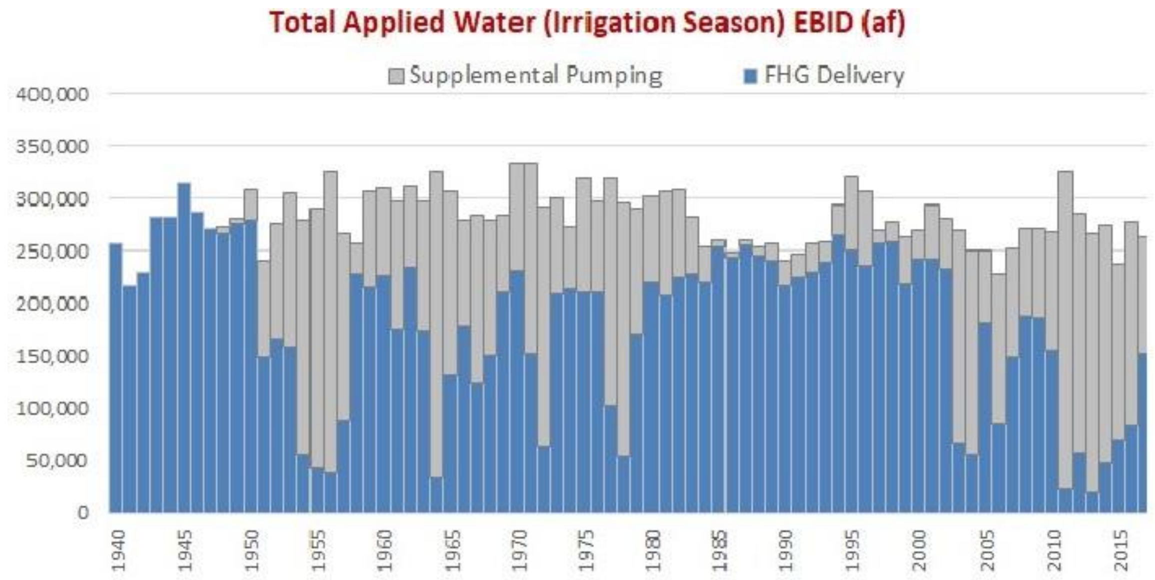


Figure 1. Total Applied Water (Irrigation season) EBID (af), adapted from Spronk Report Figure 5-15.

14. Fact No. 7 states, "In years when surface water supply is low, pumping in New Mexico below Elephant Butte reduces the amount of water the Project can deliver to Texas."

    The extent of any reduction in Project deliveries in years of low surface supply is a matter for expert analysis and expert opinion. The impacts of pumping on Project deliveries depends on many factors and can only be evaluated using a robust simulation model like the ILRG Model. Spronk Rebuttal at 86. In addition, the statement ignores the impacts that pumping in Texas, including in the Texas portion of the Mesilla Valley and in the El Paso Valley, has on Project deliveries. Id. at 373-374. Texas pumping in these areas averaged 127,500 AF/y during 1951-2017 with irrigation pumping averaging 41,600 AF/y (155,000 AF/y maximum) and non-irrigation pumping averaging 85,900 AF/y (124,000 AF/y maximum). SWE Report at 153.

15. Fact No. 10 states, "In the seven years since Texas filed its complaint in this action (and six years since the United States filed its complaint), New Mexico has not curtailed any groundwater pumping to address those complaints."

    The extent that New Mexico pumping is affecting Project operations is a complex matter requiring expert analysis and expert opinion. In addition, this statement ignores the negative effects that Texas pumping, the 2008 OA, increases in Project operational waste, and changes in EPCWID operations are having on New Mexico. Analyses using the ILRG Model indicate that Project water diversions by New Mexico during 2006 - 2017 were reduced by an average of 15,500 AF/y by Texas pumping, an average of 94,200 AF/y by imposition of the 2008 OA, an average of 86,300 AF/y by increases in Project operational waste (mostly in Texas), and by an average of 72,400 AF/y by changes in EPCWID operations. Spronk Rebuttal at 379, 533, 577, 709. Due to nonlinearities in the ILRG Model, the foregoing impacts are not fully independent and additive.

16. Fact No. 58 states, "Since 1980, groundwater pumping for non-irrigation uses (including municipal use) below Elephant Butte has nearly doubled, from about 20,000 acre-feet per year ("AF/y") to about 37,000 AF/y, driven by an increase in pumping by entities other than the City of Las Cruces whose groundwater use began after the Compact."

    This statement is generally correct regarding the volume of non-irrigation groundwater pumping in New Mexico, but it fails to mention that much larger volumes of non-irrigation groundwater pumping occur in Texas and Mexico averaging 86,700 AF/y and 150,900 AF/y, respectively during 2013 - 2017. Spronk Report at 51 and 205-207. The statement also neglects to mention that non-irrigation groundwater pumping in New Mexico currently produces approximately 17,000 AF/y in return flows to the river that offset some of the impacts of pumping. Id. at 51. Historical annual non-irrigation pumping in New Mexico, Texas, and Mexico is shown in **Figure 2**, **Figure 3**, and **Figure 4**, respectively.

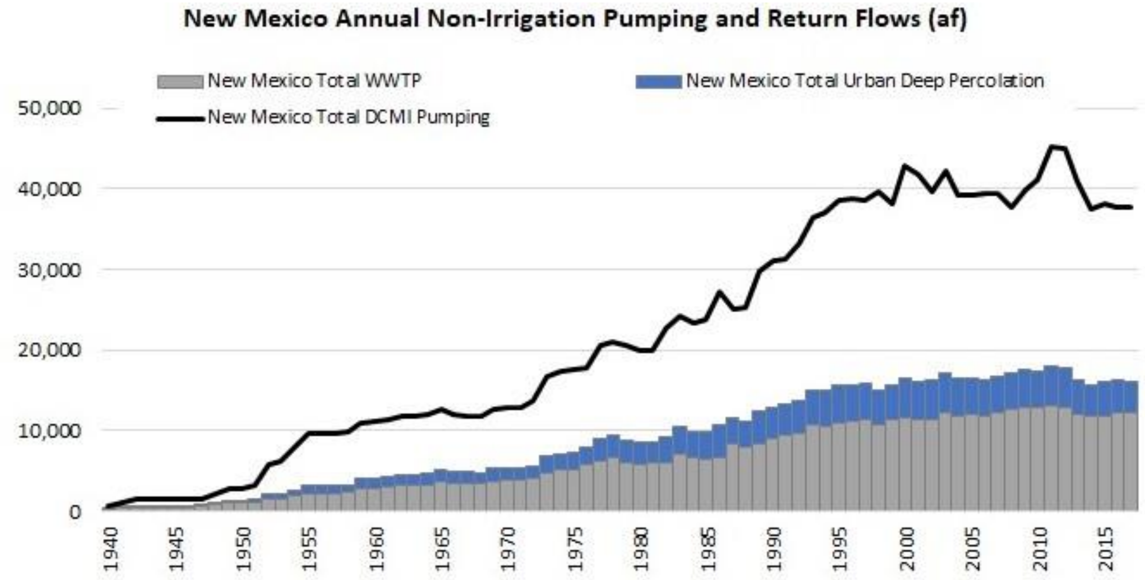


Figure 2. New Mexico Annual Non-Irrigation Pumping and Return Flows (af), adapted from Spronk Report Figure 5-26.

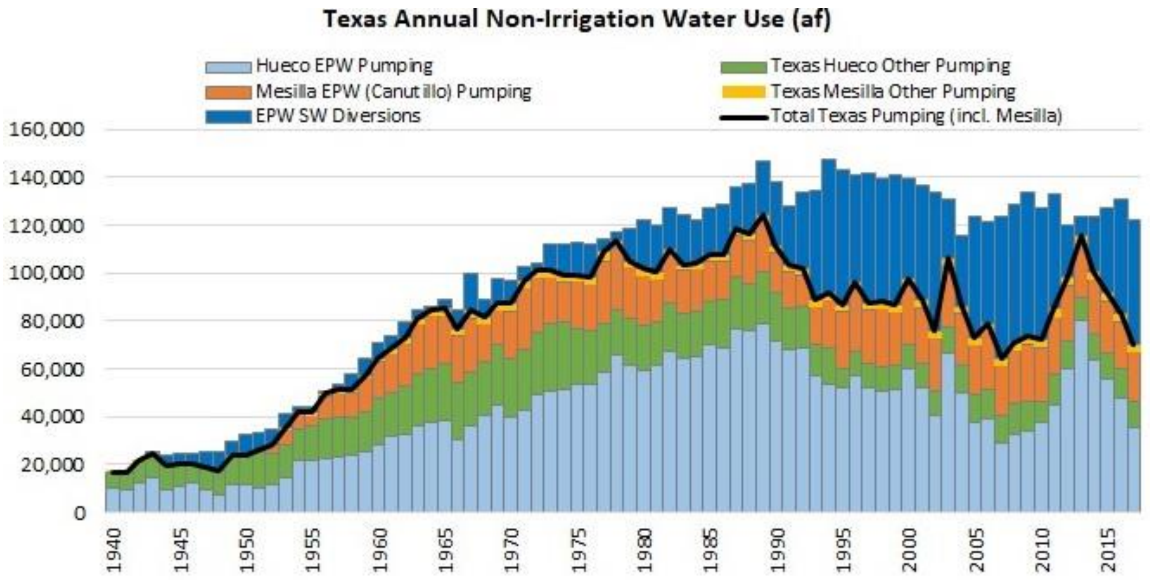


Figure 3. Texas Annual Non-Irrigation Water Use (af), adapted from Spronk Report Figure 5-27.

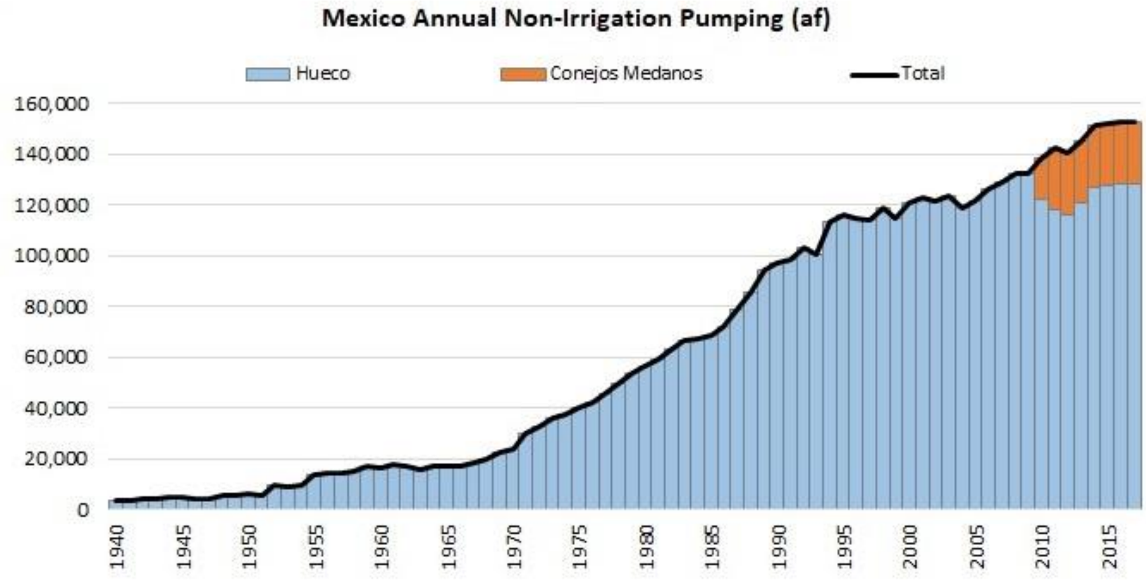


Figure 4. Mexico Annual Non-Irrigation Pumping (af), adapted from Spronk Report Figure 5-28.

17. Fact No. 61 states, "Groundwater pumping in New Mexico impacts the surface water supply for the Project because it depletes the flow of the Rio Grande and reduces the amount of water flowing in Project drains and canals."

The extent that New Mexico pumping impacts the surface water supply of the Project is a complex matter requiring expert analysis and expert opinion. Depletions of surface water flows do not affect Project deliveries in full supply years and depletions during the non-irrigation season do not affect Project deliveries because the Project is not operating then. Spronk Report at 72, 112, 122. This statement also ignores that when Reclamation developed the D1/D2 allocation procedures using Project delivery data from 1951 – 1978 it effectively grandfathered in any effects that groundwater pumping during that period had on Project operations. Id. at 118. Finally, the United States' statement ignores that an appreciable portion of any impacts that pumping has had on Texas have come from Texas pumping. Spronk Rebuttal at 373-374.

18. Fact No. 62 states, "Groundwater pumping in New Mexico in years of lower surface water supply can reduce the volume of water available for Project allocation and delivery to the Districts, and thus reduce the apportionment to Texas."

    The extent of impacts from New Mexico pumping on Project water allocations and deliveries in low supply years is a complex matter requiring expert analysis and expert opinion. To the extent that New Mexico pumping does impact Project water allocations and deliveries in low supply years, so does Texas pumping. Spronk Rebuttal at 120. Simulations with the ILRG Model show that Texas pumping reduced New Mexico's diversions of Project water by an average of 15,500 AF/y during 2006 - 2017 when the 2008 OA was in effect. Id.

19. Fact No. 63 states, "On average, groundwater pumping in New Mexico reduced Project diversions by over 60,000 acre-feet annually between 1951 and 2017."

    This statement reflects the estimated effect of New Mexico pumping on combined Project water diversions by New Mexico and Texas. Spronk Rebuttal at 119. The extent of any injury resulting from a reduction in diversions caused by New Mexico pumping is a complex matter requiring expert analysis and expert opinion. To the extent that New Mexico pumping has reduced Project diversions, so has Texas pumping. In addition, the imposition of the 2008 OA, increases in Project operational waste, and change in EPCWID operations have caused significant negative impacts to New Mexico that far exceed any impacts of New Mexico pumping on Texas. See Paragraph No. 15.

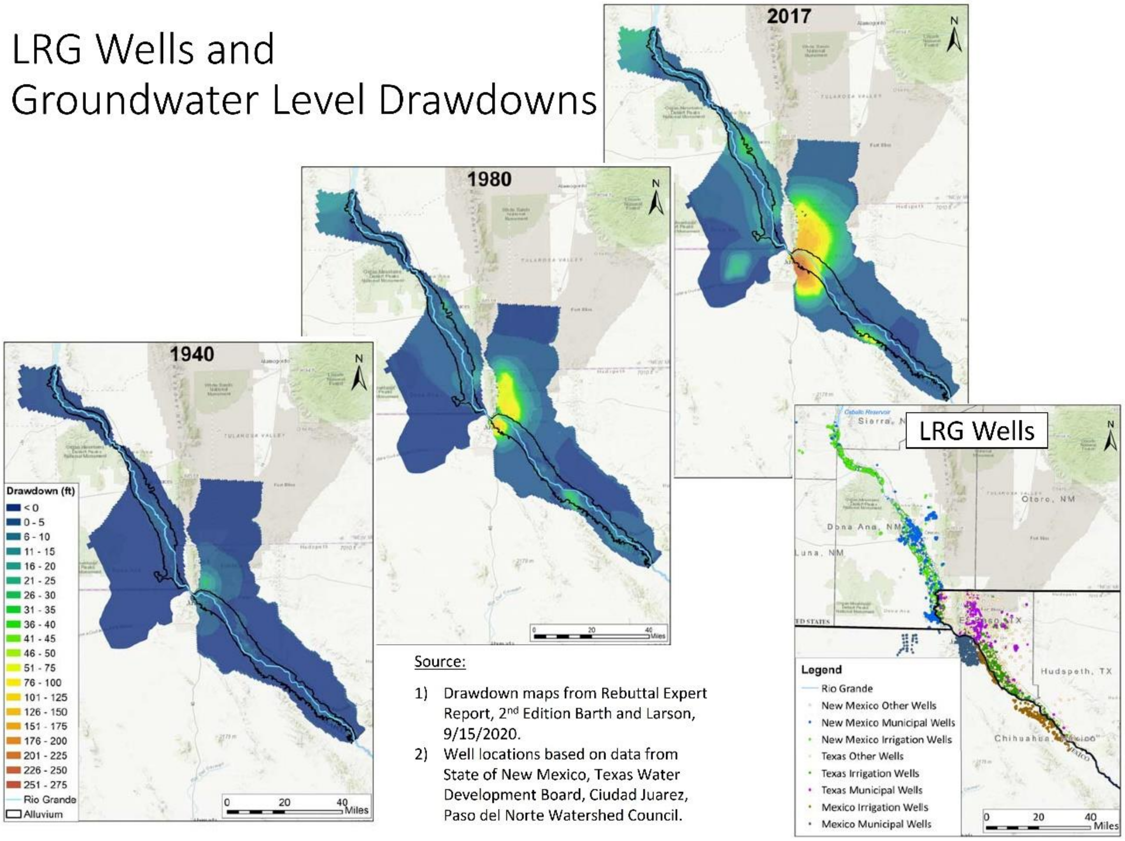
20. Fact No. 71 states, "The effect of the 2008 Operating Agreement is that EBID voluntarily cedes some of its surface water allocation to EPCWID to compensate for surface water depletion caused by groundwater pumping in New Mexico, including pumping by water users outside of EBID."

    The U.S. experts have stated that the purpose of the 2008 OA was to offset the impact of increased pumping by New Mexico. Expert Rebuttal Report of Dr. Ian M. Ferguson (12/30/2019) ("Ferguson Rebuttal") at 5. However, the level of New Mexico pumping during 1951-1978 was effectively grandfathered into the D1/D2 allocation procedure. Expert Report of Robert J. Brandes (5/31/2019) ("Brandes Report") at 16-17 and Spronk Report at 118. After that time and until commencement of the D3 allocation procedure under the 2008 OA (1979-2005), New Mexico's pumping was much less than during the D1/D2 data period. Spronk Rebuttal at 27.

State of Texas's Motion for Partial Summary Judgment

21. On page 19 of its Motion for Partial Summary Judgment: Memorandum of Points and Authorities in Support Thereof, Texas states, "the number of groundwater wells has increased from 60 in 1938 to over 8,000 in 2020. [Schorr Decl. at TX_MSJ_000697-000699.] Figures 3 and 4 are depictions showing the proliferation of wells in New Mexico from 1938 to 2020. Id."

This statement leaves out the Texas analysis which concluded that by 2016, the number of New Mexico wells had increased to more than 7,700, with about 465 wells for municipal and industrial purposes, 1,300 for irrigation purposes, and majority still for domestic purposes. Expert Report of Staffan W. Schorr and Colin P. Kikuchi at (5/31/2019) ("M&A Report") at 3. Annual pumping from the domestic wells in the LRG in New Mexico has been estimated at approximately 730 AF/y. Expert Report of Gilbert R. Barth, Ph.D. Third Edition (9/15/2020) "SSPA Report" at Appendix H 4-1. Further, as shown in **Figure 5**, there has been widespread development of groundwater wells throughout the LRG in Texas and Mexico as well as in New Mexico, and the impacts of pumping on ground water levels has been substantially greater in the Hueco Bolson in the El Paso/Juarez area than it has in the Rincon and Mesilla basins in New Mexico.



LRG Wells and Groundwater Level Drawdowns

Source:

1) Drawdown maps from Rebuttal Expert Report, 2nd Edition Barth and Larson, 9/15/2020.
2) Well locations based on data from State of New Mexico, Texas Water Development Board, Ciudad Juarez, Paso del Norte Watershed Council.

Figure 5. LRG Wells and Groundwater Level Drawdowns, NM-EX 117.

22. On page 20, Texas states, "Mining of a groundwater basin means that more water is being pumped from the groundwater basin than can be replaced, causing groundwater levels to decline and causing the further depletion of the volume of water available to Texas. Brandes Decl. at TX_MSJ_000007."

    This statement is incomplete. As shown in **Figure 5**, the depletion of ground water storage is much greater in the Hueco Bolson in Texas and Mexico than in the Rincon and Mesilla basins in New Mexico. Further, the proportion of water available to Texas under the allocation procedure of the 2008 OA is now far greater than the 43% share that Texas was allocated and received until 2005. Spronk Report at 318.

23. On page 23, Texas states, "The Project, in turn, is the means by which the water apportioned to Texas by the Compact is stored in Elephant Butte Reservoir and subsequently delivered to Texas, subject to deliveries to EBID pursuant to its contract with the United States, and to Mexico pursuant to the 1906 Treaty. [Brandes Decl. at TX_MSJ_000007.]"

    This statement implicates legal issues in this case. It is New Mexico's position that it received an apportionment of water downstream of Elephant Butte Reservoir under the Compact. In addition, this statement is incomplete and misleading. Substantial ground water development also occurred in the Mesilla Basin in Texas and the El Paso Valley in Texas, and this development impacts Project operations and has reduced deliveries of Project water to New Mexico. Finally, portions of the water delivered into Elephant Butte Reservoir cannot be delivered to Texas or New Mexico because (a) it is delivered to Mexico under the 1906 Treaty obligation, (b) is lost to evaporation and seepage, (c) it is consumed by evapotranspiration of native vegetation, and (d) it spilled with the reservoir is full at rates that exceed the ability to beneficially use it upstream of Fort Quitman. Spronk Report at 10, 40.

24. On page 22, Texas states, "Current water users in the Lower Rio Grande basin are primarily divided between irrigators and municipal users. Irrigation is the primary use of water in the Lower Rio Grande in New Mexico. Id."

    This statement is generally true in New Mexico where from 1951-2017 approximately 84% of all pumping is for irrigation. However, this is not the case in Texas where from 1951-2017 only 33% of pumping is for irrigation and the remainder is for other uses. Spronk Rebuttal at 152-153.

25. On page 25, Texas states, "Return flows are a key part of Project operations, and interference with return flows removes a critical component of deliveries to Project users. [Brandes Decl. at TX_MSJ_000008-000009.]"

    The effects on Project operation resulting from interference with Project return flows (e.g., impact of ground water pumping on return flows) is a complex matter requiring expert analysis and expert opinion. It is true that return flows are a key component of Project operation and return flows from upstream uses of Project water become a portion of the Project supply that is delivered for downstream use. However, interference with return flows does not always impact Project operations. For example, depletions during the winter when the Project is not delivering water does not impact Project operations. See Paragraph 17. In addition, depletions of return flows in full allocation years do not impact Project deliveries because additional water can be released from storage to deliver Project water orders. Spronk Report at 72, 112, 122. Increased Project releases in full supply years have the potential to diminish the amount of water available for allocation in future years of less than full supply, but this depends on many factors, including increased reservoir evaporation and spills that may occur in the interim. Id. at 72, 142. Furthermore, the effects of pumping in Texas and the cessation of use of return flows in Texas has resulted in increases in reservoir releases to meet EPCWID demands and this has reduced the supply of Project water available for allocation and delivery to EBID. Spronk Rebuttal at 120, 130.

26. On page 25, Texas states, "Project return flows consist of excess irrigation tailwater and groundwater seepage from irrigated fields that are collected in drains that convey these return flows to the Rio Grande. [Brandes Decl. at TX_MSJ_000008-000009.]"

    To the extent this statement implies that return flows consist of "excess" water applied to irrigation, this is incorrect. The accumulation of tailwater and seepage from irrigated fields is a normal part of the irrigation process, even in well-managed fields. Spronk Report at 52. In addition, this statement incorrectly implies that Project return flows must return to the bed of the Rio Grande to be usable. Because of the configuration of Project infrastructure in EPCWID, return flows in EPCWID generally do not reach the bed of the river, but this did not prevent EPCWID members from diverting these flows for irrigation use until the early 1980s. Spronk Report at 19-20. If EPCWID resumed use of the irrigation return flows that arise within its boundaries, this would reduce the reservoir releases needed to meet EPCWID demands and would make additional water available for allocation and delivery to EBID. Spronk Rebuttal at 130.

27. On page 25, Texas states, "The proportion of return flows in the river increases in the downstream direction relative to stored water from the reservoirs, and the water diverted by Project users in the lower Mesilla basin and in the El Paso Valley of Texas includes diversion of significant quantities of return flows. Brandes Decl. at TX_MSJ_000008-000009."

    This statement is overly simplified and ignores that the proportion of return flows in the river varies depending on the time of year and hydrologic conditions. Early in the irrigation season, the proportion of Project return flows in the river is lower than it is later in the irrigation season. During dry periods, the proportion of return flows in the river also tends to be lower than during wet years. Spronk Rebuttal at 168 and 170-171.

28. On page 29, Texas states, "Significant groundwater development began in the early 1950s in the Project area within the Rincon and Mesilla basins of New Mexico. Brandes Decl. at TX_MSJ_00010-00012."

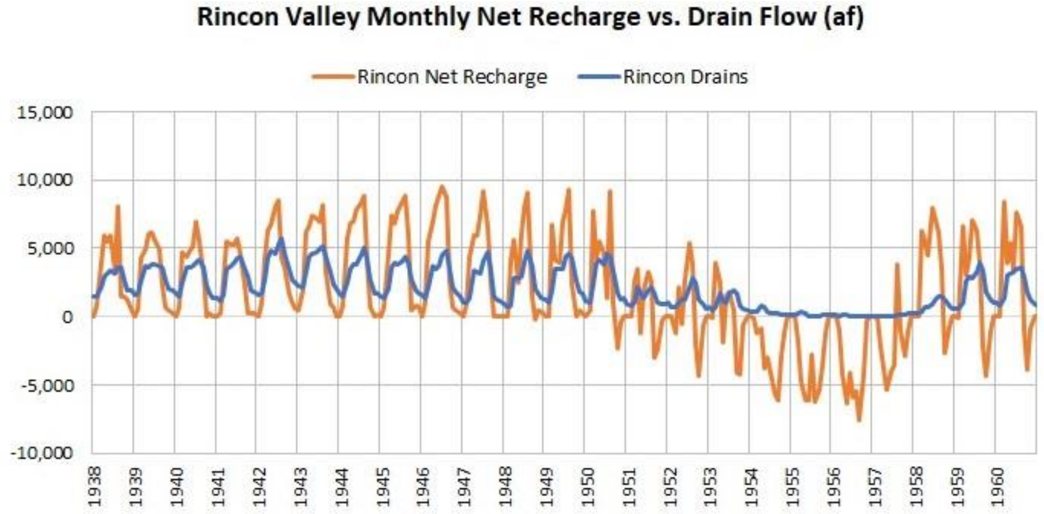
    This statement fails to note that significant groundwater development in the Mesilla and Hueco basins in Texas also began in the early 1950s. Spronk Report at 194-195. Groundwater development for irrigation in both states occurred in response to drought. Id. In addition, Texas fails to note that significant groundwater development for El Paso municipal use began in Texas prior to the early 1950s. Spronk Report at 206.

29. On page 30, Texas states, "The solution was to construct a complex system of drains that would capture excess groundwater created by irrigation and return it to the river. [Brandes Decl. at TX_MSJ_00010-00012.]"

    This statement is generally correct regarding the reason for construction of the drain system in both New Mexico and Texas but neglects to mention that the drains also allowed return flows to more easily be collected and diverted for reuse as part of Project supply, particularly within EPCWID. See Paragraph 25.

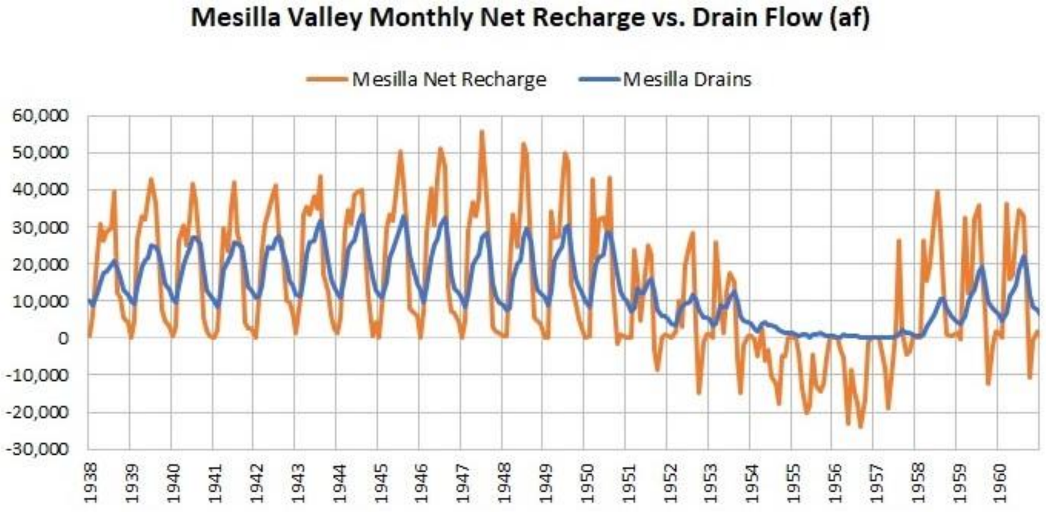
30. On page 30, Texas states, "With the construction of the drains, irrigation water not consumed by crops and other vegetation or by evaporation, percolated down through the soil into the groundwater system, which typically flowed toward and into drains specifically designed for collecting groundwater and for conveying groundwater and excess irrigation tailwater away from fields and to the Rio Grande. [Brandes Decl. at TX_MSJ_00010-00012.]"

This statement misleadingly implies that the only water collected in the drains is "irrigation water not consumed by crops and other vegetation or by evaporation," when, in fact, other sources of water, including wastewater, tailwater, and on-farm runoff, also contribute to drain flows in the Project area. The statement also neglects to mention that drain flows vary throughout the year depending on many factors, including the timing and volume of surface water deliveries and irrigation applications, weather conditions, and other factors. Spronk Rebuttal at 170-171. The historical relationship between recharge and drain flows is shown for the Rincon Valley in **Figure 6** and for the Mesilla Valley in **Figure 7**.



Note: Net recharge computed as canal seepage + on farm deep percolation minus pumping from the SWE Canal and Farm Budget Model.

Figure 6. Rincon Valley Monthly Net Recharge vs. Drain Flow (af), adapted from Spronk Rebuttal Figure 23-1.



Note: Net recharge computed as canal seepage + on farm deep percolation minus pumping from the SWE Canal and Farm Budget Model.

Figure 7. Mesilla Valley Monthly Net Recharge vs. Drain Flow (af), adapted from Spronk Rebuttal Figure 23-2.

31. On pages 30 to 31, Texas states, "This condition is illustrated in a general fashion by the diagram in Figure 10. As shown, Project water is diverted from the Rio Grande into an irrigation system canal and then distributed to individual irrigated fields, where it is either consumptively used by the growing crops or evaporated into the atmosphere. Any excess irrigation water is either discharged directly to the drain as tailwater or percolated through the subsurface into the groundwater system. Brandes Decl. at TX_MSJ_000011-000012."

    Figure 10 in the Texas Motion is highly idealized and is not representative of the myriad of conditions that exist throughout the Project. The graphic in Figure 10 implies a closed loop system for use and reuse of return flows on the same field that does not reflect that reuse of return flows within the Project typically occurs downstream. Spronk Report at 19. In addition, Figure 10 does not depict the releases from storage that are an important source of Project supply, not does it reflect the depletions of surface water caused by evaporation from water surfaces, and evapotranspiration of native vegetation and bare ground, and other processes. Spronk Report at 225.

32. On page 31, Texas states, "The bottom of the drain is below the upper level of the groundwater; thus, groundwater is induced to flow toward and into the drain."

    This statement implies that in all areas of the Project the bottoms of Project drains were below the upper level of groundwater. This statement is overly simplified and does not reflect that ground water levels relative to drain elevations vary spatially throughout the Project and temporally throughout the year and from one year to the next depending on hydrologic and water supply conditions.

33. On page 31, Texas states, "Similarly, the bottom of the river channel is below the level of the groundwater, with water shown flowing in both directions depending on the relative heights of the water in the river and the groundwater from location to location. [Brandes Decl. at TX_MSJ_000011-000012.]"

    This statement is incorrect. The flow of water between the river and the ground water depends on the relative elevations of the groundwater surface and the river surface. Further, this statement is overly simplified and does not reflect that groundwater levels relative to the river surface vary spatially throughout the Project and temporally throughout the year and from one year to the next depending on hydrologic and water supply conditions.

34. On page 31, Texas states, "The irrigation tailwater and groundwater collected in the drain flows to the river and is referred to as return flow."

    This statement is incomplete. In addition to tailwater and groundwater collected in drains, return flows in the Project area also include operational waste and on-farm surface runoff. Spronk Report at 78.

35. On page 31, Texas states, "The return flow from the drain that is discharged into the Rio Grande provides an important supply of Project water for users located downstream, namely users in the lower Mesilla basin and in the El Paso Valley of Texas. [Brandes Decl. at TX_MSJ_000011-000012.]"

    This statement ignores the fact that return flows vary spatially and temporally depending on many factors, including hydrologic conditions and Project operations. See Paragraph 25 . While reuse of return flows had long been an essential part of Project operations, Reclamation interfered with this reuse in the El Paso Valley by changes to water delivery infrastructure that eliminated river diversions that previously supplied the Riverside and Tornillo Canals and other changes. Spronk Rebuttal at 32. In addition, EPCWID ceased diversions of return flows from drains in the early 1980s eliminating an important source of its irrigation supply. These changes have increased the reservoir releases that are needed to deliver Project water to EPCWID, and therefore have reduced the supply of water available for allocation to the District's in subsequent years. Id. at 32-33.

36. On page 32, Texas states, "With the extensive development and use of groundwater in the Rincon and Mesilla basins of New Mexico that began during the early 1950s – particularly in the relatively shallow aquifers with generally high groundwater levels such as those along the Rio Grande – groundwater levels began to fluctuate and decline in some areas. Brandes Decl. at TX_MSJ_000012-000013."

While ground water levels in the Rincon and Mesilla basins declined when ground water pumping increased during drought periods with low Project allocations, the ground water levels recovered during wet periods when pumping decreased in periods of full or near full Project supply. NM-EX 006, Barroll 2nd Decl. Paragraph 44. This statement also neglects to mention that the Texas part of the Mesilla basin also underwent "extensive development and use of groundwater" for irrigation in the 1950s. Spronk Report at 65. In addition, municipal well development in the Texas part of the Mesilla basin and in the El Paso Valley have also caused ground water level declines. The groundwater level declines in Texas have increased depletions to surface water flows and increased conveyance losses in delivering Project water. Spronk Report at 65; see Paragraph 28. The extensive development and use of groundwater for municipal and irrigation use in the Hueco Bolson by Texas and Mexico have created the large and lasting cone of depression in the groundwater levels shown in **Figure 5** that is over 100 feet deep in some areas. Expert Report of Charles P. Spalding and Daniel J. Morrissey (Third Edition) (Sep. 14, 2020) ("MMA Report") at Figs. 5.4, 5.6, 6.1, 8.21, 8.22 & App. Q.

37. On page 32, Texas states, "This in turn caused reduction of discharges of groundwater into the drains, and directly into the river. [Brandes Decl. at TX_MSJ_000012-000013.]"

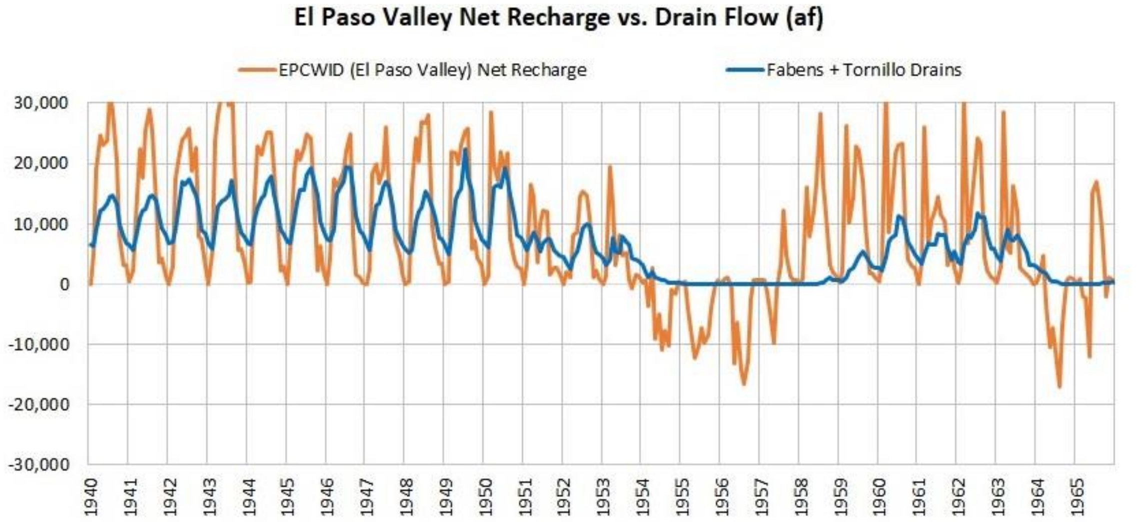
This statement fails to mention that factors other than groundwater pumping also affect the timing and amount of water that returns to Project drains. See Paragraph 30. While drain flows generally declined during drought periods when pumping was high, they recovered during wet periods when pumping was low. Spronk Rebuttal at 170-171. Finally, Texas fails to note that groundwater pumping in Texas has also caused a reduction in discharges of groundwater to drains and the river. Spronk Report at 97.

38. On page 32, Texas states, "Eventually, with enough groundwater pumping, the groundwater gradient in many areas reversed, with significant reductions in the groundwater inflows to the drains and into the river. [Brandes Decl. at TX_MSJ_000012-000013.]"

This statement is incomplete. Groundwater levels and drain flows historically recovered in both the Rincon and Mesilla valleys during periods of full or near full Project water allocations when pumping was low. See Paragraph 37. Pumping in Texas has also impacted groundwater discharges to drains and to the river and increased conveyance losses of Project water, but, unlike in New Mexico, groundwater level declines in the Hueco Bolson in Texas have not recovered in full supply years. See Paragraphs 36 and 37.

39. On pages 32 to 33, Texas states, "This condition is illustrated by the diagram in Figure 11. As shown, the level of the groundwater is below the bottom of the river channel and the drain, and water flowing in the river and into the drain moves toward and into the groundwater system, rather than the other way around, as it did prior to the initiation of groundwater pumping. Brandes Decl. at TX_MSJ_000012-000013."

Figure 11 in the Texas Motion is highly idealized and not representative of conditions everywhere in the Rincon and Mesilla basins. The condition shown in Figure 11 generally is limited to periods with low Project supply and high pumping. In addition, the conditions illustrated in Figure 11 also occur in Texas. MMA Report Figure 6.4. The historical relationship between recharge and drain flows in the El Paso Valley is shown in **Figure 8**.



Note: Net recharge computed as canal seepage + on farm deep percolation minus pumping from the SWE Canal and Farm Budget Model.

Figure 8. El Paso Valley Net Recharge vs. Drain Flow (af), adapted from Spronk Rebuttal Figure 19-3.

Spronk Rebuttal at 148.

40. On page 33, Texas states, "The discharge of return flow from the drain into the river is substantially curtailed, if not reduced to zero, thereby also reducing the flow in the river. [Brandes Decl. at TX_MSJ_000012-000013.]"

This statement fails to mention that when drain flows decline in full supply years, the reduction typically is offset by increased releases from Project storage such that there is no change in Rio Grande flow and Project deliveries. See Paragraph 25.

41. On page 33, Texas states, "The phenomenon of reduced river flows caused by groundwater withdrawals is an underlying component of what is referred to as streamflow depletions, and these streamflow depletions have increased along the Rio Grande within the Rincon and Mesilla basins since significant groundwater development began in the early 1950s. Brandes Decl. at TX_MSJ_000012-000013."

This statement misleadingly implies that streamflow depletions have steadily increased in the Rincon and Mesilla valleys in New Mexico from the 1950s through the present. Streamflow depletions attributable to groundwater pumping vary from year to year depending on hydrologic conditions and Project operations. Simulations with the ILRG Model show that streamflow depletions, as reflected in the changes in river flows between scenarios with and without pumping, vary considerably, typically little change in full supply years and greater changes in partial supply years. Spronk Rebuttal at 331-332. Texas also neglects to mention that streamflow depletions attributable to pumping in the Mesilla and El Paso valleys in Texas also impact Project supplies. See Paragraph 18.

42. On page 33, Texas states, "One of the obvious impacts of these increased streamflow depletions has been to alter the Project water budget by reducing flows in the Rio Grande that otherwise would ultimately reach water users in the lower Mesilla basin and in the El Paso Valley in Texas. Brandes Decl. at TX_MSJ_000012-000013."

This statement ignores that because the Project is operated as a single unit, changes in conditions anywhere within the Project area can affect water deliveries throughout the Project. Spronk Rebuttal at 6. This applies to depletions caused by pumping in Texas in addition to pumping in New Mexico. Id.

43. On pages 33 to 34, Texas states, "In essence, the release of a specific quantity of water from Caballo Reservoir now contributes less to the surface water supply for these users because of the losses of flow due to the increased seepage from the Rio Grande and interior drainage ways, thus altering the previously existing Project water budget. [Brandes Decl. at TX_MSJ_000012-000013.]"

While it is true that conveyance losses in delivering Project water increase because of pumping impacts on drain flows and seepage, these change have occurred throughout the Project as a result of pumping in New Mexico and Texas. See Paragraph 38.

44. On page 87, Texas states, "The volume of Project water that was split 57/43 in 1938 for the Project to make the allocation to EBID and EP#1 pursuant to the contracts with the United States reflected the acreages of irrigated land in the two Districts at that time and the generally gaining condition of the river below Caballo Reservoir as influenced by relatively high groundwater levels in the absence of significant pumping. [Brandes Decl. at TX_MSJ_000001-000016.]"

This statement is incorrect. The 57%/43% split of Project supply between EBID and EPCWID reflected the relative authorized Project acreages within each District, as reflected in the Contract between EBID and EPCWID (Feb. 19, 1938), NM_EX 324 ("1938 Downstream Contract"), and not the number of acres that were actually irrigated at that time. The actual irrigated acreage within the Project in 1938 was approximately 140,000 acres, about 20,000 acres less than the full irrigated acreage authorized in the 1938 Downstream Contract. Spronk Report at 43 & Fig. 5-4. The irrigated area within the Project increased gradually through the 1940s, reaching its maximum extent of about 160,000 acres in the early 1950s as shown in **Figure 9**. Id. It has gradually declined in both New Mexico and Texas ever since. Id. However, the actual irrigated acreage within the Project fluctuates from year to year based on a number of factors, including water supply, planting and fallowing decisions by individual farmers, and urbanization. Id. at 43. In addition, the generally gaining condition of the river in 1938 had no bearing on the adoption of the 57%/43% split of Project water between EBID and EPCWID.

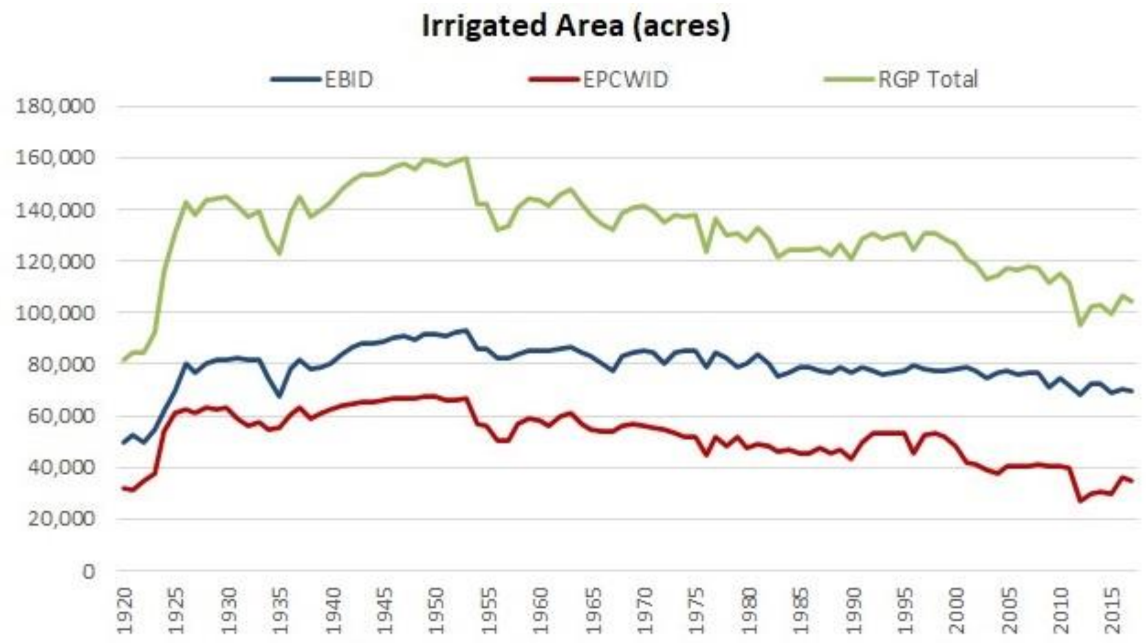


Figure 9. Irrigated Area (acres), adapted from Spronk Report Figure 5-4.

45. On page 87, Texas states, "This changed beginning in the 1950s with the extensive development of groundwater in New Mexico and the subsequent lowering of groundwater levels along the Rio Grande that altered the condition of the river from a generally gaining stream to a generally losing stream. [Brandes Decl. at TX_MSJ_000001-000016.]"

    This statement is incorrect. While some reaches of the Rio Grande were losing during periods of low Project supply and increased groundwater pumping, these reaches recovered and became gaining again during full allocation periods. Spronk Report at 90; Spronk Rebuttal at 57-58. This statement also ignores that groundwater pumping for irrigation in Texas beginning in the 1950s, and before then for municipal use in Texas, also impacted Project deliveries by depleting the Rio Grande, depleting drain flows, and increasing conveyance losses. Spronk Report at 97-98 and Paragraph 28.

46. On page 87, Texas states, "The implications of this change are obvious – river flow losses mean greater depletions and less Project water for downstream users. [Brandes Decl. at TX_MSJ_000001-000016.]"

    This statement is incorrect and misleading. River losses are impacted by factors other than pumping in New Mexico, including but not limited to crop selection, Project operating efficiency, changes in reservoir releases, changes in irrigation efficiency, and the changes in Project allocation procedure that occurred with imposition of the 2008 OA. Spronk Report at 111. In addition, there is no decrease in Project water deliveries in full supply years even with increased conveyance losses caused by pumping if additional water can be released from Project storage to compensate for the increased conveyance losses. See Paragraph 25.

47. On page 27, Texas states, "Surface water and groundwater are interconnected in the Rincon and Mesilla basins. Miltenberger Decl. at TX_MSJ_001612; Declaration of William R.

Hutchison (Hutchison Decl.), attached as TX_MSJ_000657-000661 in Texas's Appendix of Evidence."

This statement is incomplete because it does not also state that groundwater and surface water are also interconnected in portions of the El Paso Valley. The groundwater and surface water have become disconnected in the northern portions of the El Paso Valley due to municipal pumping by El Paso and Juarez. This means that Project water conveyance losses in the disconnected area are at a maximum and are not affected by variations in pumping. NM-EX 006, Barroll 2nd Decl. Paragraph 18.

48. On page 28, Texas states, "This is a losing stream condition, and the seepage rate out of the stream is dependent on the difference between the elevation of the water in the stream and the elevation of the groundwater. [Hutchison Decl. at TX_MSJ_000657-000662.]"

    This statement is incomplete. The seepage rate out of the river is not only dependent on the difference between water surface elevation of the stream and the groundwater level elevation, but also the hydraulic conductivity of the riverbed and aquifer materials. Spronk Report at 73.

49. On pages 28 to 29, Texas states, "In this case, involving a disconnected stream, the seepage rate out of the stream has reached its maximum and is based on the depth of the stream only. [Hutchison Decl. at TX_MSJ_000657-000662.]"

    The seepage rate out of the stream is also affected by the hydraulic conductivity of the riverbed and aquifer materials. Spronk Report at 73.

50. On page 29, Texas states, "Long-term groundwater pumping can result in drawdown to the point where a stream that has been historically gaining (i.e., groundwater flows into the stream providing base flow) can be changed to a losing or disconnected stream (i.e., water percolates out of the stream and recharges the underlying aquifer). [Hutchison Decl. at TX_MSJ_000657-000663.]"

    The statement is incomplete. There are factors other than pumping that can affect river gains and losses. See Paragraph 46.

51. On page 29, Texas states, "A water budget is an accounting for a defined time period of the inflows into, and the outflows from, a defined control area. Brandes Decl. at TX_MSJ_000010-000012."

    This statement is incomplete because it fails to mention that the change in storage within the defined controlled area is also important to water budget analysis. Spronk Report at 124.

52. On page 29, Texas states, "Often, performing a water budget with known volumes of inflows and outflows for a specific time period can lead to the quantification of one or more unknown variables for that same time period. [Brandes Decl. at TX_MSJ_000010-000012.]"

    This statement is correct that, to the extent that certain inflows or outflows are known, the combined amount of the unknowns, including the unknown inflows, unknown outflows, and unknown storage can be arithmetically computed. However, the individual amounts of the unknown inflows, outflows, and changes in storage cannot be disaggregated without further information.

53. On page 29, Texas states, “Performing multiple water budgets for a specific control area for different time periods can provide information regarding how certain phenomena may have changed. [Brandes Decl. at TX_MSJ_000010-000012.]”

    This statement is vague, and it is unclear what Texas means by it.

54. On page 29, Texas states, “Even a visual depiction of the water budget for a control area showing the generalized movement of water into, within, and out of the Project area under different conditions and circumstances can be informative and help to understand how the Project water supply system was originally conceived to work and how it has changed with the development of groundwater in New Mexico. [Brandes Decl. at TX_MSJ_000010-000012.]”

    Visual depictions can be informative, but they can also be misleading since they tend to be idealized and may not represent the varied conditions that exist in a large area like the Rio Grande Project. In addition, a diagram created today provides little insight into the intentions of the Project planners.

55. On page 86, Texas states, “Since 1938, the volume of groundwater pumped in the Rincon and Mesilla Valleys in New Mexico has increased. Schorr Decl. at TX_MSJ_000697-000699; Brandes Decl. at TX_MSJ_000001-000016, Figure 11.”

    This statement misleadingly implies that the volume of groundwater pumping in New Mexico has increased continuously since 1938. Significant pumping for irrigation in New Mexico did not commence until the late 1940’s. Spronk Report at 102. The volume of irrigation pumping in New Mexico has varied with the available Project supply with greater pumping in partial supply years and less pumping in full supply years. Spronk Rebuttal at 152. This statement omits that the amount of groundwater pumping in Texas is far greater now than it was in 1938. Spronk Rebuttal at 153.

56. On page 90, Texas states, “New Mexico has constructed an expensive, time consuming, and complex set of models for use in this litigation.”

    The models developed by the New Mexico experts were thoughtfully developed over a number of years and are sufficiently complex to reasonably and rationally simulate the complex Project operations, surface water flows, ground water flows and SW-GW interactions that exist in the Lower Rio Grande between Elephant Butte Reservoir and Ft. Quitman. Spronk Rebuttal at 55.

57. On pages 90 to 91, Texas states, “Its experts have created two detailed groundwater flow models using a version of a modeling system known as MODFLOW. Hutchison Decl. at TX_MSJ_000657-000660, 000664-000669. One of these groundwater models addresses the Rincon and Mesilla aquifers which underlie southern New Mexico and a small portion of Texas, and the other covers the Hueco Bolson aquifer which underlies the El Paso Valley. Id.”

    This statement is incomplete. New Mexico’s Rincon-Mesilla groundwater model also simulates ground water flow in the aquifers of the Santa Fe Group that lie below and laterally outward from the Rincon and Mesilla alluvial aquifers. Similarly, the New Mexico’s Hueco groundwater model also simulates the Santa Fe Group aquifers that extends below and laterally outward from the El Paso Valley alluvial aquifer. The simulation domains for the groundwater model components of New Mexico's ILRG Model are shown in **Figure 10**.

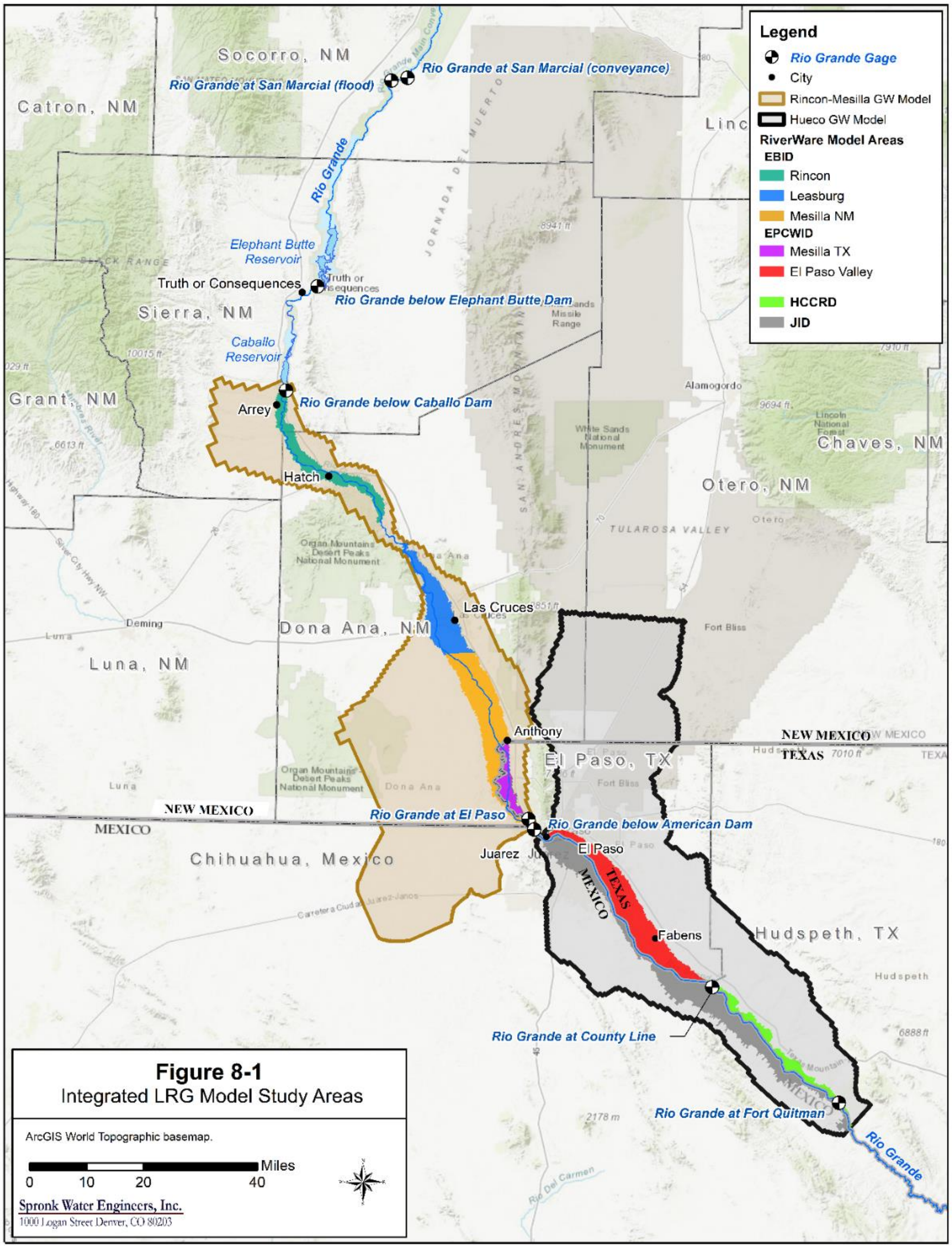


Figure 10. Integrated LRG Model Study Areas, adapted from Spronk Report Figure 8-1.

58. On page 91, Texas states, "These groundwater models have been combined with a RiverWare model of the surface waters network in the Rincon, Mesilla, and El Paso Valleys. [Hutchison Decl. at TX_MSJ_000657-000660, 000664-000669.]"

    This statement is incomplete. The RiverWare Model also simulates Project water allocation and accounting, the operation of Elephant Butte and Caballo Reservoirs, canal and on-farm operations throughout the study area, ground water flow in the alluvial aquifers underlying the Rincon, Mesilla, and El Paso Valleys, and the interaction between surface flow and alluvial groundwater flow. Spronk Report at 76. The simulation area for the RiverWare Model component of New Mexico's ILRG Model is shown in **Figure 10**.

59. On page 91, Texas states, "The ILRGM has been used by the New Mexico experts to evaluate various historic conditions and hypothetical situations involving the Compact's appropriation to Texas that New Mexico believes to be involved in this dispute. [Hutchison Decl. at TX_MSJ_000657-000660, 000664-000669.]"

    This statement is incorrect. The ILRG Model simulates only one historical condition and that is in the Historical Base Run that is used for comparison to numerous simulations of alternative scenarios involving reduced ground water pumping, alternative Project operations, modified EPCWID operations, and conjunctive use of ground water and surface water. Spronk Rebuttal at 13-15.

60. On page 91, Texas states, "Although Texas disputes the need for, and reliability of, the ILRGM to evaluate certain situations, results from this model are instructive regarding the question of whether groundwater pumping in the Rincon and Mesilla Valleys depletes the surface water flows of the Rio Grande below Elephant Butte and Caballo Reservoirs. Hutchison Decl. at TX_MSJ_000657-000660, 000664-000669."

    I agree with Texas that the ILRG Model's results are instructive. New Mexico's ILRG Model is the best available tool for evaluating the claims and counterclaims in this case because it is the only model that (a) simulates the entire area from Elephant Butte Reservoir to Fort Quitman, (b) simulates operation of the Project and LRG irrigation systems using rules that are capable of dynamic response when simulating alternative scenarios, and (c) utilizes monthly stress periods that can distinguish impacts during the irrigation season when the Project is operating from impacts during the non-irrigation season when the Project is not operating. Spronk Report at 9. The excellent calibration of the ILRG Model and its rational simulation of Project operations, surface water flows, ground water flows and SW-GW interaction are convincing evidence of the reliability of the model. Spronk Report at 112.

61. On page 91, Texas states, "New Mexico has run its ILRGM and made calculations from the ILRGM output to address the surface water depletions. [Hutchison Decl. at TX_MSJ_000657-000660, 000664-000669.]"

    This statement is incomplete. The ILRG Model was not run only to simulate surface water depletions from pumping. Rather the model simulates the impact of pumping on surface water flows and the effects on Project operations and all simulated processes that result as the changed conditions ripple spatially and temporally through the model just as they would in the real world. This is referred to as "re-operation" and is an essential element of the ILRG Model that is not present in the ground water model of the Rincon and Mesilla basins developed by the Texas experts ("Texas Model"). Spronk Report at 142-143. The ILRG

Model has been used to determine the impact on Project deliveries from pumping, changes in Project operations, changes in EPCWID operations, and in evaluating several conjunctive management scenarios. Spronk Report at 9-11.

62. On page 91, Texas states, "Again, without conceding the need for or reliability of the ILRGM, its results are the only evidence that New Mexico has disclosed on these issues and serve as admissions."

This is incorrect, as New Mexico has disclosed much evidence other than modeling regarding historical changes in streamflow and project supplies. For example, New Mexico disclosed an analysis of the difference in the annual flow of the Rio Grande at the gages below Caballo Reservoir and at El Paso as another measure of depletions. As shown in **Figure 11**, the average annual Caballo-El Paso depletions now are little different than they were circa 1938. Spronk Report at 42 and 181.

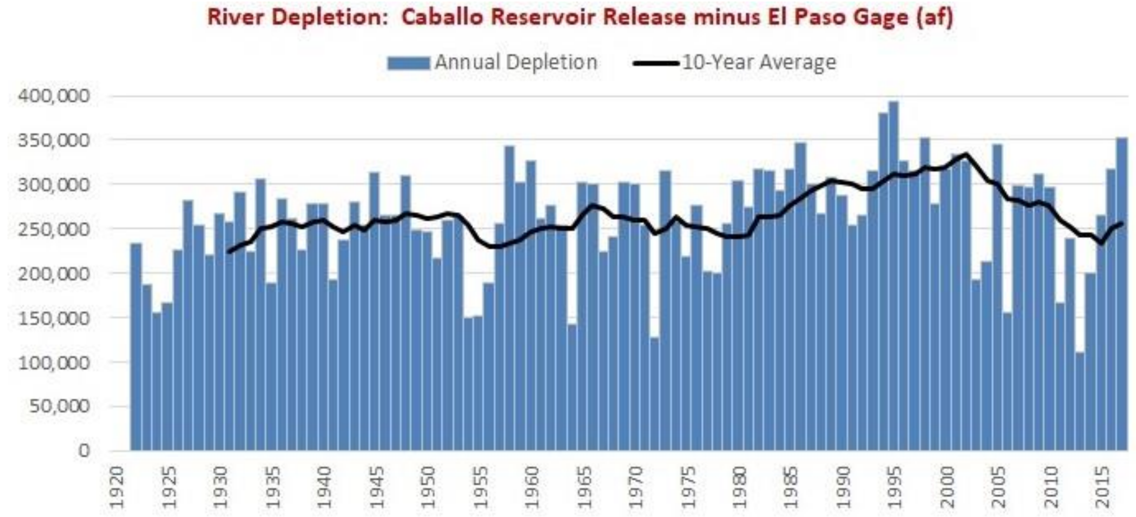


Figure 11. River Depletion: Caballo Release minus El Paso Gage, adapted from Spronk Report Figure 5-2.

63. On page 91, Texas states, "New Mexico's analysis indicates that groundwater pumping during the period of 1940 to 2017 has depleted the streamflow of the Rio Grande, on average, in the amount of 66,351 acre feet per year (AF/yr). Hutchison Decl. at TX_MSJ_000657-000660, 000664-000669."

This statement is misleading for several reasons. First, the figure Texas cited is the average annual change in simulated flow at the El Paso gage (plus changes in Northwest WWTP discharges) based on comparison of the historical base run with historical pumping (Run 1), and an alternative scenario run in which all pumping in the Rincon and Mesilla basins was turned off (Run 6). This included turning off irrigation pumping and M&I pumping in the Texas portion of the Mesilla basin. Texas pumping in the Mesilla basin accounts for a significant portion of the modeled depletions in the simulated flow at the El Paso gage. See Paragraph 18. Second, significant portions of the differences in annual El Paso flows between the historical base run and the no R-M pumping run occur during the winter or as a result of spills from Project storage and, therefore, do not represent impacts to Project deliveries. This is shown in **Table 1** which disaggregates the simulated change in El Paso flow when all pumping in the Rincon and Mesilla basins is turned off in Run 6 between the increased flows during the irrigation season, during the winter, and during reservoir spills.

Table 1. Change in Rio Grande at El Paso Flow, adapted from Spronk Rebuttal Appendix 30F.

Rio Grande at El Paso	Historical Base Run (Run 1) (1,000 af)	Rincon-Mesilla Pumping Off (Run 6) (1,000 af)	Run 6 minus Run 1 (1,000 af)
Reservoir Spills	49.4	67.8	18.4
Nov-Feb Flows	22.8	51.3	28.5
Mar-Oct Flows	263.8	296.6	32.8
Total	336.0	415.7	79.7

Spronk Rebuttal at 418.

Third, the Rio Grande at El Paso gage is not a point of delivery for Texas, and changes in the flows at this gage location have no bearing on the claims or counterclaims in this case. Spronk Report at 108.

64. On Page 91, Texas states, "New Mexico's calculations from this analysis further indicate that 52,610 AF/yr of the total depletion is attributable to New Mexico's pumping and 13,700 AF/yr is due to Texas's pumping."

This statement is misleading and is disputed. See Paragraph 63.

65. On pages 98 to 99, Texas states, "It is undisputed that New Mexico pumping intercepts and depletes the Rio Grande [Hutchison Decl. at TX_MSJ_000657-000669; see section V.F.3, supra (New Mexico admitted that its pumping depletes surface water flows)], and as such, operation of these water rights under New Mexico law conflicts with the Compact – federal law – and the *California* rule has no application."

This statement is disputed. The effect of pumping in New Mexico on the Rio Grande is a complex issue involving interactions of Project operations, surface flows, and ground water flows. Determination of the effects of New Mexico pumping on Rio Grande flows and deliveries of Project water are matters of expert analysis and expert opinion. There are times (e.g., full supply years) when New Mexico pumping has no impact on Project deliveries. See Paragraph 17. This statement is incomplete because it omits that Texas pumping also depletes the Rio Grande and deliveries of Project water. Spronk Rebuttal at 375-376.

66. On page 89, Texas states, "Mr. Lopez concedes that groundwater pumping in New Mexico below Elephant Butte Reservoir has depleted the surface water of the Rio Grande."

This statement is incomplete because it omits that Texas pumping also depletes the Rio Grande and affects deliveries of Project water. Spronk Rebuttal at 375-376; see Paragraph 65.

67. On page 85, Texas states, "In this matter, it is undisputed that groundwater pumping in New Mexico below Elephant Butte Reservoir depletes surface water flow of the Rio Grande, and that groundwater pumping has increased substantially since 1938. Brandes Decl. at TX_MSJ_000001-000016, Figure 10; Schorr Decl. at TX_MSJ_000697-000699."

This statement omits that Texas pumping also depletes the Rio Grande and deliveries of Project water, and that Texas pumping has also increased since 1938. Spronk Rebuttal at 375-376.

68. On page 16, Texas states, "Now, New Mexico's post-Compact development has depleted that water supply by capturing returns flows that otherwise would have been available. Brandes Decl. at TX_MSJ_000006."

This statement omits that Texas pumping, both for irrigation and municipal purposes, also depletes the Rio Grande and deliveries of Project water. Spronk Rebuttal at 375-376.

Declaration of William R. Hutchison

69. I was also asked by counsel for New Mexico to review the Declaration of Dr. William R. Hutchison, which Texas submitted to support its Motion for Partial Summary Judgment, to determine whether any of Dr. Hutchison's statements are inaccurate, disputed, incomplete, and/or are opinions rather than facts.

70. In paragraph 23 of his Declaration, Dr. Hutchison states, "The two major diversion points on the Rio Grande just below the El Paso Narrows are the Acequia Madre (for Mexico) and the American Canal (for Texas)."

This statement is incorrect. Previously, there were two other major river headings in the Project area downstream of the American Canal heading, including the Riverside Canal heading and the Tornillo Canal heading. In addition, there were two other minor river diversions in the Project area further downstream at the Guadalupe heading and the Hudspeth heading. JIR at 101 and Plate 21.

71. In paragraph 26 of his Declaration, Dr. Hutchison states, "Throughout the Rincon and Mesilla Basins in both New Mexico and Texas, there has been varying amounts of groundwater pumping for irrigated agriculture, municipal use, industrial, commercial, domestic, and livestock use."

This statement neglects to mention that there has been pumping in the Hueco Bolson in both Texas and Mexico for irrigated agriculture, municipal use, industrial, commercial, domestic, and livestock use. Spronk Report at 50.

72. In Paragraph 27 of his Declaration, Dr. Hutchison states, "Groundwater flow from the Rincon and Mesilla Basins to the Hueco Bolson is limited to minor flow through Fillmore Pass and the El Paso Narrows due to the geologic structure of the area. This hydrogeologic isolation between the basins means that the Rio Grande at El Paso stream gage is an ideal location to

measure and assess impacts of groundwater pumping in the Rincon and Mesilla Basins to Rio Grande flow."

This statement is incomplete and, therefore, inaccurate because the Rincon-Mesilla Basin and El Paso Valley are hydraulically connected by the surface flow of the Rio Grande. Because the Project is operated as a single unit, the effects of pumping on surface flows in Texas can propagate throughout the Project area and impact deliveries of Project water to New Mexico. Spronk Rebuttal at 46.

73. In Paragraph 36 of his Declaration, Dr. Hutchison states, "One of the important outputs from the ILRGM is the flow of the Rio Grande in the El Paso Narrows (Rio Grande at El Paso). As described above, the El Paso Narrows represents the geographic and hydrogeologic boundary between the Mesilla Basin (upstream) and the El Paso Valley (downstream). If groundwater pumping in the Rincon and Mesilla Basins results in stream depletions, it can be measured at the gaging station in the El Paso Narrows."

Dr. Hutchison implies that the El Paso Gage is a Compact delivery point, but it is not. Spronk Report at 82. Further, due to how the Project is operated, depletions to surface flows caused by ground water pumping in the Rincon and Mesilla Basins will not all manifest as depletions to Rio Grande flows at El Paso. Depletions to surface flows can also affect the following operations and processes upstream of El Paso:

- Project storage and evaporation.
- Diversions of Project water at the Arrey Canal, Leasburg Canal, Mesilla Eastside Canal, Mesilla Westside Canal.
- Deliveries of Project water for irrigation use in EBID and the Mesilla portion of EPCWID.
- Evapotranspiration of native vegetation upstream of the El Paso gage.
- Evaporation from the Rio Grande water surface upstream of the El Paso gage.

Spronk Report at 93 and Spronk Rebuttal at 439-440.

74. In Paragraph 36 of his Declaration, Dr. Hutchison also states, "Any model that simulates surface water-groundwater interactions of the Rincon and Mesilla Basins should reproduce historic flows at this measuring point and should be capable of quantitatively assessing depletions at this measuring point."

The El Paso gage is not a Compact delivery point. Spronk Report at 82. While simulation of the flows at El Paso gage and other points is relevant for assessing model calibration, assessment of depletions to surface flows at the El Paso gage is irrelevant to addressing the claims and counterclaims in this case. More important is use of the model to assess impacts to deliveries of Project water to EBID and EPCWID. Spronk Rebuttal at 45.

75. In Paragraph 38, of his Declaration Dr. Hutchison states, "The relevant ILRGM runs for this declaration are:

    - Run 3 – NM Pumping Off (all New Mexico pumping off);
    - Run 6 – RM Pumping Off (all Rincon-Mesilla pumping off); and
    - Run 7 – TX Mesilla Pumping Off (all Texas pumping in the Mesilla."

    Dr. Hutchison states that the relevant ILRGM runs for his declaration are Run 3, 6 and 7, however these are not the only runs relevant in this case. While Dr. Hutchison discusses Runs 3, 6, and 7 in his declaration, the New Mexico experts disclosed many other ILRG Model runs, all of which are relevant to this case. These include other runs in which certain types of pumping and/or pumping in certain geographic areas were turned off, runs with alternative Project allocations, a run with reduced Project operational waste, runs with alternative EPCWID Operations, and various conjunctive administration runs.

76. In Paragraph 39 of his Declaration, Dr. Hutchison states, "These 'pumping off' runs hypothetically assumed no groundwater pumping from 1940 to 2017 and resulted in higher simulated Rio Grande at El Paso flows as compared to the historic operation simulation (Run 1). Under the pumping off runs, groundwater elevations in the Rincon and Mesilla Basins are generally higher than the groundwater elevations in the Rincon and Mesilla Basins in the Run 1 simulation. The higher groundwater elevations result in more groundwater discharge to the surface water system (canals, drains and the Rio Grande itself), and, thus, results in higher surface water flows."

    This statement is incomplete because it does not list changes in other simulated model outputs from the model including the following:

    - Increased Project storage, reservoir evaporation, releases of Project water, and spills. Spronk Report at 10-11.
    - Increased deliveries of Project water to EBID farmers, EPCWID farmers, and EPW. Spronk Rebuttal at 119.
    - Increased evapotranspiration by native vegetation and increased evaporation from water surface areas. Spronk Report at 10-11.

    Spronk Rebuttal at 12 and 417-418.

77. In Paragraph 40 of his Declaration, Dr. Hutchison states, "The New Mexico experts interchangeably use the terms 'depletion' and 'pumping impact' in the text of their reports, the figures associated with the reports, and the Excel spreadsheets that contain the results of the ILRGM simulations. New Mexico experts generally calculated depletion as the difference between the stream flow associated with a "no pumping" run of the ILRGM and the stream flow associated with the historic operation run of the ILRGM (Run 1)."

    This statement is incomplete. The New Mexico experts used the ILRG Model to compute pumping impacts on many model outputs in addition to streamflows. See Paragraph 73.

78. In Paragraph 42 of his Declaration, Dr. Hutchison states, "New Mexico completed a specific analysis of Rio Grande at El Paso depletions using data and results from the ILRGM results

described above. Attachment 4 is the DataAnn sheet of the Excel file named Ferguson Rebuttal revised 9-15-20 v116.xlsx that was disclosed by New Mexico."

Analysis of differences in Rio Grande at El Paso flows between the historical base run and selected alternative scenario runs were computed primarily to compare these results to the changes in El Paso flow determined by Dr. Hutchison using the Texas Model. These results demonstrate the inferiority of the Texas Model due to its limited geographic scope, lack of Project reoperation in alternative runs, and coarse annual stress periods. Spronk Report at 143. The purpose of the analysis of model results shown in Attachment 4 was to rebut the opinion of Dr. Ian Ferguson (U.S. Expert) that the impact of Texas Mesilla pumping on El Paso flows was 20% of the total impact of all pumping in the Rincon-Mesilla basin. As illustrated in the far righthand columns, the Texas Mesilla pumping in some years causes impacts that are far greater than 20% of the total impact of Rincon-Mesilla basin pumping. Spronk Rebuttal at 22-23 and 147, Fig. 19-2.

79. In Paragraph 43 of his Declaration, Dr. Hutchison states, "The first line of Attachment 4 distinguishes results from the ILRGM, and calculations completed in the spreadsheet for the depletion analysis. The first eight columns are labeled 'ILRG,' which means that the data in the columns are directly from ILRGM. The final 11 columns are labeled 'Calc,' which means that the data in the columns are calculations completed in this spreadsheet based on ILRGM results. Please note that the blue color of the 'Calc' columns was from the original Excel file disclosed by New Mexico."

This statement is incomplete because Attachment 4 does not show all of the simulated impacts from pumping.

80. In Paragraph 47 of his Declaration, Dr. Hutchison states, "The Northwest WWTP discharge enters the Rio Grande downstream of the Rio Grande at El Paso stream gage. Thus, the sum of Rio Grande at El Paso and the Northwest WWTP discharge represents the available flow for diversions to the Acequia Madre (Mexico) and the American Canal (Texas) below the El Paso Narrows."

This statement is not accurate. During the irrigation season when Project water is being delivered, the flow at El Paso represents the flow that is being simulated for delivery to the American Canal (Texas) and the Acequia Madre (Mexico). In some years, the irrigation season flows also include additional water spilled from Project storage. During the non-irrigation season when water is not being released from Project storage, the simulated difference in the Rio Grande at El Paso plus NW WWTP flow represents the additional drain flows and river gains that would occur without pumping. Streamflow during this time is not considered Project water. In summary, a substantial portion of the simulated annual changes in Rio Grande at El Paso flows in the ILRG Model do not reflect changes in Project water deliveries. Spronk Rebuttal at 23 and 119.

81. In Paragraph 49 of his Declaration, Dr. Hutchison states, "The annual depletions were presented in Figure 19-2 (page 147) of the September 5, 2020 version of the report by Greg Sullivan and Heidi Welsh and is reproduced below."

The results shown in Figure 19-2 from the Spronk Rebuttal Report represent the annual total impact of Rincon-Mesilla pumping computed as the sum of the impacts during the irrigation season and non-irrigation season. A substantial portion of the annual impacts shown in

Figure 19-2 do not reflect impacts to deliveries of Project water for beneficial use. See Paragraph 63.

82. In Paragraph 52 of his Declaration, Dr. Hutchison states, "Average stream depletions (or groundwater pumping impacts) as calculated at the Rio Grande at El Paso gage for the period 1940 to 2017 based on ILRGM results (as shown in Attachment 4) were reported by experts retained by New Mexico as follows:

    - Total Rincon-Mesilla Groundwater Pumping Impact: 66,351 AF/yr
    - New Mexico Groundwater Pumping Impact: 52,610 AF/yr
    - New Mexico Groundwater Pumping Impact: 79 percent of total impact
    - Texas Mesilla Groundwater Pumping Impact: 13,700 AF/yr
    - Texas Mesilla Groundwater Pumping Impact: 21 percent of total impact"

    The summary of the impact to Rio Grande at El Paso flows from the ILRG Model Runs disclosed by New Mexico represents average annual changes in (a) flows being delivered past the El Paso gage for delivery to EPCWID and Mexico during the irrigation season, (b) spills from Project storage in wet years, and (c) return flows during the non-irrigation that are not considered to be Project water (e.g., Spronk Rebuttal at 418).

83. In Paragraph 53 of his Declaration, Dr. Hutchison states, "The analysis presented in the spreadsheet (Attachment 4) completed by New Mexico experts establishes that groundwater pumping in New Mexico has depleted surface water flow in the Rio Grande."

    This statement is incomplete misleading. The impacts shown in Attachment 4 represent total year-around changes in El Paso flows including changes in project spills and changes in non-irrigation season flows that are not considered Project water available for beneficial use.

84. In Paragraph 55 of his Declaration, Dr. Hutchison states, "The ILRGM can be used for analyses that focus on large geographic areas and over a period of few to several years."

    This statement is vague. The ILRG Model was used by the New Mexico experts to analyze numerous alternative scenarios and the results from these scenarios are appropriate for accessing the claims and counterclaims in this case. The ILRG Model is the best available tool to analyze the claims and counterclaims in this case. Spronk Report at 9. Spronk Rebuttal at 51 and 112.

85. In Paragraph 56 of his Declaration, Dr. Hutchison states, "Limitations of the ILRGM affect the reliability of results focused on a single year or time periods less than one year, and results that focus on a small geographic area. The geographic and temporal scale limitation of ILRGM results is primarily because the RiverWare model 'governs' the results (Daniel J. Morrissey deposition of December 10, 2019, page 65, lines 13 to 23)."

    This statement is misleading. In his deposition testimony, Mr. Morrisey was simply comparing differences between how RiverWare and MODFLOW models simulate the exchange of ground water and surface water. These differences are irrelevant because the performance of the ILRG Model is reflected in its remarkable calibration. Spronk Rebuttal at 112. Further, the calibrated and tuned ILRG Model is the best available tool for evaluating claims, counterclaims, and answering questions about the effects of certain actions on Project operations and deliveries of water to LRG water users. The ILRG Model is superior to the Texas Model for use in the litigation because (a) it simulates the entire LRG Area between the El Paso Gage and Fort Quitman, (b) it employs monthly stress periods that allow it to simulate the important seasonal variations in ground water and surface water flows, and (c) it is capable of simulating the dynamic response of Project operations to changes in flow through rule-based simulation processes. Spronk Rebuttal at 9.

86. In Paragraph 57 of his Declaration, Dr. Hutchison states, "All models are simplifications of real-world systems. The New Mexico RiverWare model calculates surface water-groundwater interaction within 'groundwater objects' that are several square miles in area. In contrast, the New Mexico groundwater models of the Rincon-Mesilla Basins and the Hueco Bolson calculates surface water-groundwater interactions in cells that are 10 acres in area. The groundwater objects in the RiverWare model are analogous to the groundwater model cells when comparing the surface water-groundwater interaction calculations. Daniel J. Morrissey acknowledged that the calculations in the RiverWare model are more 'generalized' than in the groundwater models (Daniel J. Morrissey deposition of December 10, 2019, page 65, lines 6 to 12)."

See Paragraph 85.

87. In Paragraph 58 of his Declaration, Dr. Hutchison states, "In summary, the ILRGM calculations rely on surface water-groundwater interaction calculations that are averaged over an area of several square miles and ignore groundwater model calculations that are averaged over an area of 10 acres in the groundwater models."

See Paragraph 85. In addition, the differences between MODFLOW and RiverWare in the spatial scale of the computed groundwater-surface water interactions need to be considered in the context that much of the Project operation and water use data that are used in the models are available at only irrigation unit or irrigation district scales. These data are necessarily averaged across the smaller computational areas in the RiverWare and MODFLOW components of the ILRG Model. Expert Report of John C. Carron and Steven T. Setzer (Third Edition) (September 15, 2020) ("Hydros Report") at Appendix A page 6-7.

88. In Paragraph 59 of his Declaration, Dr. Hutchison states, "The surface water-groundwater interaction issue is one of the most important aspects of this litigation. Stream depletion is a reduction in streamflow that is caused by groundwater pumping. Calculations of stream depletion with the groundwater models are averaged over areas of about 10 acres, but calculations with the RiverWare model represent averages over areas that are several square miles. The choice by New Mexico experts to rely on the RiverWare model results instead of the groundwater model results is inconsistent with their claims of the sophistication and necessary complexity of the ILRGM (e.g. Daniel J. Morrissey deposition of December 9, 2019, page 44, line 22 to page 45, line 4)."

See Paragraph 85.

89. In Paragraph 60 of his Declaration, Dr. Hutchison states, "Reliance on the ILRGM and its simplified representation of the surface water-groundwater interactions in the RiverWare model is appropriate for evaluating impacts of pumping over a large scale (i.e., impacts of pumping in New Mexico and impacts of pumping in Texas) and over a few to many years."

See Paragraphs 84 and 85.

90. In Paragraph 61 of his Declaration, Dr. Hutchison states, "However, the limitations prevent reliable use of ILRGM results for analyses over smaller scales (several square miles) and for short time scales (months to a single year)."

    See Paragraphs 84 and 85. This statement is vague, as it is unclear what specific small scaled geographic areas or short times scales that Dr. Hutchison is referring to. The ILRG Model is reliable and suitable for analyzing the claims and counterclaims in this case. It has been shown to be far superior to the Texas Model and therefore is the best available modeling tool for use in this case. Spronk Rebuttal at 13.

Declaration of Robert J. Brandes

91. I was also asked by counsel for New Mexico to review the Declaration of Dr. Robert Brandes, submitted by Texas in support of its Motion for Partial Summary Judgment, to determine whether any of Dr. Brandes's assertions are inaccurate, disputed, incomplete, and/or are opinions rather than facts.

92. In Paragraph 11 of his Declaration, Dr. Brandes states, "The primary purpose of the joint investigation was to compile factual data essential to support an apportionment of the waters of the Rio Grande above Ft. Quitman. JIR at vi-vii. A true and correct copy of the JIR is attached hereto as Attachment 2."

    This statement is incomplete. The JIR also reflects the understanding and expectations of Reclamation and the States of Colorado, New Mexico, and Texas about the continued development of the Project and how the Project would be operated. Spronk Report at 115.

93. In Paragraph 12 of his Declaration, Dr. Brandes states, "The Rio Grande winds southward approximately 400 miles across New Mexico, and crosses into Texas near the city of El Paso, where it defines the 1,250-mile international boundary between the United States and Mexico as it traverses to the Gulf of Mexico. The entire Rio Grande basin is depicted on the map below entitled Figure 1."

    This statement is generally correct, however the map in Figure 1 is misleading because it is not to scale and incomplete because it doesn't show the entire basin to the Gulf of Mexico and doesn't show important gages and other features.

94. In Paragraph 13 of his Declaration, Dr. Brandes states, "Along its entire course, the Rio Grande provides a source of surface water that is used extensively to meet the needs of municipalities, industries, and agricultural irrigators, as well as to support various environmental uses. Numerous dams and reservoirs exist along the river primarily for water supply and flood control purposes; consequently, flows in much of the river are substantially controlled and regulated."

    This statement is generally correct but lacks specificity.

95. In Paragraph 14 of his Declaration, Dr. Brandes states, "With respect to the usage of water, the river is divided into two distinct sections at Fort Quitman. The Upper Rio Grande basin (the area above Fort Quitman, Texas) is comprised of parts of Colorado and New Mexico, and a very small part of Texas. The Upper Rio Grande basin itself is divided into three sections: (1) the San Luis section in Colorado, (2) the Middle section in New Mexico, and (3) the Elephant Butte-Fort Quitman section in New Mexico, Texas, and Mexico. JIR at 7.

This case is centered primarily upon issues involving the Elephant Butte-Fort Quitman section of the Upper Rio Grande basin. Figure 2 depicts the Upper Rio Grande basin."

Figure 2 in Dr. Brandes's Declaration is illegible.

96. In Paragraph 17 of his Declaration, Dr. Brandes states, "The states of Colorado, New Mexico, and Texas agreed to the Rio Grande Compact in 1938 (1938 Compact or Compact). As a result of the negotiations to formalize the 1938 Compact, depletions were frozen at pre-1938 conditions. Two delivery schedules, or indices, were adopted: one for Colorado to New Mexico, and one for New Mexico to Elephant Butte Reservoir. These schedules were derived from streamflow data and analyses developed primarily by the JIR – an effort to provide the needed data to resolve the impasse over the apportionment of the Rio Grande waters above Fort Quitman."

    The Project has never been operated based on depletions at pre-1938. However, to the extent that conditions existing at the time of the Compact are relevant to this case, Dr. Hutchison's characterization of those conditions based on stream depletions in the single year of 1938 are inappropriate. As shown in **Figure 11**, depletions in the Lower Rio Grande varied widely from year to year around the time of the Compact. Spronk Report at 181. This is due to a variety of factors, including temperature and precipitation, variations in crop choice and irrigation practices, fallowing decisions, and so on. Because stream depletions vary so much from year to year, analysis of depletions in a single year is inappropriate to characterize a Compact condition or 1938 conditions. To the extent that a "1938 Condition" is relevant to this case, it should consider (a) that new Project lands continued to be developed and put into irrigation until the mid-1950s, (b) the parties would have expected changes in crops and improvements in irrigation practices, and (c) the conjunctive use of ground water and surface water through development of irrigation wells occurred in both states with the encouragement of Reclamation to maintain the viability of the Project through the unprecedented droughts that occurred after the Compact.

97. In Paragraph 18 of his Declaration, Dr. Brandes states, "The total water supply available for diversion by Elephant Butte Irrigation District (EBID), El Paso County Water Improvement District No. 1 (EP#1), and Mexico included storage in and releases from Elephant Butte Reservoir and return flows generated within EBID and EP#1. New Mexico's post-Compact development has depleted that water supply by capturing returns flows that otherwise would have been available."

    This statement is incomplete and disputed. First, Dr. Brandes fails to mention other supplies allocated as Project water, including tributary inflows and municipal return flows that are also used in EBID and EPCWID. Dr. Brandes also fails to mention that EPCWID is not charged for its use of municipal return flows in the El Paso Valley. Finally, Dr. Brandes implies that it was only the post-Compact development in New Mexico that depleted Project supplies. Because the Project is operated as a single unit, development anywhere within the Project can affect Project deliveries and therefore impact the supply to all Project water users. Paragraph 42. Spronk Rebuttal at 46.

98. In Paragraph 20 of his Declaration, Dr. Brandes states, "Mining of a groundwater basin means that more water is being pumped from the groundwater basin than can be replaced, causing groundwater levels to decline and, in the context of this case, has caused further depletion of

the volume of water available to Texas. Groundwater pumping in New Mexico continues unabated today."

See Paragraph 22. In addition, Dr. Brandes misrepresents the extent of pumping in New Mexico. New Mexico's pumping capacity was largely developed by the mid-1950s. Spronk Report at 101. Since that time, most of New Mexico's irrigation pumping has been to supplement the available Project water supply, with more pumping in dry years with lower Project water allocations and less pumping in years with greater allocations. The average irrigation pumping in New Mexico during recent years is not much greater than it was during the 1950s. Spronk Report at 89. While pumping in dry years caused ground water levels to decline in dry years, increased deliveries of Project water in average and wet years combined with reduced pumping resulted in recovery of ground water levels. The unprecedented ground water level declines during the recent drought were caused by the 2008 OA, which substantially reduced Project water deliveries to New Mexico, resulting in increased pumping. Municipal and other non-irrigation pumping by New Mexico has increased modestly during recent decades but, at approximately 37,000 AF/y, remains much less than the historical irrigation pumping. Spronk Rebuttal at 5.

99. In Paragraph 21 of his Declaration, Dr. Brandes states, "Colorado, New Mexico and Texas adopted the Compact in 1938 to ensure, among other things, a prescribed delivery of water from the Rio Grande in Elephant Butte Reservoir. The Project is dependent on the Compact for its water supply. The Project, in turn, is the means by which the water apportioned to Texas by the Compact is stored in Elephant Butte Reservoir, and subsequently delivered to Texas (subject to deliveries to EBID, pursuant to its contract with the United States, and to Mexico, pursuant to the 1906 Treaty). The relationship between the Compact and the Project is critical to the ability to effectively supply water from the Rio Grande to users in Texas, EBID, and Mexico. Both the Project and the Compact were conceived and implemented prior to the significant development of groundwater in the Rincon and Mesilla basins of New Mexico, which began in the early 1950s."

See Paragraph 23.

100. In Paragraph 22 of his Declaration, Dr. Brandes states, "Today, the Project includes Elephant Butte Dam and Reservoir, Caballo Dam and Reservoir located immediately below Elephant Butte Dam, a hydropower plant at Elephant Butte Dam, three diversion dams on the Rio Grande in New Mexico (Percha, Leasburg, and Mesilla), two diversion dams on the Rio Grande in Texas (American and International, both owned and operated by the International Boundary and Water Commission), and an extensive system of canals, laterals, waste ways, and drainage ways that support irrigation operations in EBID and EP#1. The major dams and reservoirs and the diversion dams included in the Project are identified on the map of the region in Figure 5."

Dr. Brandes does not mention that the Project previously included four additional river diversions within the Project area in Texas downstream of American Dam, including at the Riverside Dam, the Tornillo heading, the Guadalupe heading, and the Hansen heading. See Paragraph 70. These additional dams facilitated reuse of return flows and other sources of water that arose within the EPCWID area. Although the Tornillo, Hansen, and Guadalupe headings were removed as part of the Rio Grande Rectification, EPCWID continued to use return flows for irrigation by diverting water from drains until the early 1980s. Spronk Rebuttal at 33.

101. In Paragraph 23 of his Declaration, Dr. Brandes states, "There are 159,650 acres authorized within the Project, with 90,640 acres within EBID in New Mexico and 69,010 acres within EP#1 in Texas. These acreages translate to approximately a 57/43 split for the distribution of irrigable acres between EBID and EP#1 (collectively 'Districts')."

This statement lacks context. The original authorized acres consisted of 88,000 acres in EBID and 67,000 acres in EPCWID. The 1938 Downstream Contract provided for a 3% increase in the original authorized acres. However, the actual irrigated area in the Project in 1938 was less than the authorized acres. Project lands continued to be developed after 1938 and peaked at approximately 160,000 acres in the early 1950s. Spronk Report at 43. The irrigated Project lands have declined since that time to approximately 70,000 acres in EBID and 35,000 acres in EPCWID. Id. at 183.

102. In Paragraph 24 in his Declaration, Dr. Brandes states, "Releases of Project water stored in Elephant Butte and Caballo Reservoirs are made at the start of the irrigation season (typically February) to Project users in New Mexico and Texas, and to Mexico. The Districts request releases of stored water during the irrigation season in response to irrigation demands. As a practical matter, however, diversions by the Districts and Mexico consist of varying amounts of reservoir storage, return flows from upstream irrigation operations, and occasional arroyo inflows. Return flows are a key part of Project operations, and interference with return flows removes a critical component of deliveries to Project users. Project return flows consist of excess irrigation tailwater and groundwater seepage from irrigated fields that are collected in drains that convey these return flows to the Rio Grande. The proportion of return flows in the river increases in the downstream direction relative to stored water from the reservoirs, and the water diverted by Project users in the lower Mesilla basin and in the El Paso Valley of Texas includes diversion of significant quantities of return flows."

The statement is incomplete. See Paragraphs 25-27. Interference with return flows through depletions from pumping do not necessarily affect Project deliveries. In full-supply years, Reclamation can release additional water from storage if return flows are reduced. Spronk Report at 12. Dr. Brandes also fails to consider that Texas has ceased using return flows that arise in the Hueco area. Spronk Rebuttal at 24. This has increased the amount of water that must be released from Project storage to meet Texas demands. Spronk Rebuttal at 130. Dr. Brandes further fails to mention that Project return flows also include reasonable operational waste and not just excess water supply. Dr. Brandes also implies that Project return flows must return to the bed of the Rio Grande channel to be usable, but this is not correct. This is particularly the case in EPCWID in the El Paso Valley where municipal return flows are discharged to canals and irrigation return flows accrue in drains, and these return flows are available for use in EPCWID even though they don't accrue to the Rio Grande channel. Records show that EPCWID diverted water from drains for irrigation use until the early 1980s and EPW WWTP returns continue to be a significant source of irrigation supply for EPCWID farmers. Spronk Report at 58 and 59. In addition, the proportion of return flows in the river varies depending on the time of year with relatively less returns early in the irrigation season and relatively more returns late in the season. The proportion of return flows in the river also varies with the hydrologic condition, with generally relatively less returns in dry periods and relatively more returns in wet periods. Spronk Rebuttal at 168, 170-171.

103. In Paragraph 25 of his Declaration, Dr. Brandes states, “Figure 6 is Table 90 of the JIR. It shows the percentage of net diversions for each valley for reservoir releases, arroyo flow, and drain flow for the period prior to the Compact. The net diversions in the Rincon portion of EBID contained 0.3 percent drain flow and seepage (return flows) and net diversions in the Mesilla portion of EBID contained 7.4 percent, while the net diversions into the Franklin canal in EP#1 contained 35.1 percent return flows and the net diversions into the Tornillo canal in EP#1 contained 57.7 percent return flows and only 38.2 percent of reservoir releases.”

The percentages of net diversions in various divisions of the Elephant Butte to Ft. Quitman area in Figure 6, from Table 90 of the JIR, are averages derived from analysis of 1930-1936 data and estimates. JIR at 100. The percentages represent Project facilities that included river diversions in the El Paso area at Riverside, Hansen, Guadalupe, and Tornillo dams that no longer serve the EPCWID. The removal of these dams and cessation of use of drain flows by EPCWID in the early 1980s has resulted in an increase in releases from Project storage that are needed to deliver Project water to EPCWID. These increased releases have reduced the supply of Project water available for allocation and delivery to New Mexico. Spronk Rebuttal at 130-132 and 703-704.

104. In Paragraph 27 of his Declaration, Dr. Brandes states, “Within the Project area from Elephant Butte Reservoir downstream to Fort Quitman, Texas, the Rio Grande covers approximately 210 river miles. Project water was to be allocated between irrigators in southern New Mexico and in the El Paso Valley of Texas in proportion to the irrigated acreage of Project lands within each state.”

See Paragraph 44.

105. In Paragraph 28 of his Declaration, Dr. Brandes states, “A water budget is an accounting for a defined time period of the inflows into, and the outflows from, a defined control area. Often, performing a water budget with known volumes of inflows and outflows for a specific time period can lead to the quantification of one or more unknown variables for that same time period. Performing multiple water budgets for a specific control area for different time periods can provide information regarding how certain phenomena may have changed. Even a visual depiction of the water budget for a control area showing the generalized movement of water into, within, and out of the area under different conditions and circumstances can be informative and help to understand how the Project water supply system was originally conceived to work and how it has changed with the development of groundwater in New Mexico.”

See Paragraphs 51 - 54.

106. In Paragraph 29, Dr. Brandes states, “I have utilized conceptual water budgets to illustrate the effect of groundwater depletions in the Project area within the Rincon and Mesilla basins of New Mexico where significant groundwater development began in the early 1950s. Prior to the development of extensive groundwater pumping in the Rincon and Mesilla basins, groundwater levels generally were relatively high and fluctuated in response to the seasonal application of irrigation water from the Rio Grande on Project lands. In the early days of the Project, this phenomenon created a serious problem. Soon after the Project began delivering water to the irrigators, groundwater levels rose in New Mexico to and above ground level, thereby waterlogging and making useless land previously capable of growing crops. The

solution was to construct a complex system of drains that would capture excess groundwater created by irrigation and return it to the river. This "return flow" became a significant source of irrigation water for downstream irrigators, particularly in Texas, a fact recognized and catalogued in the JIR. With the construction of the drains, irrigation water not consumed by crops and other vegetation or by evaporation, percolated down through the soil into the groundwater system, which typically flowed toward and into drains specifically designed for collecting groundwater and for conveying groundwater and excess irrigation tailwater away from fields and to the Rio Grande. This condition is illustrated in a general fashion by the diagram in Figure 10."

This statement is incomplete. See Paragraphs 29-31. In addition, significant ground water development for irrigation commenced in the Rincon, Mesilla, and El Paso Valleys in the late 1940s in response to developing drought conditions. Spronk Report at 78. There also was development of ground water for municipal use in El Paso and Juarez prior to the 1950s. Spronk Report at 206-207. Before extensive irrigation and municipal groundwater development in the Hueco bolson by Texas and Mexico, groundwater levels in the El Paso valley were relatively high and fluctuated in response to the seasonal application of irrigation water. NM-EX 121, MMA Report, App. Q. Ground water levels rose throughout the Project in response to irrigation, including in Texas. Return flows logically would have been a significant source of irrigation water to the Project prior to the drain construction.

107. In Paragraph 30 of his Declaration, Dr. Brandes states, "As shown in Figure 10, Project water is diverted from the Rio Grande into an irrigation system canal and then distributed to individual irrigated fields, where it is either consumptively used by the growing crops or evaporated into the atmosphere. Any excess irrigation water is either discharged directly to the drain as tailwater or percolated through the subsurface into the groundwater system. The bottom of the drain is below the upper level of the groundwater; thus, groundwater is induced to flow toward and into the drain. Similarly, the bottom of the river channel is below the level of the groundwater, with water shown flowing in both directions depending on the relative heights of the water in the river and the groundwater from location to location. The irrigation tailwater and groundwater that is collected in the drain flows to the river and is referred to as return flow. The return flow from the drain that is discharged into the Rio Grande provides an important supply of Project water for users located downstream, namely users in the lower Mesilla basin and in the El Paso Valley of Texas. This important source of water for Project users was contemplated in the early development of Project operations and in the negotiations among the states leading up to the adoption of the 1938 Compact."

See Paragraphs 31 - 35.

108. In Paragraph 31 of his Declaration, Dr. Brandes states, "For example, the JIR investigation determined that approximately 35 percent of the total supply of Project water delivered to Texas in the El Paso Valley was from upstream return flows, with the majority of the balance originating as releases from Caballo Reservoir. Conversely, since water for Project users in New Mexico was diverted from the Rio Grande farther upstream, i.e., above the river outfalls of most drains, less than seven percent of New Mexico's total deliveries originated from return flows."

This statement is incomplete. The percentages referenced by Dr. Brandes are taken from Table 90 of the JIR. The relative portions of the Project supply for the El Paso Valley were determined based on assumed reuse of return flows downstream to the Tornillo Canal. EPCWID's cessation of irrigation use of return flows that arise in the El Paso Valley have adversely impacted EBID. See Paragraph 26.

109. In Paragraph 32 of his Declaration, Dr. Brandes states, "With the extensive development of groundwater in the Rincon and Mesilla basins of New Mexico that began during the early 1950s – particularly in the relatively shallow aquifers with generally high groundwater levels such as those along the Rio Grande – groundwater levels began to fluctuate and decline in some areas. This in turn caused discharges of groundwater into the drains, and directly into the river, to be reduced. Eventually, with enough groundwater pumping, the groundwater gradient in many areas reversed, with significant reductions in the groundwater inflows to the drains and into the river. This condition is illustrated by the diagram in Figure 11."

    See Paragraph 36-39.

110. In Paragraph 33 of his Declaration, Dr. Brandes states, "As shown in Figure 11, the level of the groundwater is below the bottom of the river channel and the drain, and water flowing in the river and in the drain moves toward and into the groundwater system, rather than the other way around, as it was prior to the initiation of groundwater pumping. The discharge of return flow from the drain into the river is substantially curtailed, if not reduced to zero, thereby also reducing the flow in the river."

    See Paragraphs 39 and 40.

111. In Paragraph 34 of his Declaration, Dr. Brandes states, "The phenomenon of reduced river flows caused by groundwater withdrawals is an underlying component of what is referred to as streamflow depletions, and these streamflow depletions have increased along the Rio Grande within the Rincon and Mesilla basins since significant groundwater development began in the early 1950s. One of the obvious impacts of these increased streamflow depletions has been to alter the Project water budget by reducing flows in the Rio Grande that otherwise would ultimately reach water users in the lower Mesilla basin and in the El Paso Valley in Texas. In essence, the release of a specific quantity of water from Caballo Reservoir now contributes less to the surface water supply for these users because of the losses of flow due to the increased seepage from the Rio Grande and interior drainage ways, thus altering the previously existing Project water budget."

    See Paragraphs 41 - 43.

112. In Paragraph 37 of his Declaration, Dr. Brandes states, "Regarding the 57/43 split, referable to Project allocations, the Project delivers the water available to it at the points of diversion on the river. The volume of Project water that was split 57/43 in 1938 for the Project to make the allocation to EBID and EP#l pursuant to the contracts with the United States reflected the acreages of irrigated land in the two Districts at that time and the generally gaining condition of the river below Caballo Reservoir as influenced by relatively high groundwater levels in the absence of significant pumping. This changed beginning in the 1950s with the extensive development of groundwater in New Mexico and the subsequent lowering of groundwater levels along the Rio Grande that altered the condition of the river from a generally gaining stream to a generally losing stream. The implications of this change are obvious - river flow losses mean greater depletions and less Project water for downstream users. The Project has no control over New Mexico's depletions and can only allocate the amount of water

remaining after the New Mexico groundwater pumping depletes Project water in the river, including Reservoir releases."

This statement is incorrect. The 57/43 split refers to a division of the allocation of Project water deliveries to the end users. Until 1978, the Project was operated to allocate equal water to each Project acre and deliver it directly to Project water users, resulting in approximately 57% of Project water being allocated to lands in New Mexico and 43% to lands in Texas. The D1/D2 Curves were developed to maintain the same relative allocation of deliveries to Project lands in both States following the transfer of ownership and operational responsibility for the Project's delivery infrastructure to the Districts. Using the D1/D2 Curve allocation procedures, Project deliveries were accounted for at the river headings rather than at the farm headgates. During the D1/D2 allocation period, Project water allocations were computed based on the water in Project storage. Spronk Report at 22-23. The pumping that existing during the D1/D2 data period was effectively grandfathered into the D1/D2 curves and associated allocation procedure. During the time after the D1/D2 data period and prior to implementation of the allocation under 2008 OA (1979-2005) pumping in New Mexico did not rise above the level that existed during the D1/D2 data period. Spronk Rebuttal at 27. See Paragraphs 44 - 46.

Declaration of Staffan Schorr

113. I was also asked by counsel for New Mexico to review the Declaration of Staffan Schorr, submitted by Texas in support of its Motion for Partial Summary Judgment, to determine whether any of Mr. Schorr's assertions are inaccurate, disputed, incomplete, and/or are opinions rather than facts.

114. In Paragraph 11 of his Declaration, Mr. Schorr states, "From my work in this case, I have concluded that the volume of groundwater pumped in the Rincon and Mesilla Valleys of New Mexico has increased since 1938."

See Paragraph 55. Ground water development for irrigation occurred in New Mexico and Texas after 1938 in response to unprecedented drought and with the encouragement of Reclamation. Spronk Report at 102 and 194.

115. In Paragraph 13 of his Declaration, Mr. Schorr states, "Also based on my work on this matter, I conclude that the number of groundwater wells in the Rincon and Mesilla Valleys (below the Elephant Butte and Caballo Reservoirs and above the New Mexico-Texas state line at El Paso, Texas) has increased since 1938 from less than 60 to about 8000 in 2020. I made this conclusion based on well data and information my office obtained, and that I personally reviewed and analyzed, from the New Mexico OSE."

See Paragraph 21.

116. In Paragraph 14 of his Declaration, Mr. Schorr states, "I was asked by counsel to prepare a map of the groundwater wells in the Rincon and Mesilla Valleys of New Mexico (below the Elephant Butte and Caballo Reservoirs and above the New Mexico-Texas state line at El Paso, Texas) existing in 1938, and the groundwater wells in the same geographic area that currently exist as of October 2020. To do that, I obtained well data from the New Mexico OSE and displayed wells based on location coordinates, well type, and installation date specified in the datasets."

See Paragraph 21.

117. In Paragraph 15 of his Declaration, Mr. Schorr states, "Figures 3 and 4, depicted above, accurately reflect the change in number and distribution of groundwater wells in New Mexico in the Rincon and Mesilla Valleys in New Mexico (below Elephant Butte and Caballo Reservoirs and above the New Mexico-Texas state line at El Paso, Texas)."

See Paragraph 21.

New Mexico's Integrated Lower Rio Grande Model

118. New Mexico's ILRG Model is the best available tool for evaluating the claims and counterclaims in this case because it is the only hydrologic model available to evaluate the effects of groundwater pumping and changes in historical Project operations on Project deliveries to Texas and New Mexico. Spronk Expert Report at 9. The ILRG Model is superior to the Texas Model because (a) it simulates the entire Lower Rio Grande area from Elephant Butte Reservoir to Fort Quitman, (b) it employs monthly stress periods that allow it to simulate the important seasonal variations in groundwater and surface water flows, and (c) it is capable of simulating the dynamic response of Project operations to changes in flow throughout the entire Project area. Spronk Report at 9. Conversely, the Texas Model fails to accurately evaluate pumping effects to Project deliveries because it does not simulate the dynamic response of Project reservoir releases to changes in flows that occur without pumping, provides no simulations for the area downstream of the El Paso gage and thus cannot simulate the feedback response from a large part of the Project area, and uses annual stress periods that prevent distinguishing impacts that occur during the Project release period (irrigation season) from impacts that occur during the non-irrigation season. In short, the absence of dynamic simulation of Project operations renders the Texas Model of no utility in analyzing the key issue presented in this case: impacts to Project deliveries from groundwater pumping and changes in historical Project operations. Spronk Report at 113.

119. The ILRG Model has been used to run several model scenarios that evaluate New Mexico's pumping, Texas's pumping, the impacts of implementing the 2008 OA, the impacts of changes to historical Project operations and accounting in EPCWID on overall Project allocations, and various potential conjunctive use scenarios. The ILRG Model is the only model in this case that is capable of analyzing and quantifying the effects of these scenarios. Spronk Report at 47. The Texas Model is incapable of such analyses.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on December 21, 2020

Greg K Sullivan

Gregory K. Sullivan, P.E.

No. 141, Original

IN THE
SUPREME COURT OF THE UNITED STATES

◆

STATE OF TEXAS,

Plaintiff

STATE OF NEW MEXICO and
STATE OF COLORADO,

Defendants

◆

OFFICE OF THE SPECIAL MASTER

◆

DECLARATION OF LEE WILSON, PH.D.

◆

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TX v. NM # 141
New Mexico Exhibit
NM_EX-013

DECLARATION OF LEE WILSON, PH.D.

I, Lee Wilson, pursuant to 28 U.S.C. § 1746, state as follows upon my personal knowledge and experience.

1. On June 15, 2020, I was disclosed by the State of New Mexico as a non-retained rebuttal expert witness in the matter *of State of Texas v. State of New Mexico and State of Colorado* (USSC No. 141, Original). I have no changes to the content of that disclosure, which included my opinions in rebuttal to U.S. Expert J. Phillip King, and my curriculum vitae. In addition, on July 23, 2020, I was deposed on my expert opinions.

2. A short summary of my professional experience is set forth in "Resume of Lee Wilson" which is provided in NM-EX 604. I am a graduate of Yale (B.A.) and Columbia (Ph.D.) Universities where I trained in geology, hydrology and environmental science. I am a Certified Professional Hydrogeologist (American Institute of Hydrology, #220). I have nearly 50 years of experience on the Rio Grande and have been a consultant to the City of Las Cruces ("City") for 40 years. I am familiar with surface and groundwater hydrology, water rights, and water use in the Lower Rio Grande Basin and with the Rio Grande Project in both New Mexico and Texas.

3. A summary of my experience as an expert witness is provided in "Expert Testimony of Dr. Lee Wilson" which is provided in NM-EX 605. This document identifies more than 100 proceedings in which I have been designated as an expert witness, including prior cases of Original Jurisdiction.

I. Facts alleged by the United States

4. In its Motion for Summary Judgment submitted on November 5, 2020, the United States alleges "Facts [which] are not disputed or cannot genuinely be disputed." Citing in part a 1954 report by C. S. Conover of the United States Geological Survey, USMF 56 states:

> [t]he City of Las Cruces (the City or Las Cruces), which is located partly within the EBID boundary, had two wells in use prior to 1937, five wells in use as of 1947, and 45 wells in use as of 2017, many of them drilled after 1980.

Dr. Douglas R. Littlefield, a professional historian who has long conducted research regarding the City's water supply, has documented that use of surface water to supply the city's businesses and homes dates back to 1849, more than a century before Conover's report. He has further documented how groundwater contributed to the City's supply in the 1870s, and that by 1937 this supply came from many wells other than the two recognized by Conover. This establishes that Conover's report is incomplete as to the City's water supply in1937. USMF 56 is therefore disputed.

5. USMF 57 states as follows:

> While the City's permitted (*i.e.*, post-1980) wells are subject to volume limitations and some offset requirements to account for estimated surface water depletions attributable to

the pumping, the City is authorized to pump up to 21,869 acre-feet annually under its pre-1980 groundwater right ("LRG-430"), subject only to a condition that the City forgo consumption of municipal effluent in cases of drought (defined as years when the Project's surface water allocation is equivalent to 2.0 af/ac).

6. USMF 57 is incomplete and therefore misleading. Here I respond to USMF 57 by presenting facts about the City's actual use of water under LRG-430 et al. I focus on the years 2016-2019 to ensure the facts are representative of current conditions. Unless otherwise noted, I rely on data from records which the State Engineer requires the City to compile and submit, and which were provided to me by City consultant John Shomaker and Associates.

a. USMF 57 addresses only the City's LRG-430 *et al.* water rights which comprise a portion of the City's portfolio and which consist of 21,869 AFY adjudicated with a priority of 1905. Pumping of the LRG-430 wells that lie in the Jornada Basin had no effect on the Rio Grande in 2016-2019. The effluent generated from use of that :RG-430 water is treated and discharged to the Rio Grande and can be considered an imported supply, i.e., a water supply sourced from outside the Mesilla Basin.

b. The primary water source for the City other than LRG-430 is its East Mesa Well Field under Permit Nos. LRG-3283 through 3285 and LRG-3288 through 3296 for 10,200 AFY. In 2016-2019 about one-quarter of the City's diversions of approximately 21,000 acre-feet per year came from this well field, which is located in the Jornada Bolson and is hydrologically isolated from the Rio Grande. It is established that pumping in the Jornada in 2016-2019 had no significant effect on Rio Grande streamflows except that, as noted below, wastewater arising from such withdrawals contributed to the City's effluent discharge to the Rio Grande and were additive to flows of the Rio Grande. This wastewater can be considered an imported supply to benefit the river.

c. **15,260.5** acre-feet per year was the average quantity of the City's LRG-430 diversions within the Mesilla Bolson in 2016-2019. The next three paragraphs quantify physical offsets to these diversions. The two paragraphs that then follow quantify other factors for consideration in determining the City's impacts on the river.

d. **9,181.5** acre-feet per year was the City's average wastewater from all sources that was discharged directly to the Rio Grande in 2016-2019. Subtracting that value from the Mesilla diversions, the maximum net river effect of those diversions cannot much exceed 6,000 acre-feet per year. However, the actual impact of the City's LRG pumping is much less as quantified below.

e. **3,500** acre-feet per year of urban recharge occurs within Las Cruces each year, which replenishes the aquifer and offsets the City's withdrawals. This quantification reflects the opinion of New Mexico expert Gilbert R. Barth, most recently set forth in his September 15, 2020 rebuttal report. On page 5-9 of that report, Dr. Barth discussed how his model simulates urban deep percolation, which is groundwater recharge from outdoor use (e.g., lawn irrigation) and conveyance losses (pipeline leaks). In his Appendix I, he reports that as an input to his model he utilized estimates of urban deep percolation for Las Cruces (and seven other urban areas). At my request, Dr. Barth has provided me with these estimates – specifically a monthly quantification of Las Cruces urban recharge for 1940-2017. For at least the period 1985 through 2017 the annual recharge value has been on the order of 3,500 acre-feet per year, a value I consider appropriate through 2019.

f. Based on the September 15 expert report of Dr. Gilbert Barth, my conservative estimate is that 3.5 percent (**545** acre-feet per year) of the City's groundwater is derived from storage rather than depletions of the Rio Grande.

g. At least **3,000** acre-feet per year of the City's pumping was grandfathered in when the D-2 curve was adopted in 1980 as the baseline for allocation of Project supplies to New Mexico and to Texas (D-1 dealt with Mexico). The D-2 curve relates Project releases from Elephant Butte Reservoir to the amount of water available for Project diversions as observed during the period 1951-1978, the first time when shortages of supply were common. My quantification of the grandfather benefit is based on p. 3-31 of New Mexico's expert rebuttal report by hydrologists Gilbert R. Barth and Steven P. Larson, dated September 15, 2020, and I believe that to be a minimum. Note further that at page 1 of the text of her report of June 15, 2020, Dr. Margaret Barroll states "… it is important to note that the US rebuttal experts concede that the D-2 Curve 'grandfathered-in' the groundwater pumping occurring from 1951-78".

h. **3,522.95** acre-feet per year is the quantity of stream depletions to which the City is entitled through its ownership of water righted land in EBID. My quantification is based on the product of the City's EBID water righted acreage (1354.98 acres) times the water right (consumptive irrigation requirement) adjudicated by the State of New Mexico to such acreage (2.6 acre-feet per acre per year). These water rights are included in the City's water rights portfolio set out in its formal "Forty Year Plan" filed with the Office of the Stat Engineer, but are not now used as offsets to support the City's water supply. The entirety of the City's supply is derived from groundwater.

In summary, the effect of the City on the Rio Grande in 2016-2019 is not the 15,260.5 acre-feet per year withdrawn by its Mesilla Bolson LRG-430 wells but rather the information now available indicates that ***the City effectively surpluses the river***. The basis for this fact conclusion is outlined below.

- 15,260.5 AFY withdrawal from Mesilla Bolson under LRG-430
- At least 545 AFY of withdrawal comes from storage
- Therefore 14,700 AFY is the approximate value for stream-connected withdrawal
- About 12,700 AFY wet water benefit from wastewater (rounded value 9,200 AFY0 and recharge (3,500 AFY)

- At least 6,500 AFY entitlement from grandfathered rights (at least 3,000 AFY) and EBID rights (rounded 3,500 AFY)
- 4,500 AFY surplus based on 19,200 AFY benefit against 14,700 AFY maximum impact

The surplus is a large number compared to possible rounding and approximation errors in the individual numbers and should be relied upon beyond the information in USMF 57.

7. USMF 58 addresses groundwater pumping for non-irrigation uses (including municipal use) below Elephant Butte. The claim is that such use has increased to about 37,000 acre-feet per year, driven by an increase in pumping by “entities other than the City of Las Cruces whose groundwater use began after the Compact”. If this is meant to assert that the City of Las Cruces groundwater use only began after the Compact, it is wrong (late) by many decades and is therefore disputed.

II. Facts alleged by the State of Texas

8. Referring to the City of Las Cruces, at p. 22-23 the Texas Motion for Summary Judgment acknowledges a fact set forth in my June 15, 2020 disclosure, that the City of Las Cruces owns EBID acres. I understand this to be a recognition that the City has a right to use water released from Elephant Butte Reservoir.

9. The Texas claim that non-Project water uses were frozen by adoption of the 1938 Rio Grande Compact is not consistent with the U.S. rebuttal report by their expert J. Phillip King who stated as fact that adoption of the D-2 curve established 1951-1978 as the baseline for allocation of water to Texas. To this day D-2 remains the basis for calculating the amount of water delivered to Texas, whereas deliveries in New Mexico are governed by the new D-3 curve. I consider Dr. King’s report to correctly dispute the Texas claim.

I declare under penalty of perjury that the foregoing is true and correct.
Executed on December 21, 2020

Lee Wilson

____

Lee Wilson, Ph.D.

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NM_EX-116

Section 4
Domestic Pumping

Domestic/stock withdrawals are represented as net depletions using locations developed in the NMOSE model (*SSPA*, 2007). NMR-M domestic withdrawals were calculated by applying an annual temporal signal to the estimated “base rate” of net domestic pumping applied in the NMOSE model. The base rate was then adjusted by an annual scaling factor (beginning at 0.154 in 1940 and increasing to 1.21 in 2019) calculated using the number of domestic wells completed each month, which was extracted from data originally downloaded from NMOSE and compiled by *Schoorr and Kikuchi* (2019). The scaling factor was calculated for completions in New Mexico (because this was the most complete dataset) and applied to both Texas and New Mexico domestic pumping. The scaling factor was computed as a ratio between the number of domestic wells completed in December 2000, the year for which the base rate was estimated in the NMOSE model (*SSPA*, 2007), and the number of domestic wells in each month.

Figure H-8 illustrates a time series of domestic pumping. The average annual domestic pumping in New Mexico is 730 af/year, with a total of 59,000 af for the entire simulation period. The average annual domestic pumping in Texas is 62 af/year, with a total of 5,000 af for the entire simulation period. No domestic wells are simulated in the portion of the model domain extending into Mexico (DCMI wells in this portion of the domain are detailed in Section 3 of this Technical Appendix).

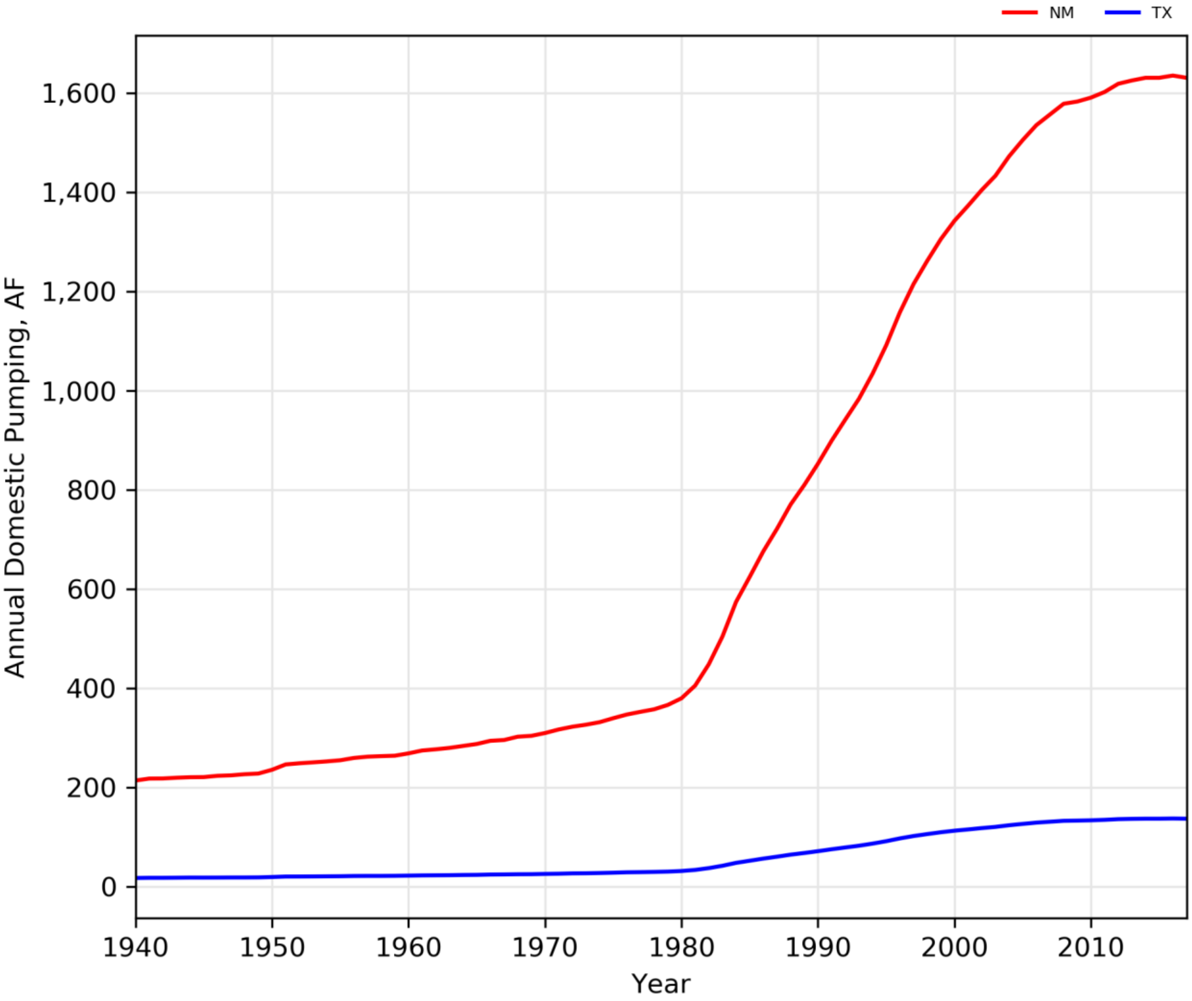

Figure H-8. Annual Domestic Pumping

5.5.4 Wastewater Treatment Plant Discharges

Wastewater treatment plant (WWTP) discharges are added to the SFR network as inflows at eight locations within the NMR-M model domain: Hatch; Salem; Las Cruces and East Mesa WRF (combined); South Central Regional; Anthony, NM; Anthony, TX; Sunland Park, Santa Teresa, and El Paso Electric (combined); and Northwest. The Northwest WWTP discharge location is south of the Rio Grande at El Paso gage and therefore is not reflected in the simulated flows extracted from the gage location. The time series of WWTP discharges are developed from historical records (*Sullivan and Welsh,* 2019) and conceptually represent a return flow from commercial, municipal, and industrial pumping, the primary source of municipal water supply. The flows are added to the SFR network at segment locations corresponding to the WWTP discharge points.

5.5.5 Surface Water Runoff

Surface water runoff from farms is added to the SFR network as diffuse overland runoff to drain segments. Volumes of surface water runoff are provided to the NMR-M model by the RiverWare model on a farm service area resolution (details provided in Section 6). The RiverWare model estimates surface water runoff (*Carron and Setzer,* 2019). The surface water runoff is distributed to drain segments within the SFR network based on the proportional length of each segment within the service area.

5.6 PEST

The model-independent parameter estimation code, PEST (*Doherty*, 2010), was used to control forward model runs, and perform parallel runs in support of model calibration efforts, including calculating parameter sensitivities, observation sensitivities, and parameter correlations, and to estimate parameter values. PEST consists of a suite of utilities for communicating with a model, in this case, MODFLOW and its associated pre- and post-processors. PEST controls execution of the model to produce outputs that can be processed into sensitivities, or parameter updates to pass back to the model.

All NMR-M forward model runs are accomplished using PEST to control the model execution, including running required pre- and post-processors. The PEST control file provides a

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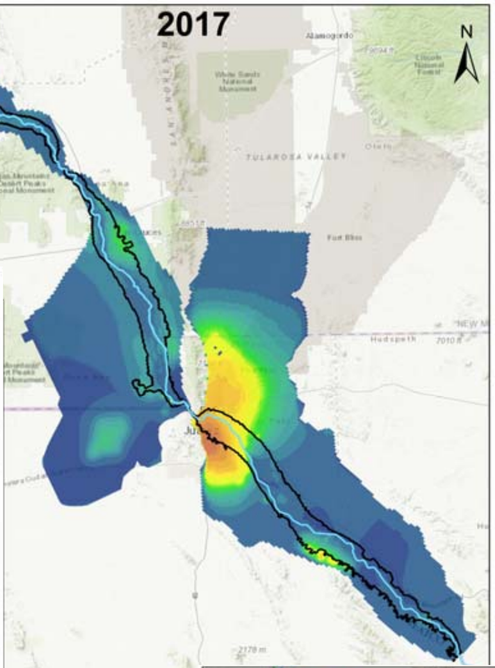
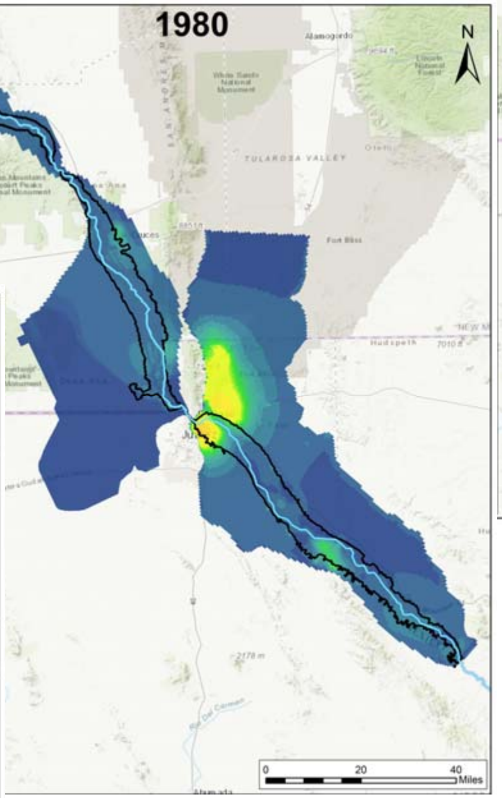
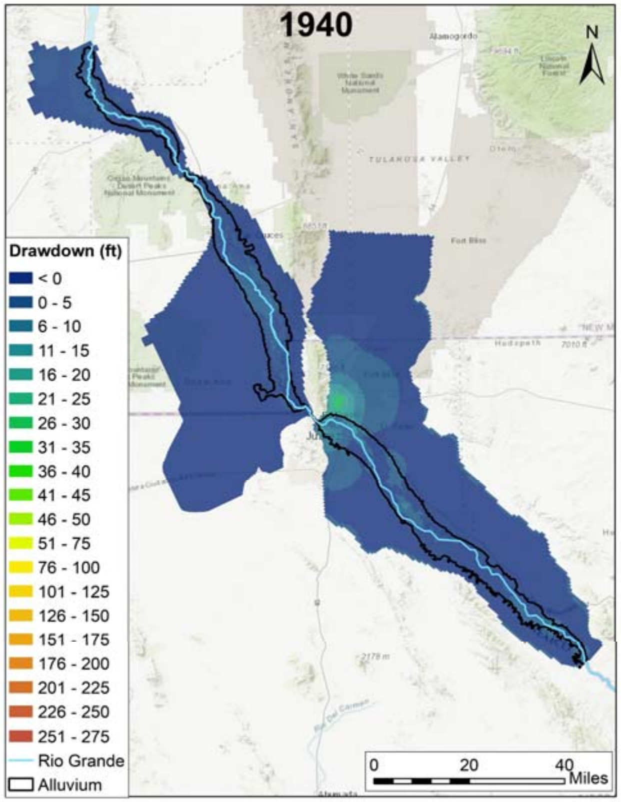
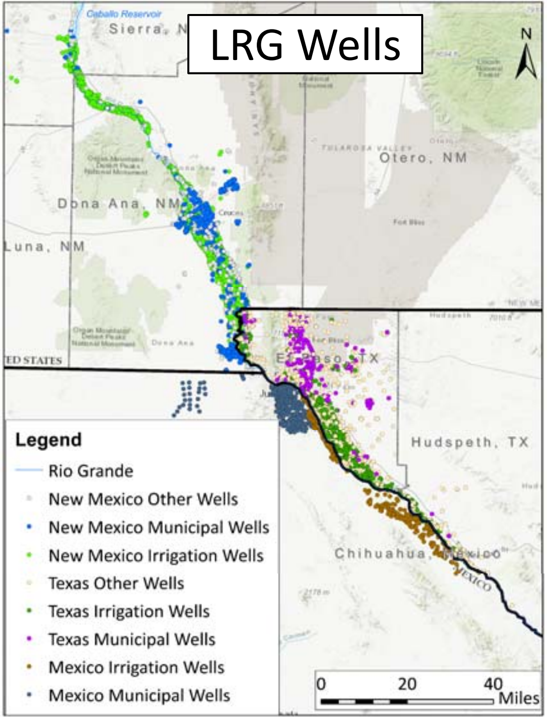
LRG Wells and Groundwater Level Drawdowns





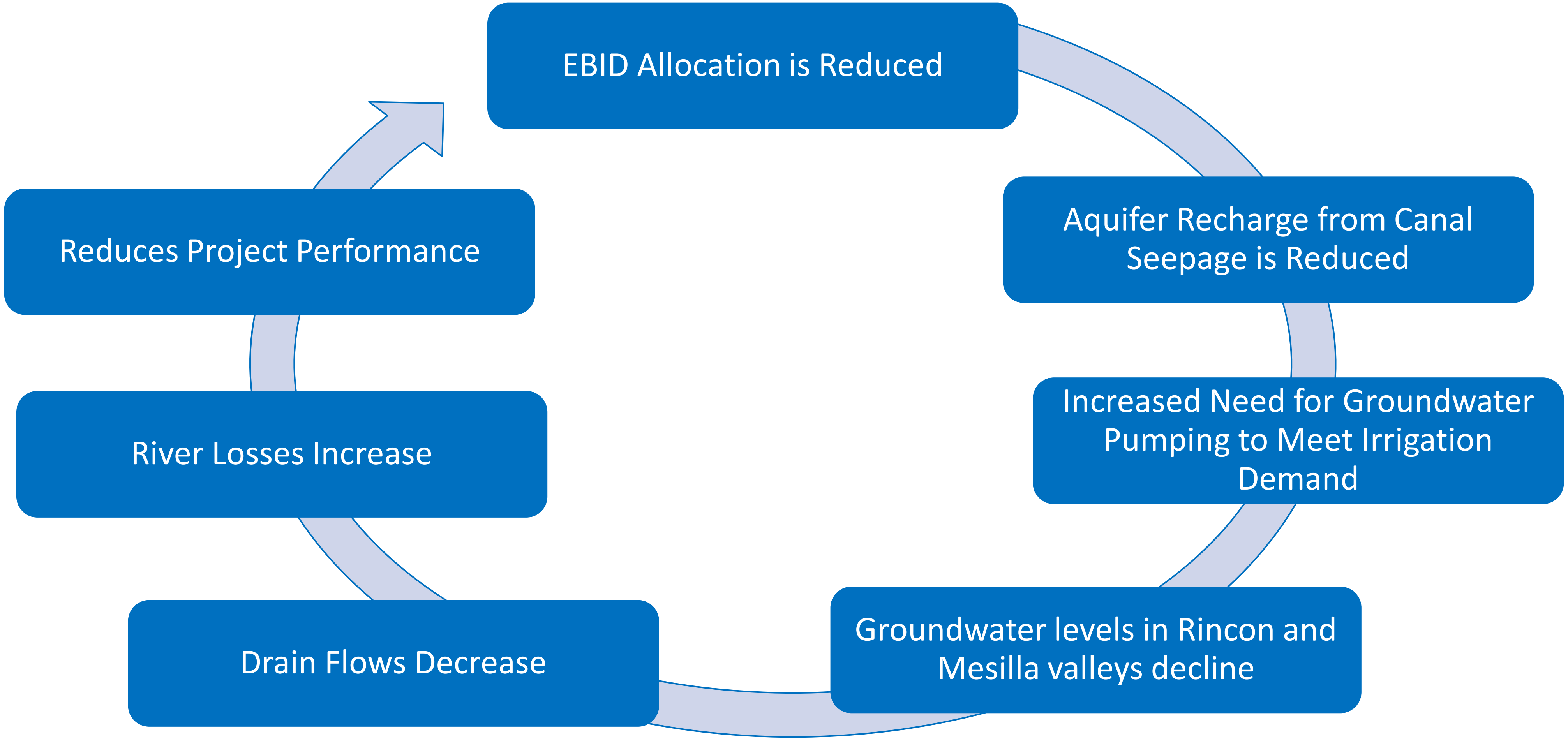




Source:

1) Drawdown maps from Rebuttal Expert Report, 2nd Edition Barth and Larson, 9/15/2020.
2) Well locations based on data from State of New Mexico, Texas Water Development Board, Ciudad Juarez, Paso del Norte Watershed Council.

Effect of 2008 OA on New Mexico: A Vicious Cycle



EBID Allocation is Reduced

Aquifer Recharge from Canal Seepage is Reduced

Increased Need for Groundwater Pumping to Meet Irrigation Demand

Groundwater levels in Rincon and Mesilla valleys decline

Drain Flows Decrease

River Losses Increase

Reduces Project Performance

Data from Margaret Barroll, Ph.D.
Expert Report (10-31-19), Section 9
Rebuttal Report (6-15-20), page 47

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New Mexico Exhibit
NM_EX-118

TX v. NM # 141
New Mexico Exhibit

NM_EX-119

No. 141, Original

In the

SUPREME COURT OF THE UNITED STATES

STATE OF TEXAS,

Plaintiff,
v.

STATE OF NEW MEXICO and
STATE OF COLORADO,

Defendants

OFFICE OF THE SPECIAL MASTER

UNITED STATES OF AMERICA'S DISCLOSURE OF EXPERT REBUTTAL WITNESS DR. IAN M. FERGUSON

NOEL J. FRANCISCO
Solicitor General
JEAN E. WILLIAMS
Deputy Assistant Attorney General
FREDERICK LIU
Assistant to the Solicitor General
JAMES J. DuBOIS
STEPHEN M. MACFARLANE
R. LEE LEININGER
JUDITH E. COLEMAN
JOHN P. TUSTIN
DAVID GEHLERT
THOMAS K. SNODGRASS
Attorneys, Environment and Natural Resources Division
U.S. Department of Justice

Counsel for the United States

Opinion: With respect to Dr. Barroll's opinions regarding the reduction in annual diversion allocation to EBID under the "D3 Method" in the 2008 Operating Agreement ("OA"), Dr. Barroll incorrectly suggests that the adjustment to EBID's annual diversion allocation under the "D3 Method" is strictly negative. *See* Barroll Rep., opinions 6, 12, and 19. The "D3 Method" allocation procedure increases EBID's annual diversion allocation compared to the "D1/D2 Method" in years when actual current-year Project delivery performance exceeds historical delivery performance as represented by the D2 Curve.

Dr. Barroll also incorrectly suggests that the "D3 Method" is based on the assumption that any negative departure from historical Project performance is caused by New Mexico. *See* Barroll Rep. opinion 12 & § 6.3.1. The "D3 Method"—including both the Diversion Ratio adjustment to EBID's annual diversion allocation and carryover accounting for unused allocation balance—is part of a negotiated settlement between EBID, El Paso County Water Improvement District No. 1 ("EPCWID"), and Reclamation, and not on explicit assumptions regarding the cause of "negative departures from historical Project performance." *Id.* Dr. Ferguson's rebuttal opinions are based in part on the facts that (1) the D2 Curve incorporates effects of groundwater pumping on Project water supplies during the period 1951-1978, including the impacts of significant groundwater pumping in New Mexico during these years; (2) the majority of groundwater pumping in the Rincon and Mesilla Valleys occurs in New Mexico; and (3) groundwater pumping in the Rincon and Mesilla Valleys affects Project water supplies under current Project operations, while groundwater pumping in the El Paso Valley does not impact current Project operations.

C. Causes of Increased Groundwater Pumping in New Mexico.

Opinion: Dr. Barroll incorrectly attributes recent increases in groundwater pumping for supplemental irrigation within EBID to a reduction in annual diversion allocations to EBID under the OA. Dr. Barroll's attribution of increases in groundwater pumping to the OA fails to recognize that increased groundwater pumping in New Mexico and corresponding impacts on the Project occurred prior to the OA. Estimates of groundwater pumping in the Rincon Valley and the New Mexico portion of the Mesilla Valley provided in the expert report of Sullivan and Welsh show that groundwater pumping in New Mexico increased from 1985 to 2002, despite full diversion allocations to EBID through this period. Pumping in New Mexico continued to increase from 2003 to 2005, prior to the implementation of the "D3 Method" allocation procedure. Similar estimates are provided in the report of Hutchinson.

Increases in groundwater pumping in New Mexico occurred prior to the OA due to increases in water demands for supplemental irrigation within EBID, increases in water demands for irrigation of groundwater-only lands outside of EBID, and increases in water demands for domestic, municipal, industrial, and commercial uses. Current demands within EBID exceed the historical full-supply delivery of 3.024 AF per acre.

Increased groundwater pumping to meet these demands, and the corresponding impacts on Project surface-water supplies, was a major driver in negotiation of the OA. The reduction in EBID's annual diversion allocation under the "D3 Method" was negotiated as a means to offset these impacts. Under the "D3 Method," EBID foregoes a portion of its annual diversion allocation to offset the impacts of groundwater pumping in New Mexico on Project allocations and deliveries to EPCWID.

D. Rebuttal to Specific Opinions by Dr. Barroll.

Dr. Ferguson expects to offer the following opinions in response to the opinions or "conclusions" listed in Dr. Barroll's Report at pp. ix-xi (set forth in italics below).

> *Barroll Opinion 1: The Rio Grande Project 2008 Operating Agreement has greatly reduced the surface water supply to New Mexico farmers, to the detriment of New Mexico. Texas, however, has benefitted by the 2008 Operating Agreement through an increase in the allocation of water to its irrigation district, and because that district can now carry over large amounts of unused allocation from one year to the next.*

Opinion: Dr. Barroll's opinion fails to acknowledge that groundwater pumping in New Mexico and corresponding impacts on the Project occurred prior to 2008, when the OA was agreed to, and that the "D3 Method" was negotiated as a means to offset those impacts. This failure to recognize the impacts of groundwater pumping in New Mexico on the Project also appears in Barroll Opinions 6, 8, 9, and 14. Dr. Barroll also incorrectly states that the OA results in increased annual diversion allocations to EPCWID. The annual allocation to EPCWID may be greater under the "D3 Method" than under the "D1/D2 Method" only in years when the Usable Water available for current-year allocation is between 763,842 acre-feet and 790,000 acre-feet. In all other years, the annual allocation to EPCWID under the "D3 Method" is the same or less than under the "D1/D2 Method." During multi-year droughts, the annual allocation to EPCWID is less under the "D3 Method" due to the Drought Correction Factor in the OA.

> *Barroll Opinion 3: A 1938 Contract between the Districts sets forth a division of Project water supply between the Districts in accordance with the proportions of Project acreage: 88,000 of 155,000 Project acres (57%) to EBID, and 67,000 of 155,000 Project acres (43%) to EPCWID. From 1938 through 1978, Reclamation operated the Project so that EBID farmers were entitled to 57% of the U.S. share of Project Supply and EPCWID farmers were entitled to 43% of the U.S. share of Project Supply.*

Opinion: Dr. Ferguson has reviewed the 1938 Contract and Project delivery records prior to 1978, and concludes that Dr. Barroll's statement that the 1938 Contract "sets forth a division of Project water supply between the Districts in accordance with the proportions of Project acreage" is incorrect. The 1938 Contract specifically states "in the event of a shortage of water for irrigation in any year, the distribution of the available supply in such a year, shall so far as practicable, be made in the proportion of 67/155 thereof to the lands within the El Paso County Water improvement District No. 1, and 88/155ths to the lands within the Elephant Butte Irrigation District." Under the 1938 contract, the division of Project water supply between EBID and EPCWID based on acreage is explicitly limited to years in which there is a "shortage of water for irrigation" – it does not apply to all years.

Dr. Barroll's statement that "from 1938 through 1978, Reclamation operated the Project so that EBID farmers were entitled to 57% of the US share of Project supply" is also incorrect. From 1938 through 1950, Reclamation operated the Project without allotments – *i.e.*, farmers were able to call for water as needed, with no allotment or limit imposed. From 1951-1978, Reclamation allotted water equally to all Project acres. However, Reclamation did not guarantee equal delivery to all lands; rather, actual deliveries to farms depended on the amount of water called for by farmers. Farm delivery data provided in the expert report of Sullivan and Welsh demonstrate that the proportion of annual farm deliveries from 1938-1978 delivered to EBID ranged from 49-60 percent.

> *Barroll Opinion 4: Starting in 1979, Reclamation explicitly allocated Project Supply to the Districts in the ratio of 57% to EBID and 43% to EPCWID. The total amounts allocated were defined using the D1/D2 Curves. The amounts of water diverted by the Districts and delivered to their farmers were consistent with this 57:43 ratio.*

Opinion: The amounts of water diverted by the Districts and delivered to their farmers depended on the amounts of water called for by the districts and farmers, respectively. River diversion data provided in the expert report of Sullivan and Welsh demonstrate that the percentage of annual diversions to EBID from 1979 to 2007 ranged from 52 to 59 percent of the total annual diversion to the Districts and annual farm deliveries to EBID during this period ranged from 32 to 62 percent of the total annual farm delivery by the Districts. Table A.8 of Appendix A of Dr.

MONTGOMERY
& ASSOCIATES
Water Resource Consultants

May 31, 2019

EXPERT REPORT OF:

Staffan W. Schorr and Colin P. Kikuchi

WATER BUDGET ESTIMATES IN SUPPORT OF GROUNDWATER MODEL DEVELOPMENT: RINCON AND MESILLA BASINS, NEW MEXICO, TEXAS, AND NORTHERN MEXICO, 1938 THROUGH 2016

In the matter of:

No. 141, Original
In the Supreme Court of the United States
State of Texas v. State of New Mexico and State of Colorado

Prepared for:

Somach Simmons & Dunn
500 Capitol Mall, Suite 1000
Sacramento, CA 95814

Prepared by:

Staffan W. Schorr
Montgomery & Associates
1550 East Prince Road
Tucson, Arizona 85719

Colin P. Kikuchi
Montgomery & Associates
1550 East Prince Road
Tucson, Arizona 85719

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NM_EX-120

5. The water budgets presented herein are prepared to the basin scale for aggregating inflows and outflows. I used a basin scale approach because important components of the water system, such as surface water deliveries to farms and groundwater exchange between sub-areas within the basins, could not be estimated on a localized monthly scale for the entire study period. Although this basin scale water budget ignores the spatial distribution of individual components, it does provide useful insight on the general functional behavior of the system.

6. I prepared separate water budgets for Rincon Basin and Mesilla Basin because the basins are separated by a bedrock constriction, which limits the hydrologic connection between the basins.

7. The overall water budget for each basin comprises three types of budgets: Land-Surface Water Budget, Surface Water Budget, and Groundwater Budget. I used this approach to facilitate budget development by compartmentalizing common components.

8. The Land-Surface Water Budget comprises a Farm Water Budget and Non-Farm Water Budget. The Non-Farm Water Budget was prepared for lands outside farm lands. Water inflows to the Non-Farm Water Budget include precipitation and groundwater withdrawals. The Non-Farm Water Budget is split into three sub-budgets to account for the source of water supply and land use. An Urban Applied Water Budget was prepared for urban use of applied groundwater. An Urban Precipitation Water Budget was prepared for urban use of precipitation. An Upland Watershed Water Budget was prepared for all native or undeveloped lands in the upland portions of the watershed, outside farm and urban lands. Although the Non-Farm Water Budget could be prepared as a single water budget, I used this approach to facilitate budget development by compartmentalizing components based on water supply and land use.

9. The number of groundwater production wells located in Rincon and Mesilla basins has increased since 1938, shown on Figures 4.6 and 4.7. I obtained well databases from the states of New Mexico and Texas for water product well information and well installation history. In 1939, less than 60 New Mexico wells existed in the basins, with vast majority used for domestic purposes and five wells for irrigation purposes. By 2016, the number of New Mexico wells located in the basins increased to more than 7,700, with about 465 wells for municipal and industrial purposes, 1,300 for irrigation purposes, and majority still for domestic purposes. A substantial number of well records in the New Mexico wells database are missing installation dates and are not included in these well counts; these undated wells may or may not exist. The number of water production wells located in Texas portions of Mesilla Basin increased from 3 wells in 1938 to 239 wells in 2016, with about half being used for irrigation purposes.

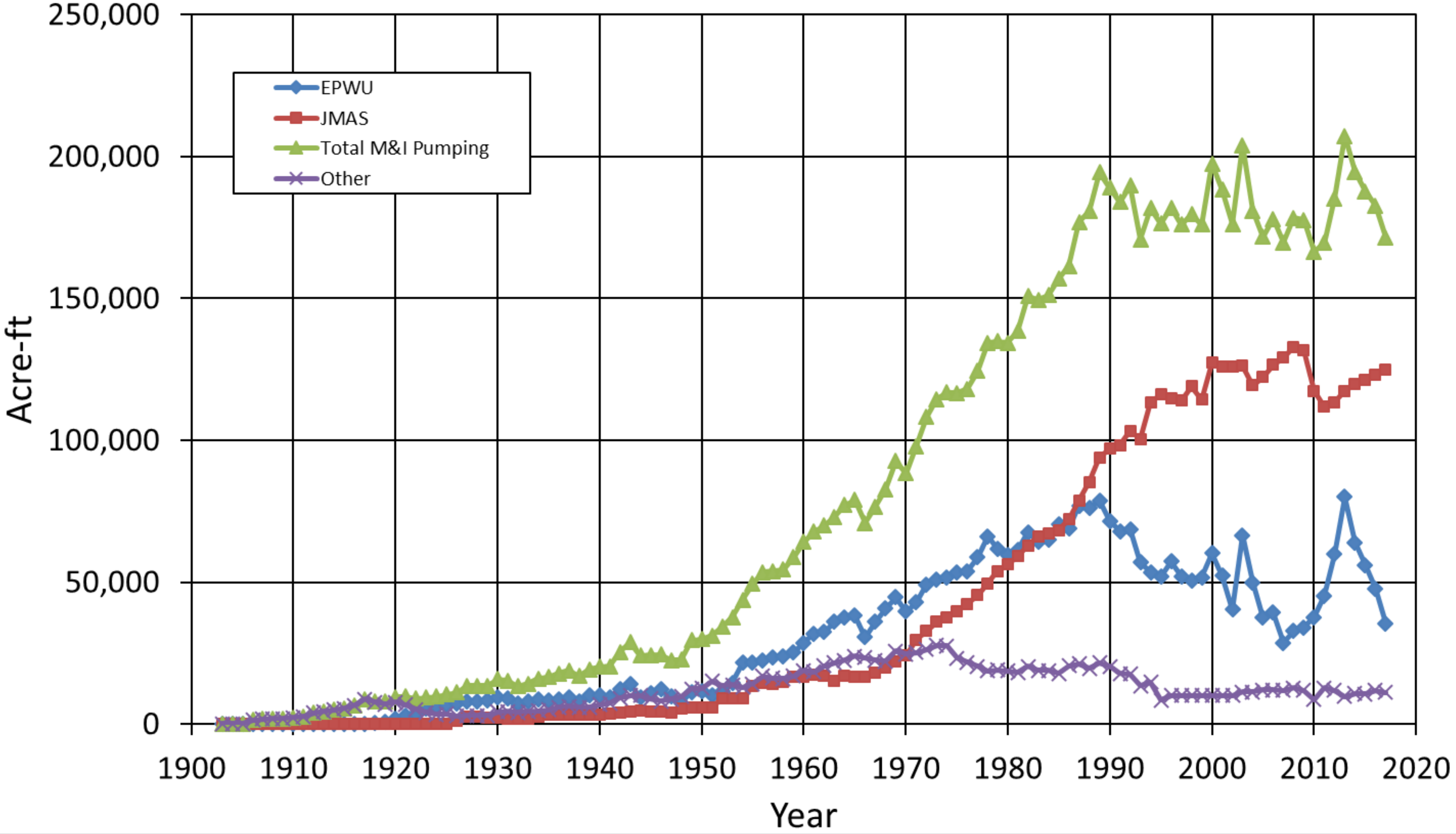

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Figure 5.4 – Graph showing annual municipal and industrial pumping, 1903 to 2017.

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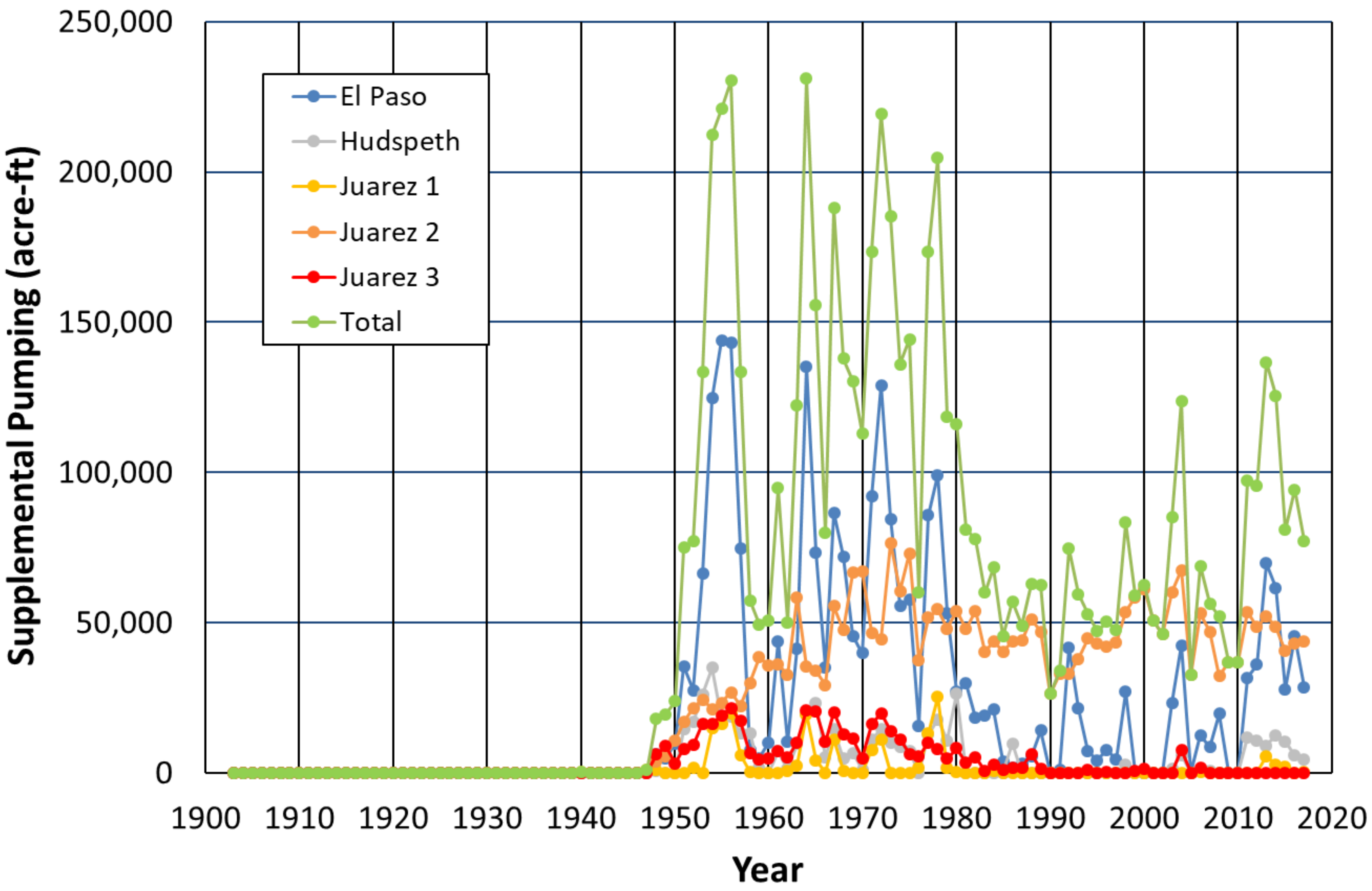
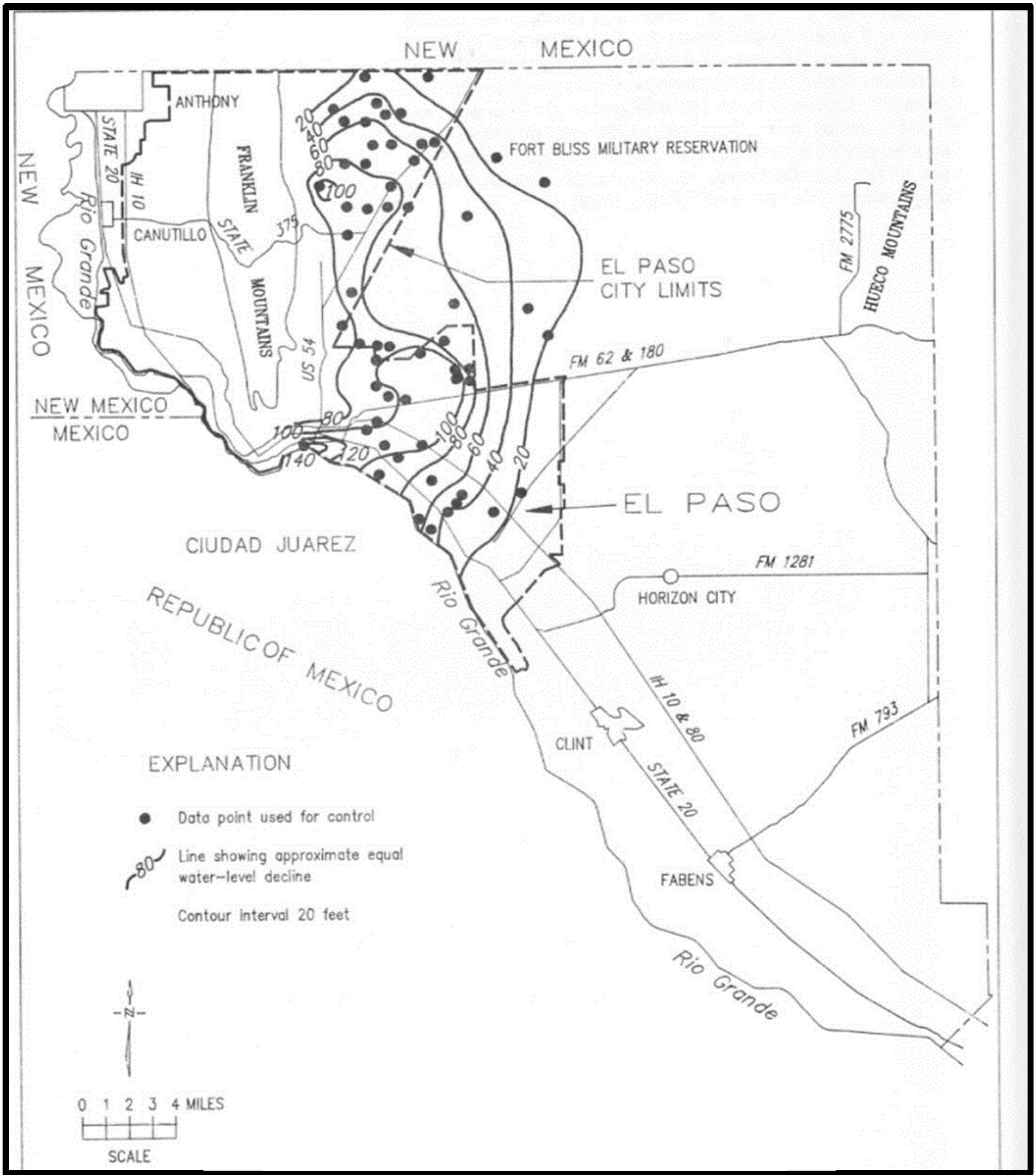


Data Source: Sullivan and Welsh (2020) and Setzer and Carron (2020)

Figure 5.6 – Graph showing estimated supplemental irrigation pumping, 1903 to 2017.



Modified from White (2003)

Figure 6.1 - Map showing groundwater elevation declines in the Hueco Bolson between 1903 and 1989.

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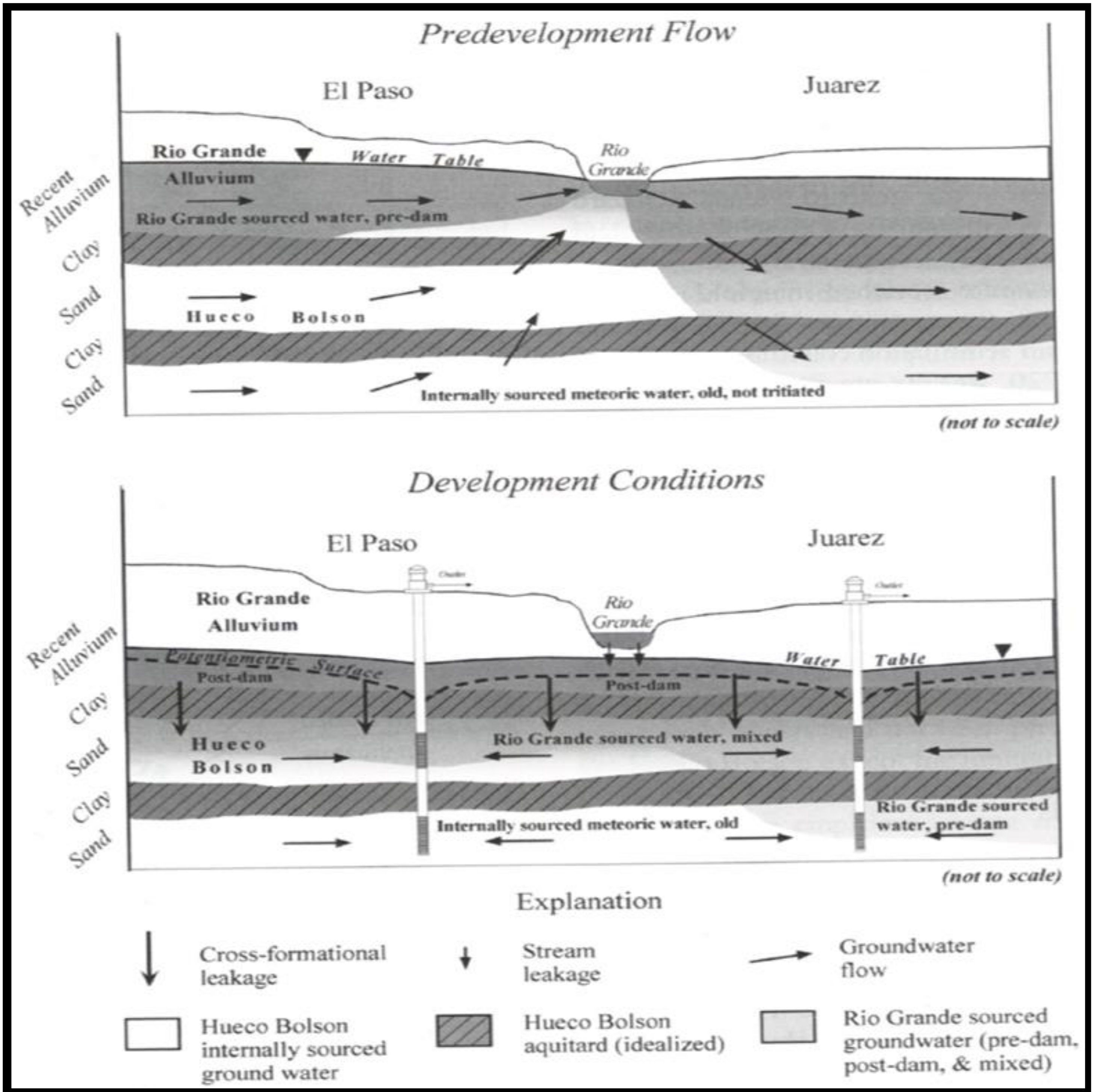
GROUND WATER HYDROLOGISTS



Modified from Hutchison and Hibbs (2008)

Figure 6.4 – Conceptual model showing changes in flow direction between pre-development conditions and post-development conditions in the Hueco Bolson.

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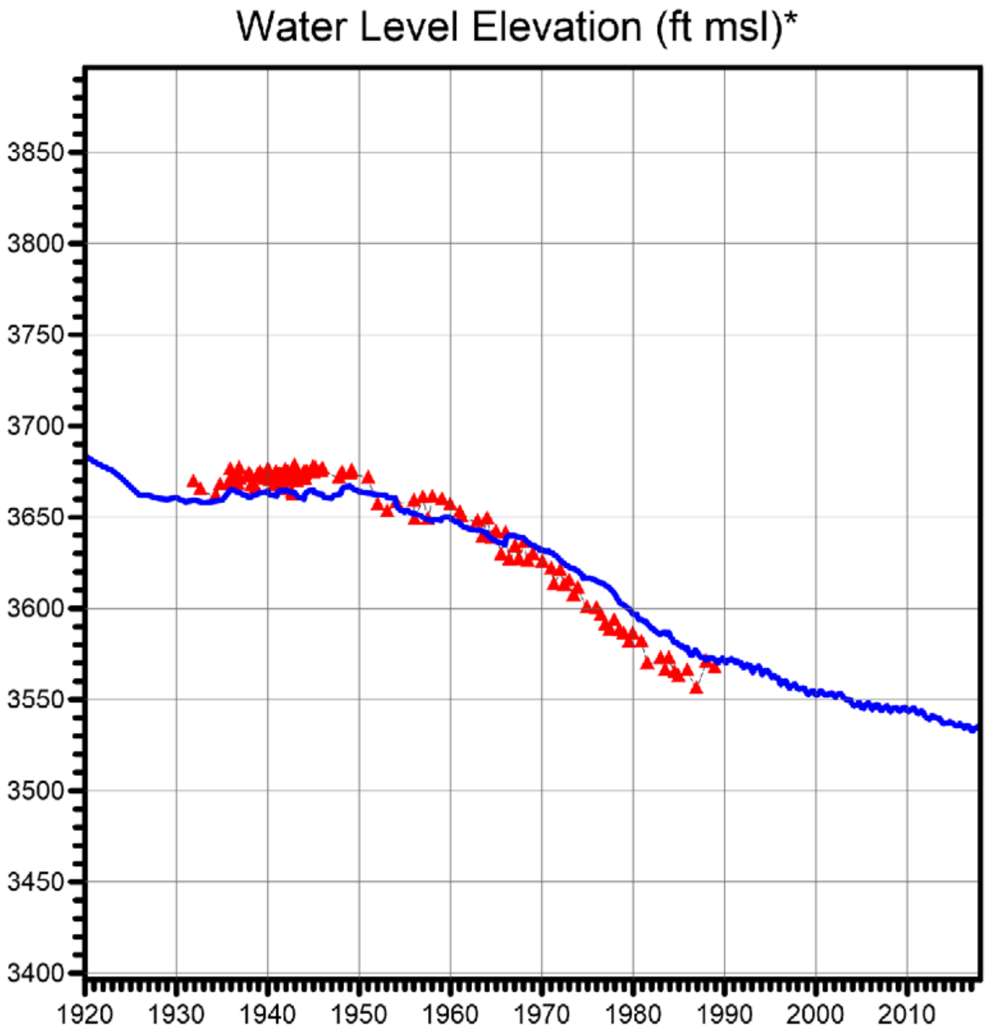
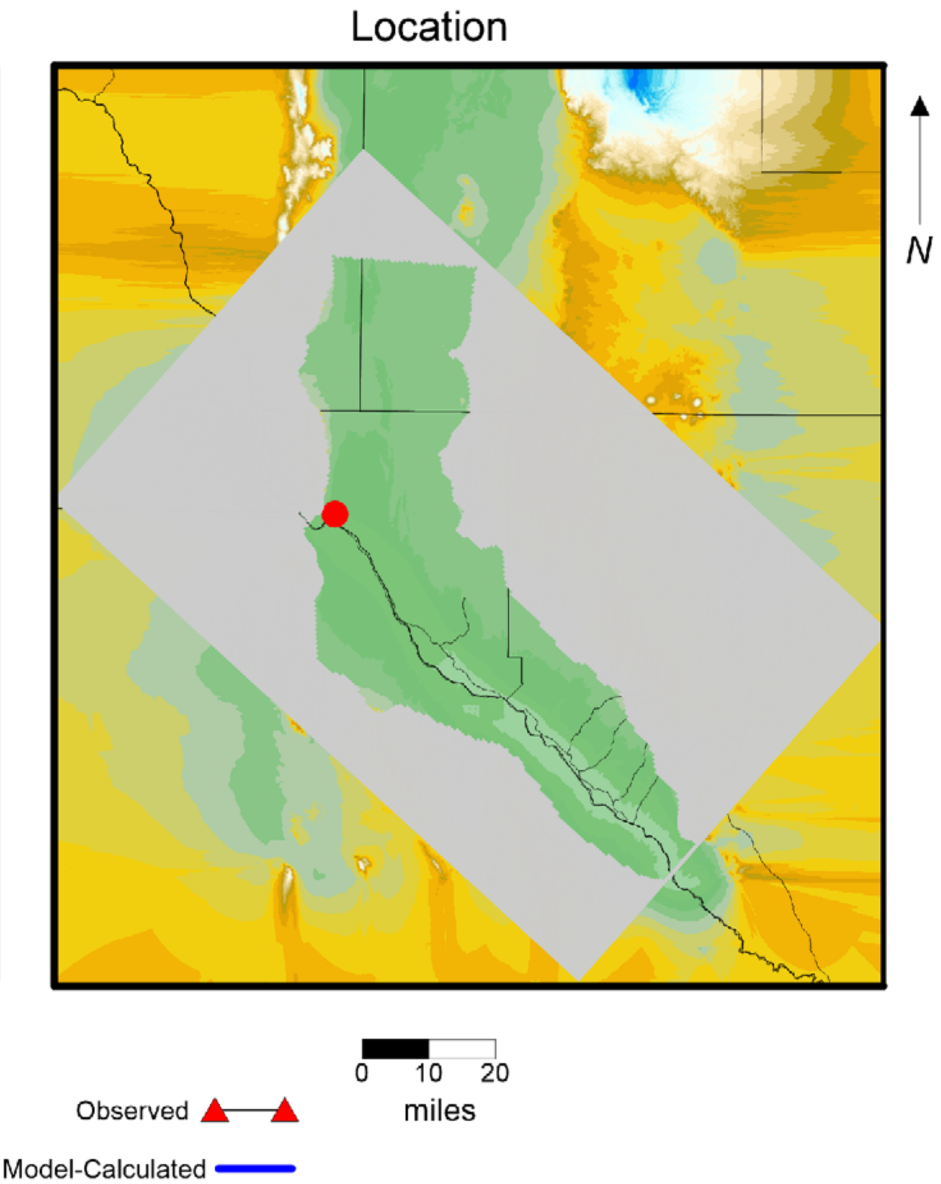
Observed Data From: Final_Water_Level_Set_9_25_2019_culled.dat
Model Run Data From: Hueco_Run0_v111 (06/2020)

Datum currently assigned as NAVD 1988





Number of Measurements	123
Range of Elevation	3555.76 to 3677.47
Average Elevation	3646.51
Screen Top Elevation	3280.67
Screen Bottom Elevation	2863.67

Values of -999 mean not available

Figure 8.21 - Hydrograph and location map for well 4913804.

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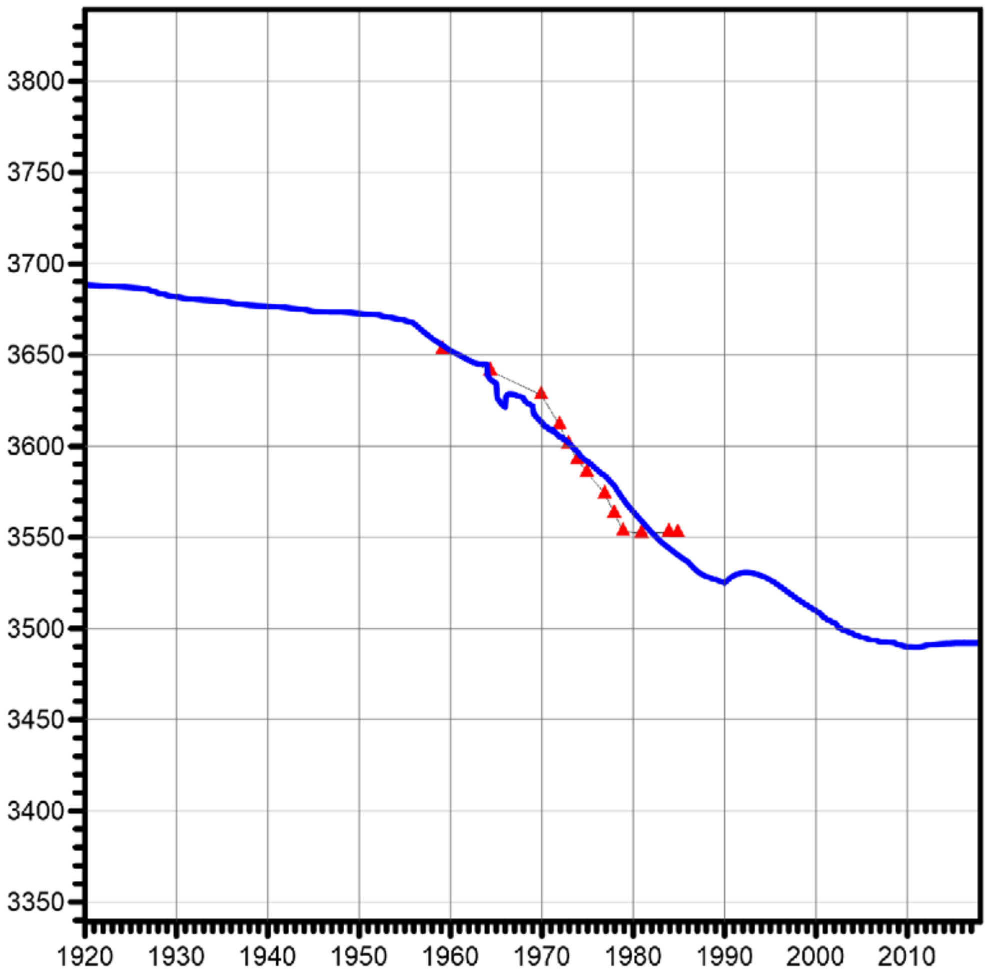
GROUND WATER HYDROLOGISTS

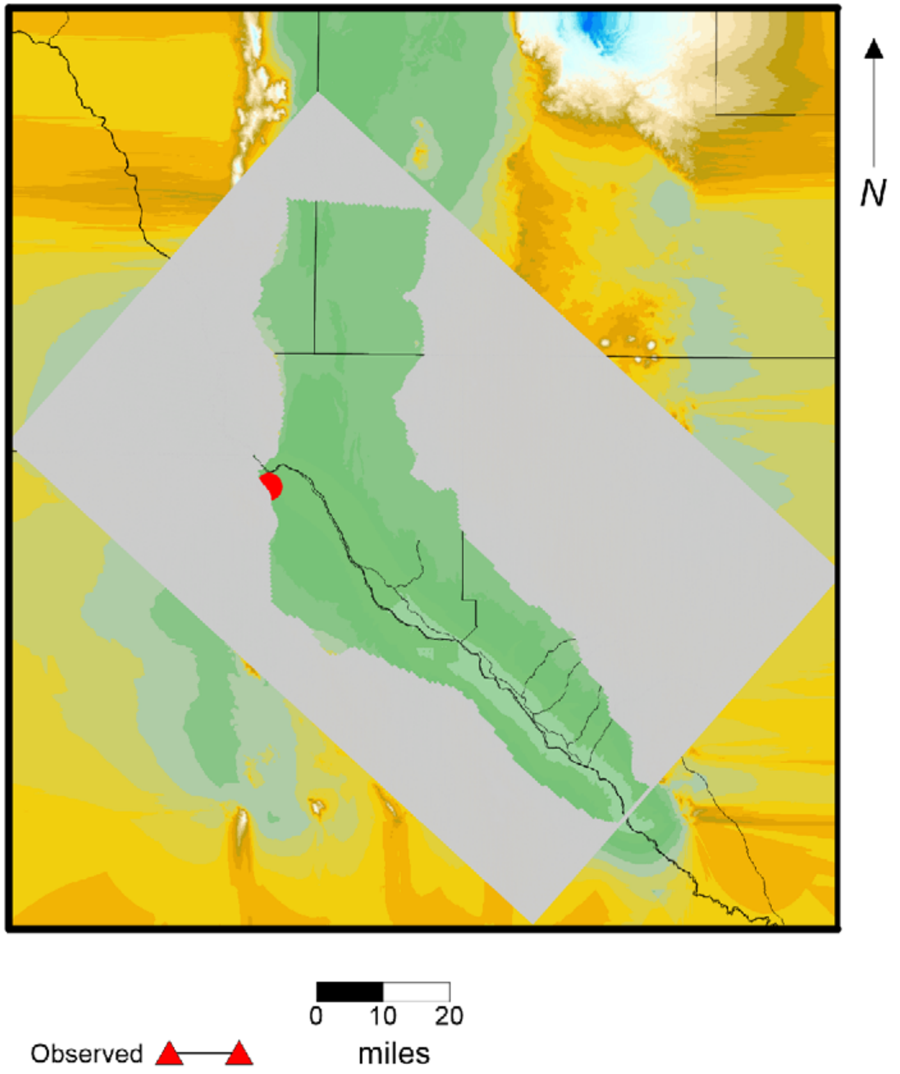
Observed Data From: Final_Water_Level_Set_9_25_2019_culled.dat
Model Run Data From: Hueco_Run0_v111 (06/2020)

Datum currently assigned as NAVD 1988

Water Level Elevation (ft msl)*



Location



Number of Measurements	13
Range of Elevation	3552.15 to 3652.9
Average Elevation	3589.33
Screen Top Elevation	3695.87
Screen Bottom Elevation	3367.79

Values of -999 mean not available

Observed ▲—▲

Model-Calculated ━━

Figure 8.22 - Hydrograph and location map for well JMAS13R.

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GROUND WATER HYDROLOGISTS

Appendix Q – Maps Showing Change in Simulated Groundwater Levels

Readme

The following plots show drawdowns as calculated by the Hueco groundwater model. These images were produced using Aquaveo's software product Groundwater Modeling System (GMS), version 10.4 and ARCGIS. Drawdowns were calculated relative to steady state calculated groundwater levels in the first model stress period. Data from the NM Hueco Model was shared with SSPA who created the final images after including simulated groundwater level changes in the Rincon-Mesilla using data from the NM RM Model. The drawdowns for the Rincon-Mesilla Model were calculated relative to simulated conditions for 1940.

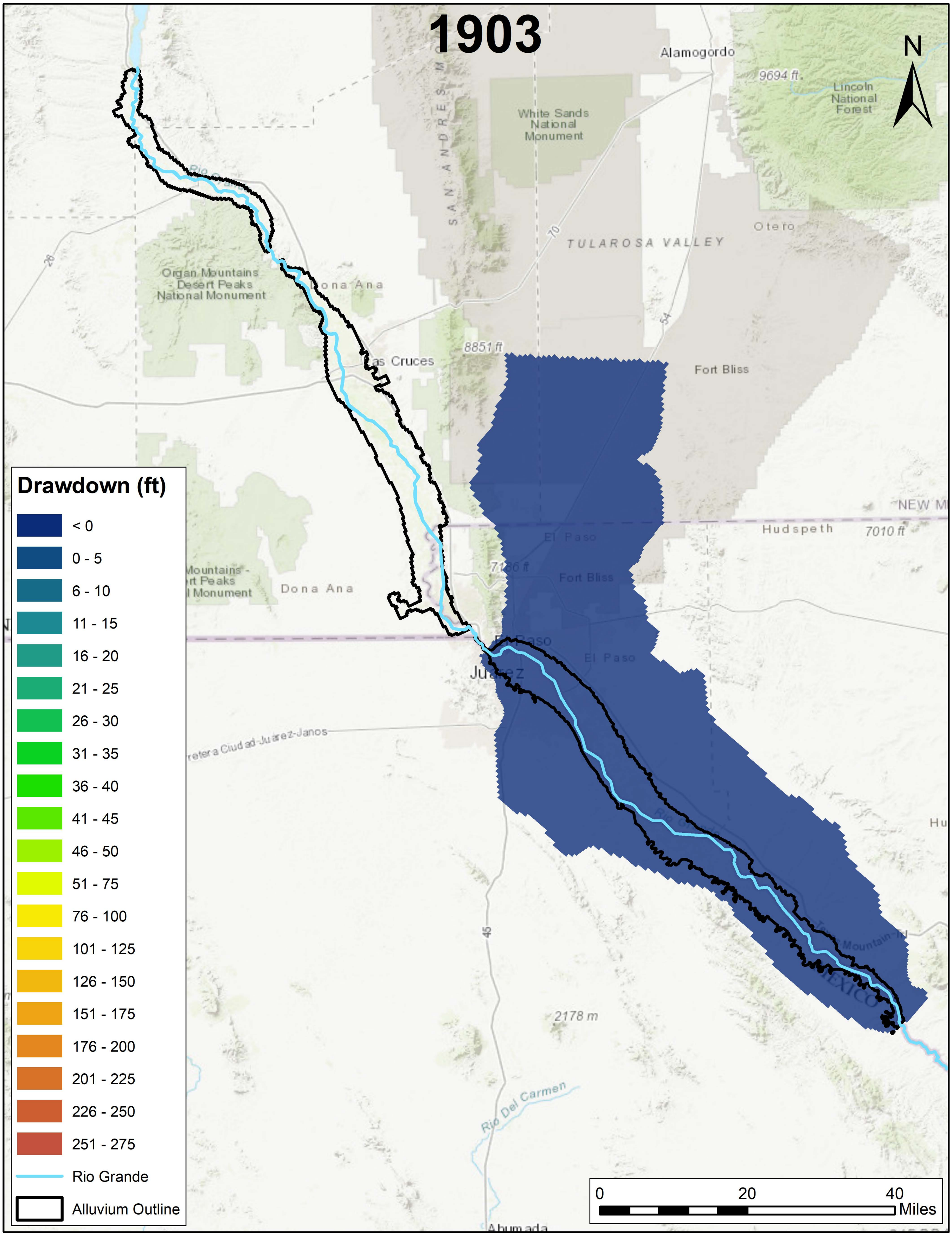


Figure 1 Simulated groundwater elevation drawdowns in the Rincon-Mesilla and Hueco basins using the NMR-M and Hueco groundwater models, respectively. Drawdowns are relative to 1940 and 1903 groundwater elevations for the Rincon-Mesilla and the Hueco, respectively. Groundwater elevation drawdowns reflect December conditions in each year.

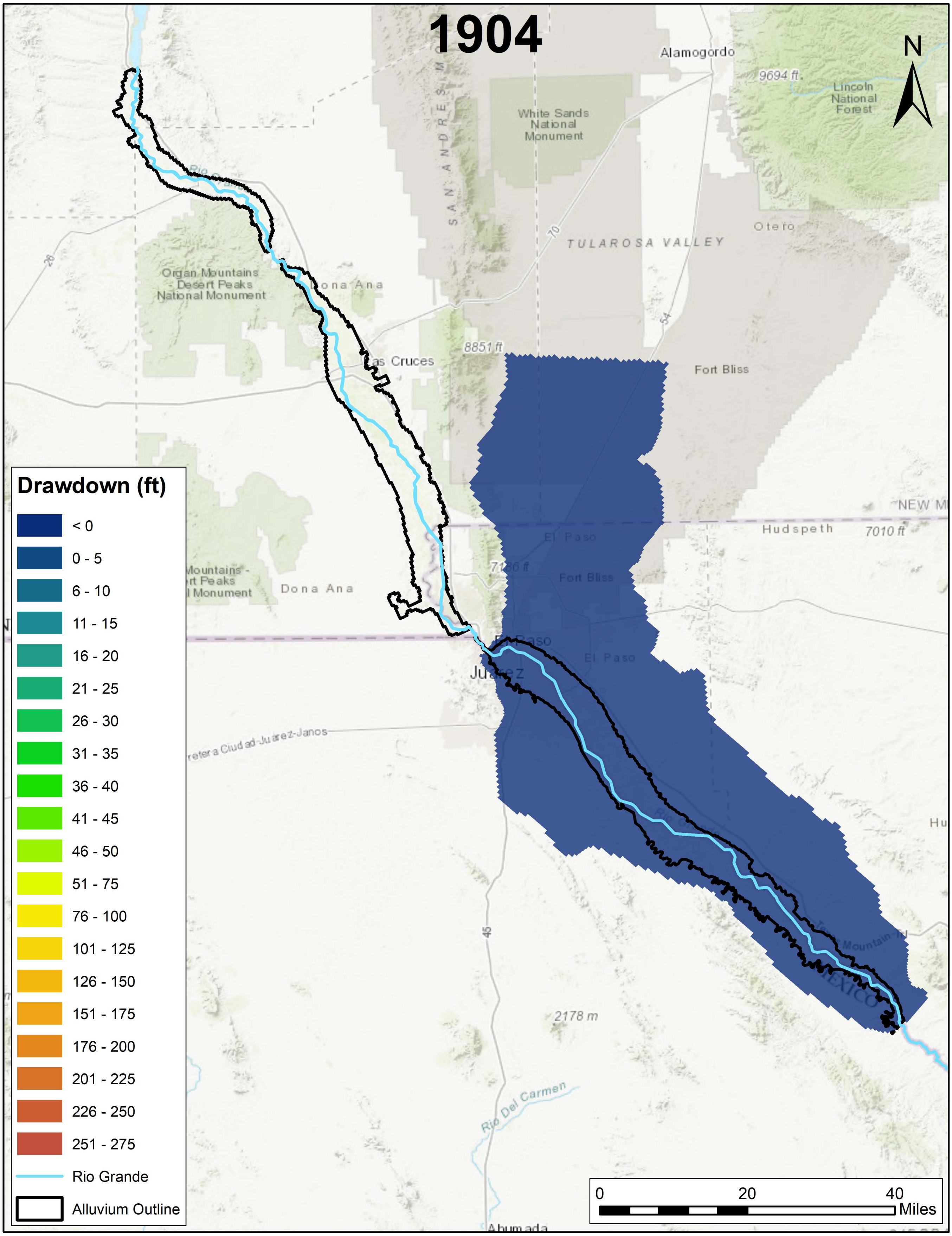
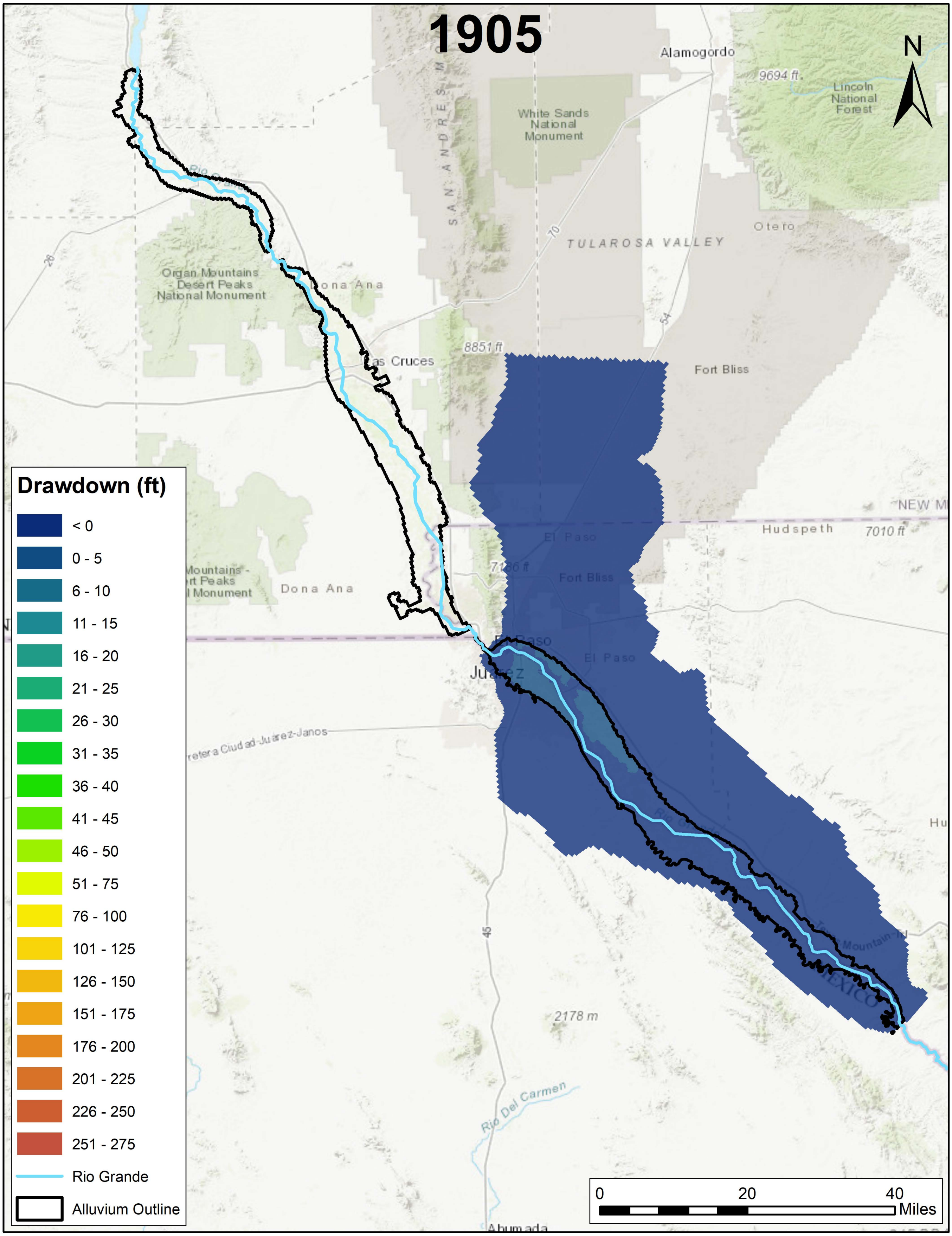


Figure 1 Simulated groundwater elevation drawdowns in the Rincon-Mesilla and Hueco basins using the NMR-M and Hueco groundwater models, respectively. Drawdowns are relative to 1940 and 1903 groundwater elevations for the Rincon-Mesilla and the Hueco, respectively. Groundwater elevation drawdowns reflect December conditions in each year.



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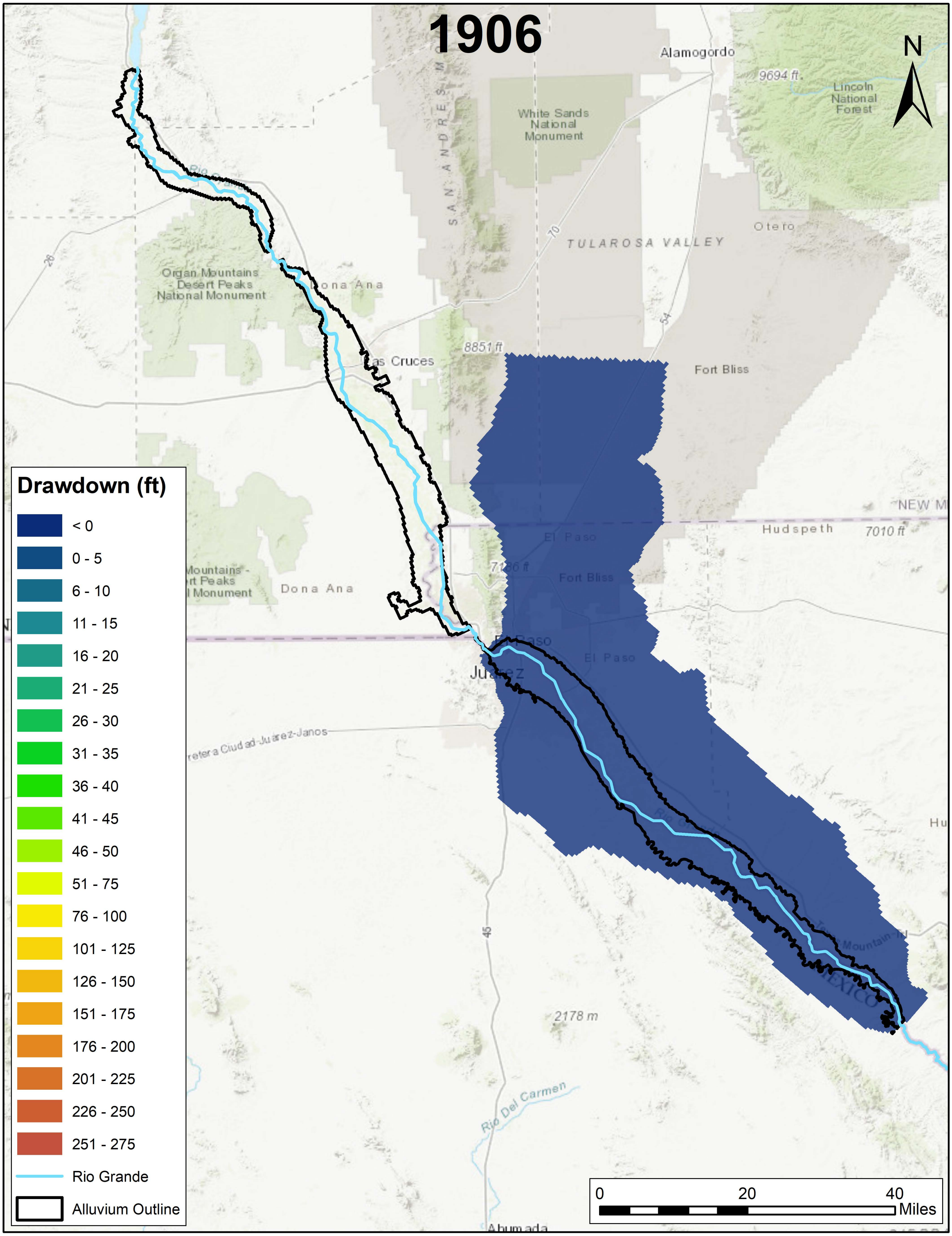
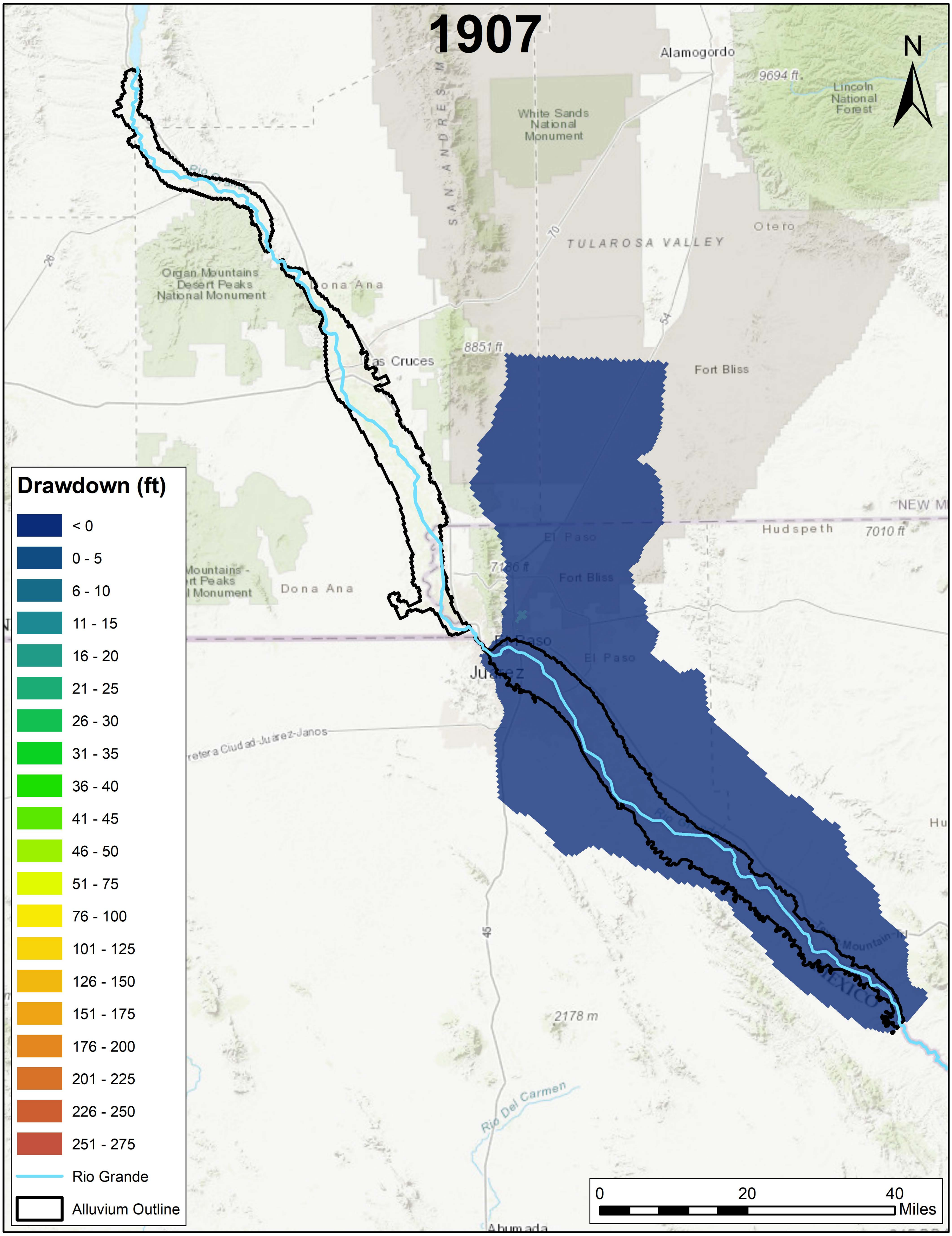


Figure 1 Simulated groundwater elevation drawdowns in the Rincon-Mesilla and Hueco basins using the NMR-M and Hueco groundwater models, respectively. Drawdowns are relative to 1940 and 1903 groundwater elevations for the Rincon-Mesilla and the Hueco, respectively. Groundwater elevation drawdowns reflect December conditions in each year.



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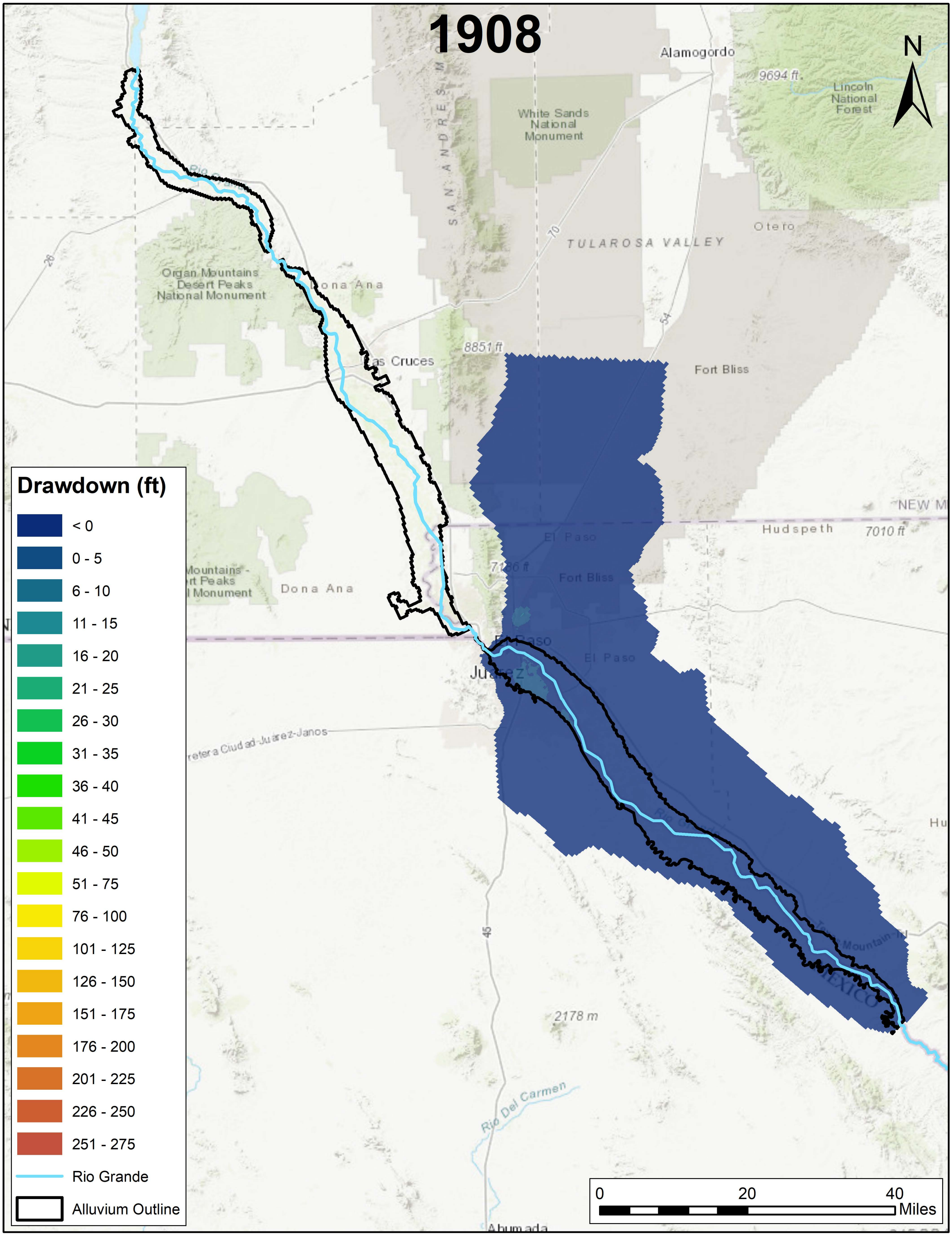

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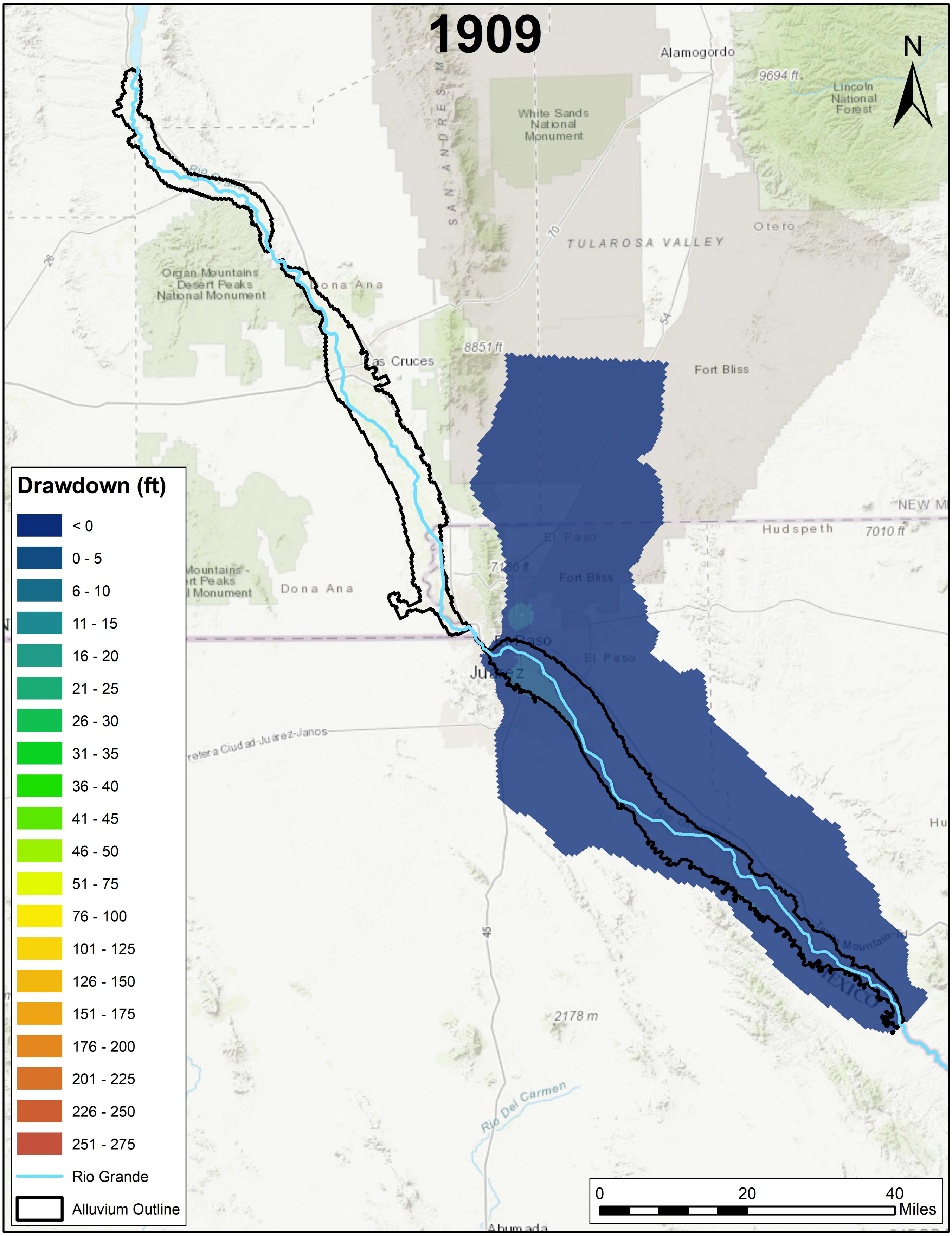

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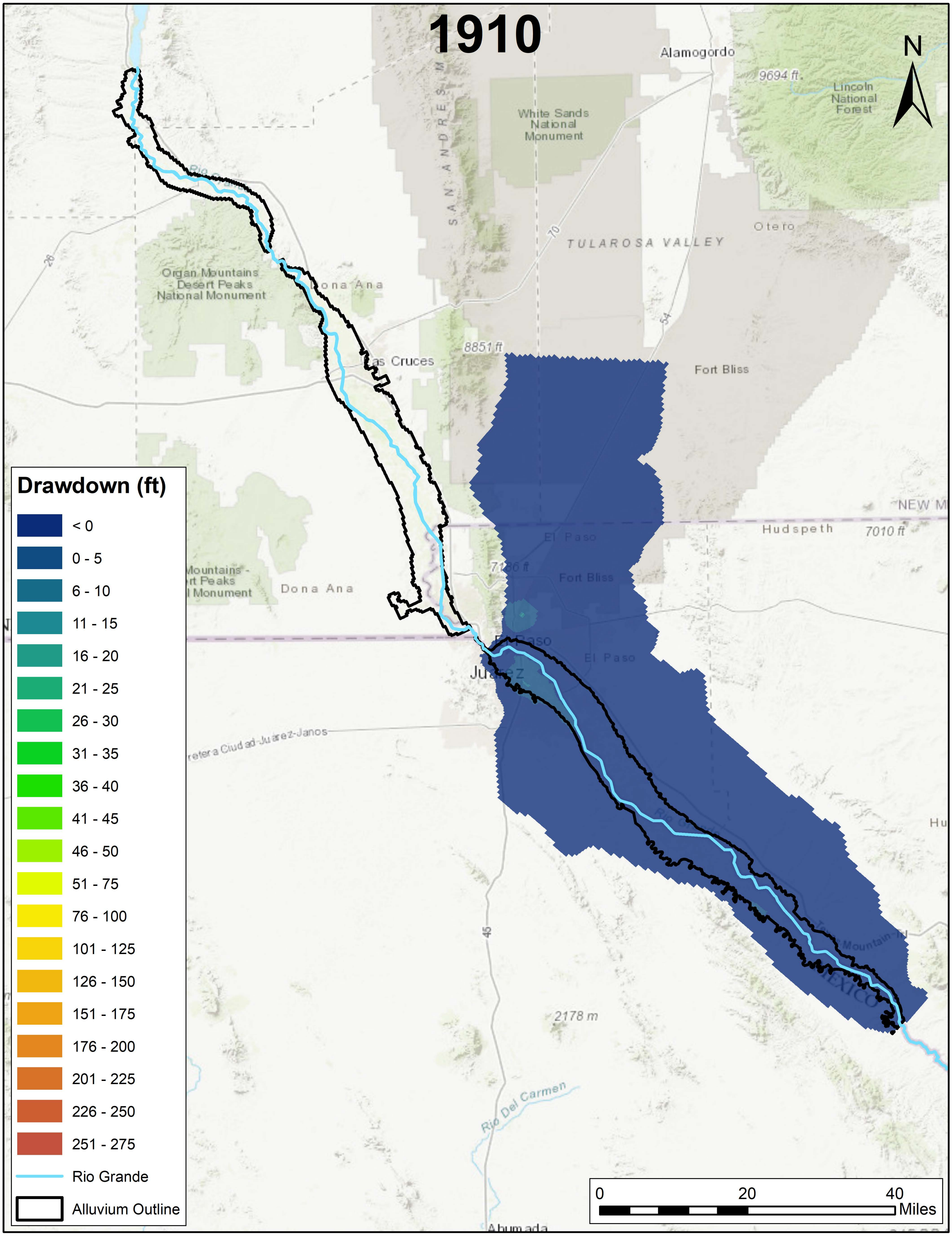

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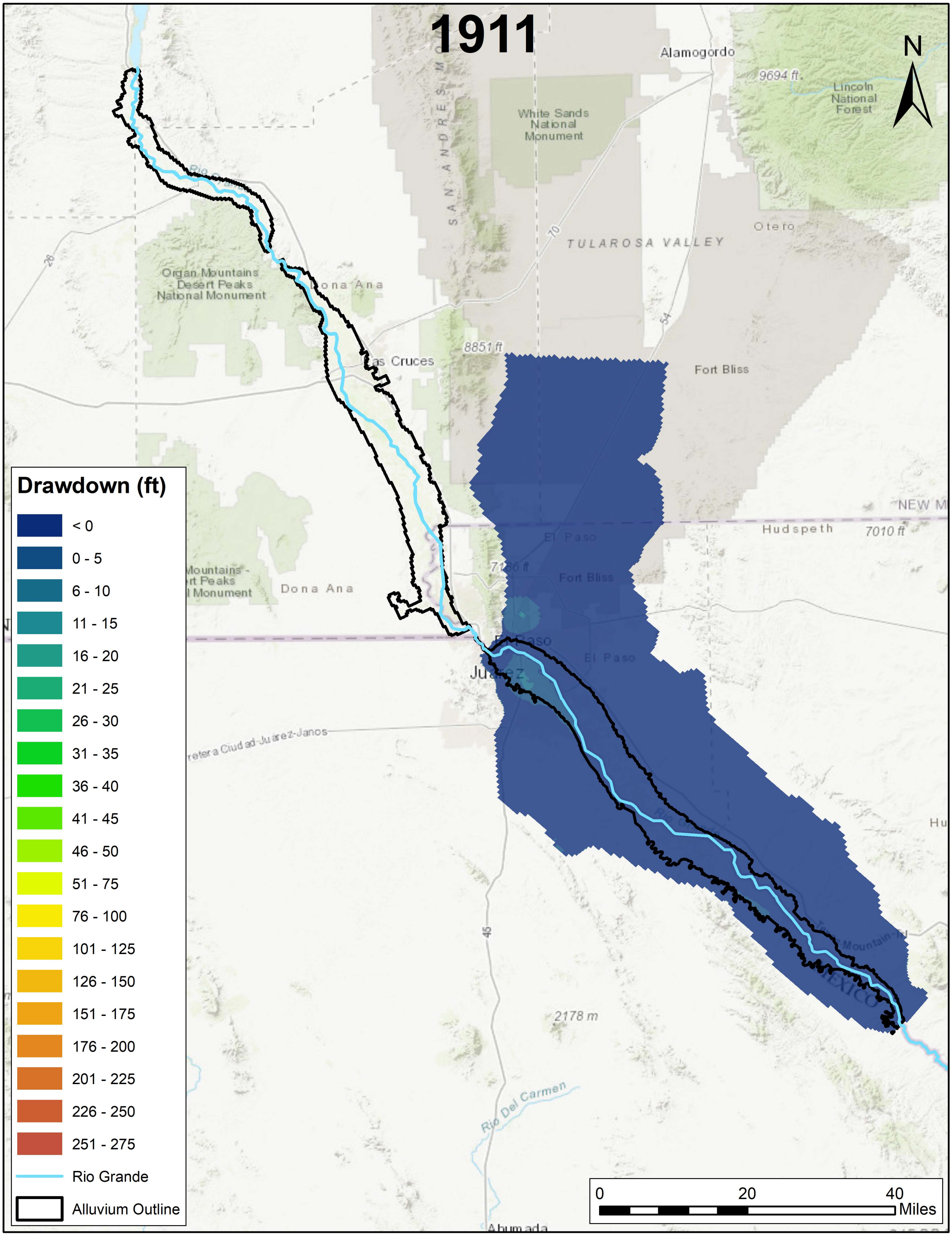

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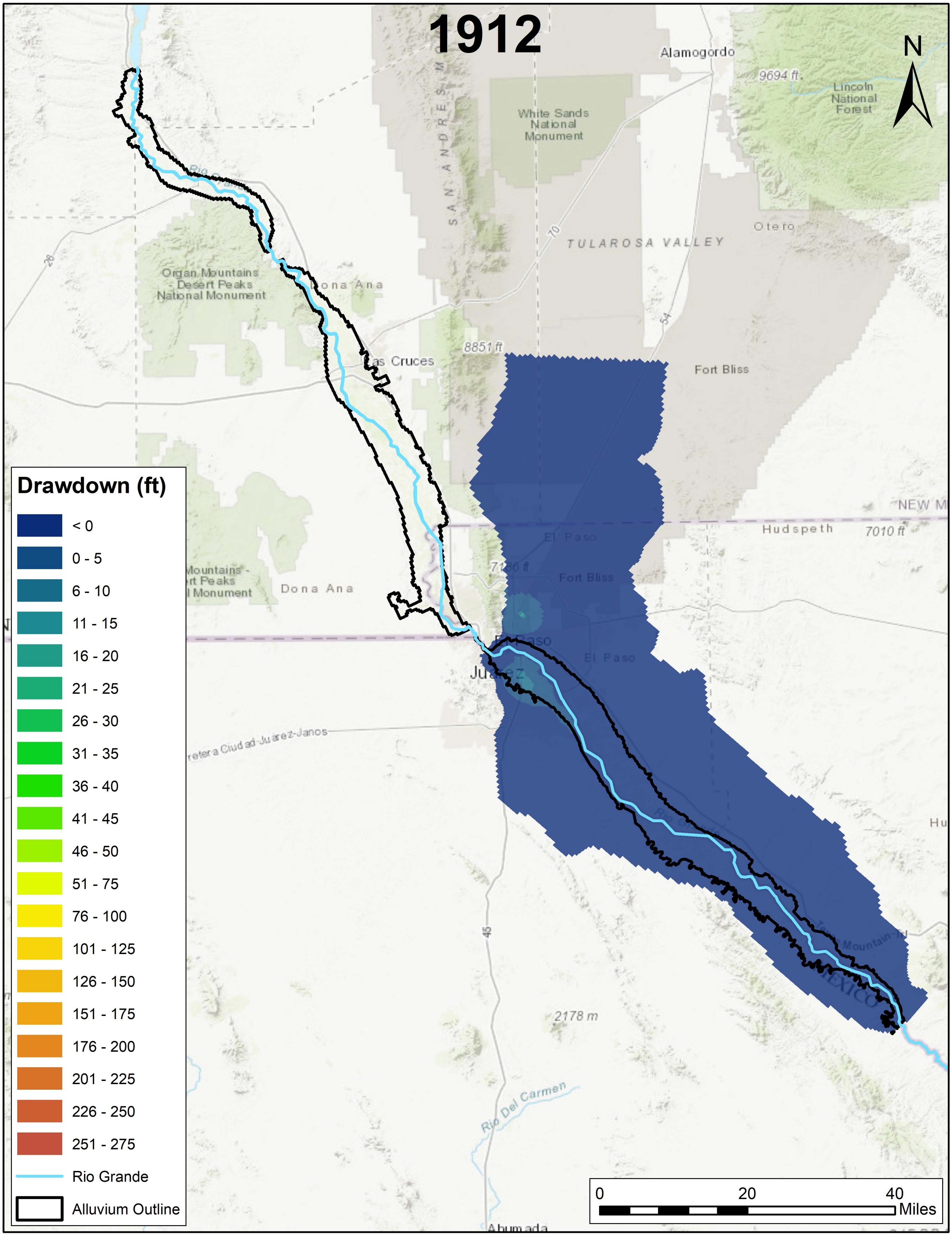

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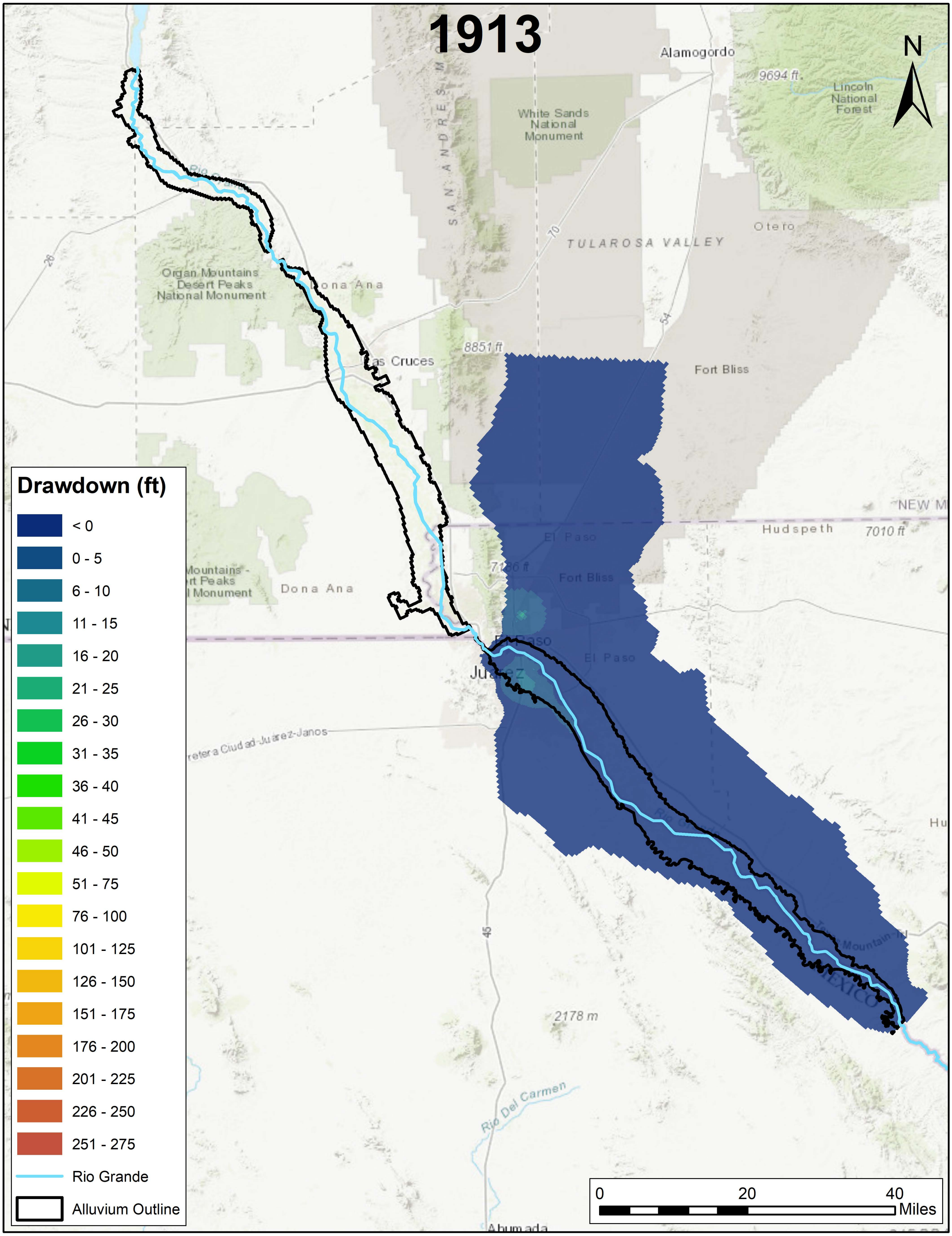

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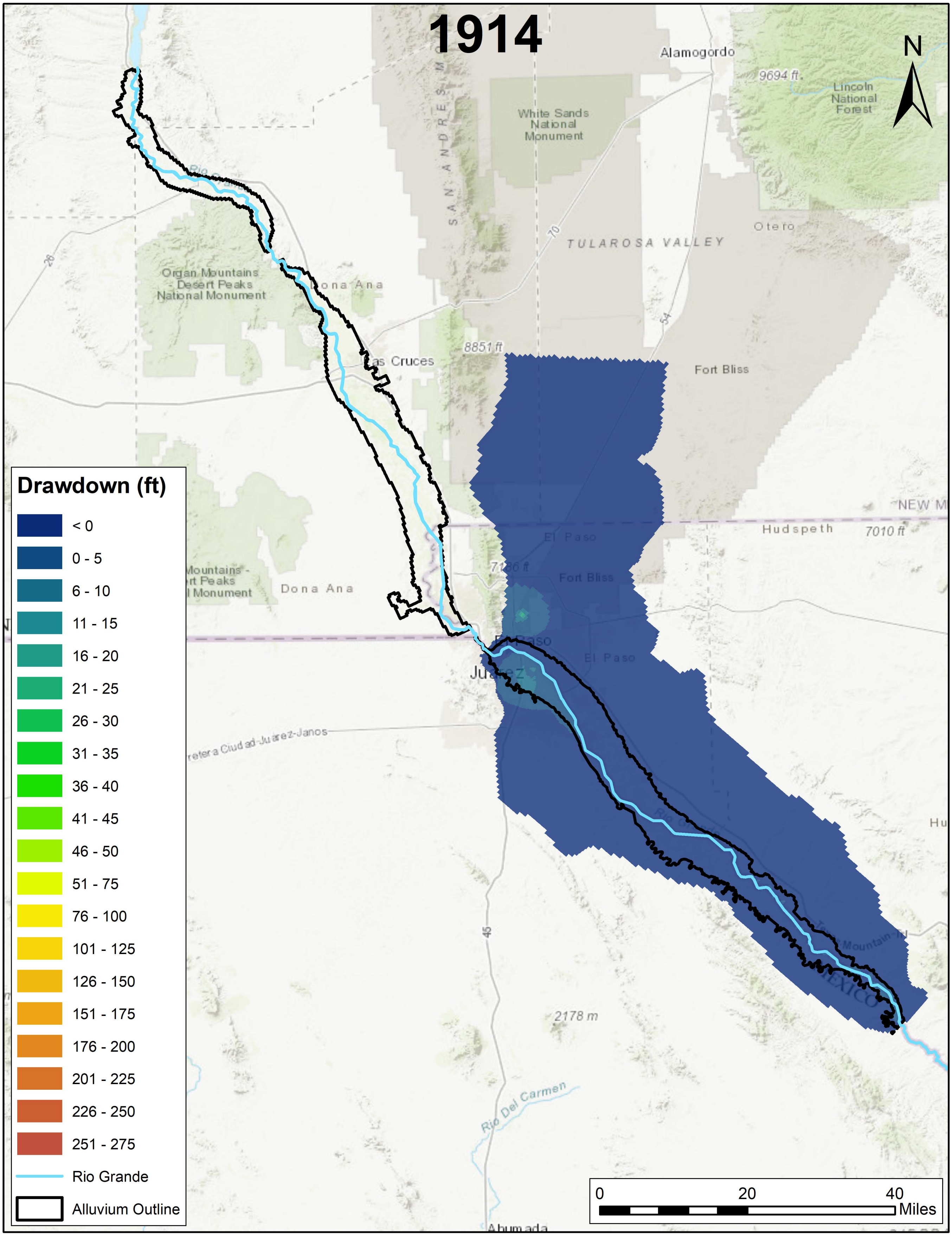

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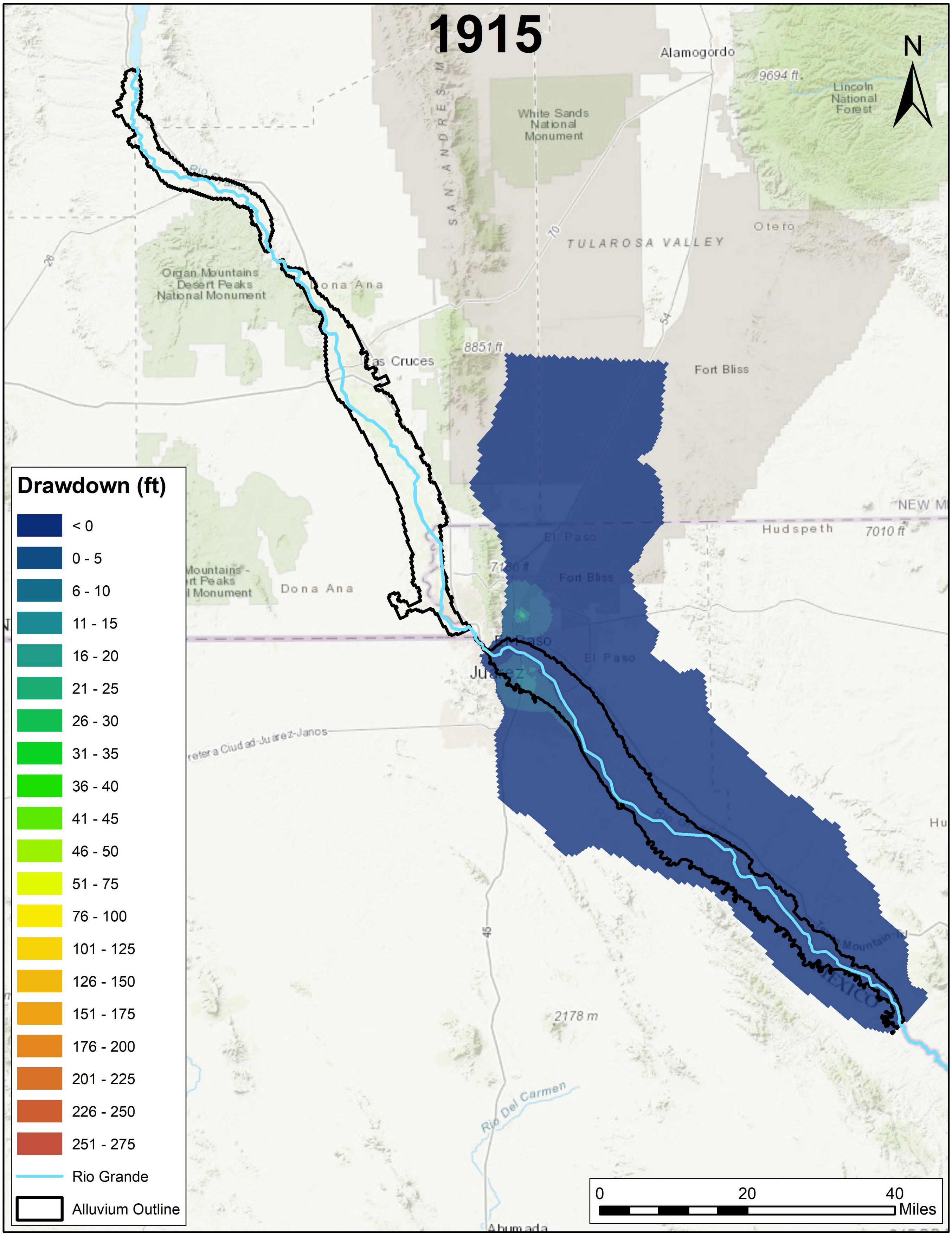

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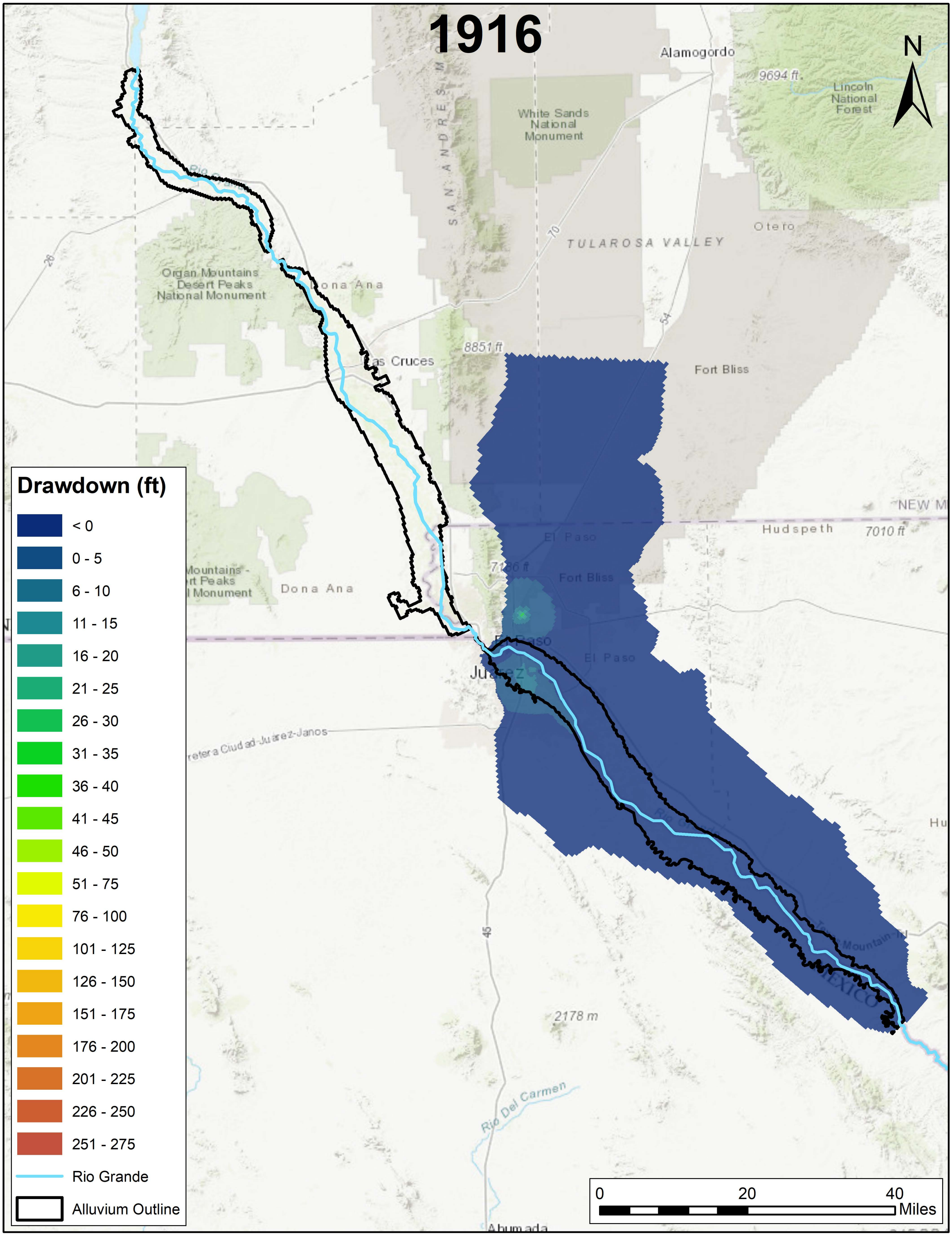

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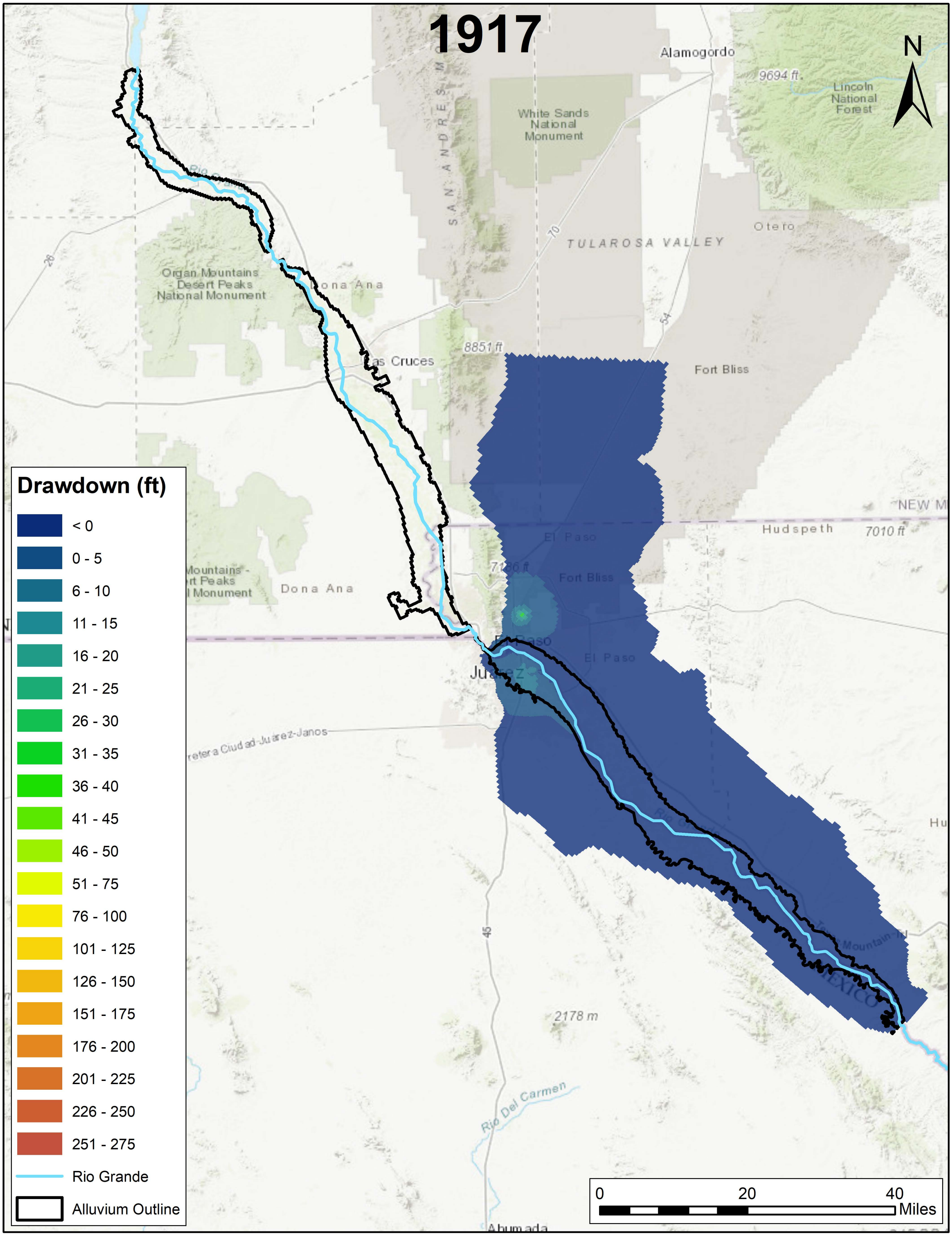

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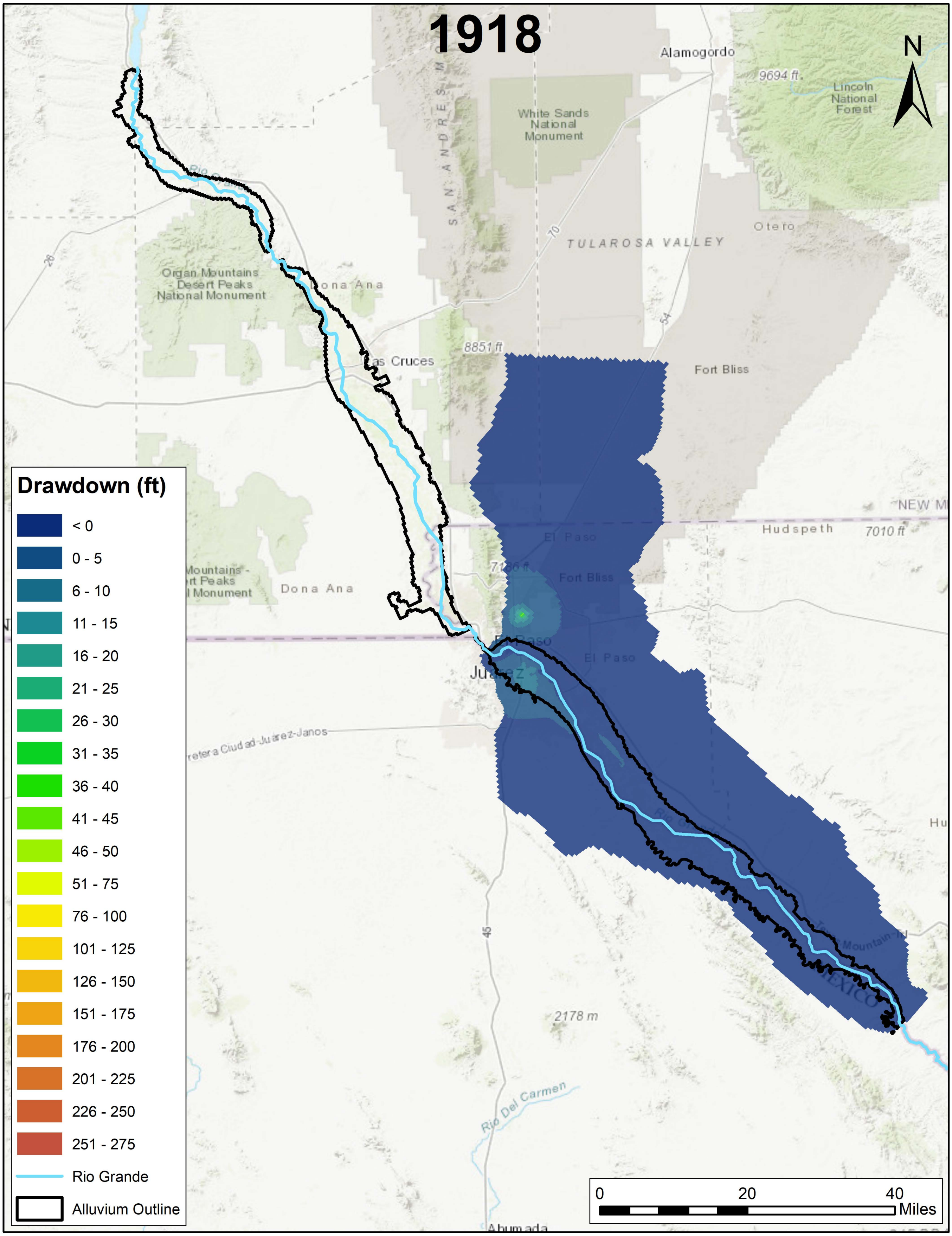

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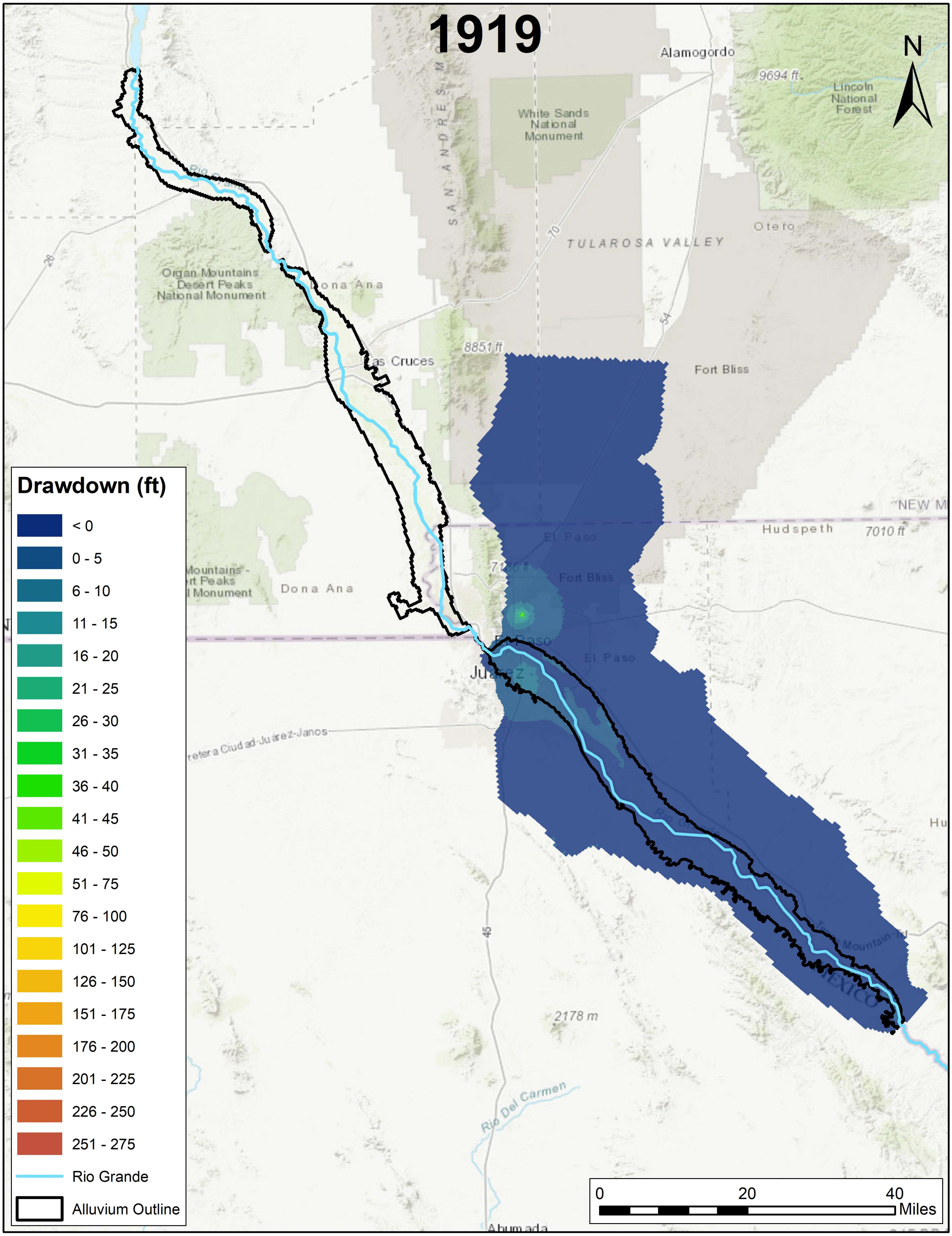

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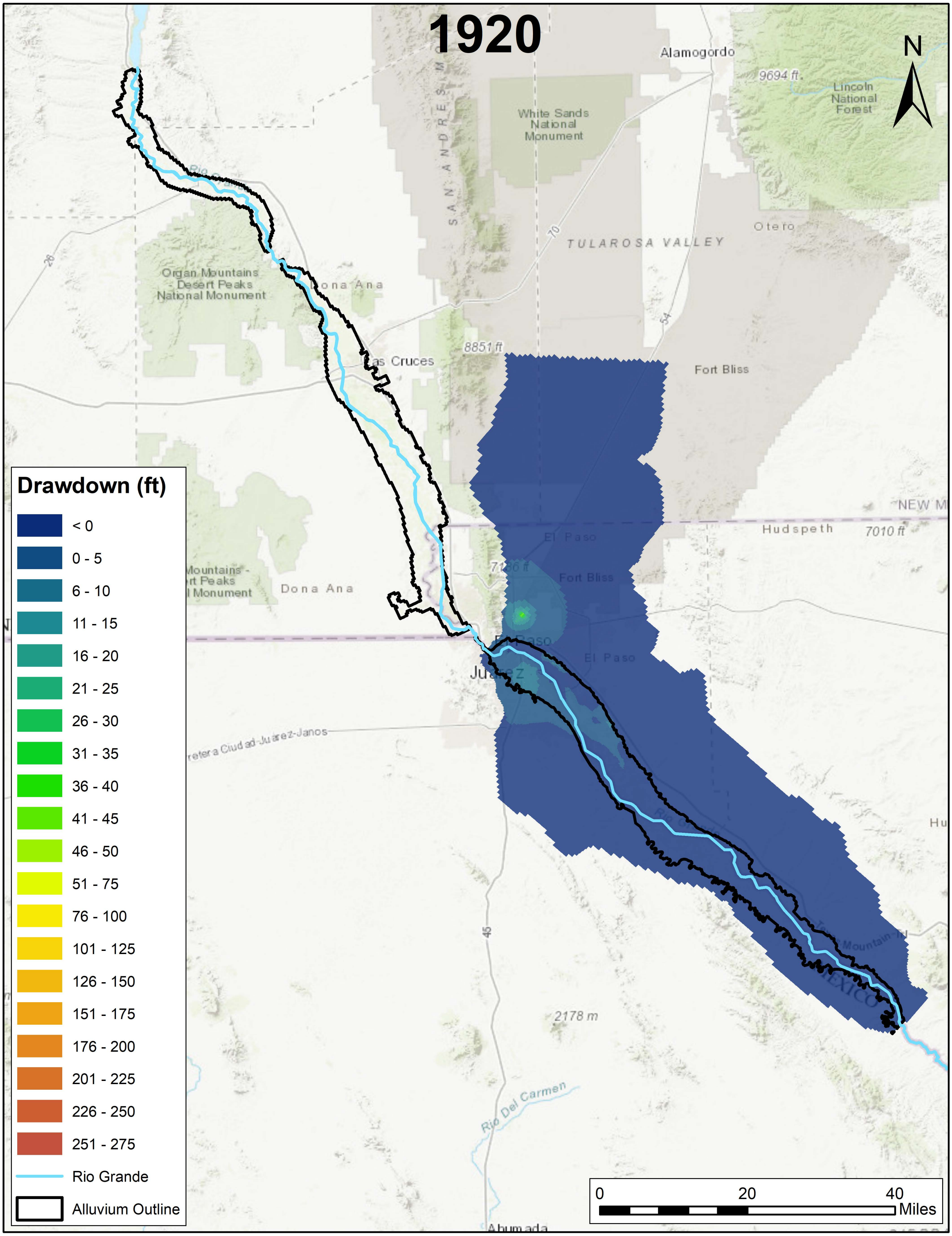

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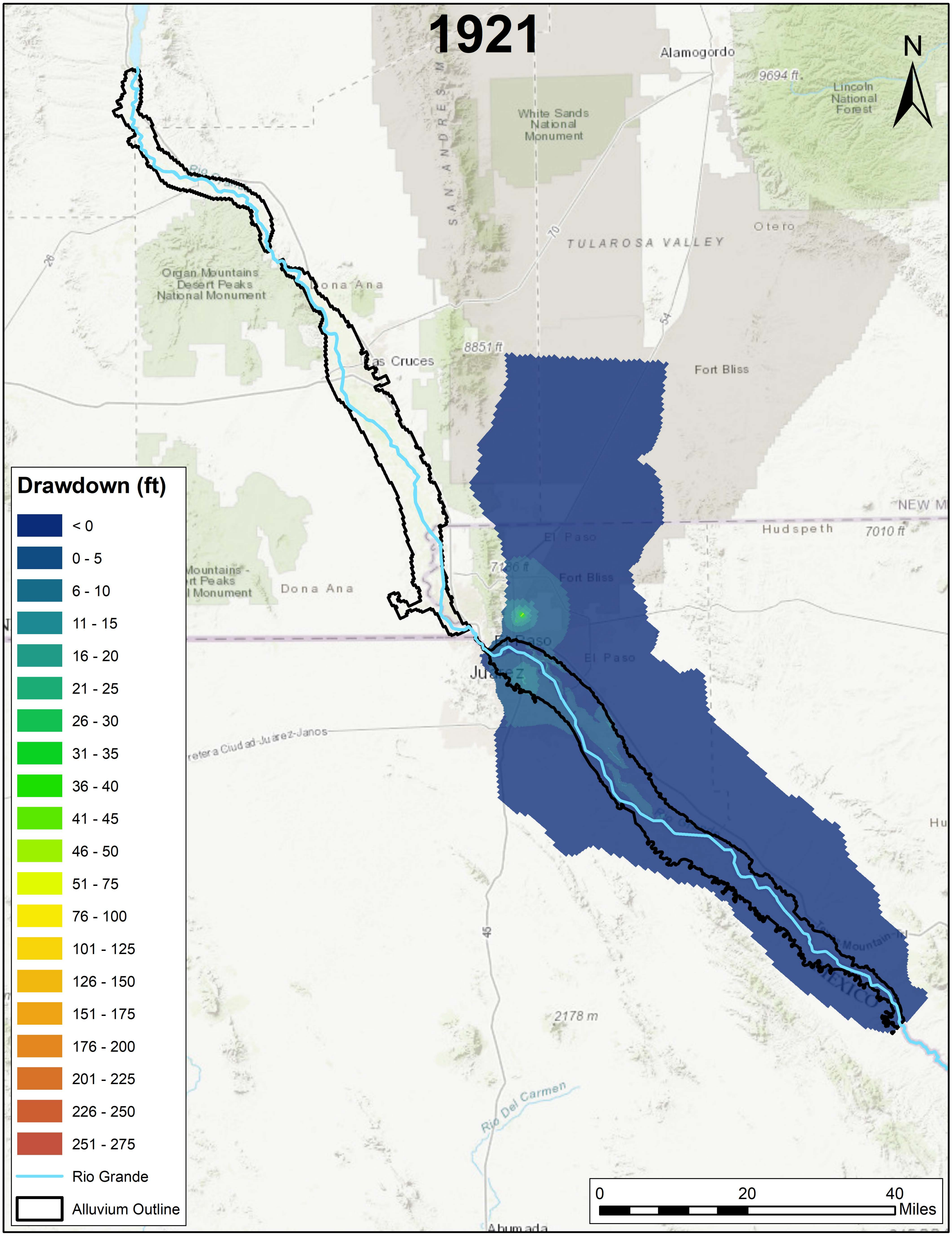

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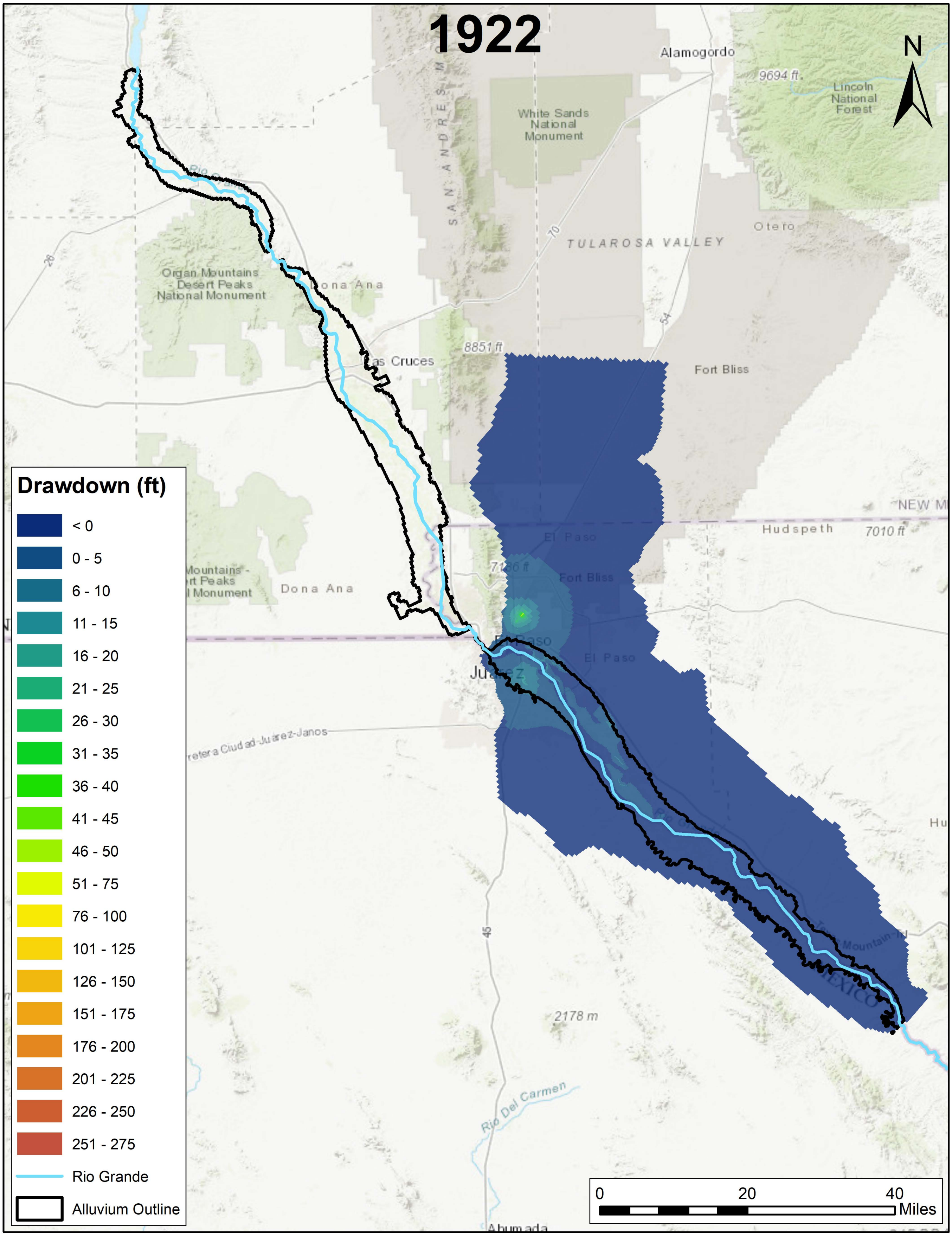

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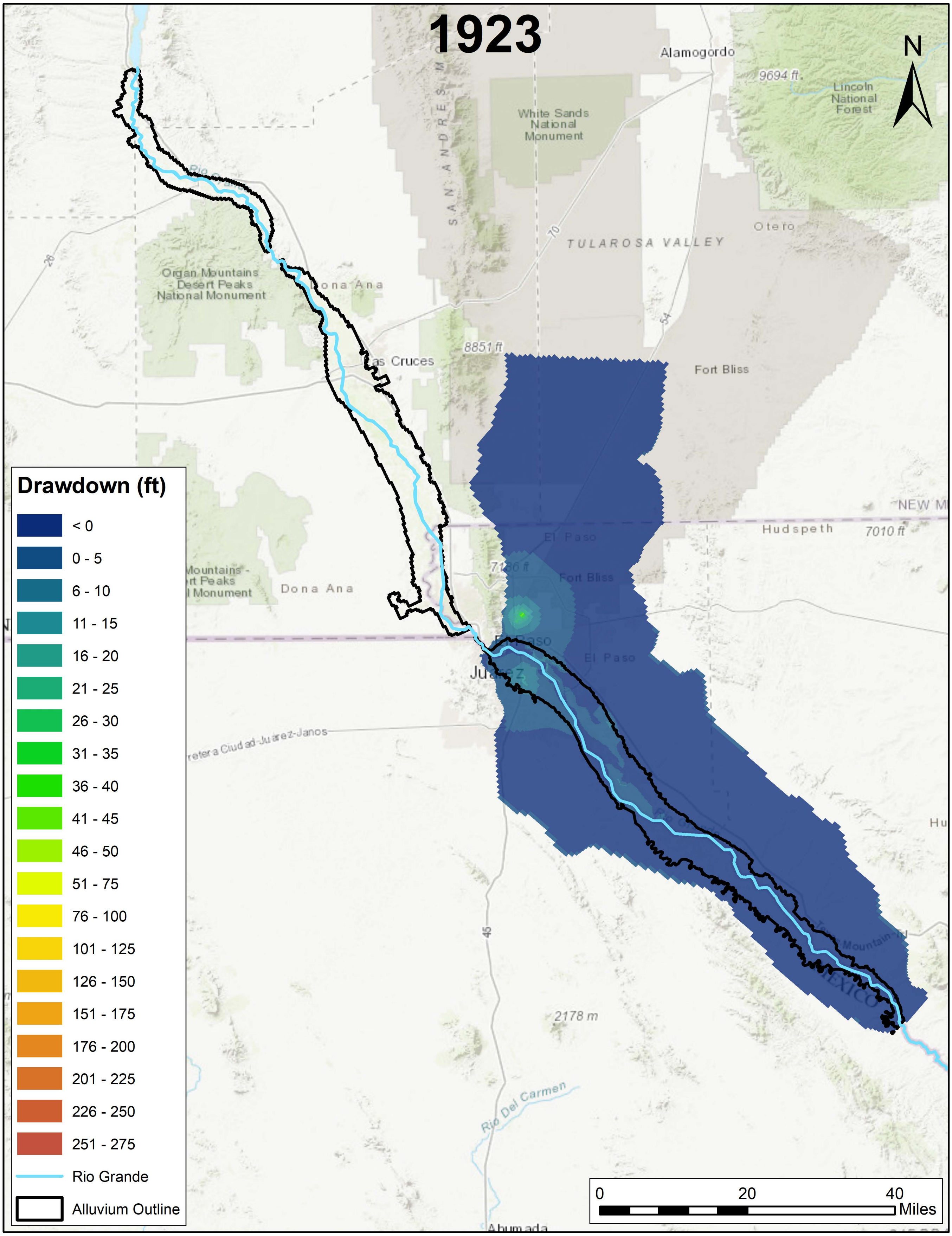

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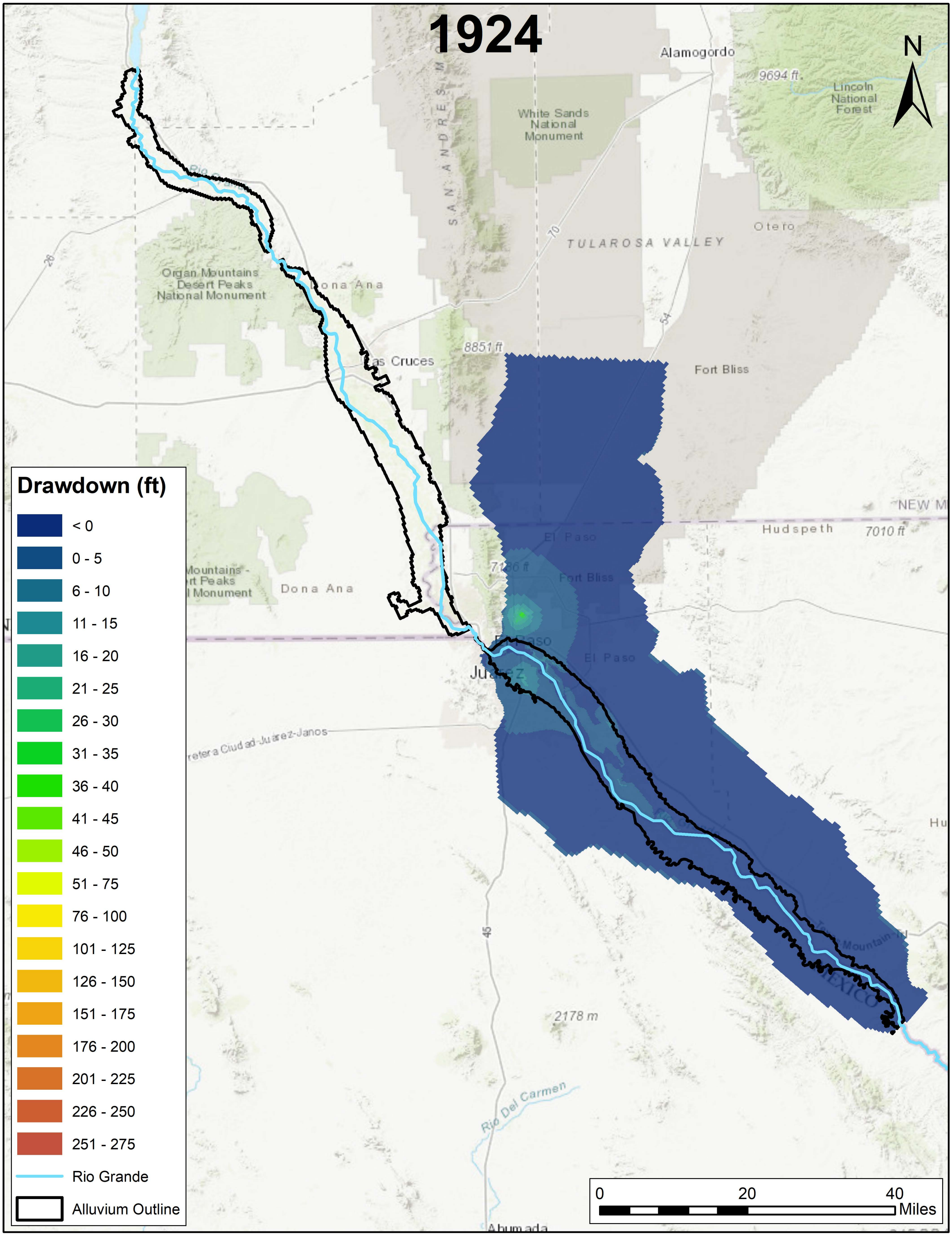

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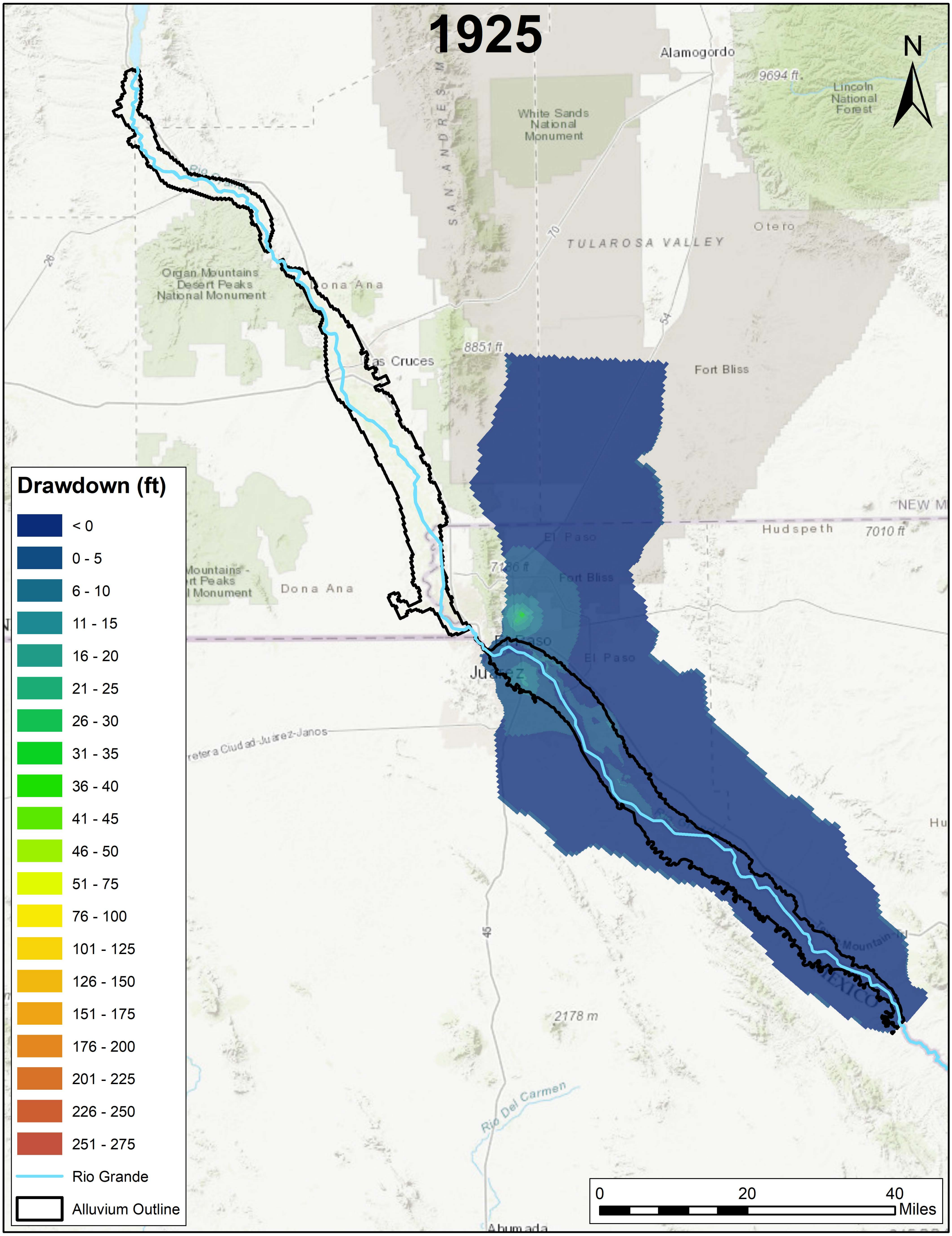

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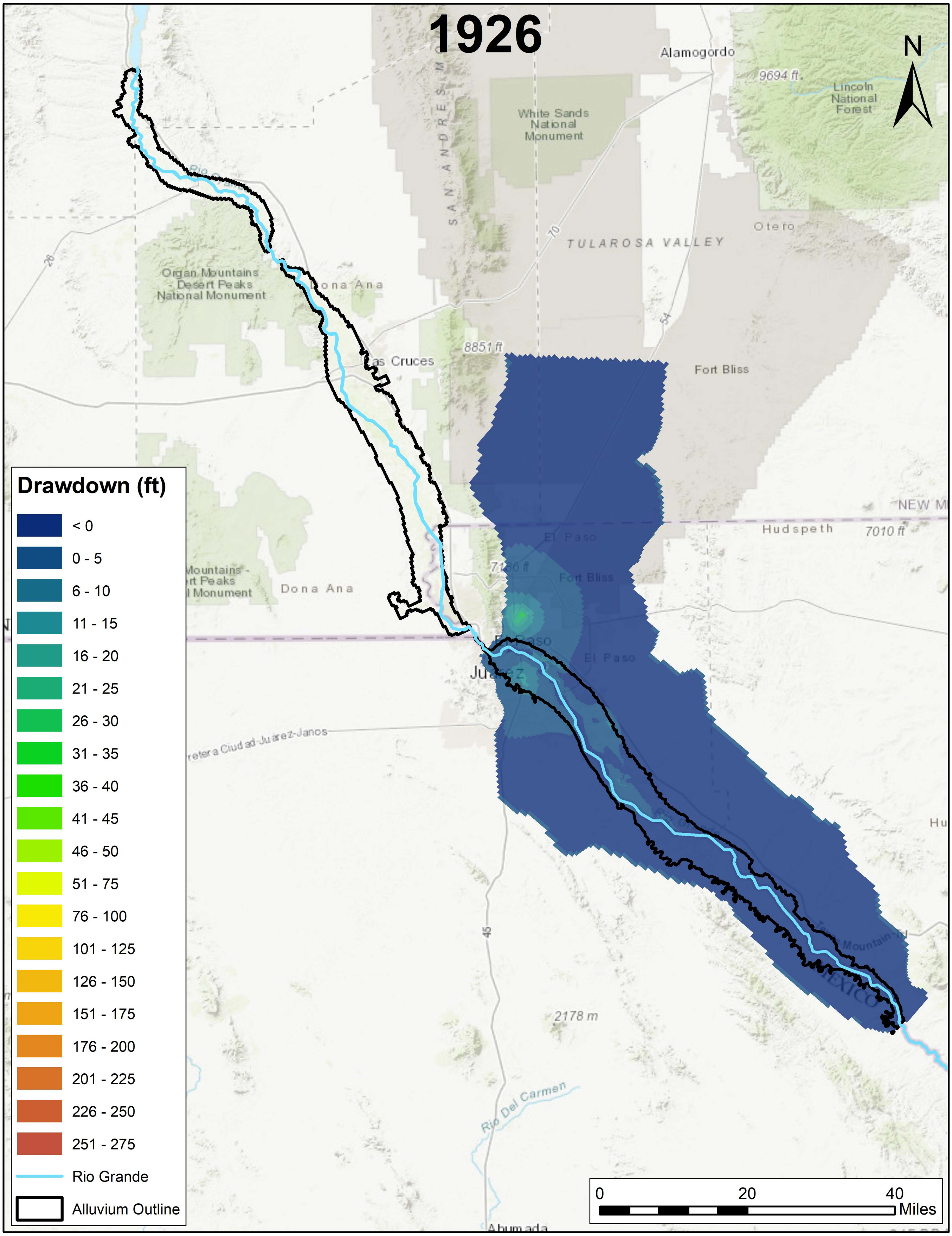

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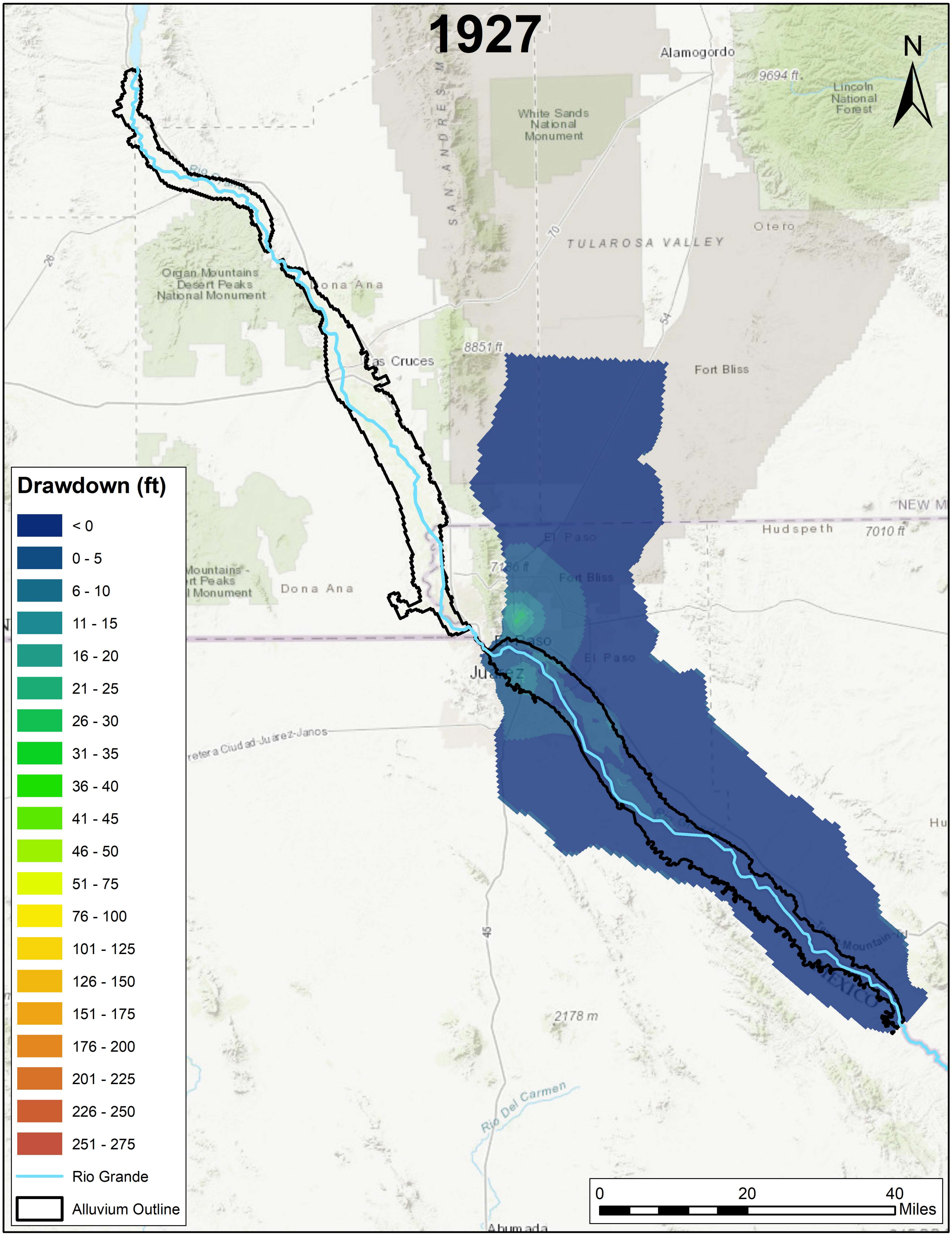

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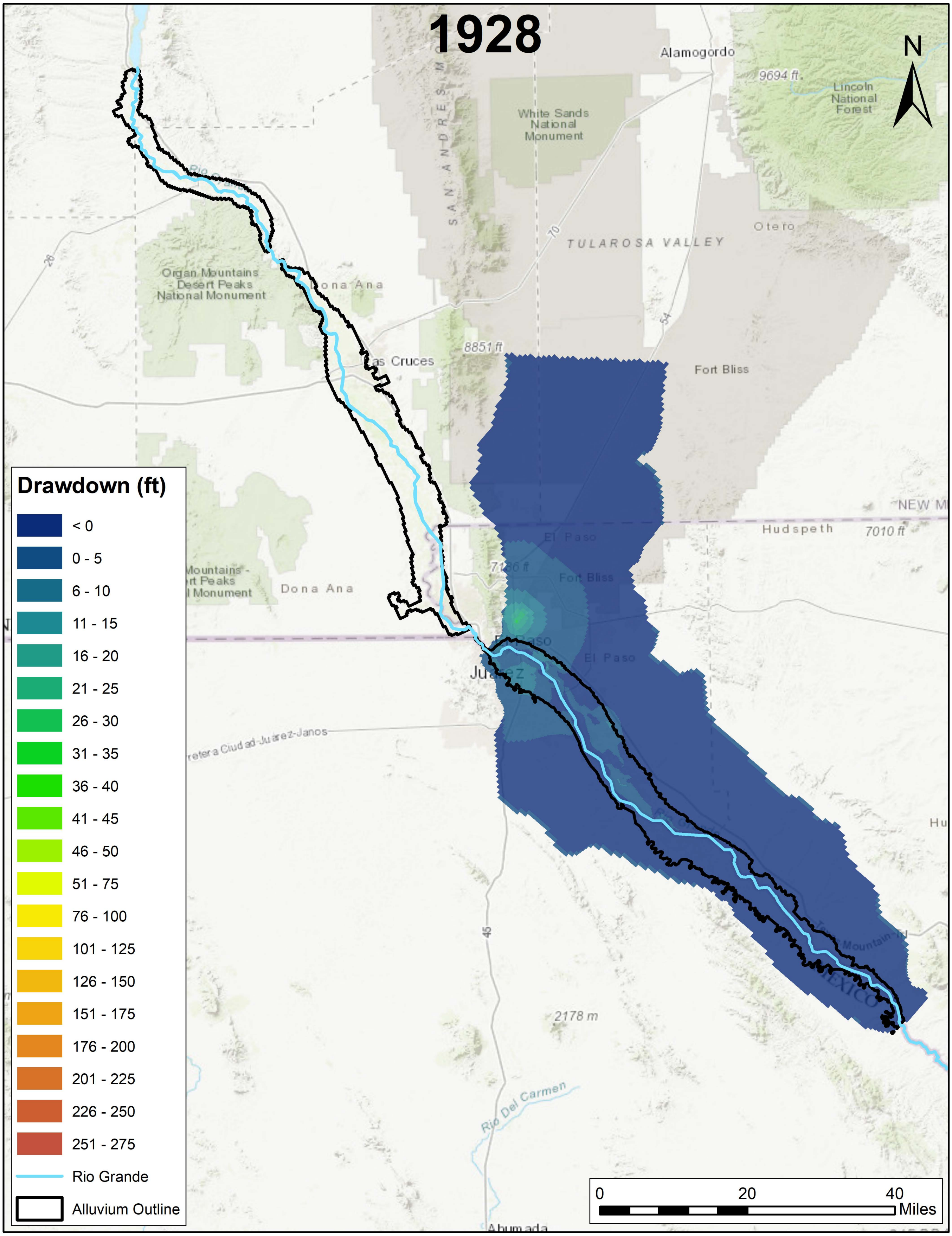

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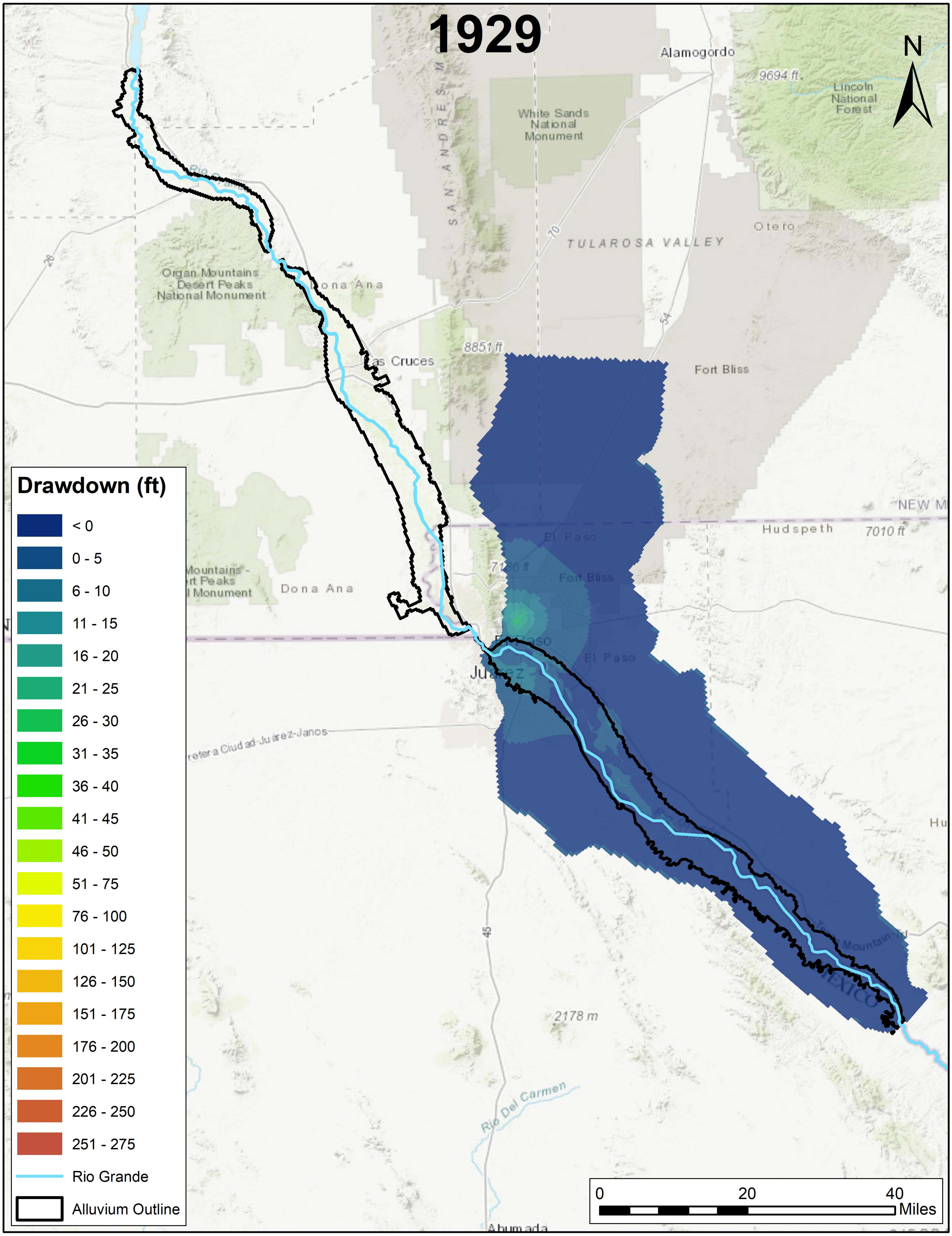

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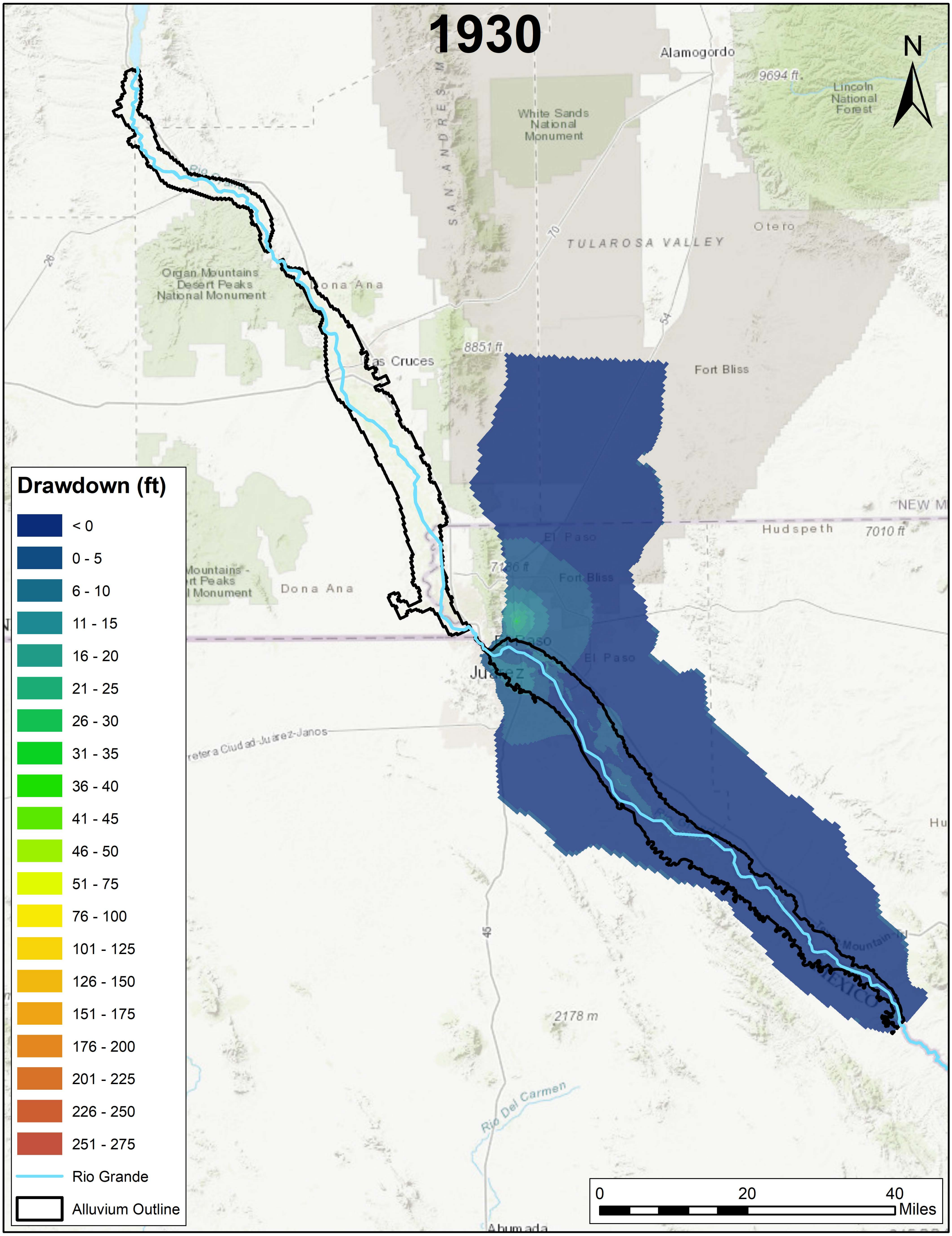

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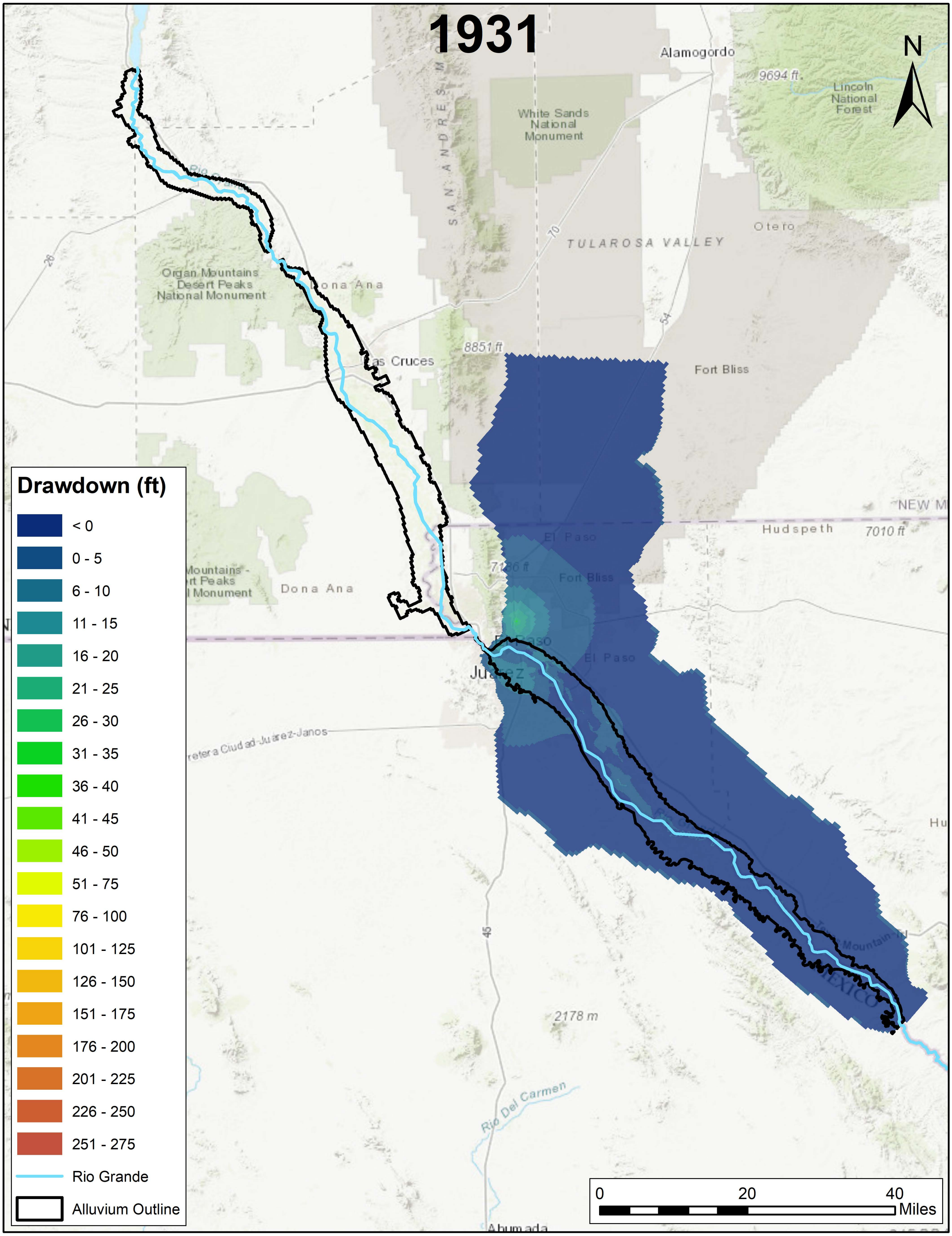

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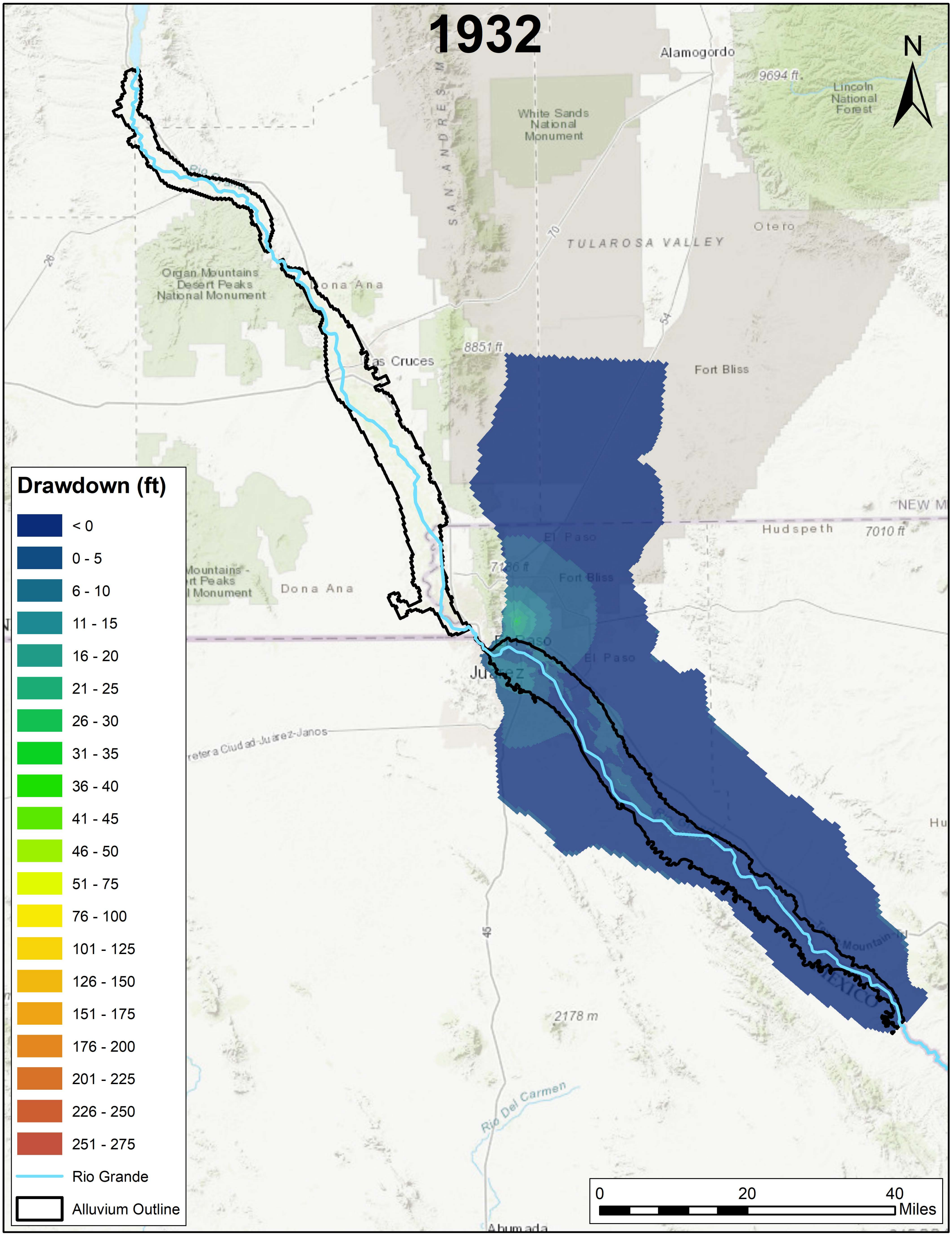

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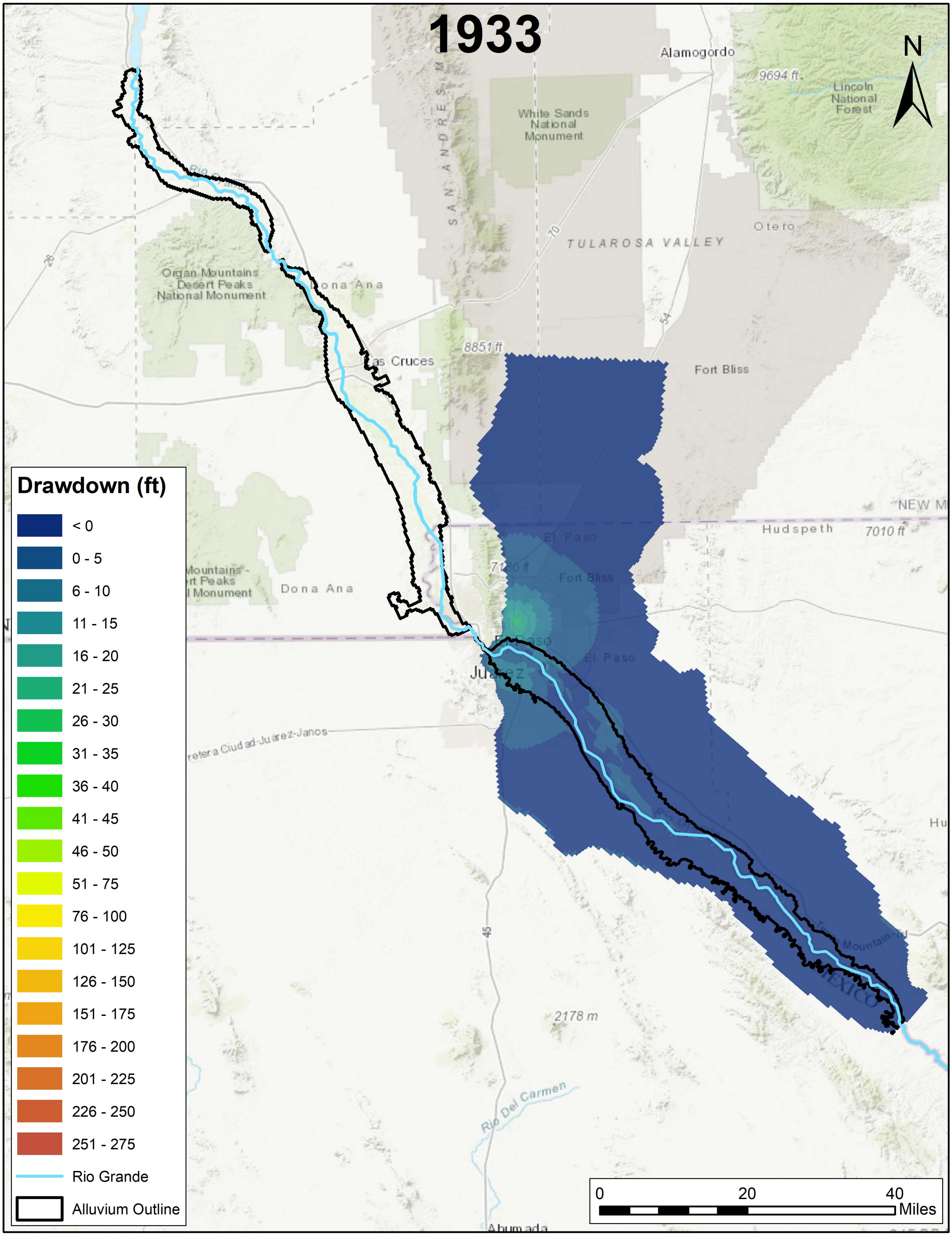

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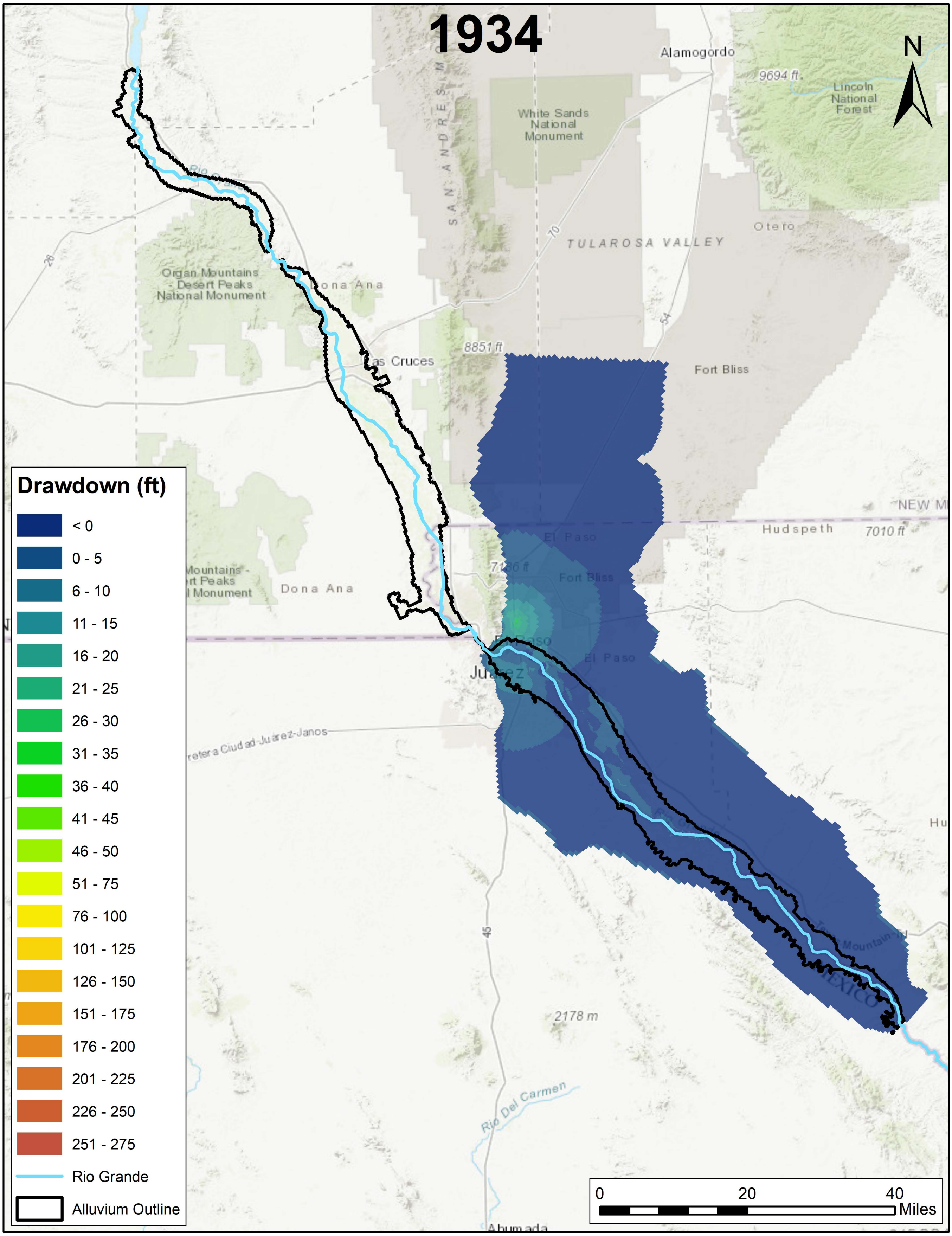

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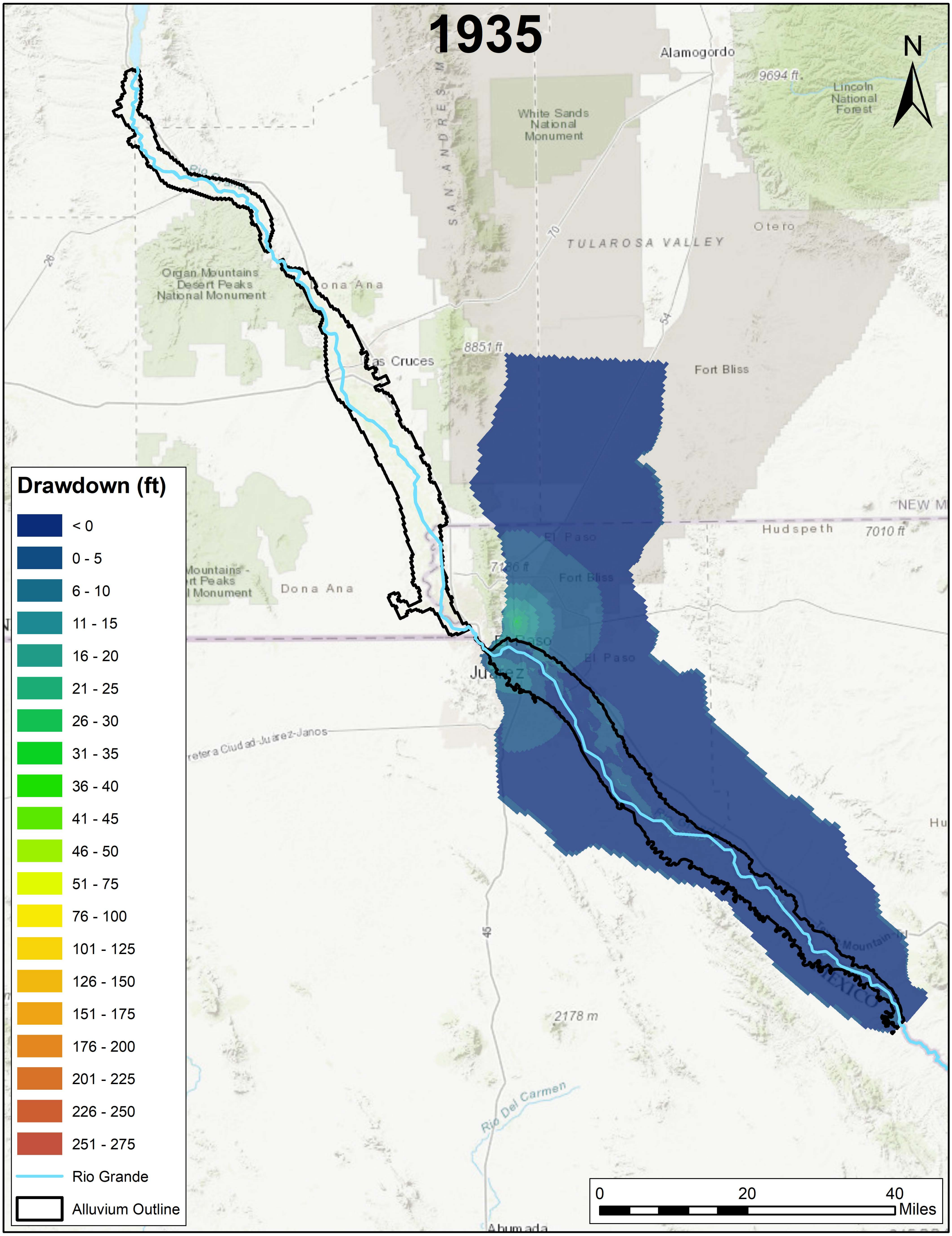

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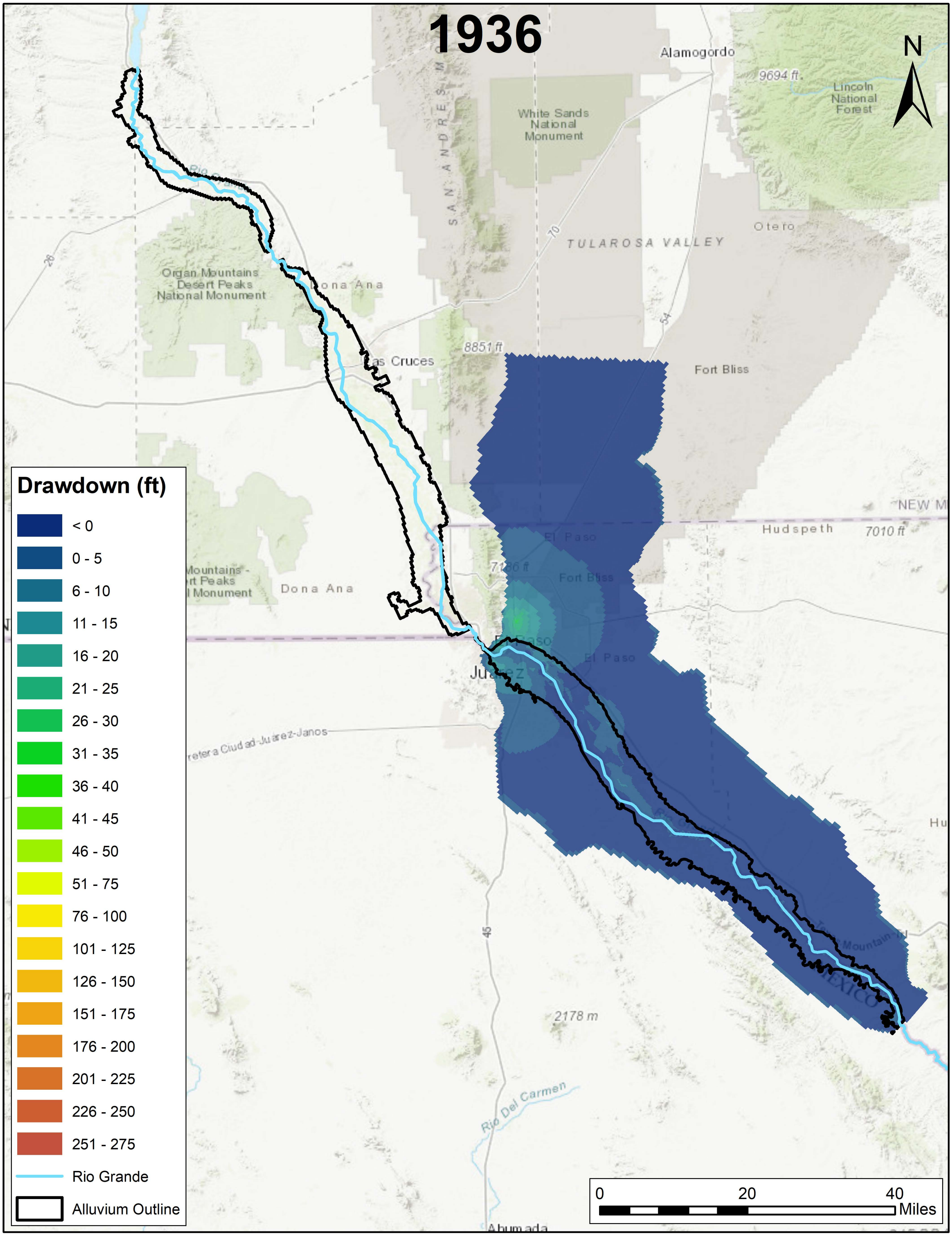

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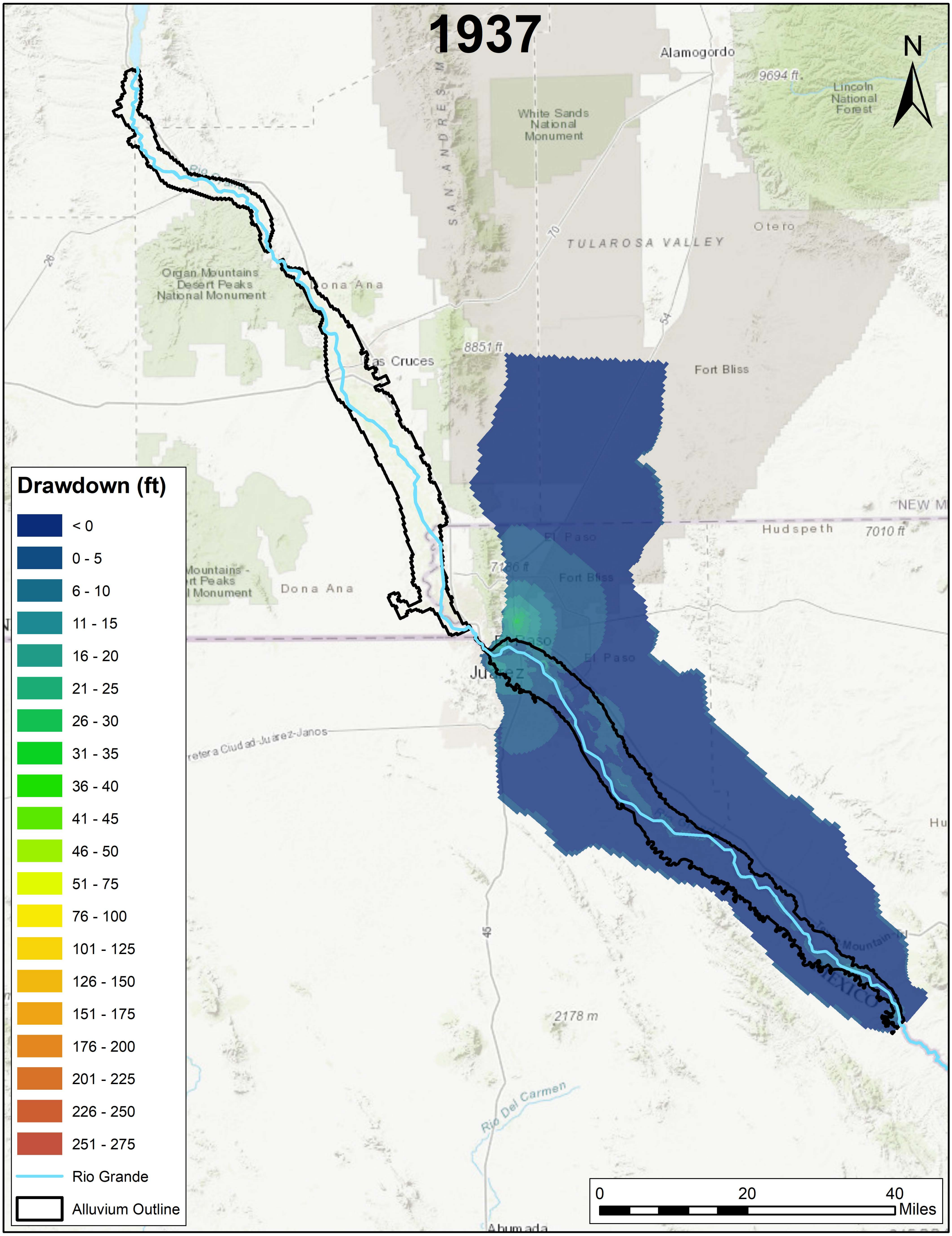

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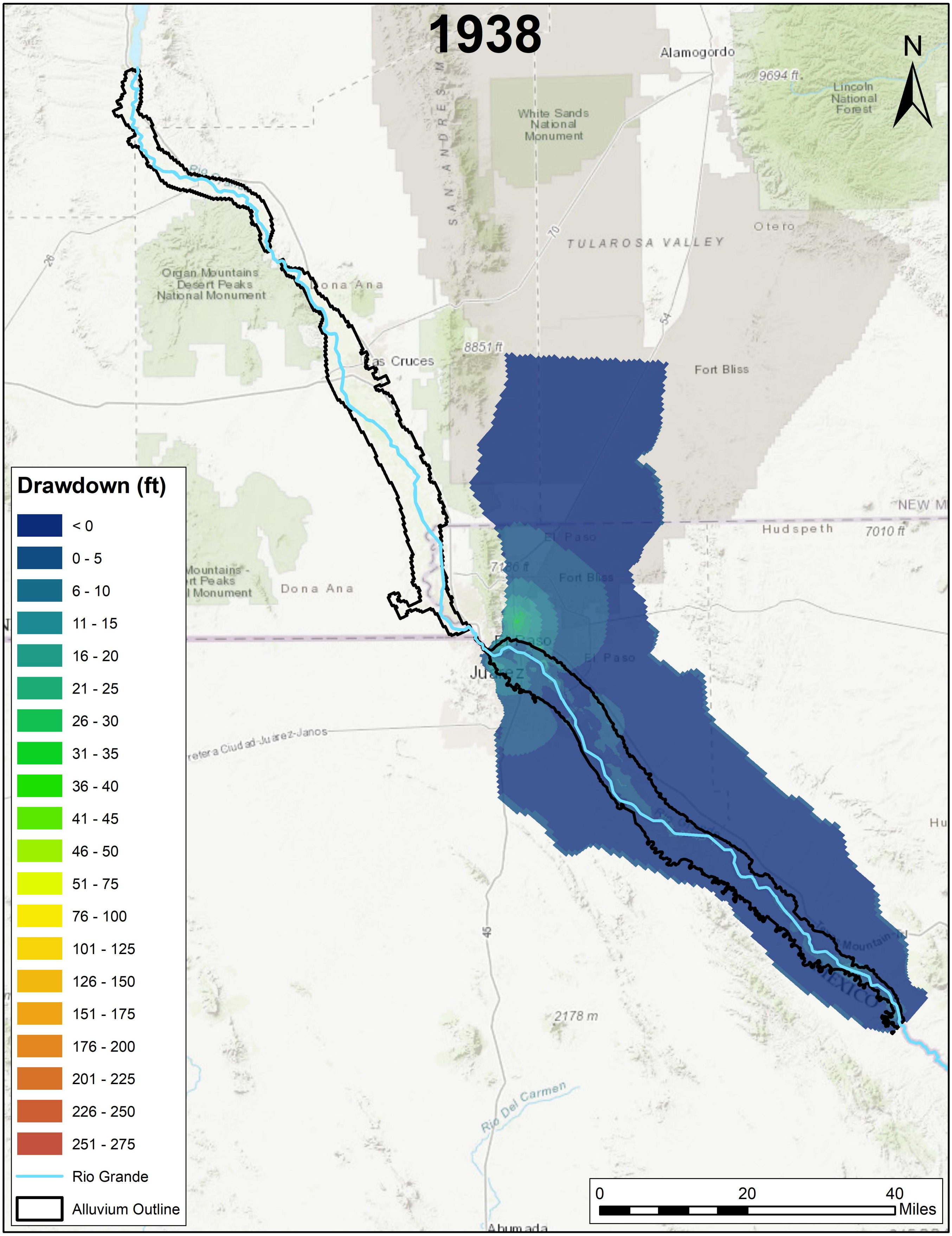

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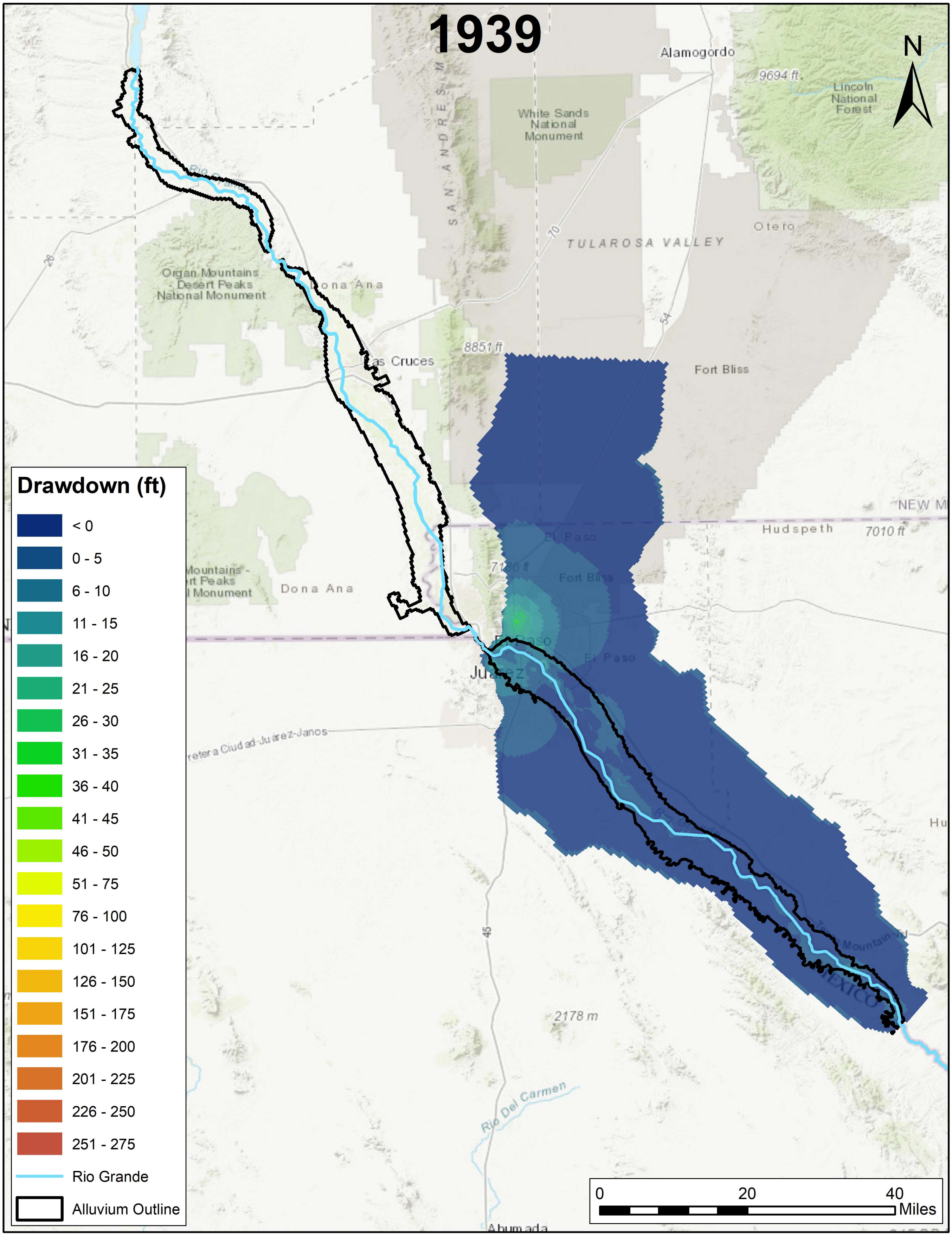

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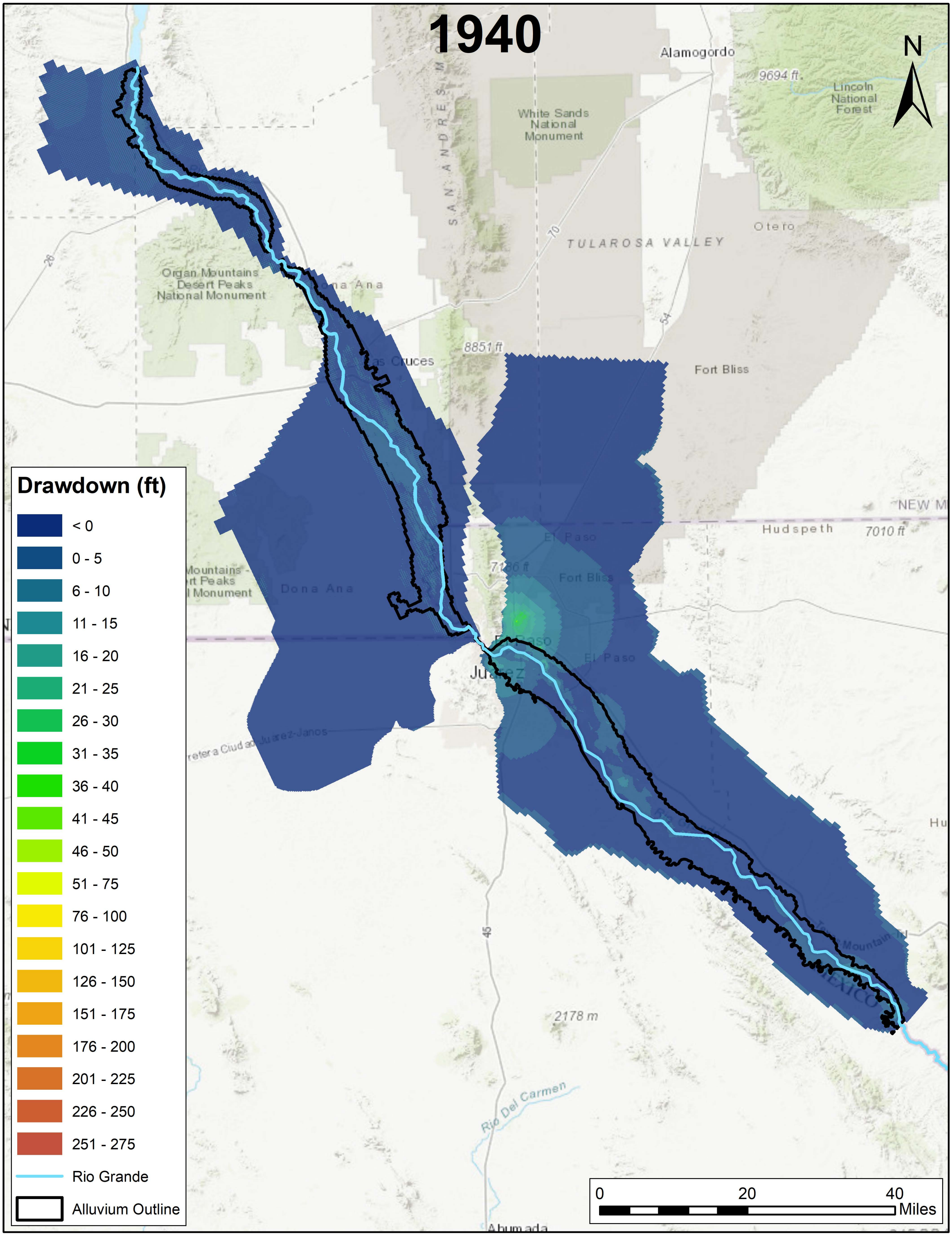

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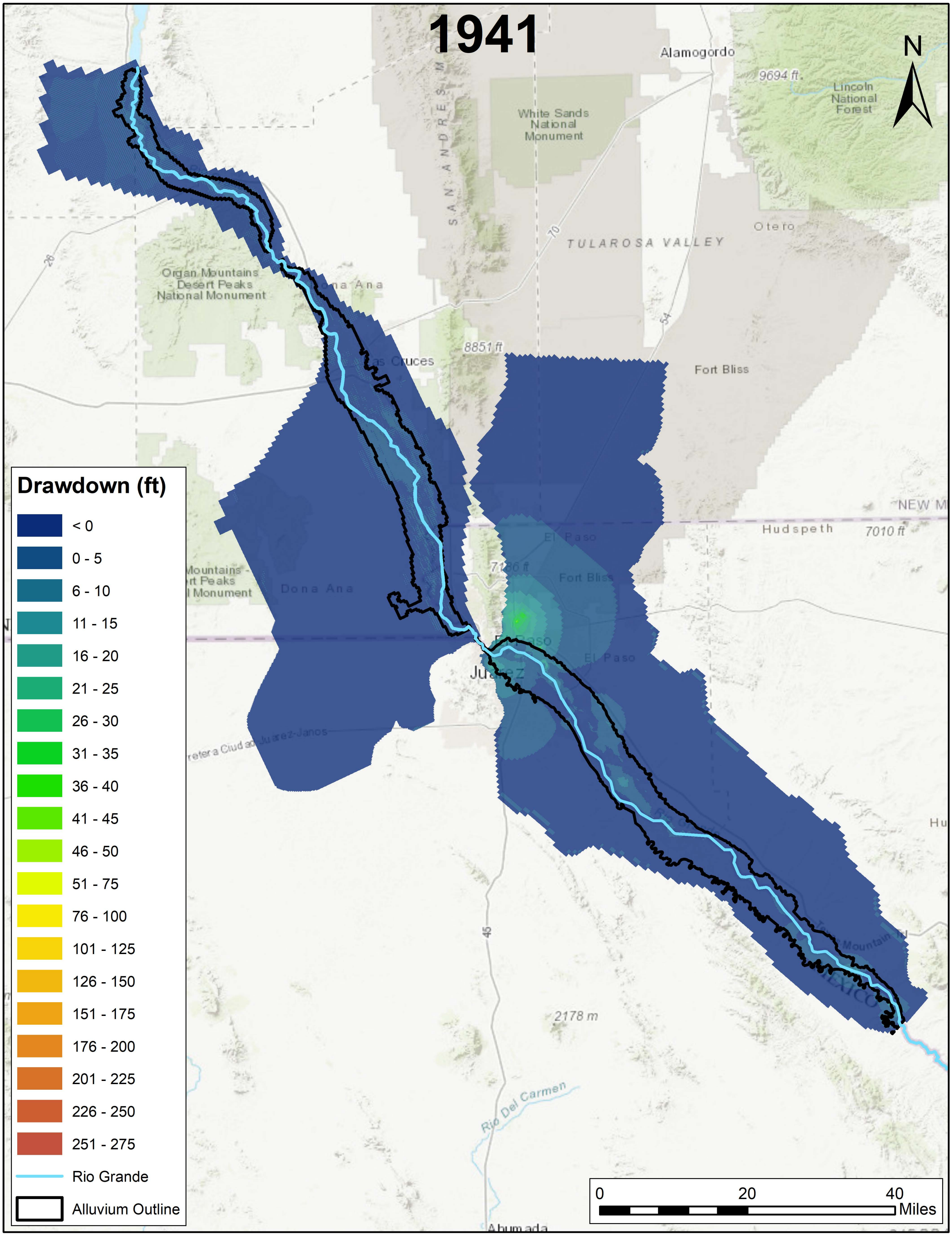

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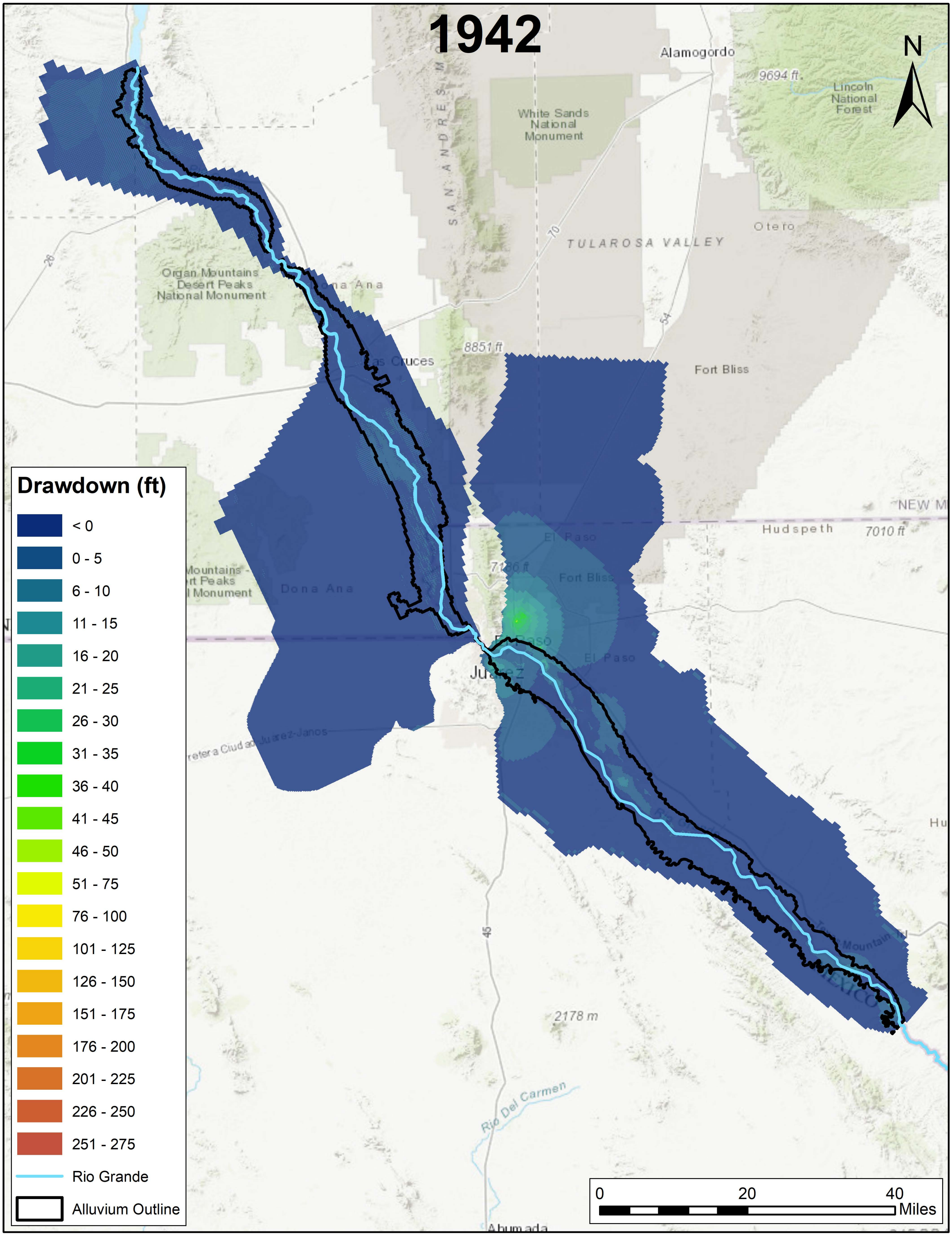

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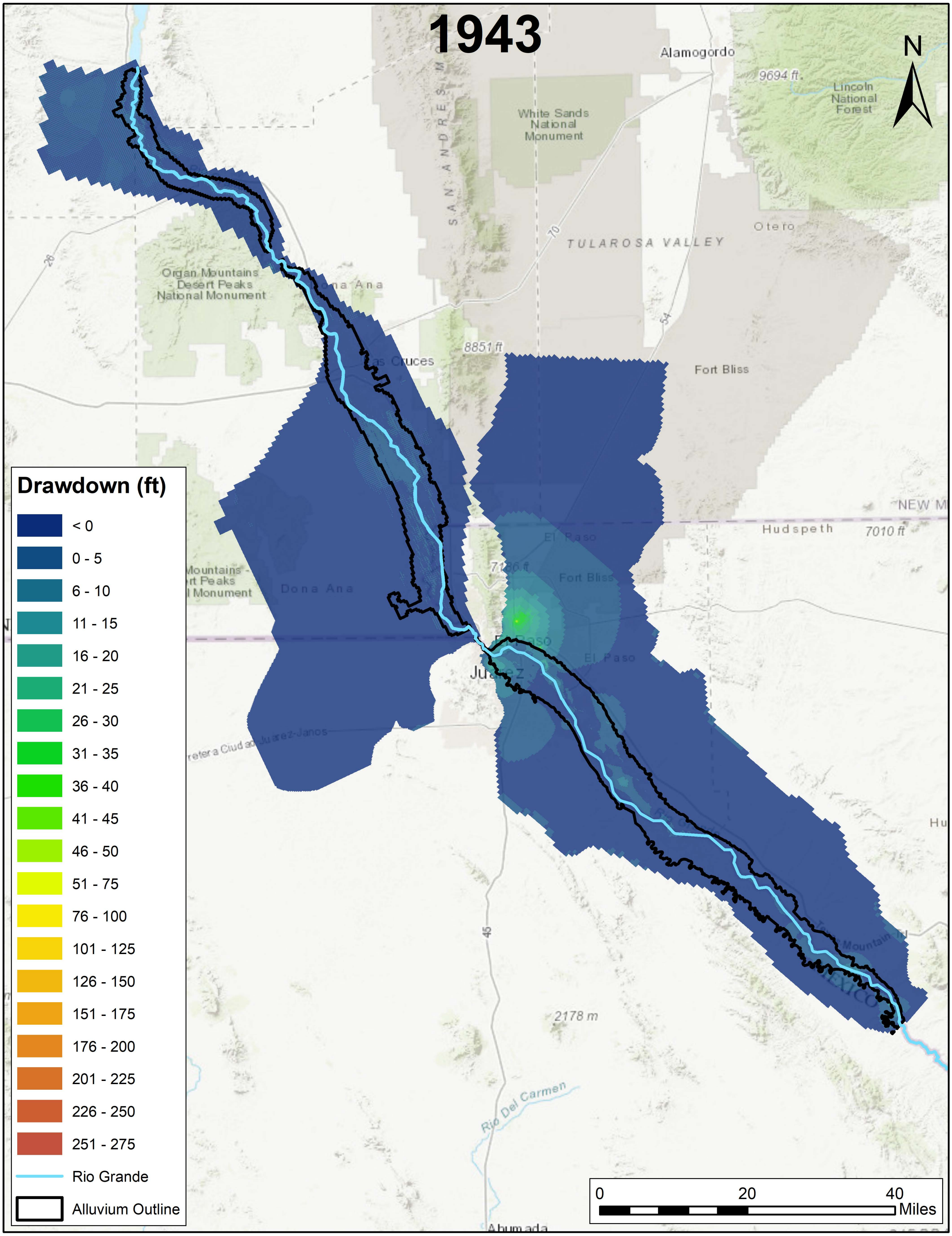

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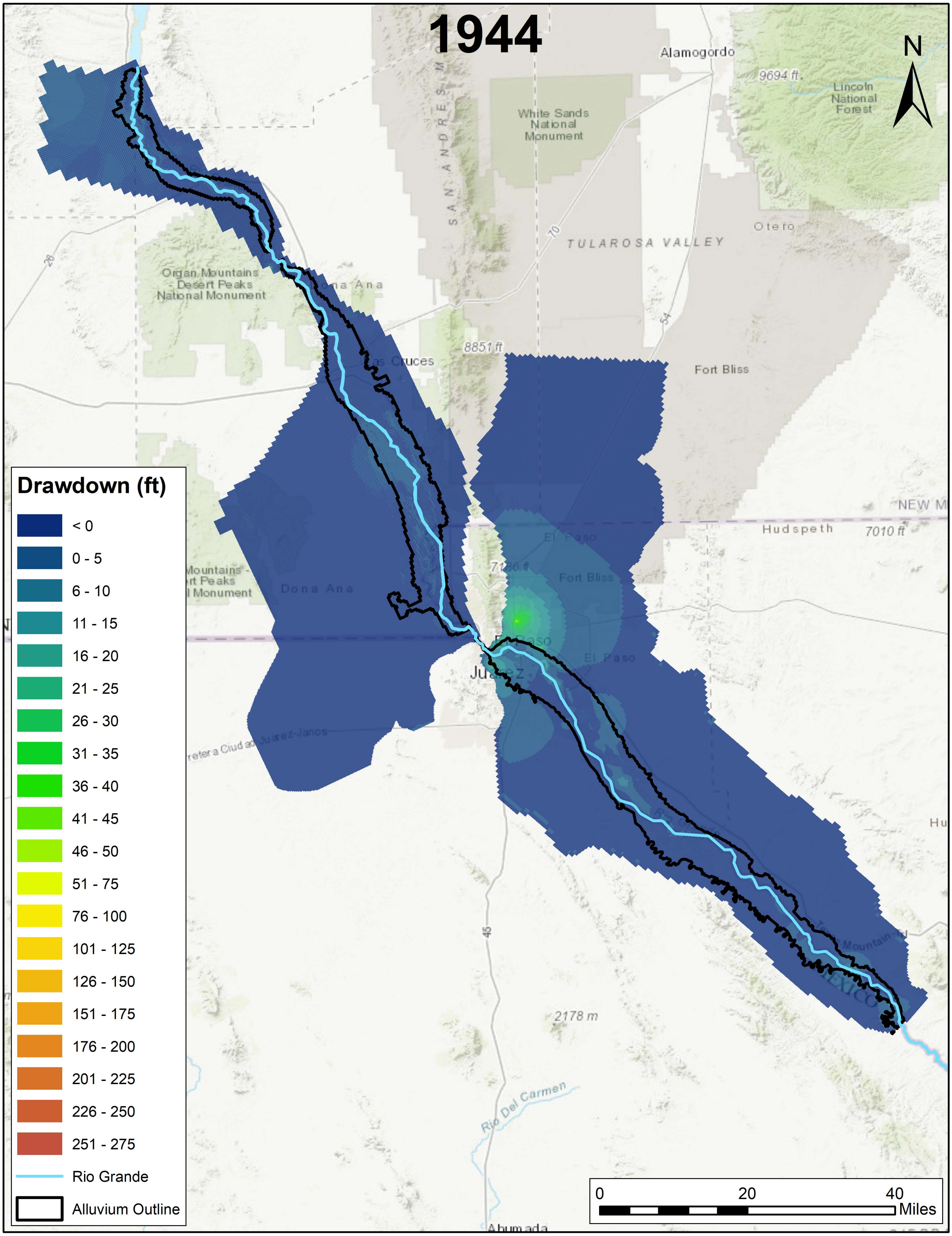

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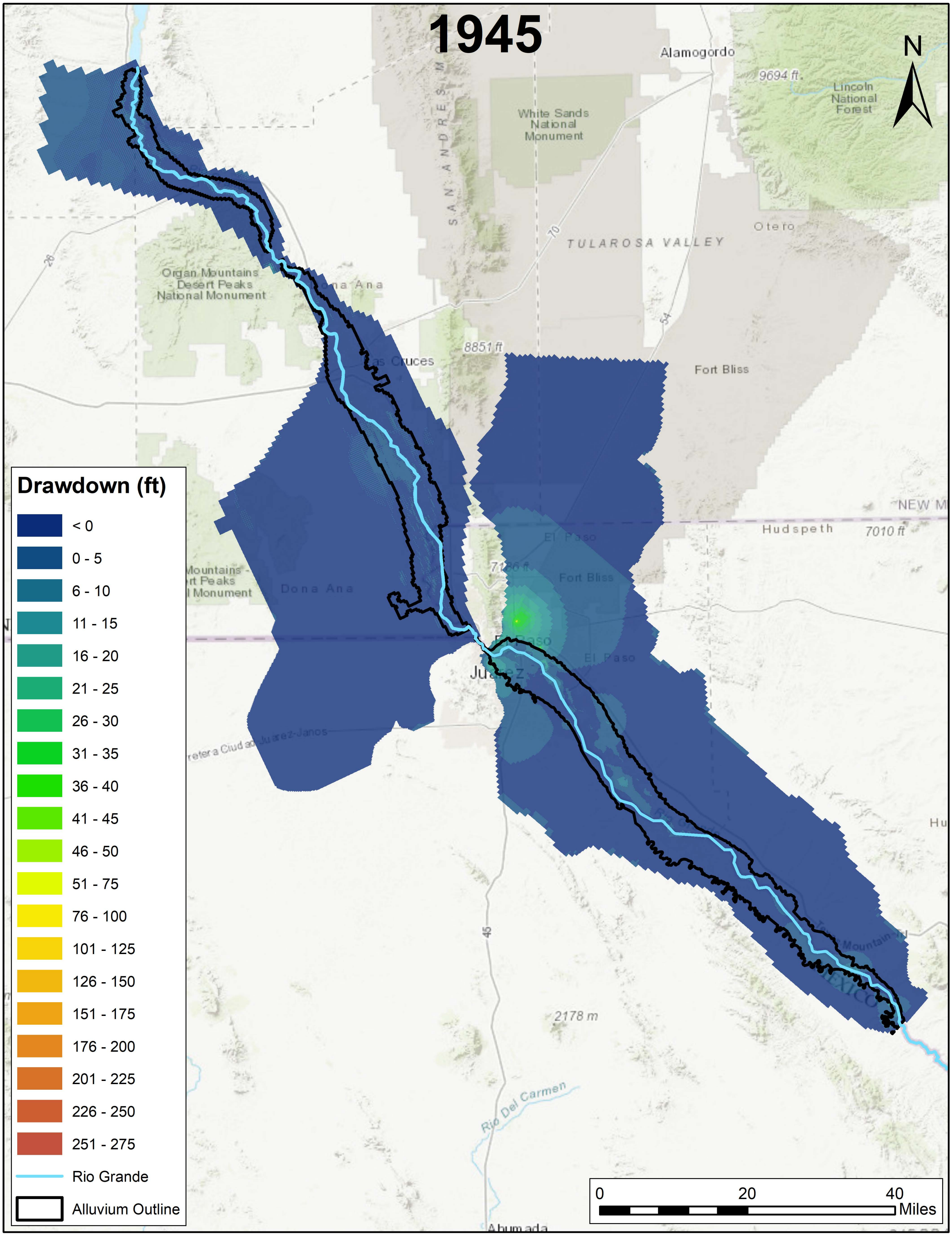

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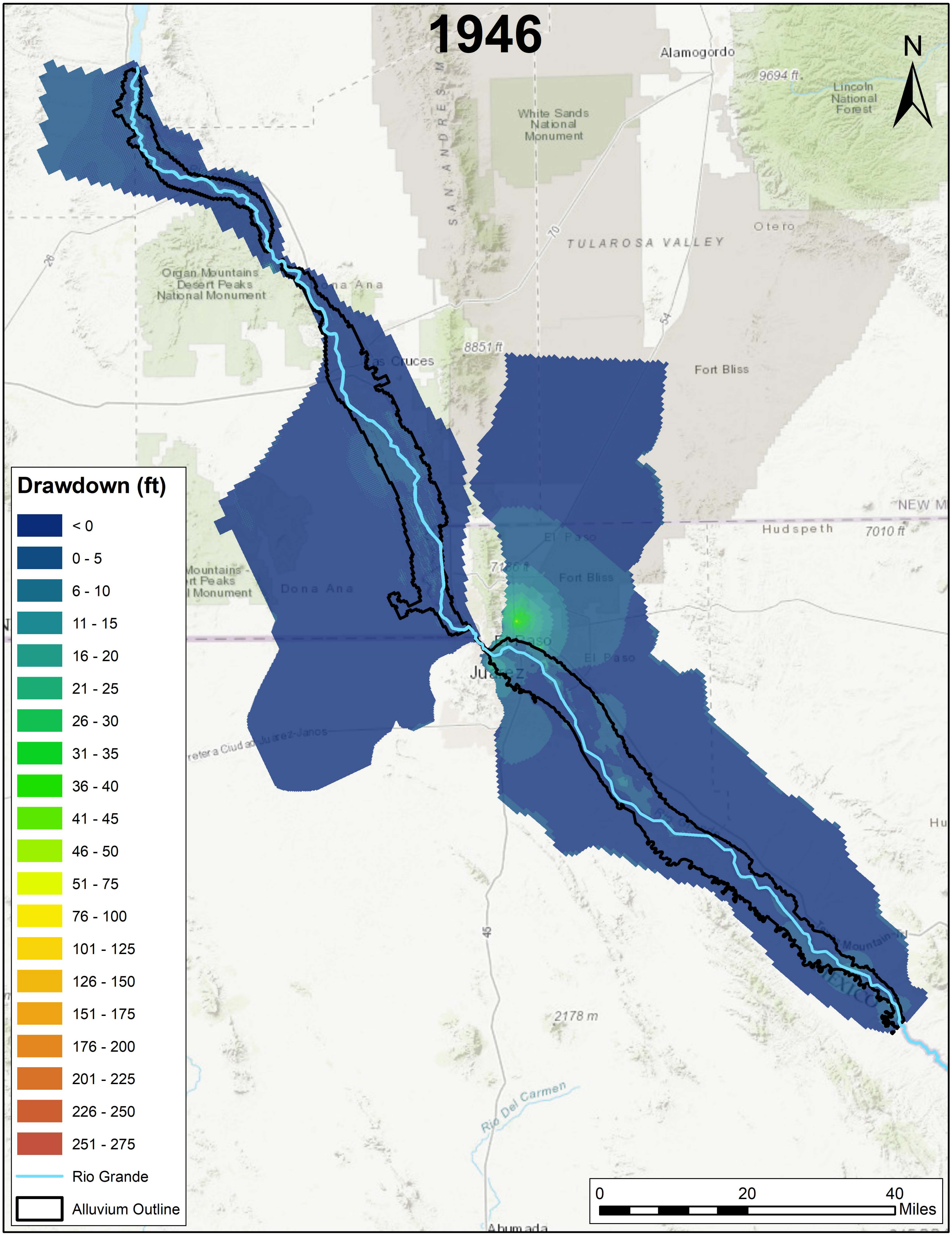

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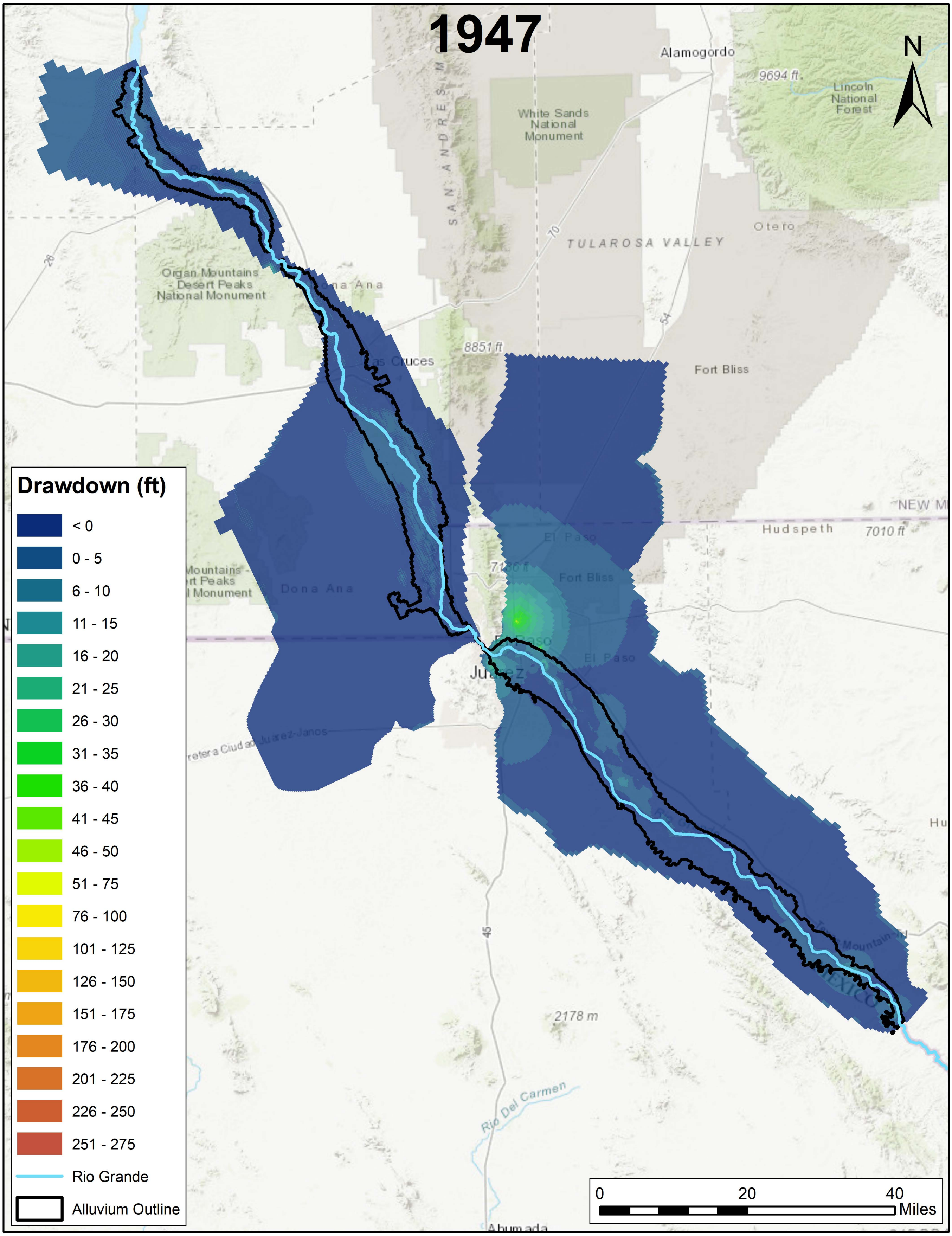

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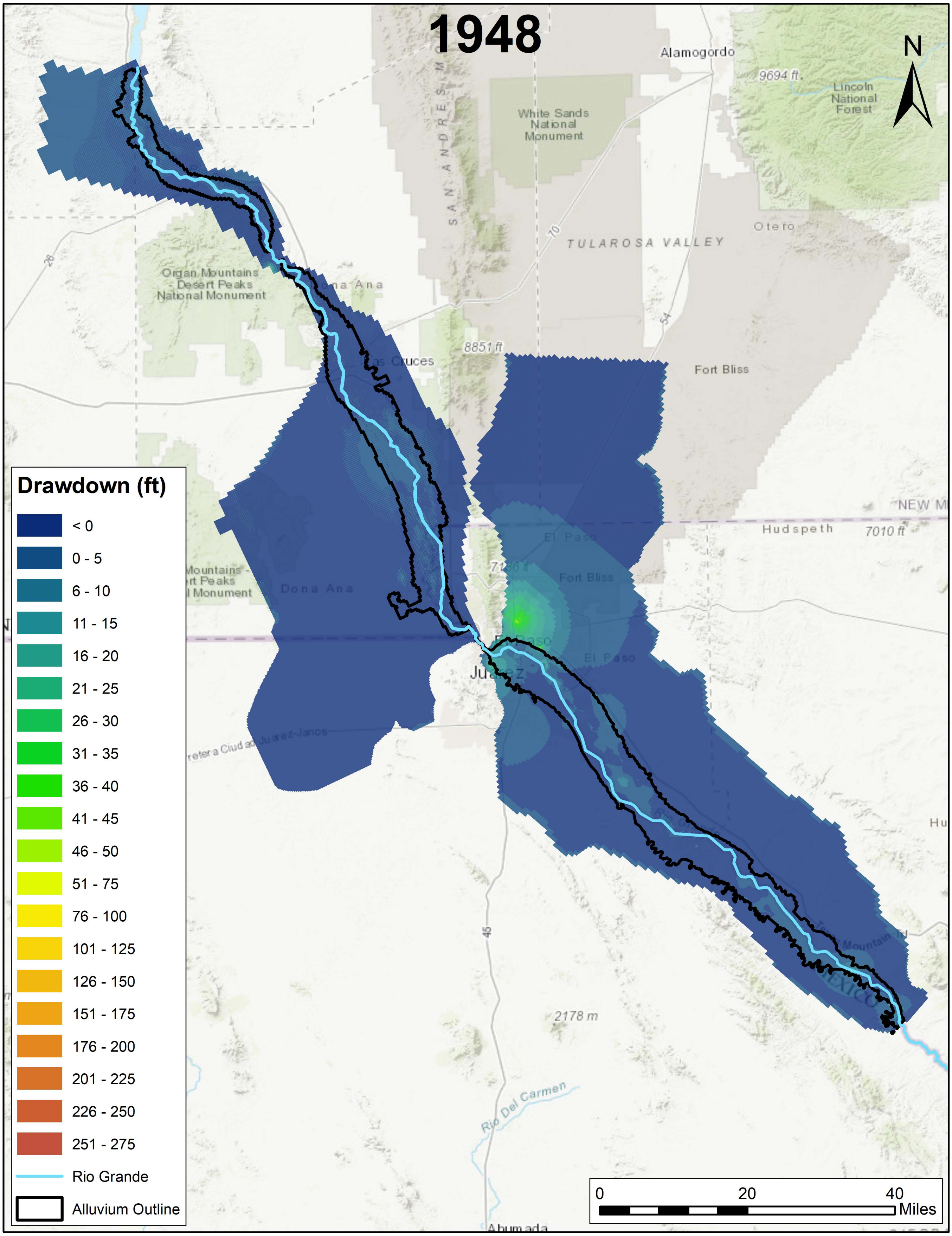

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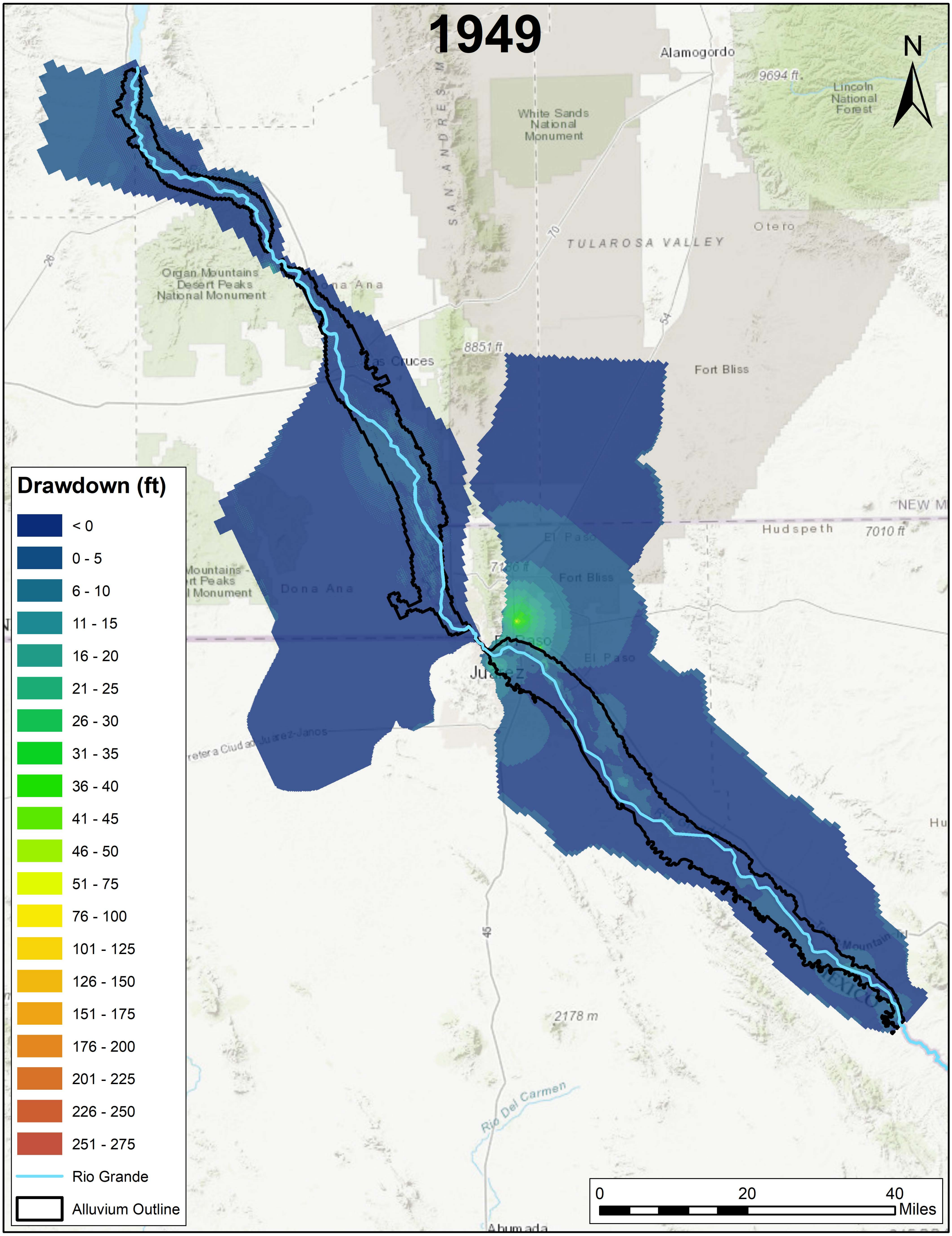

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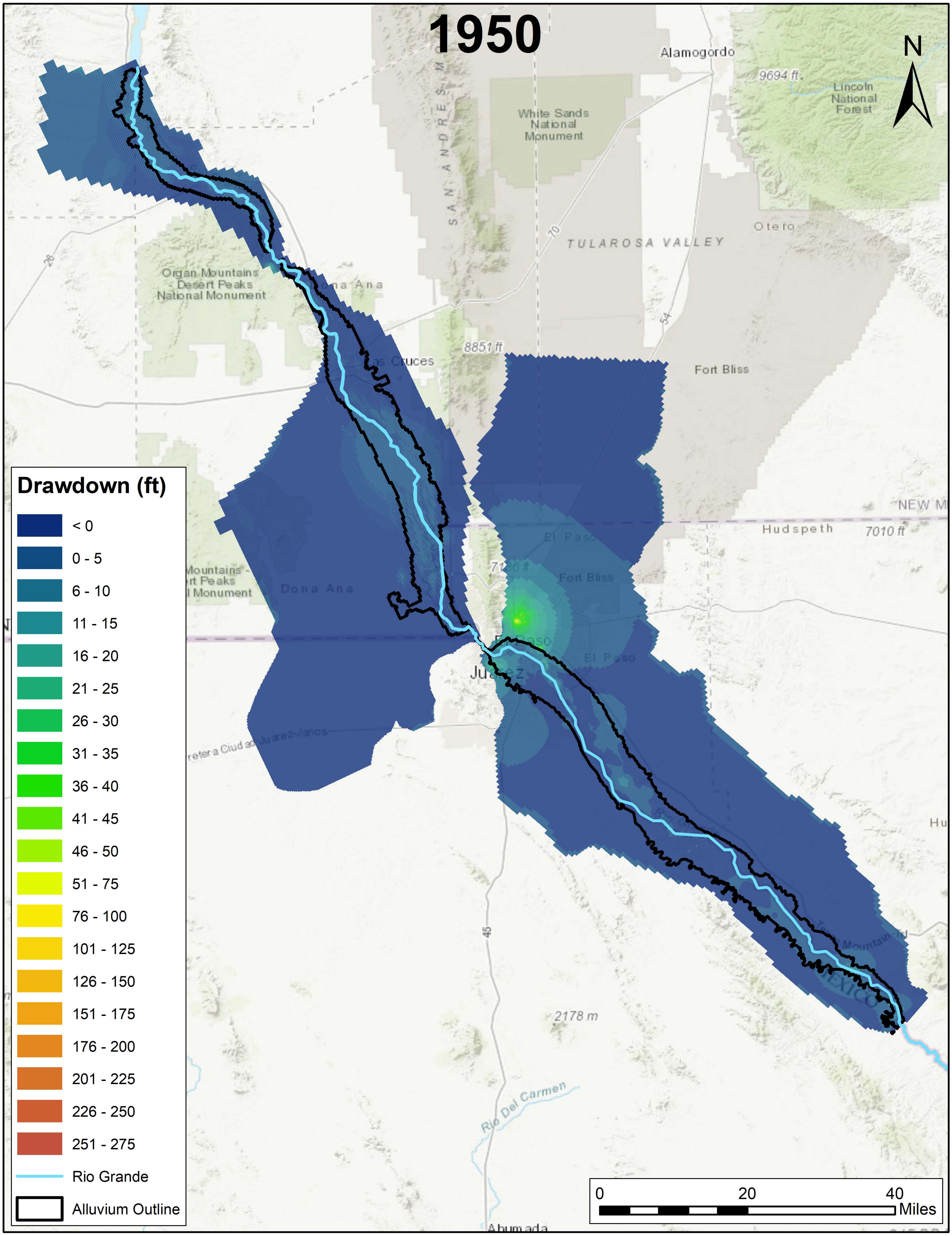

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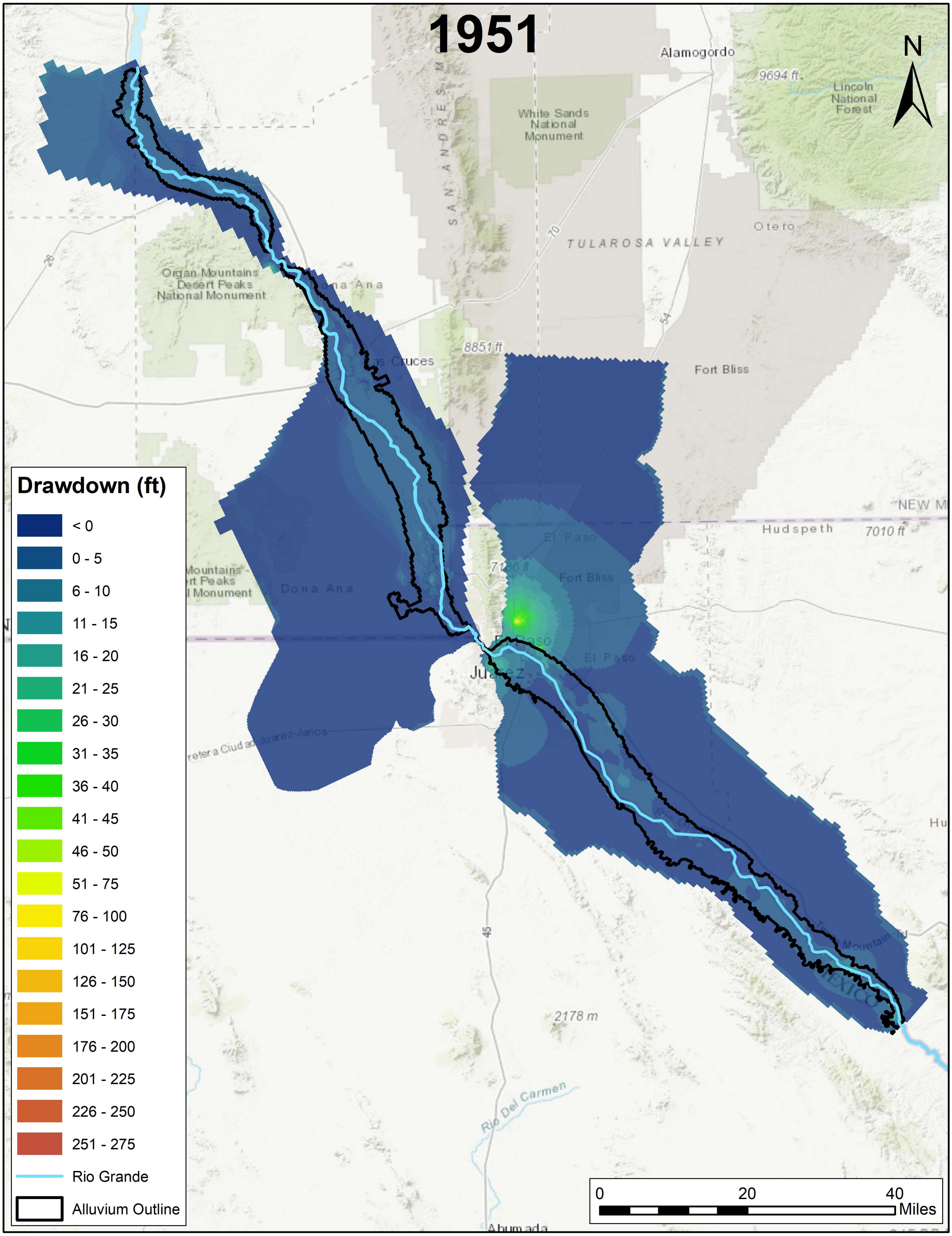

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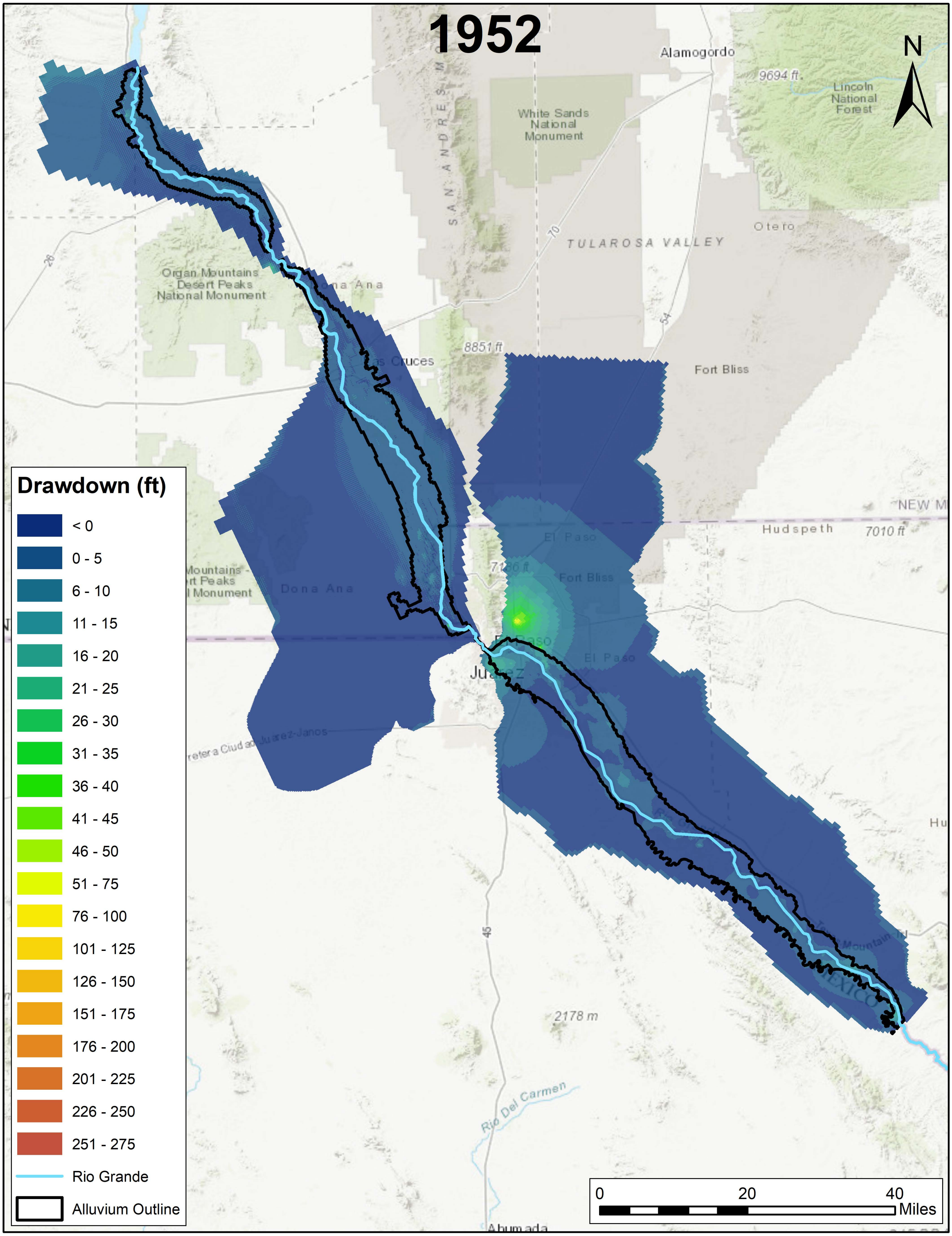

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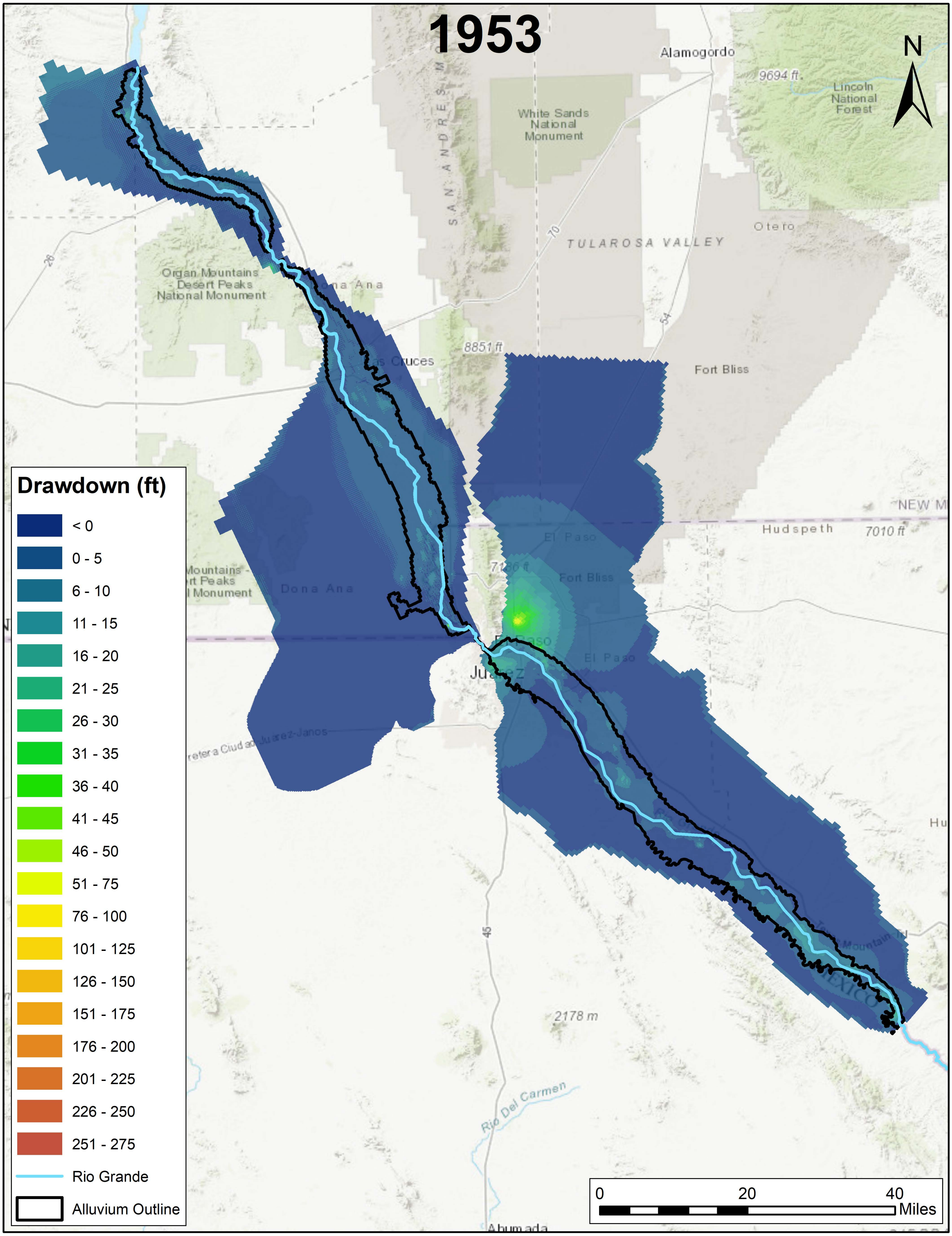

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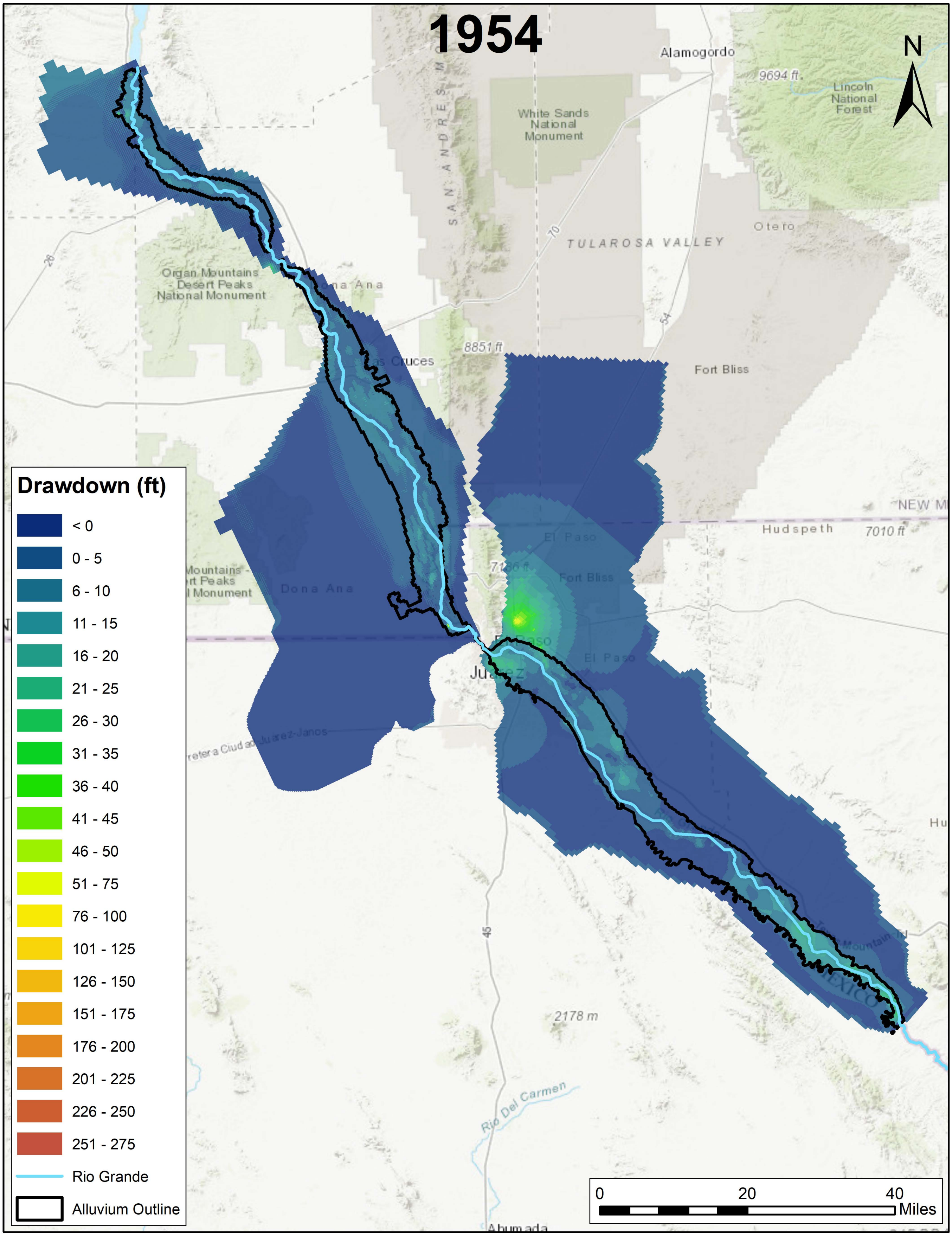

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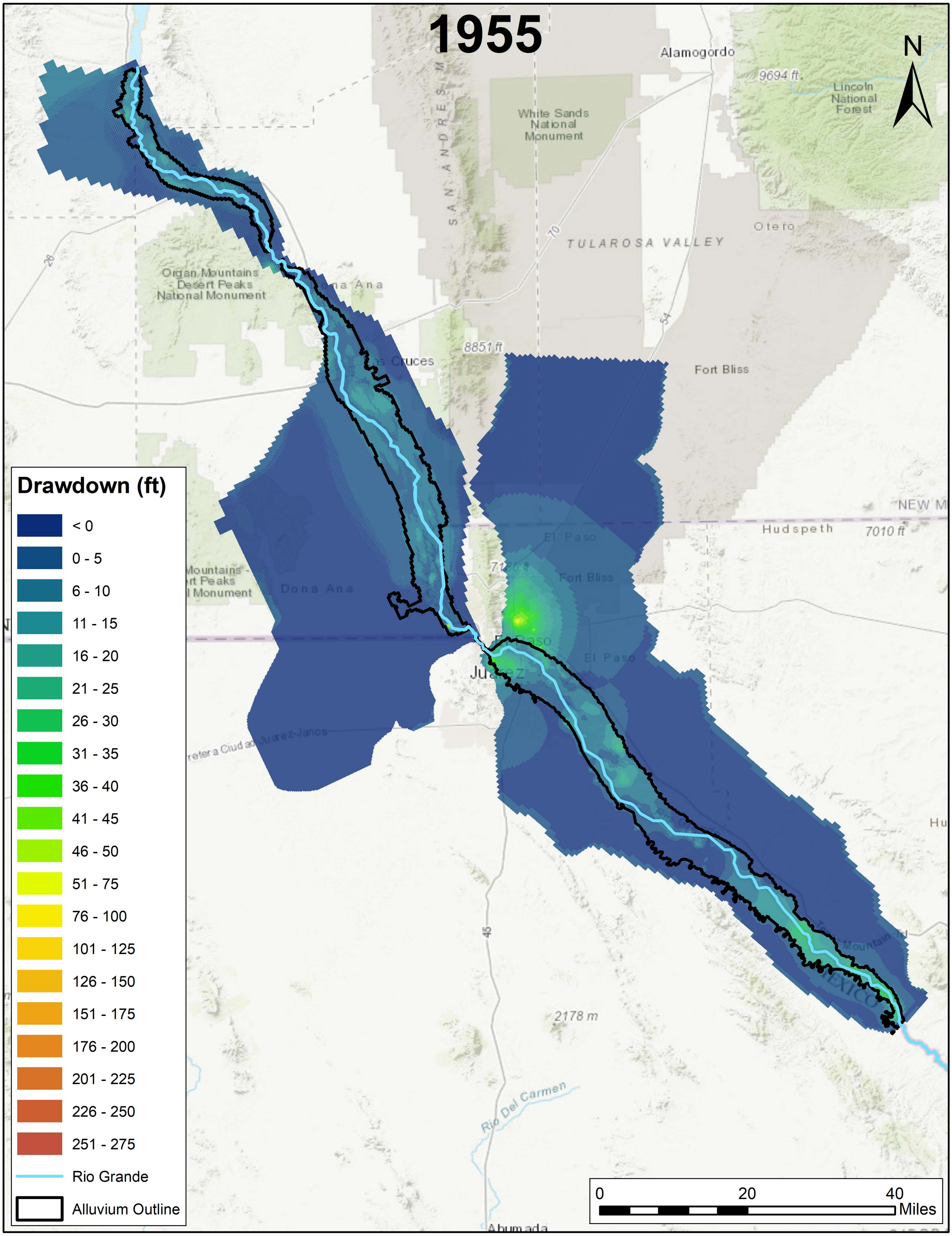

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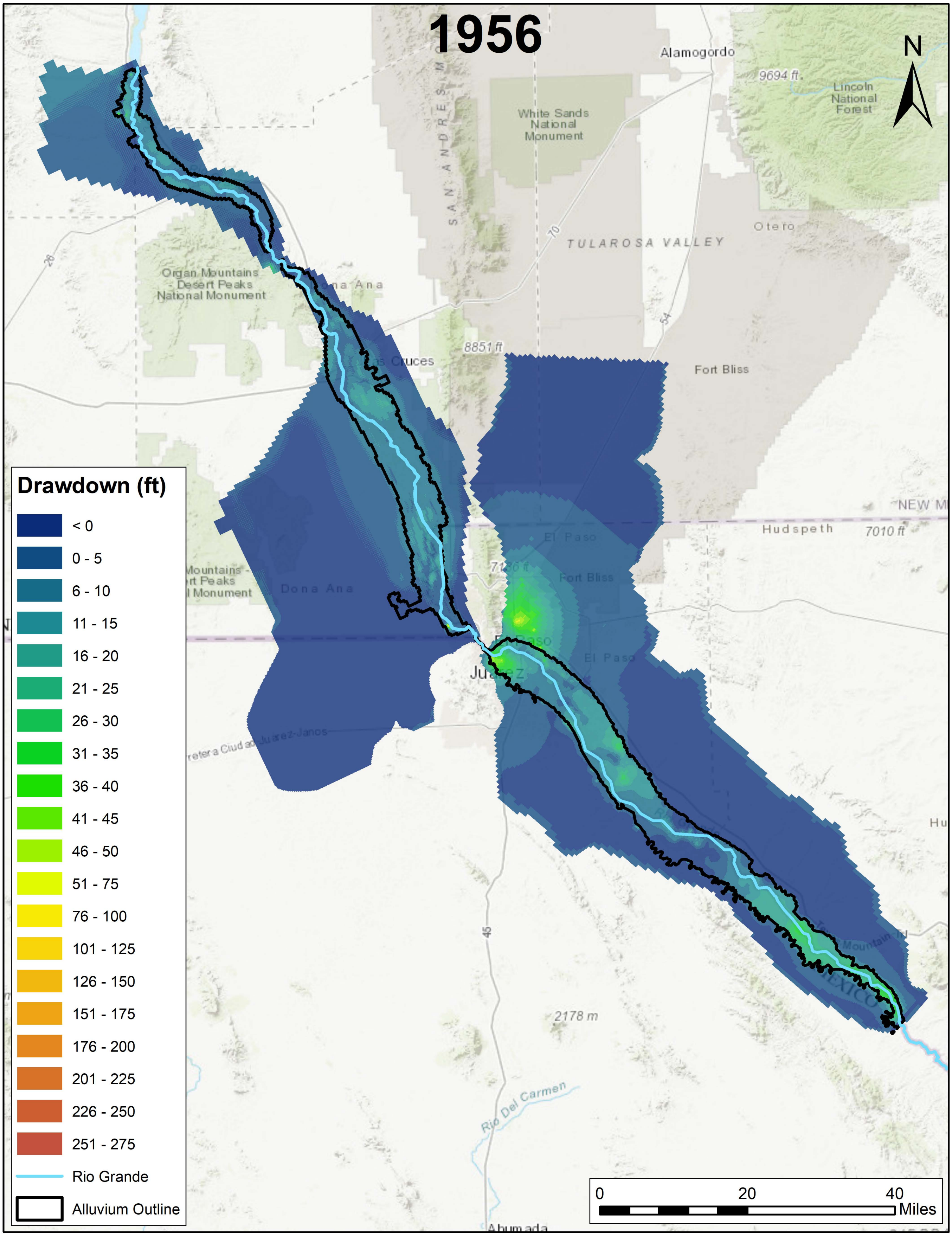

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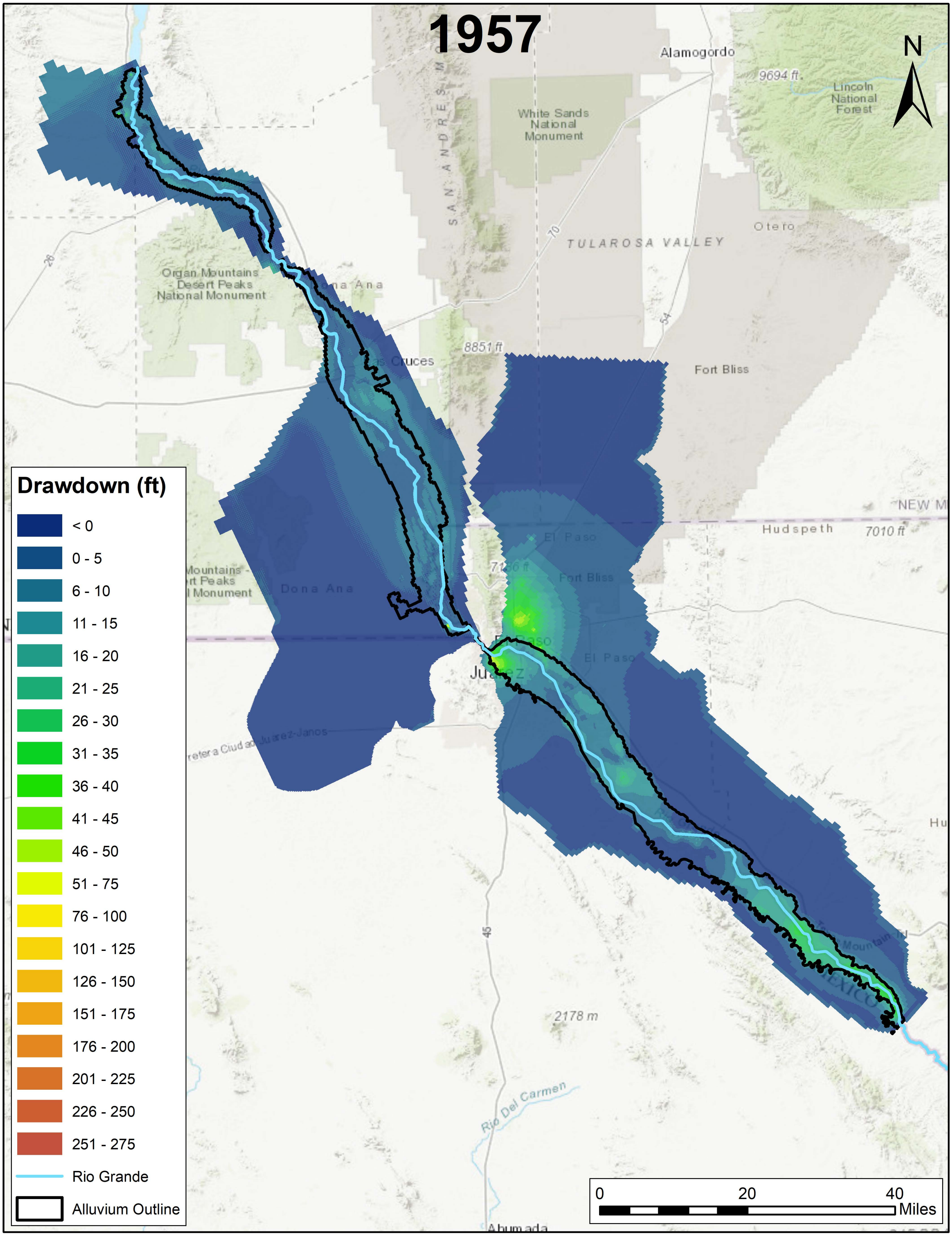

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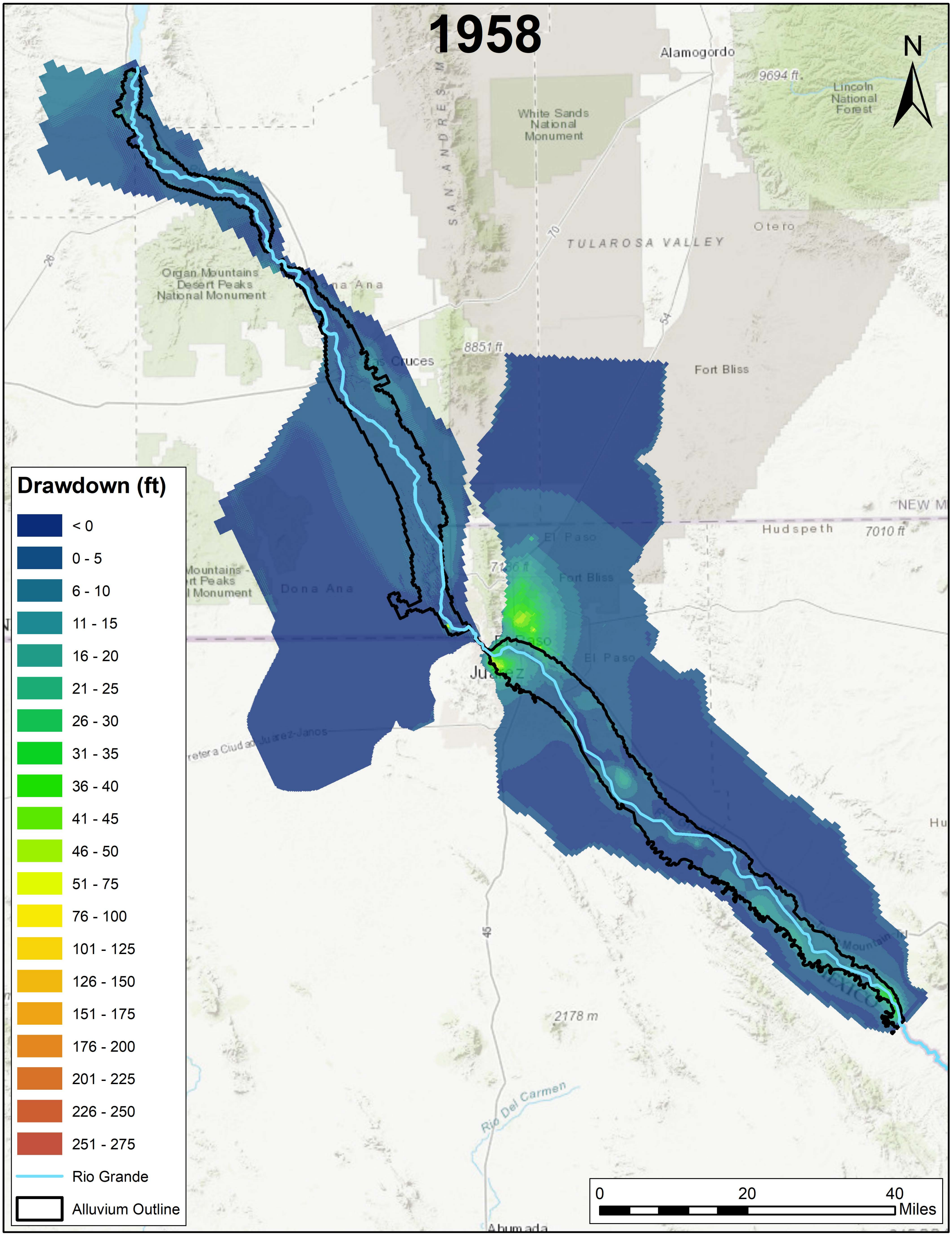

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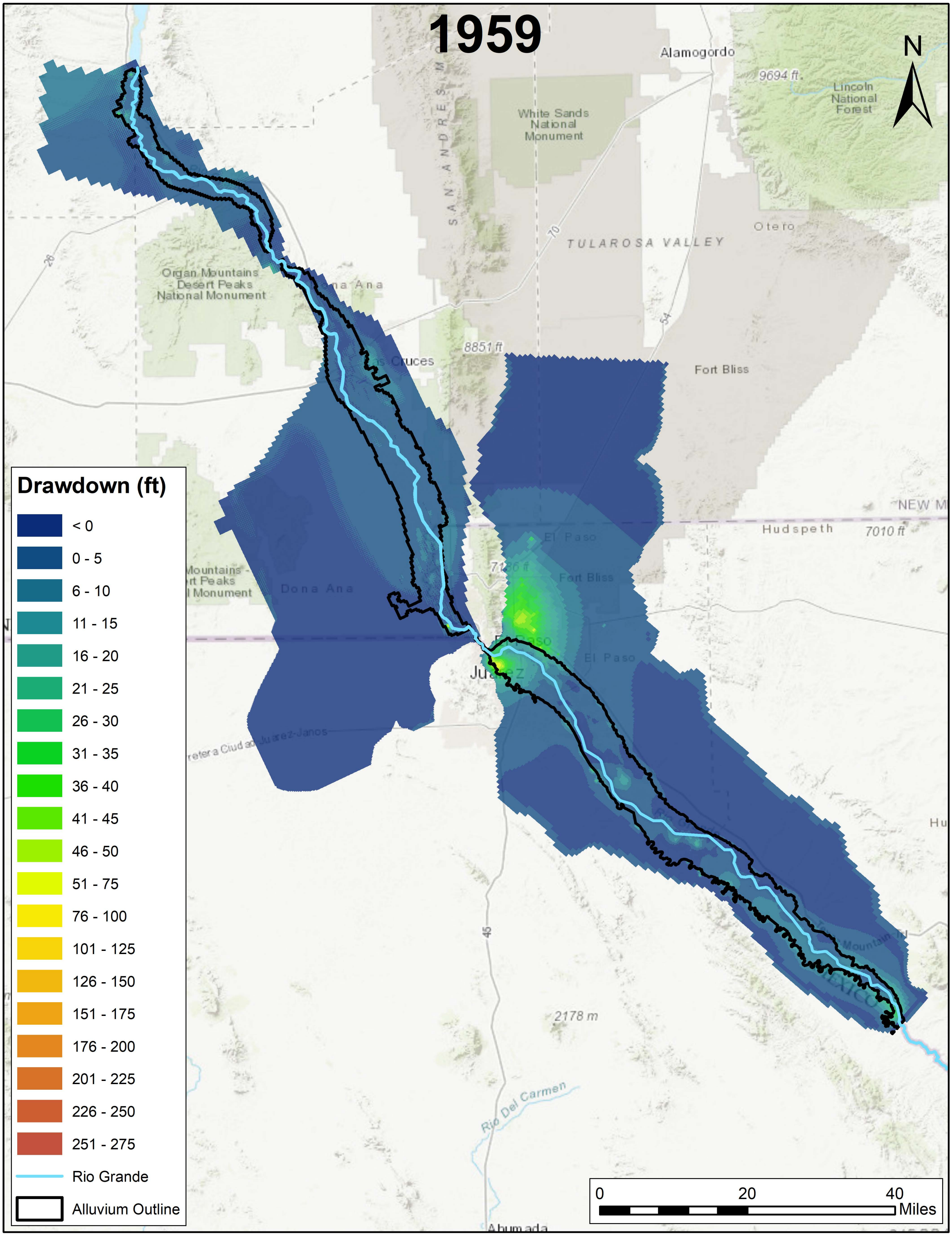

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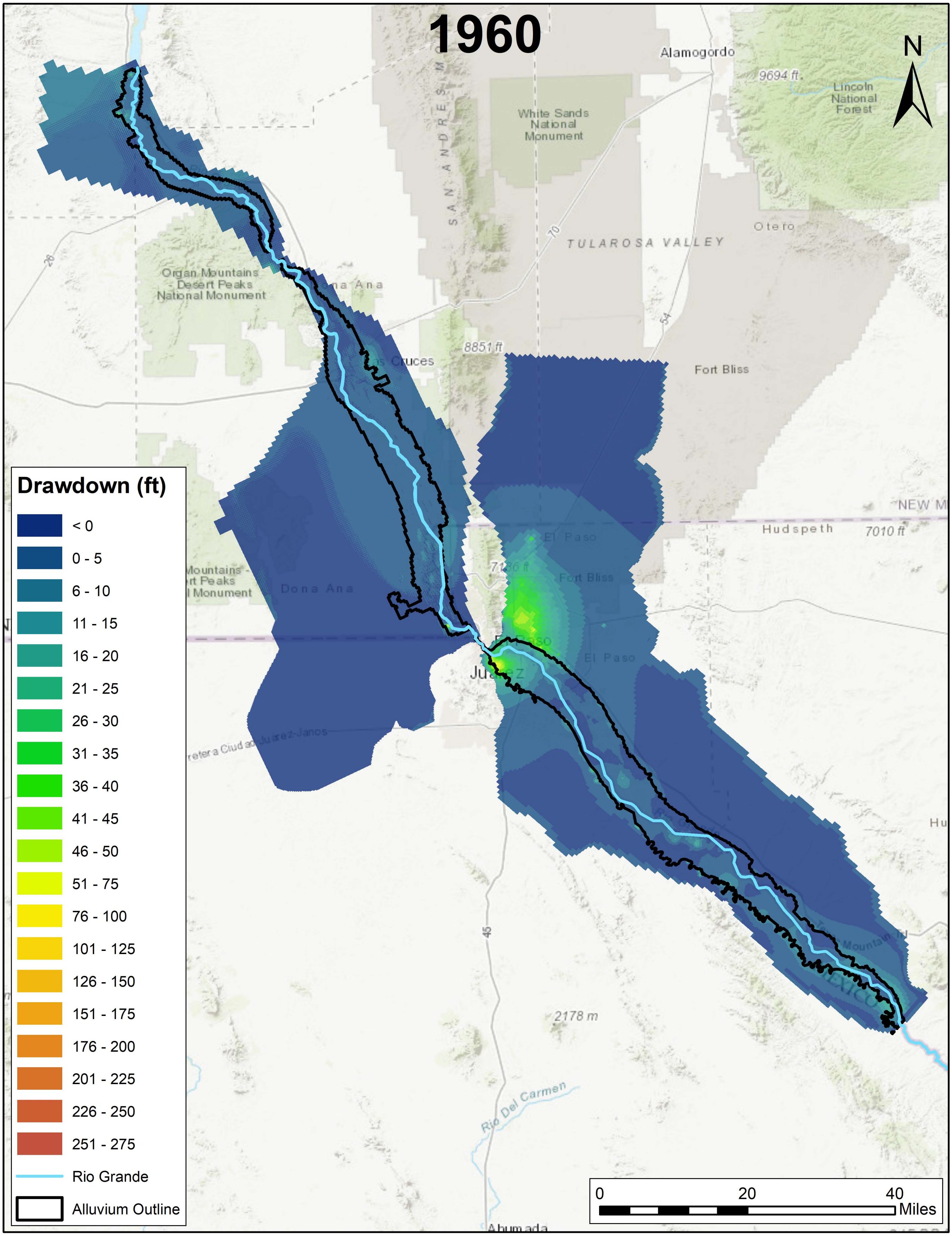

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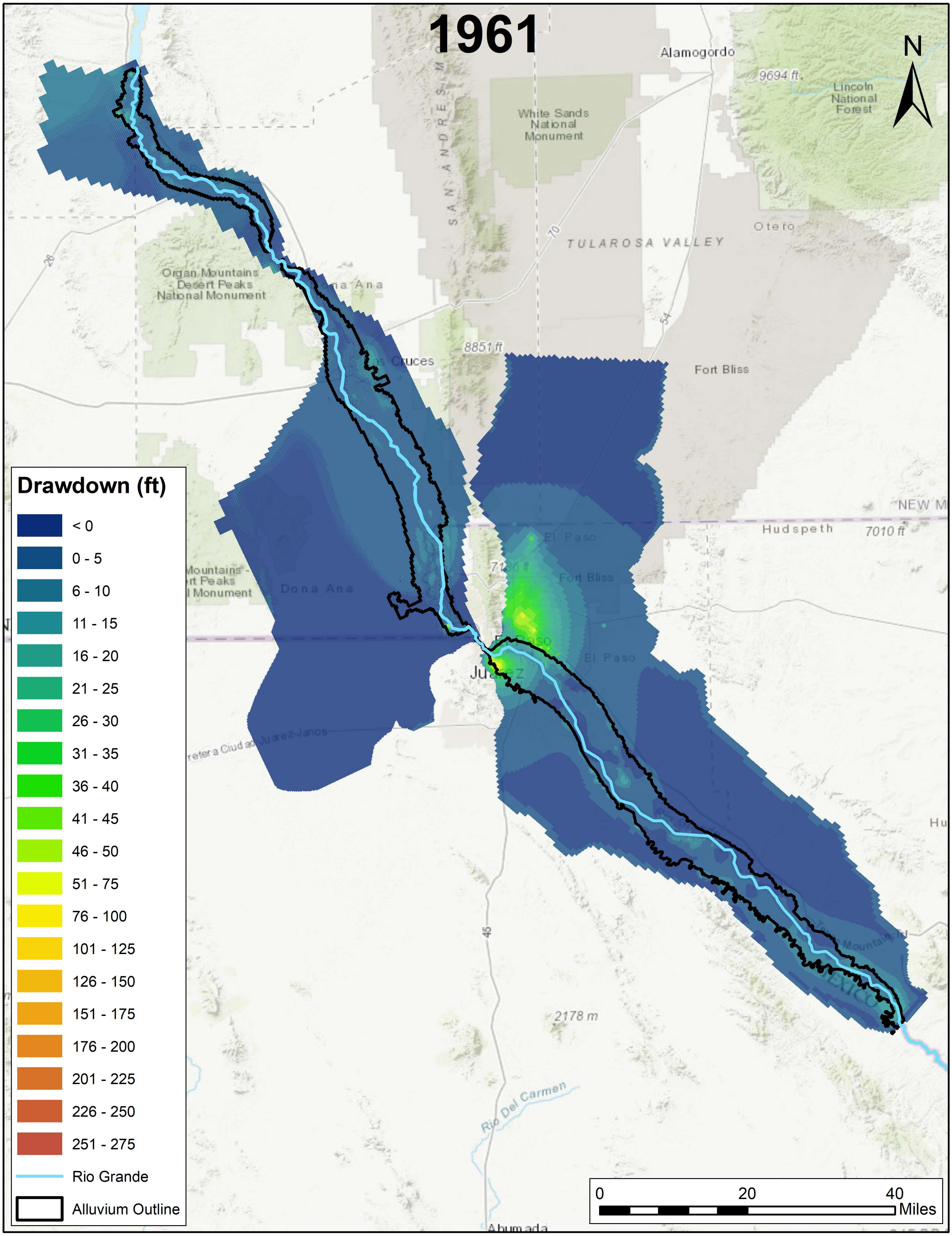

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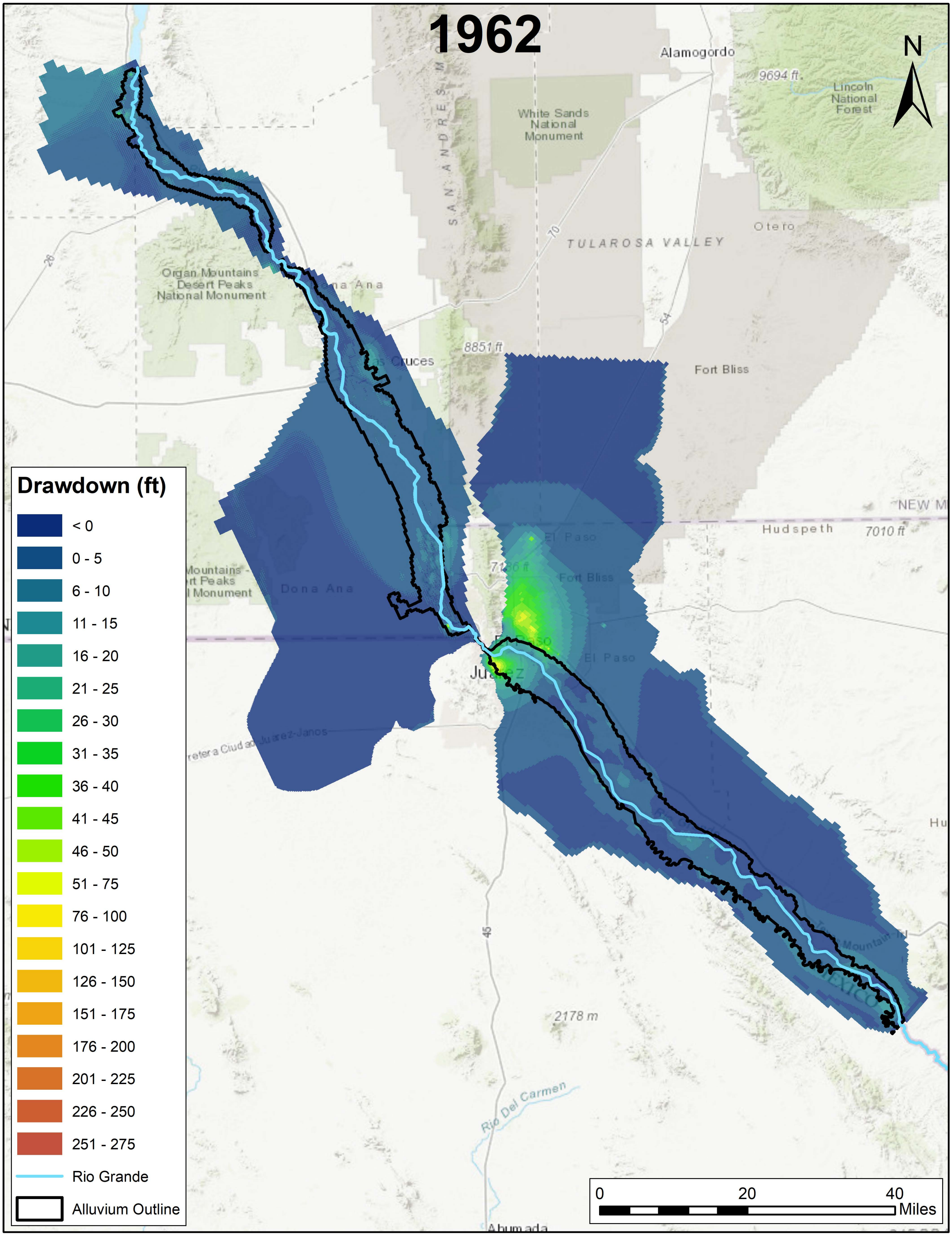

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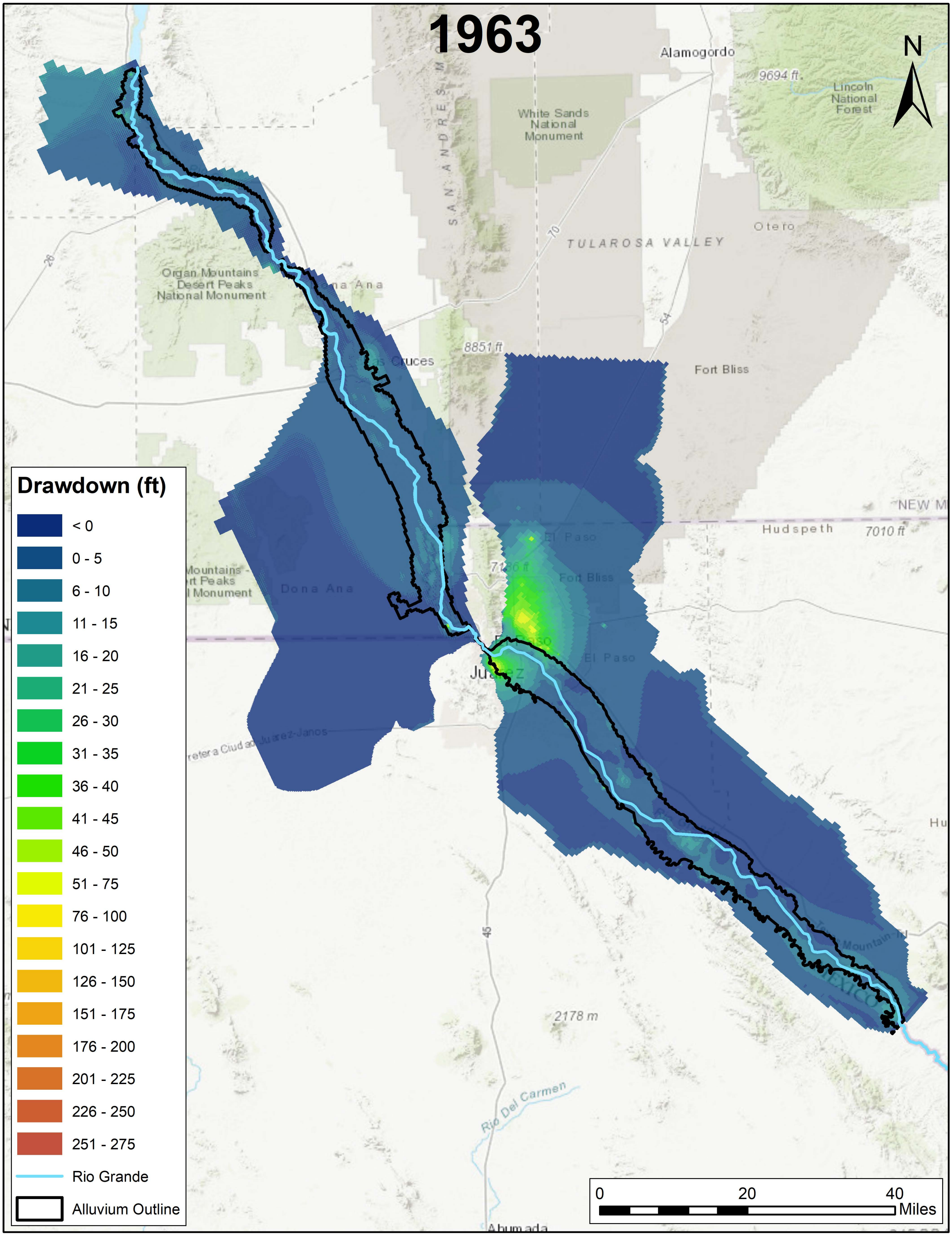

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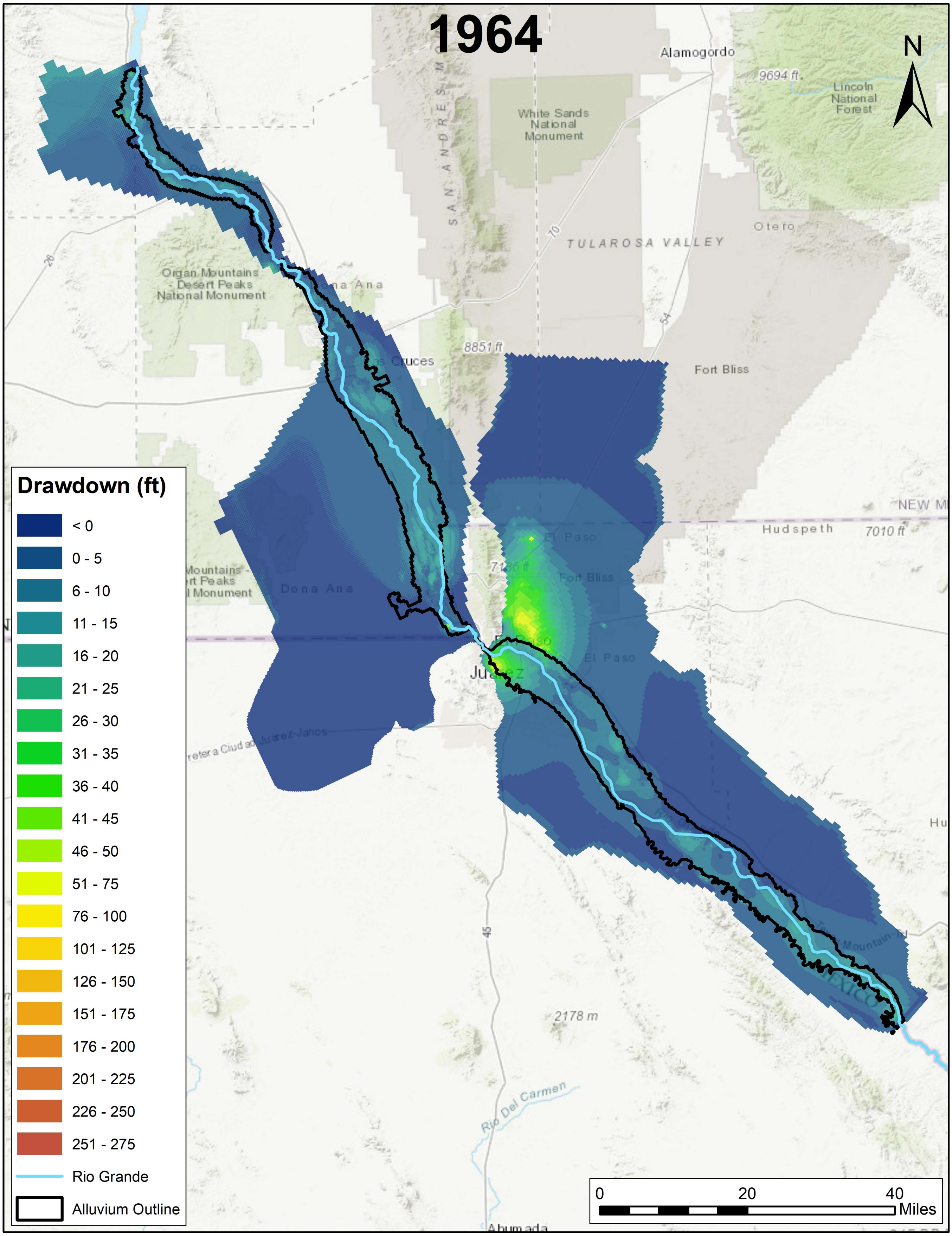

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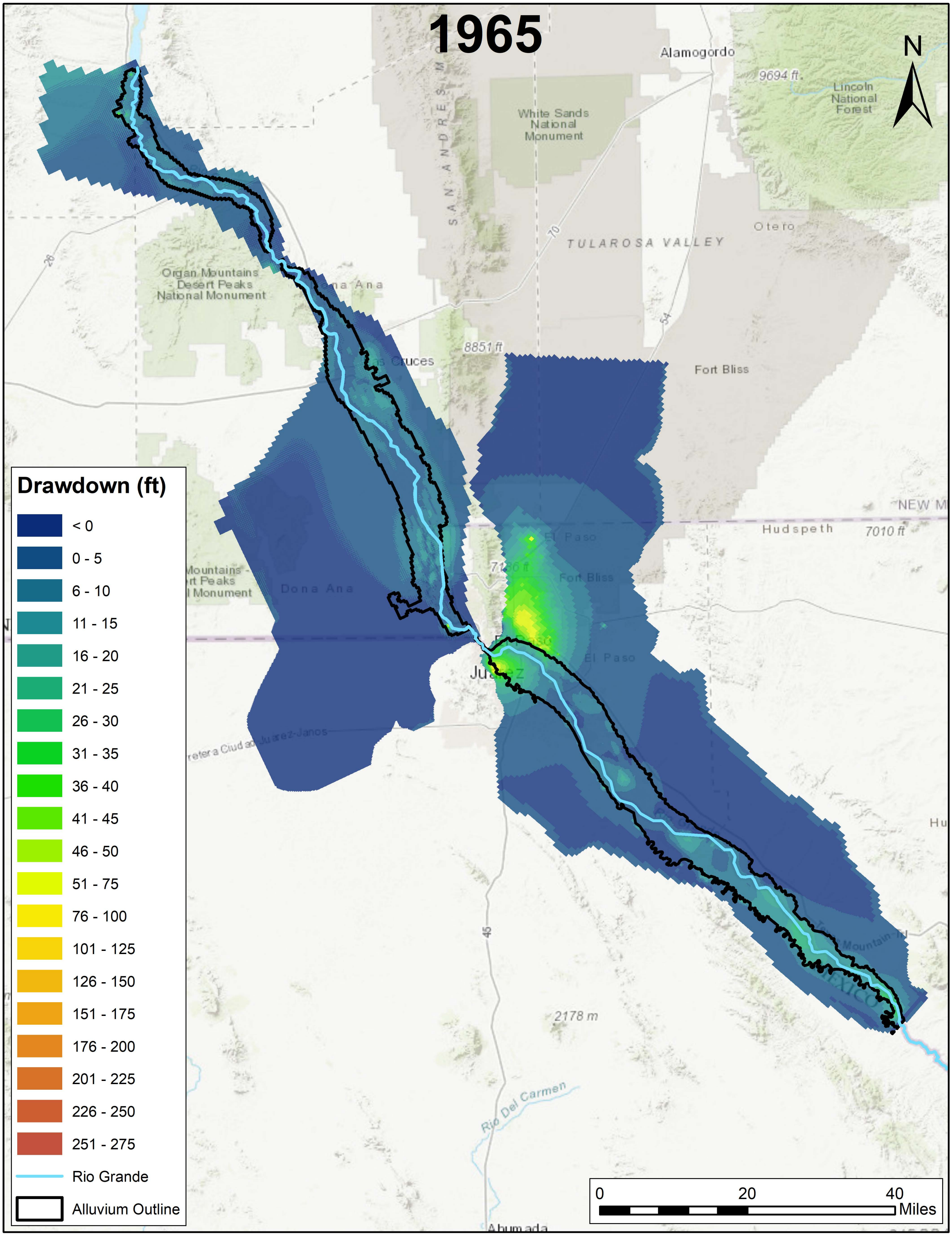

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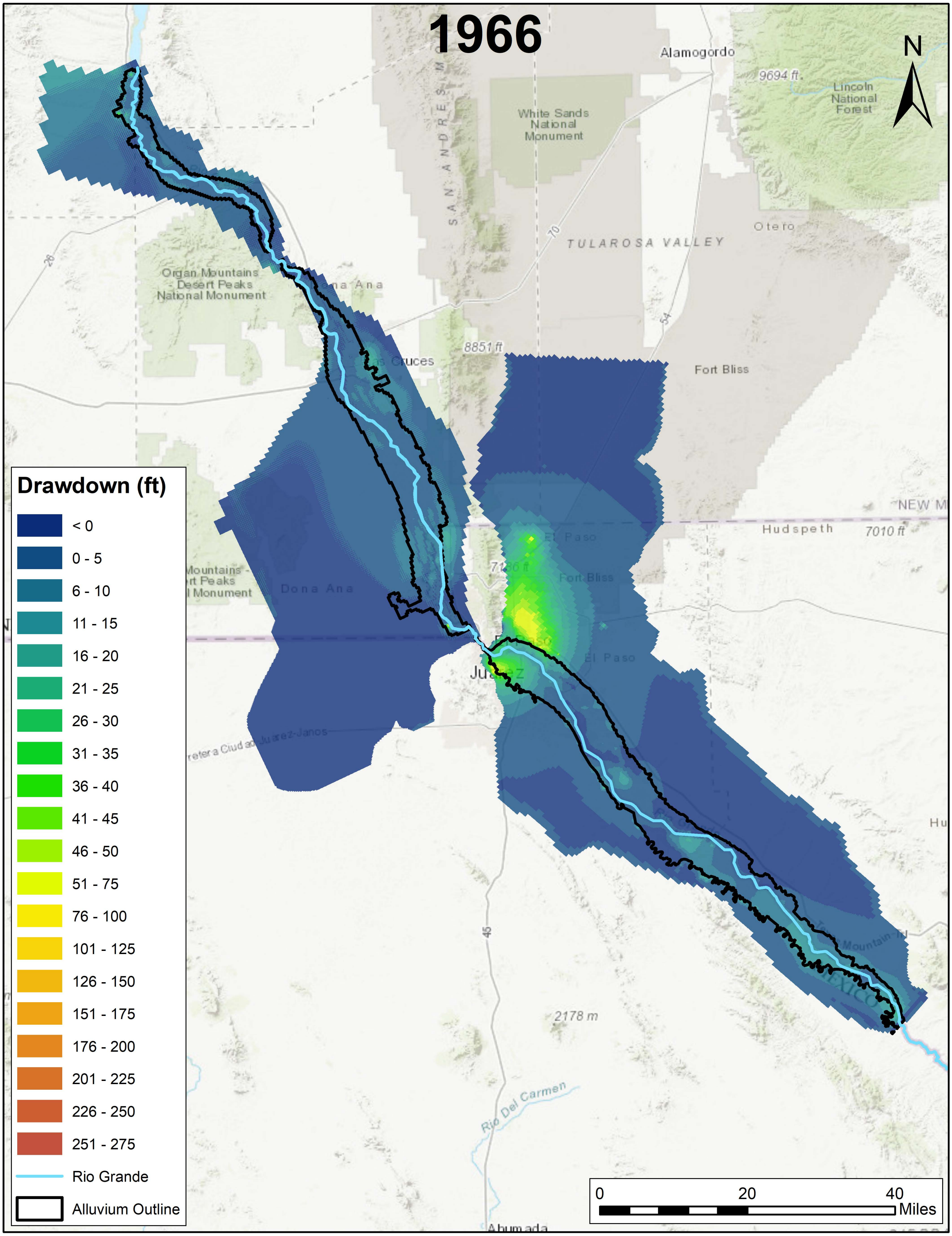

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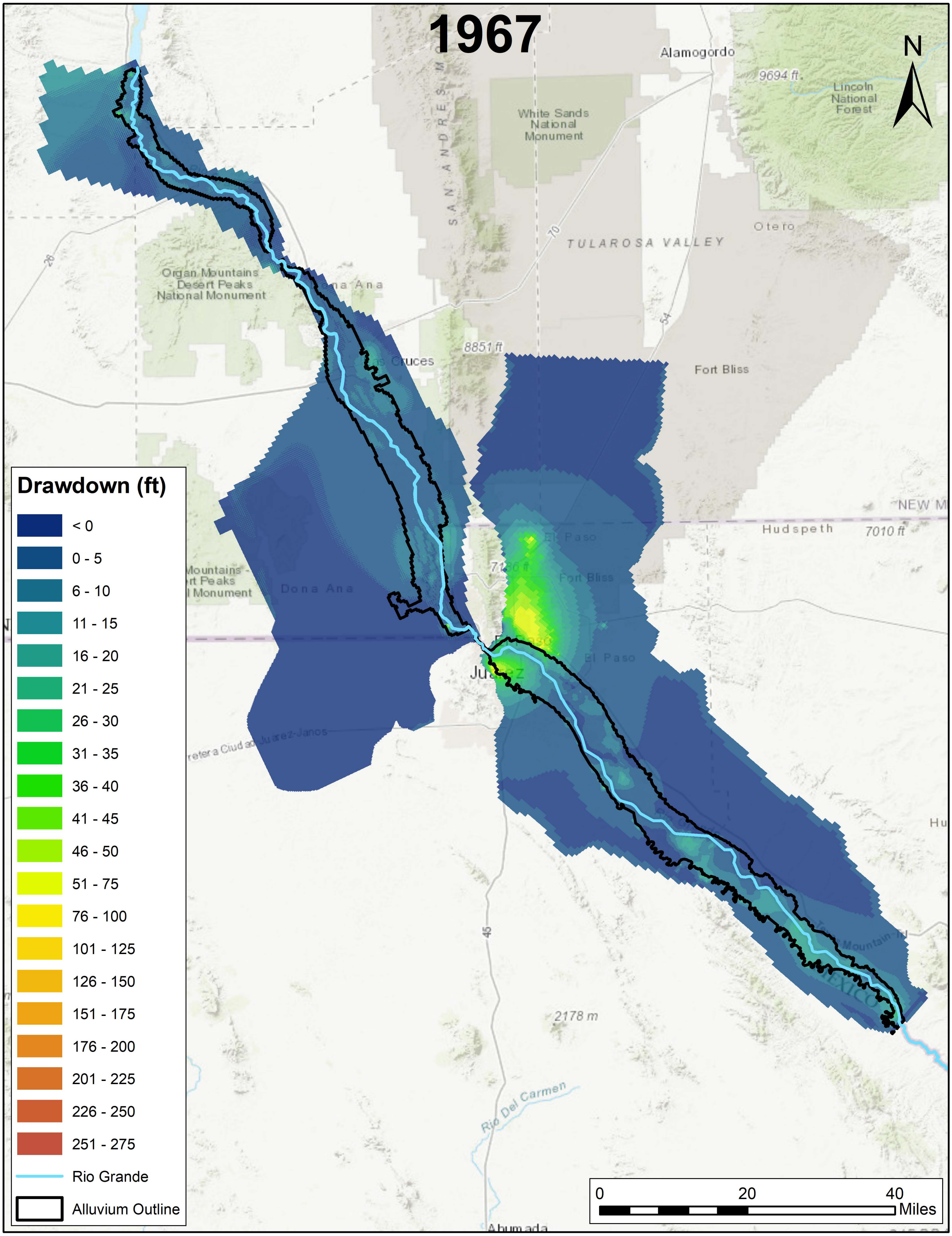

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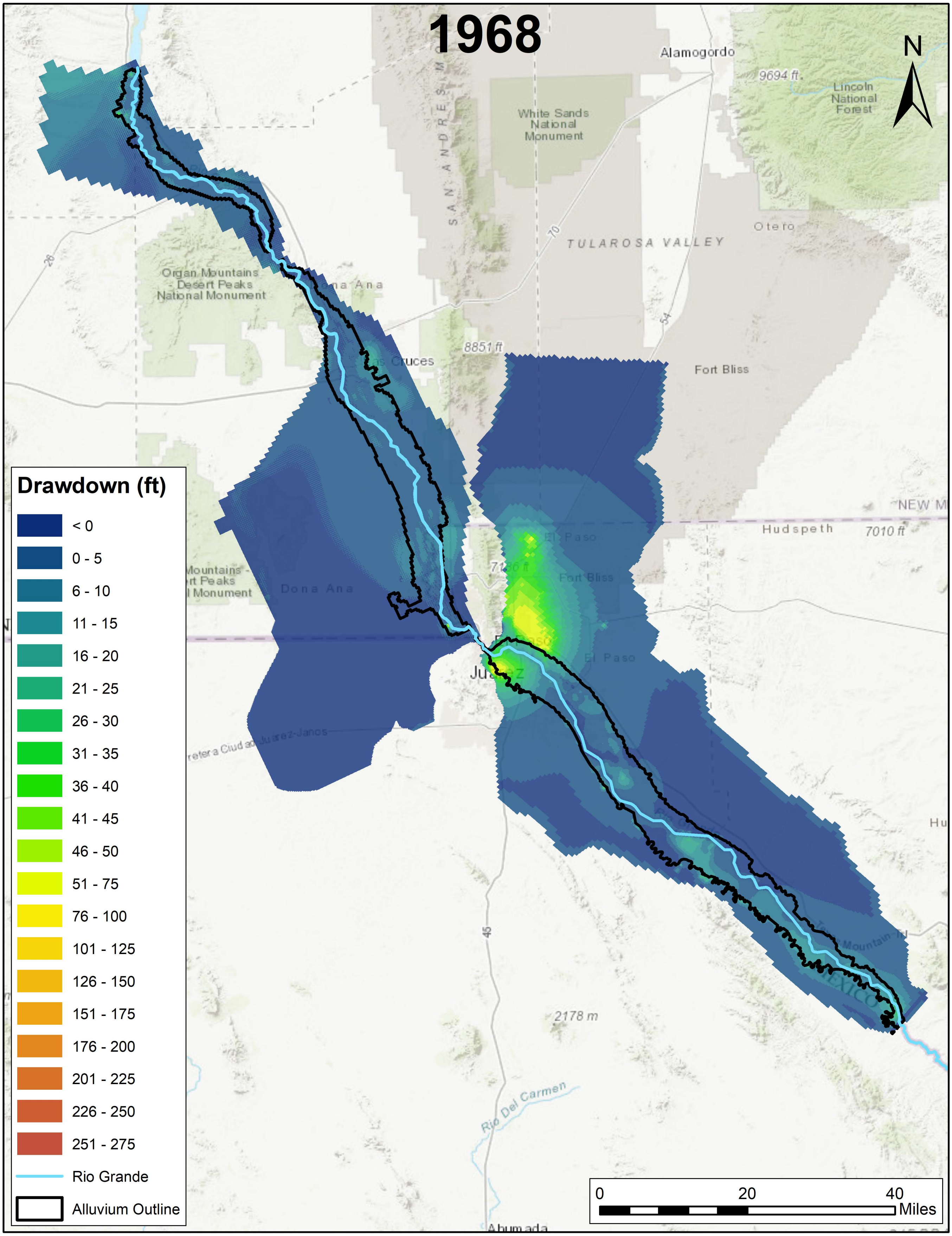

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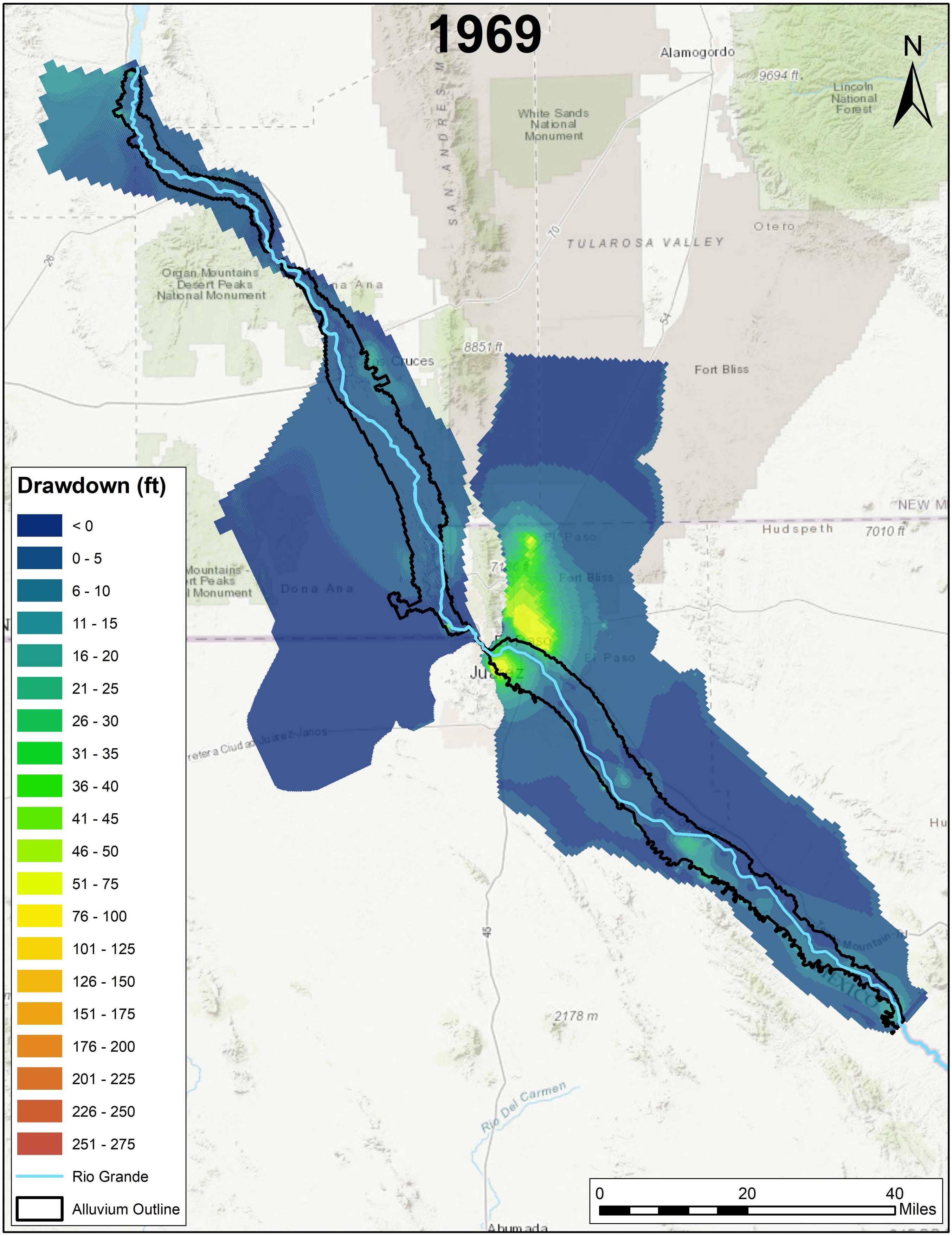

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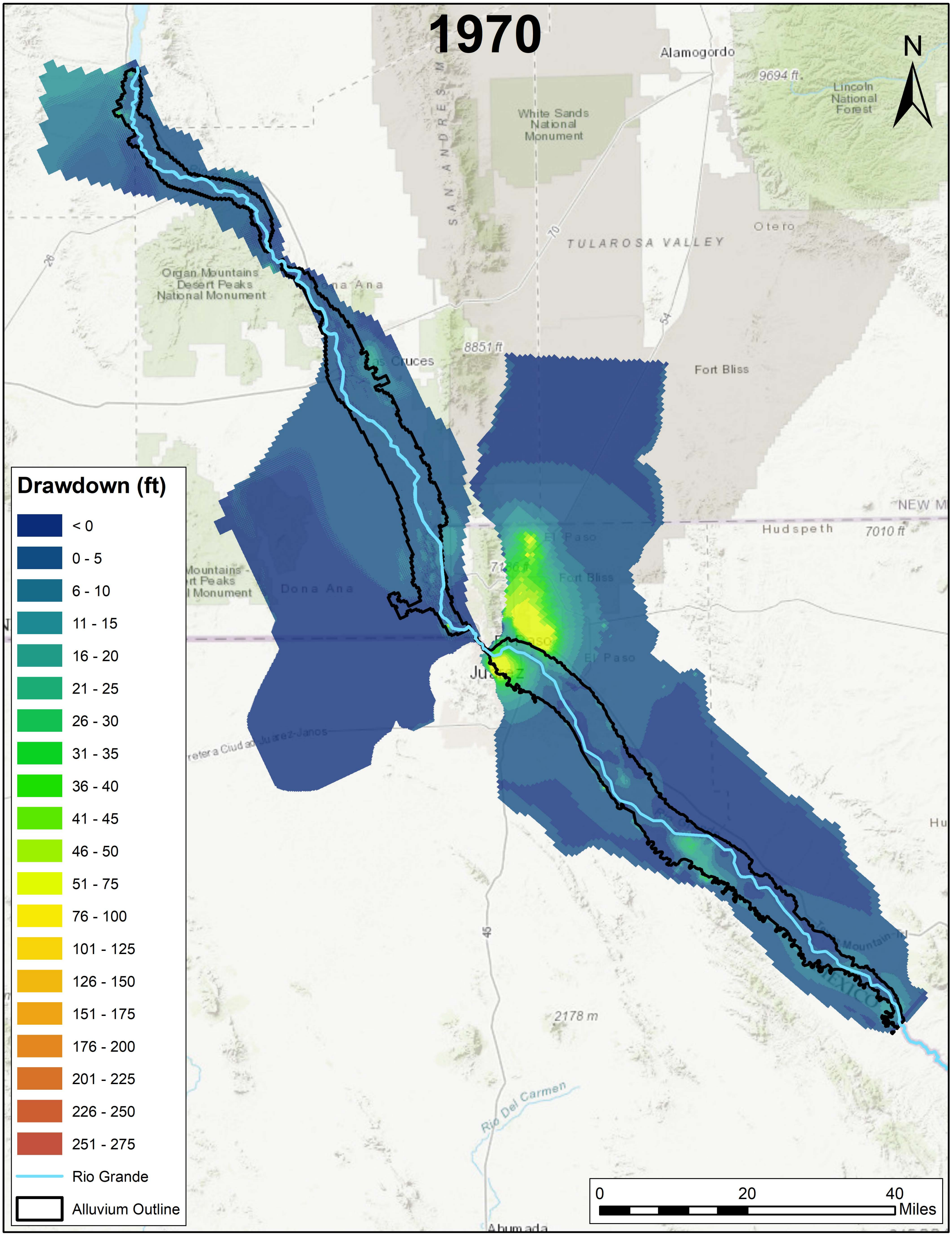

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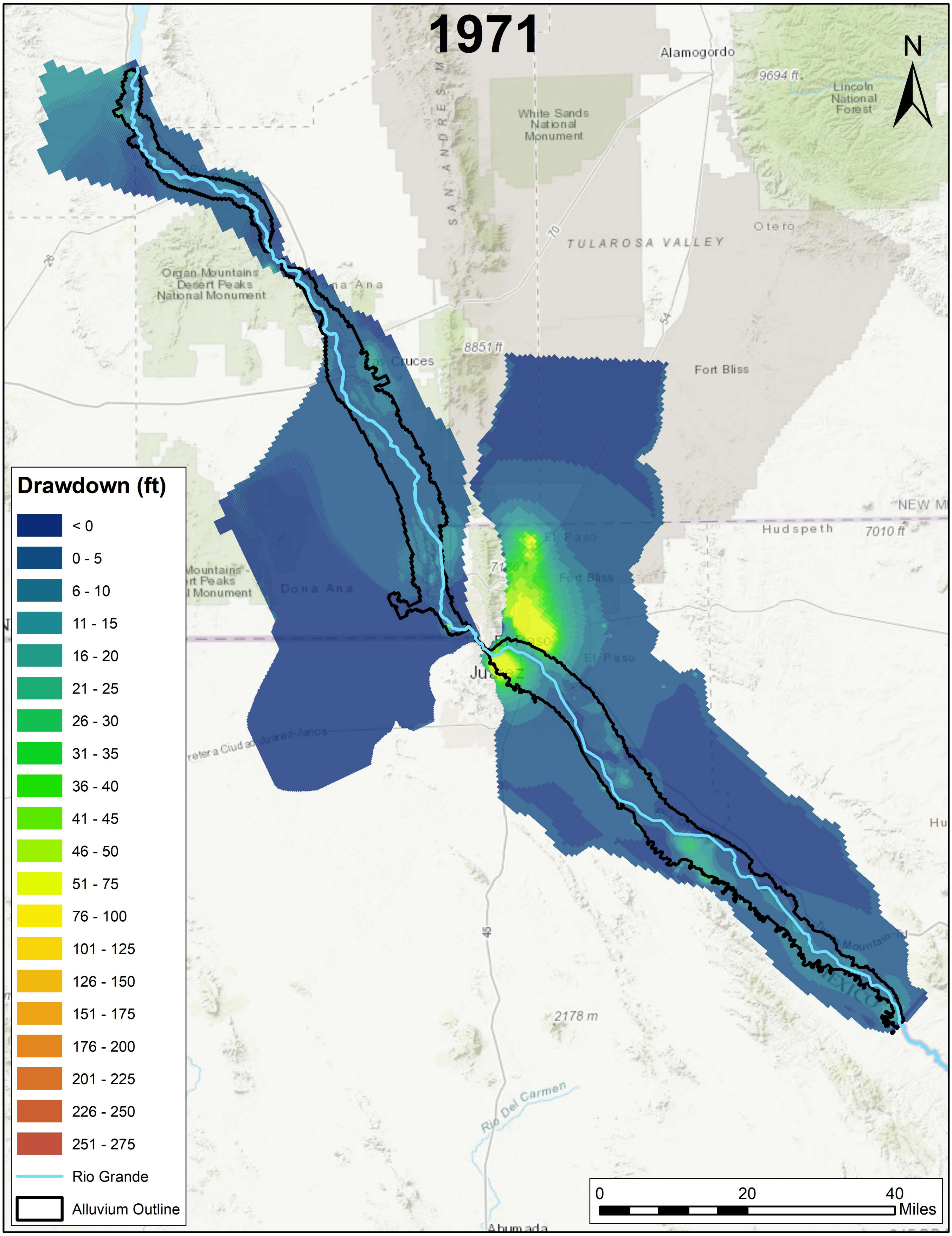

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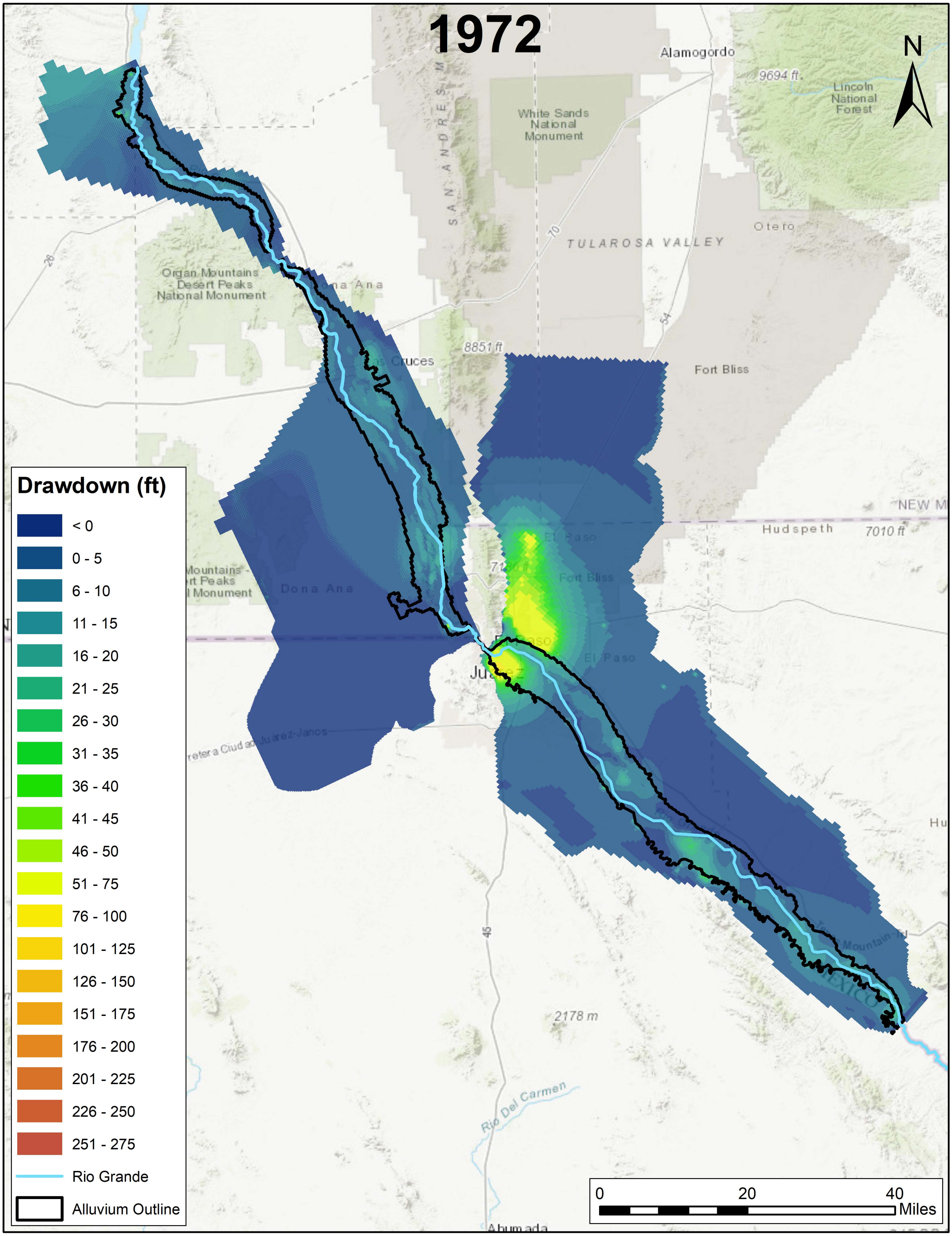

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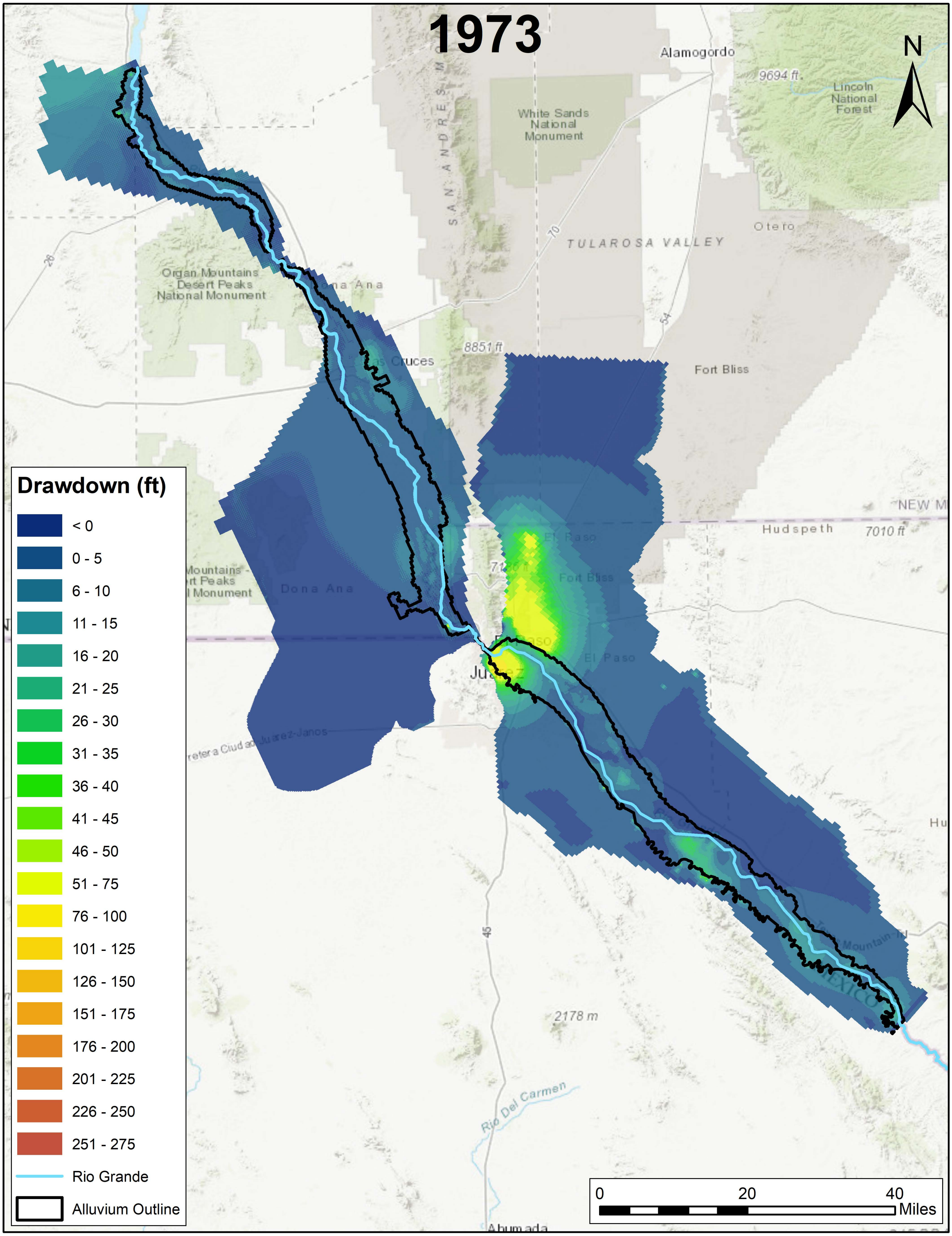

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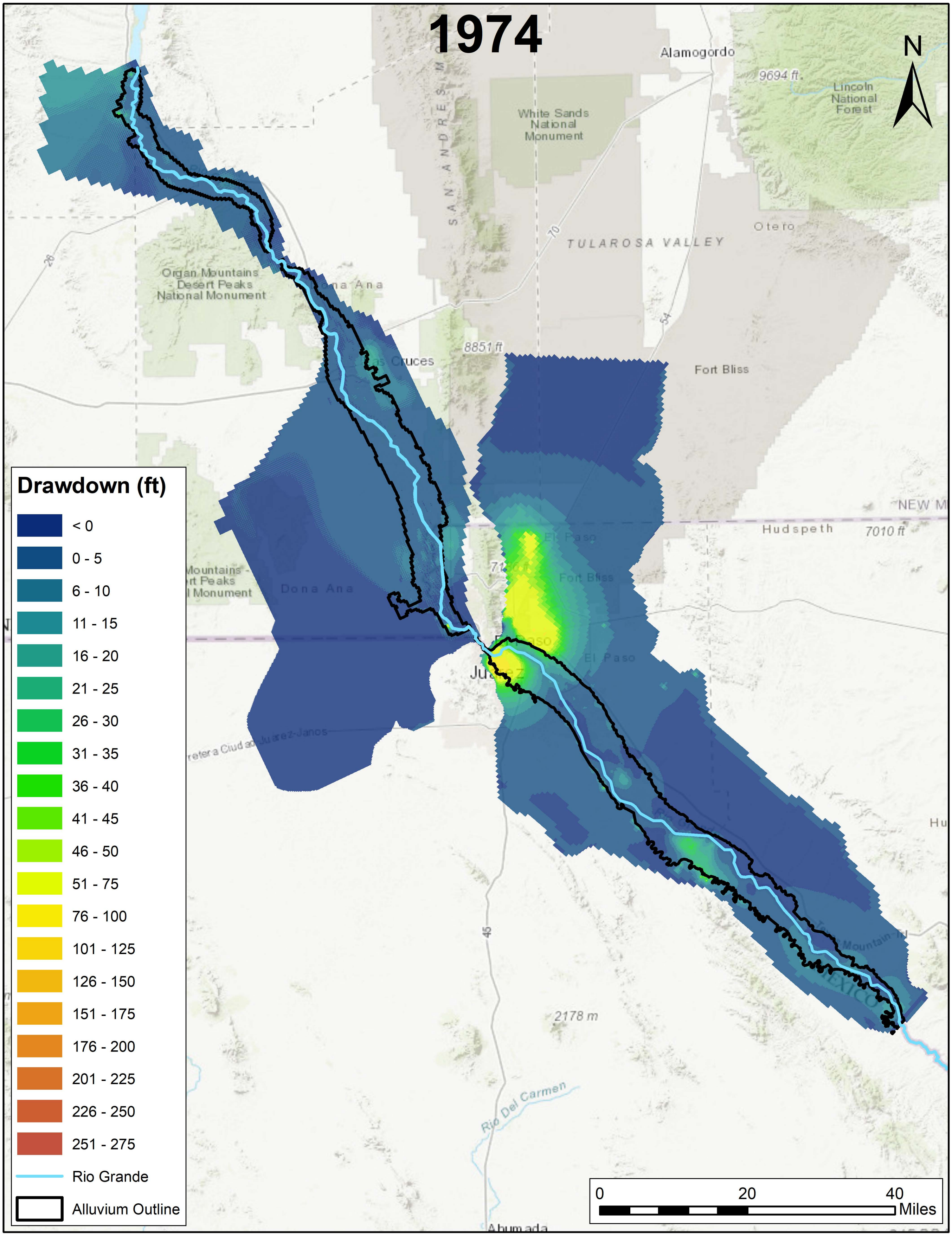

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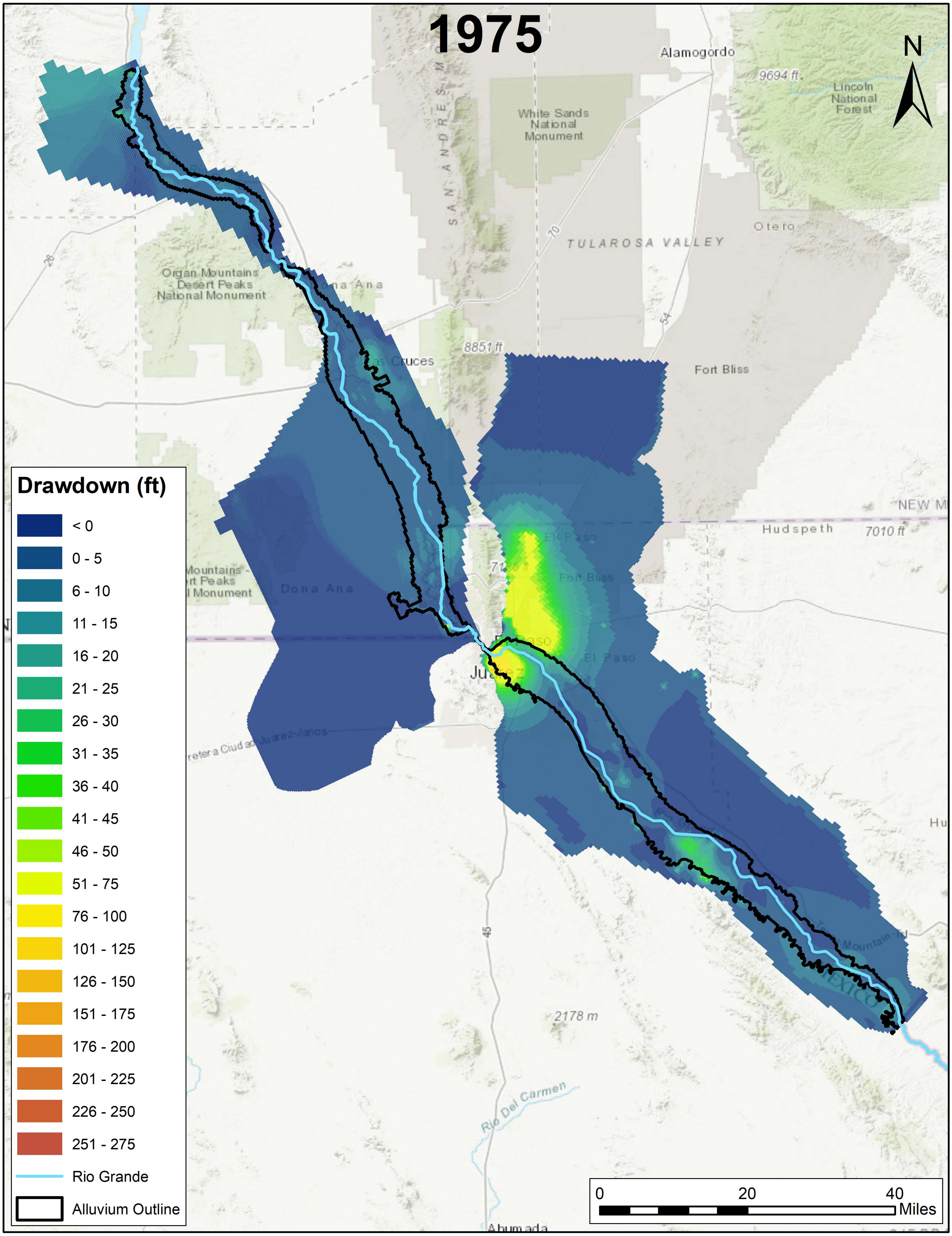

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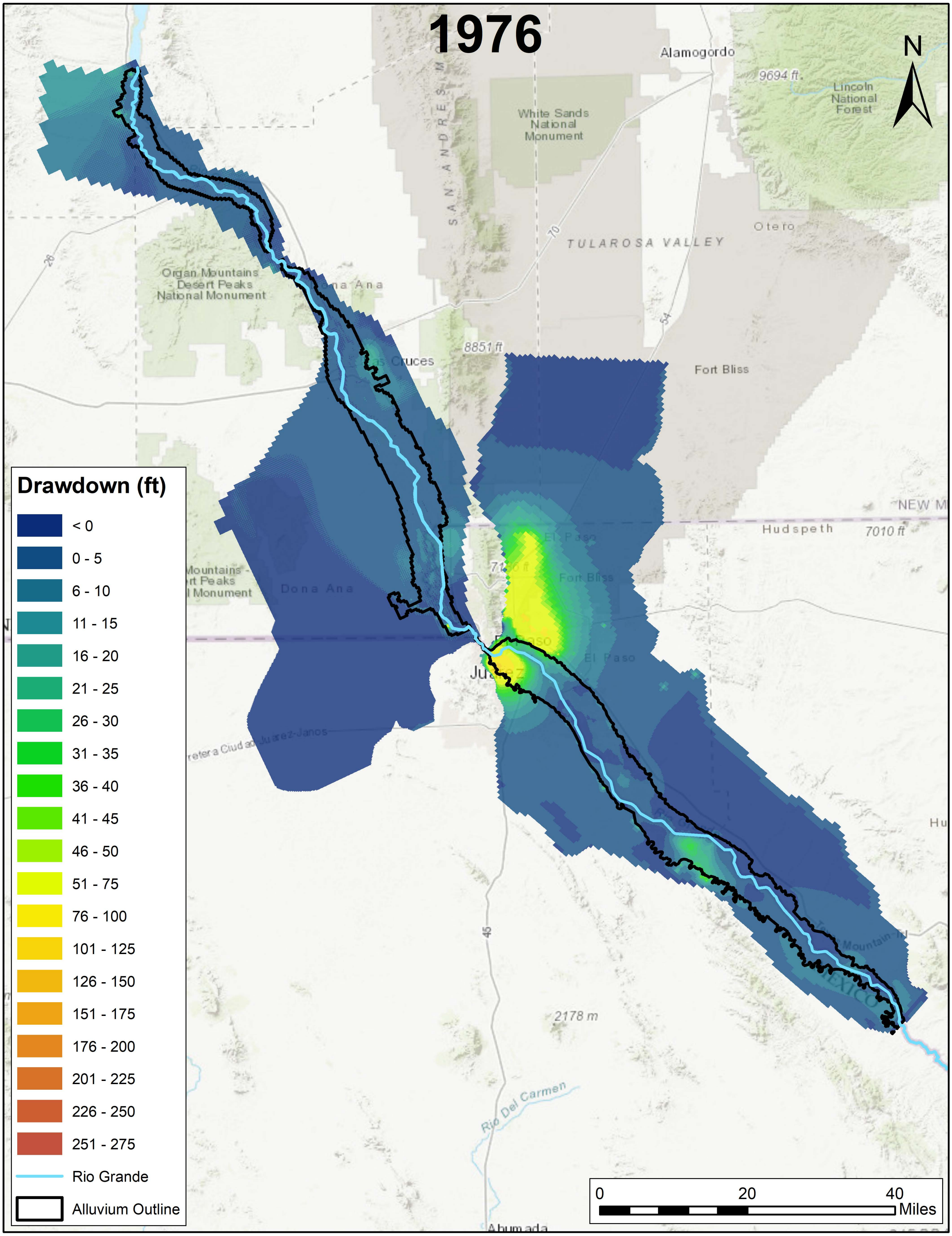

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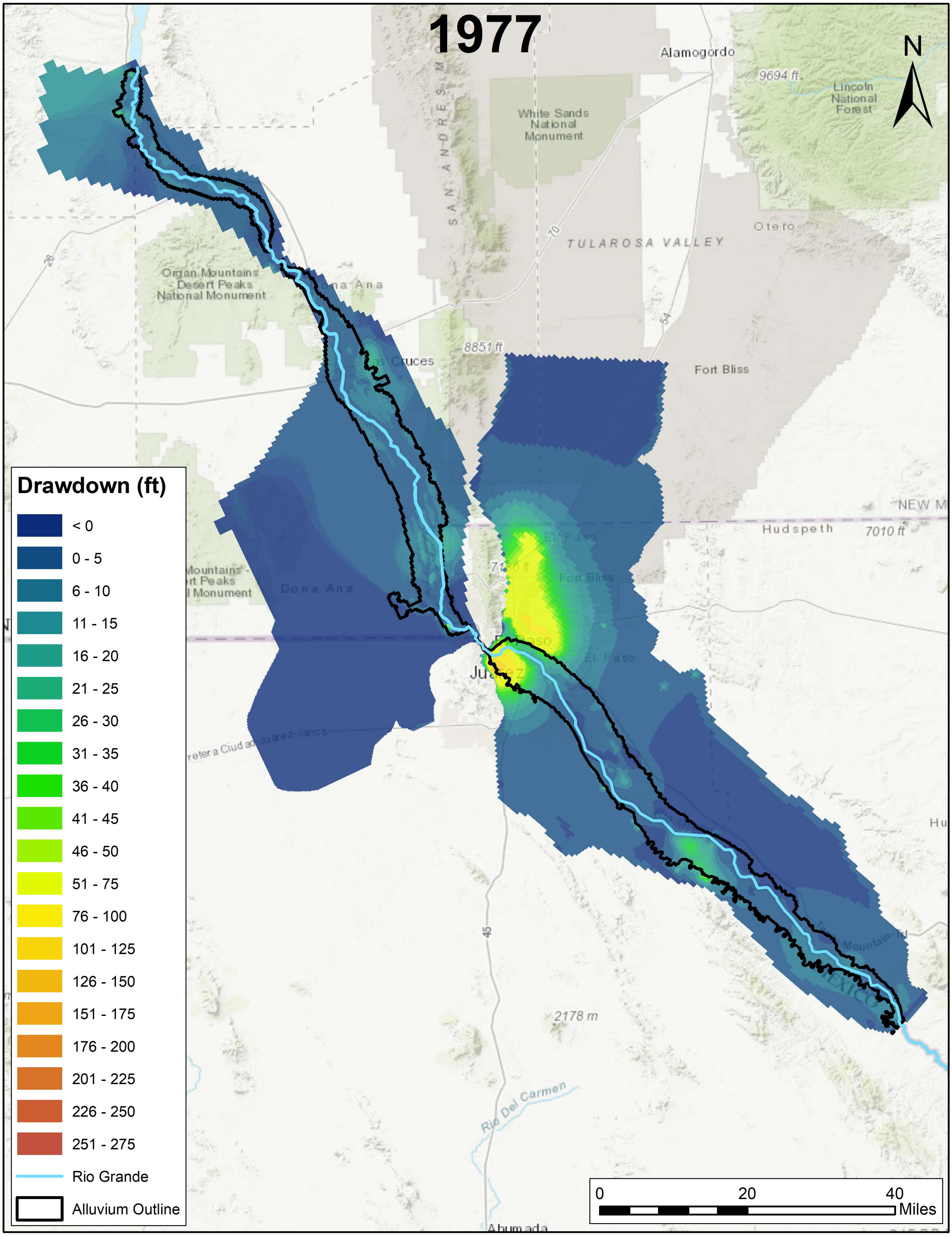

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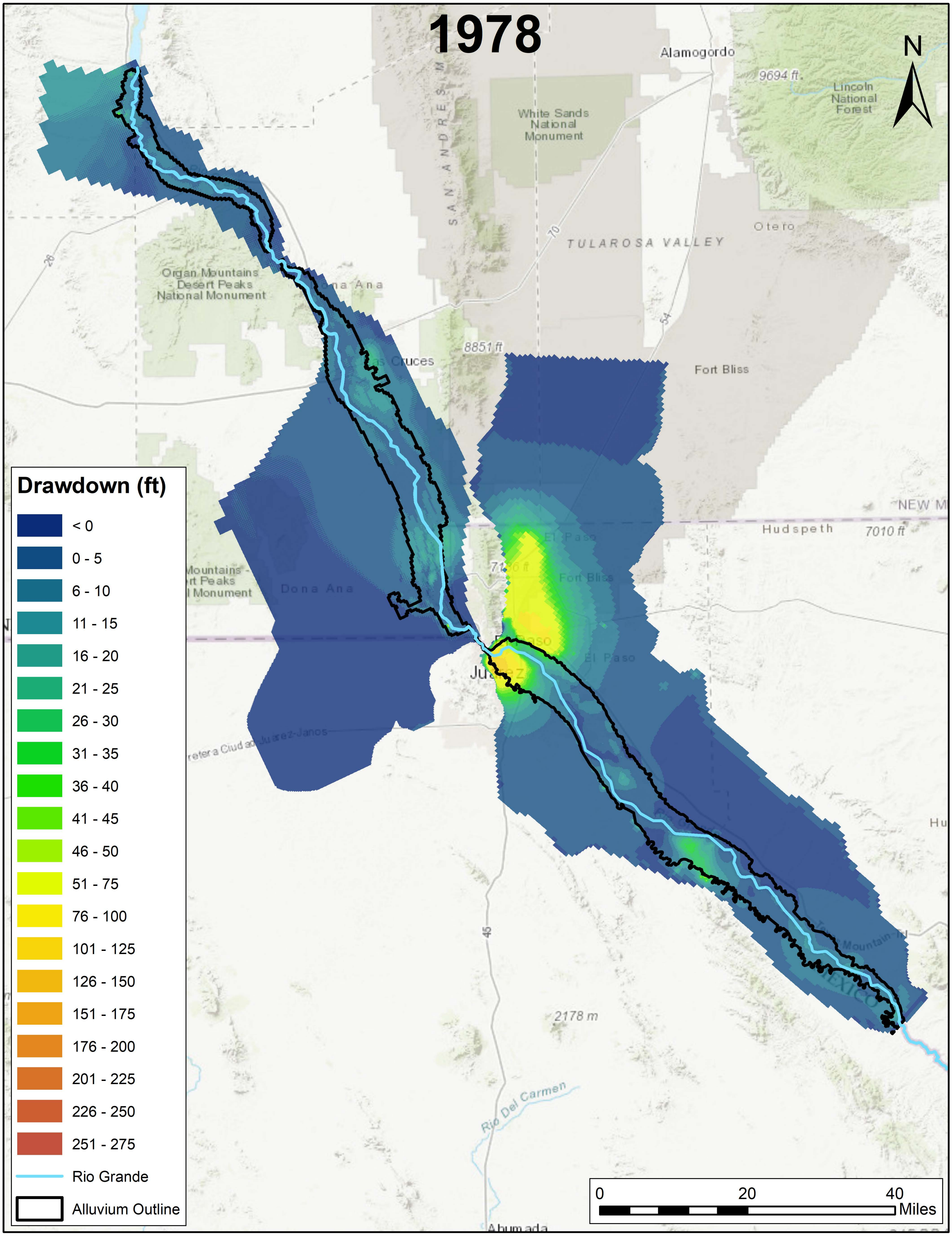

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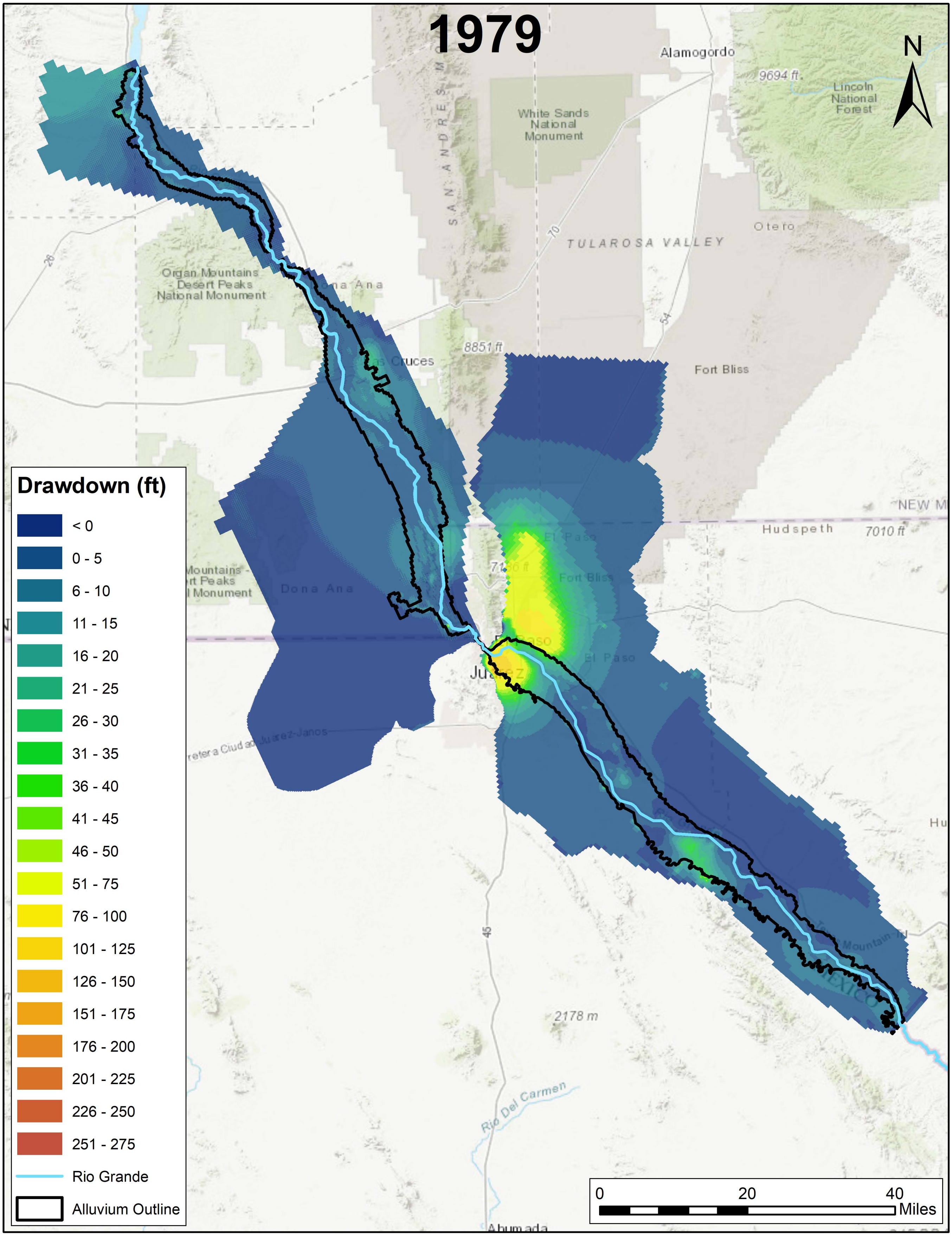

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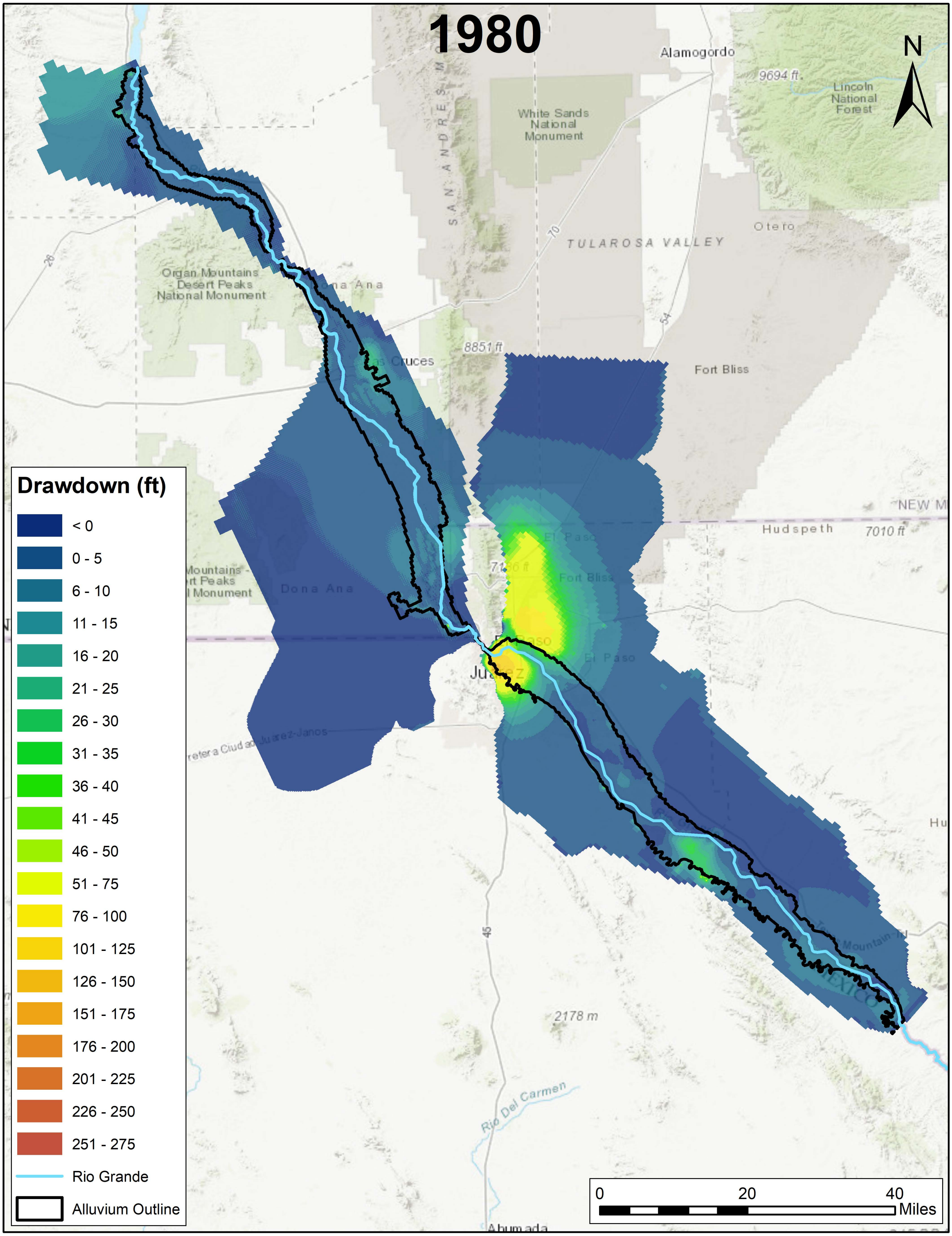

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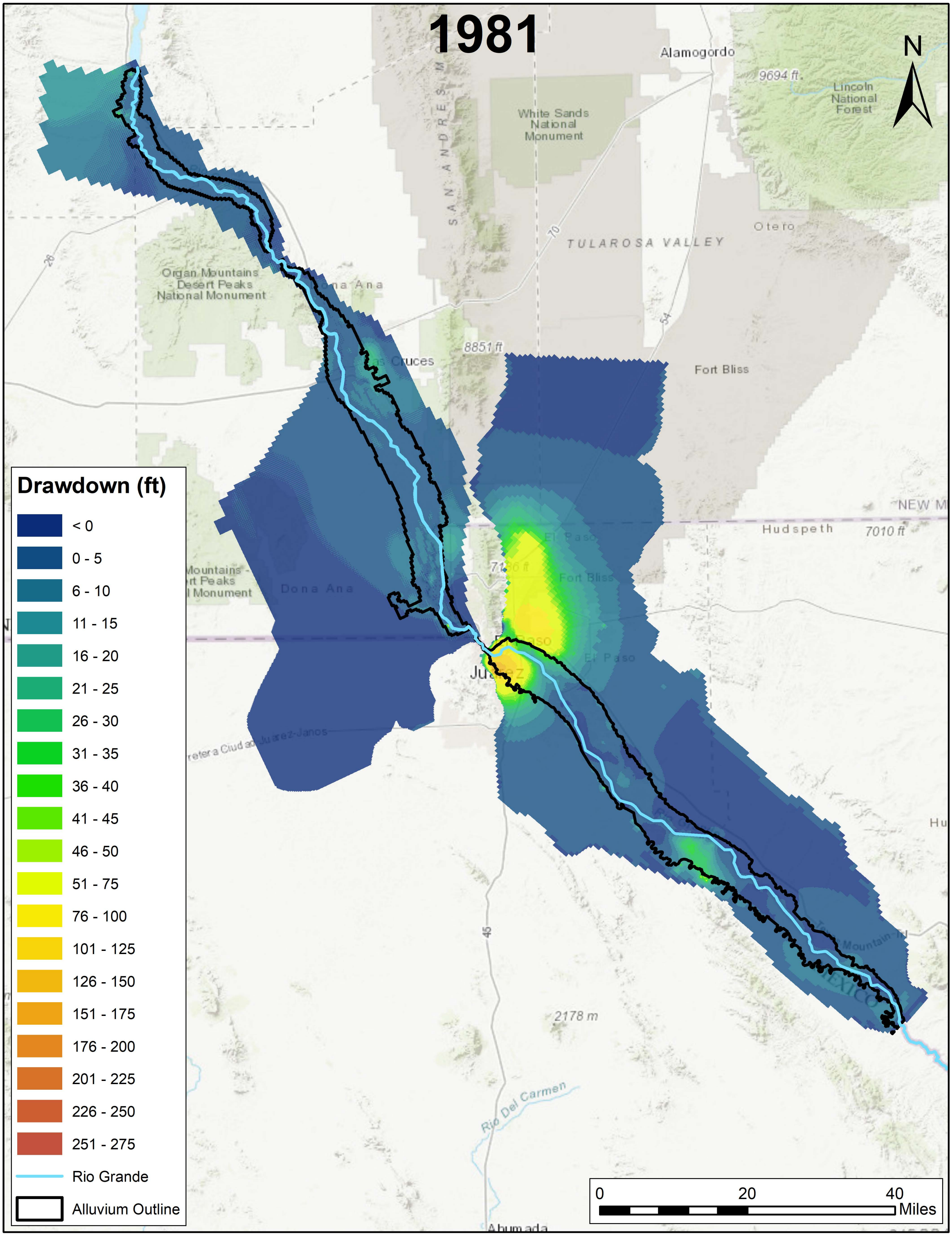

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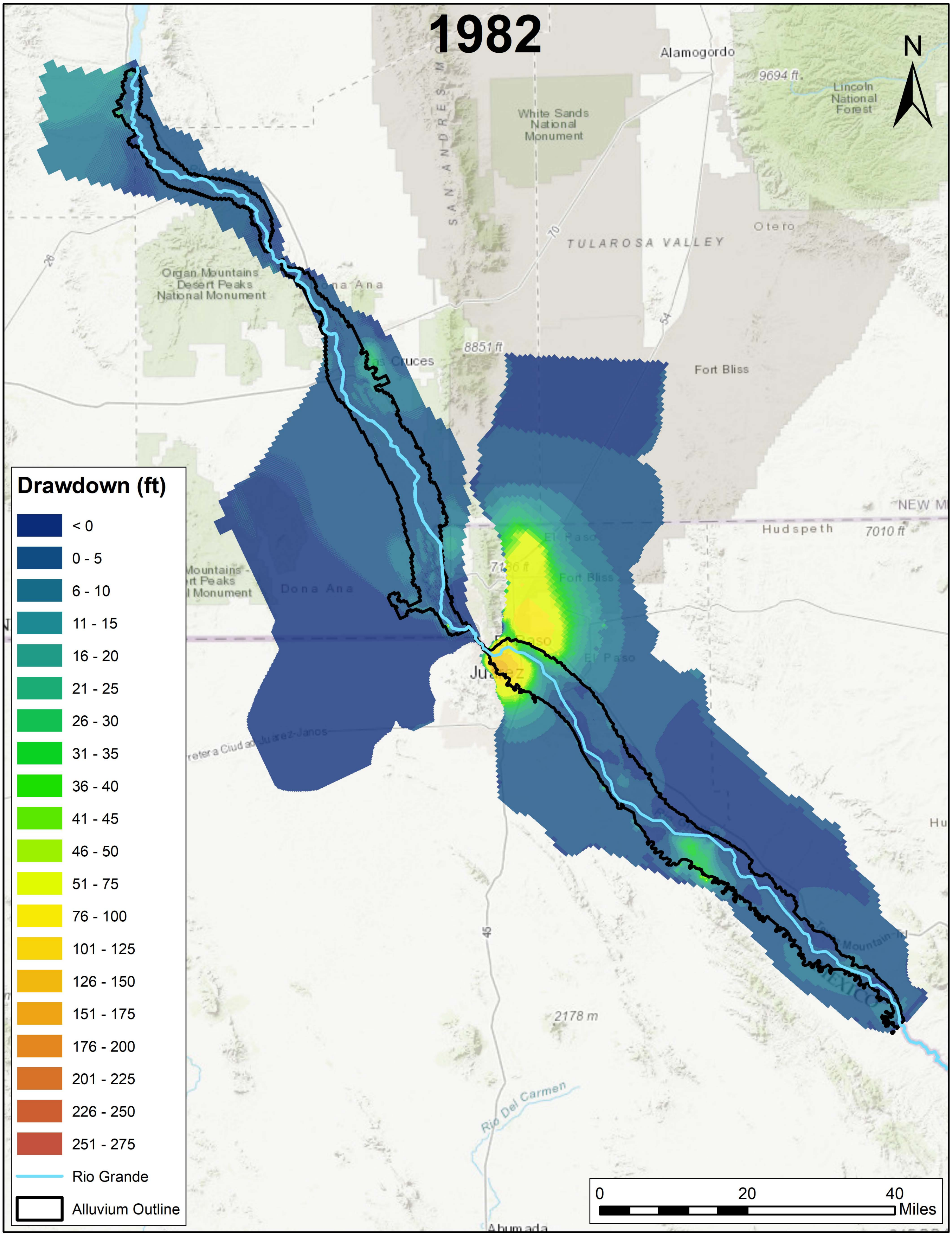

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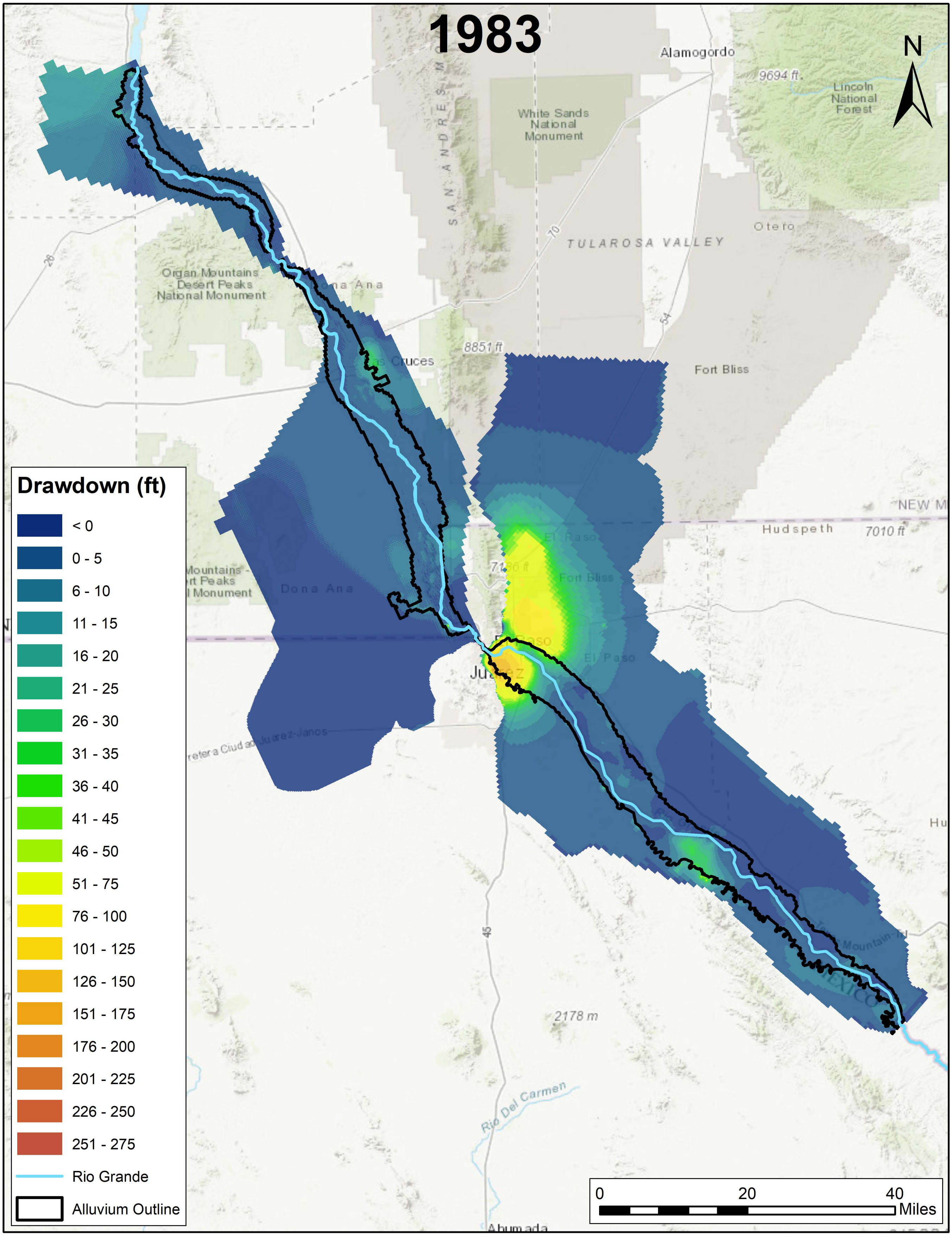

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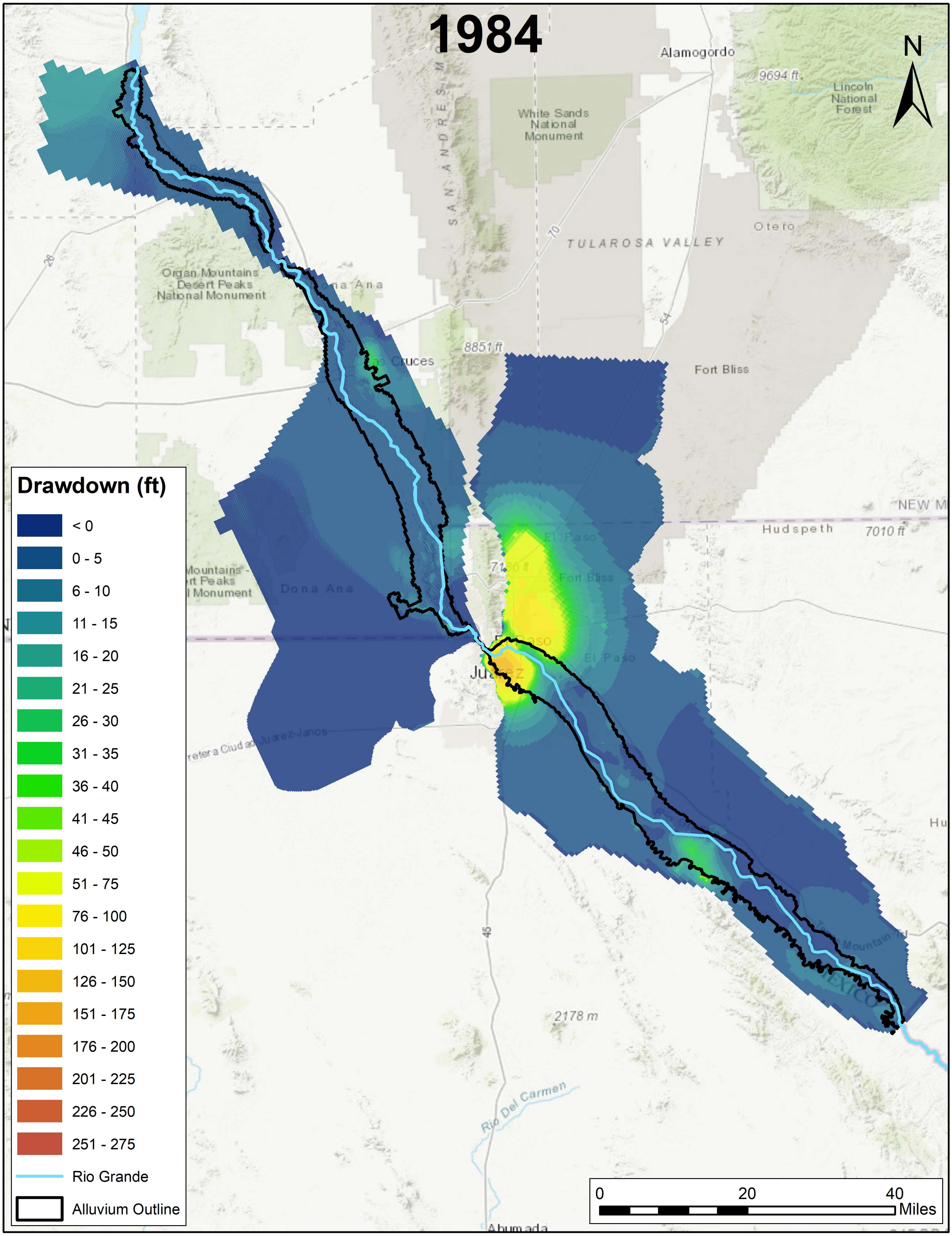

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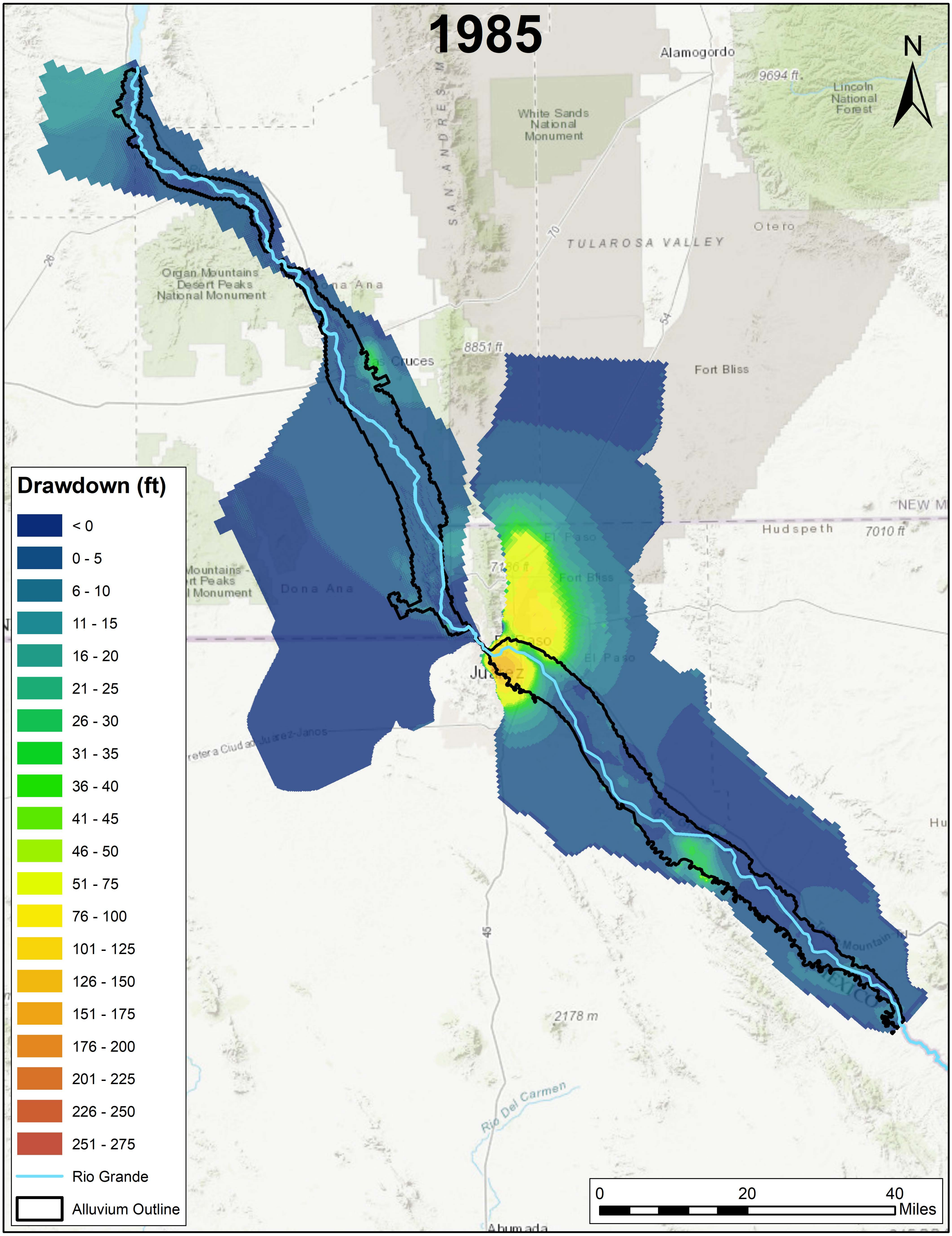

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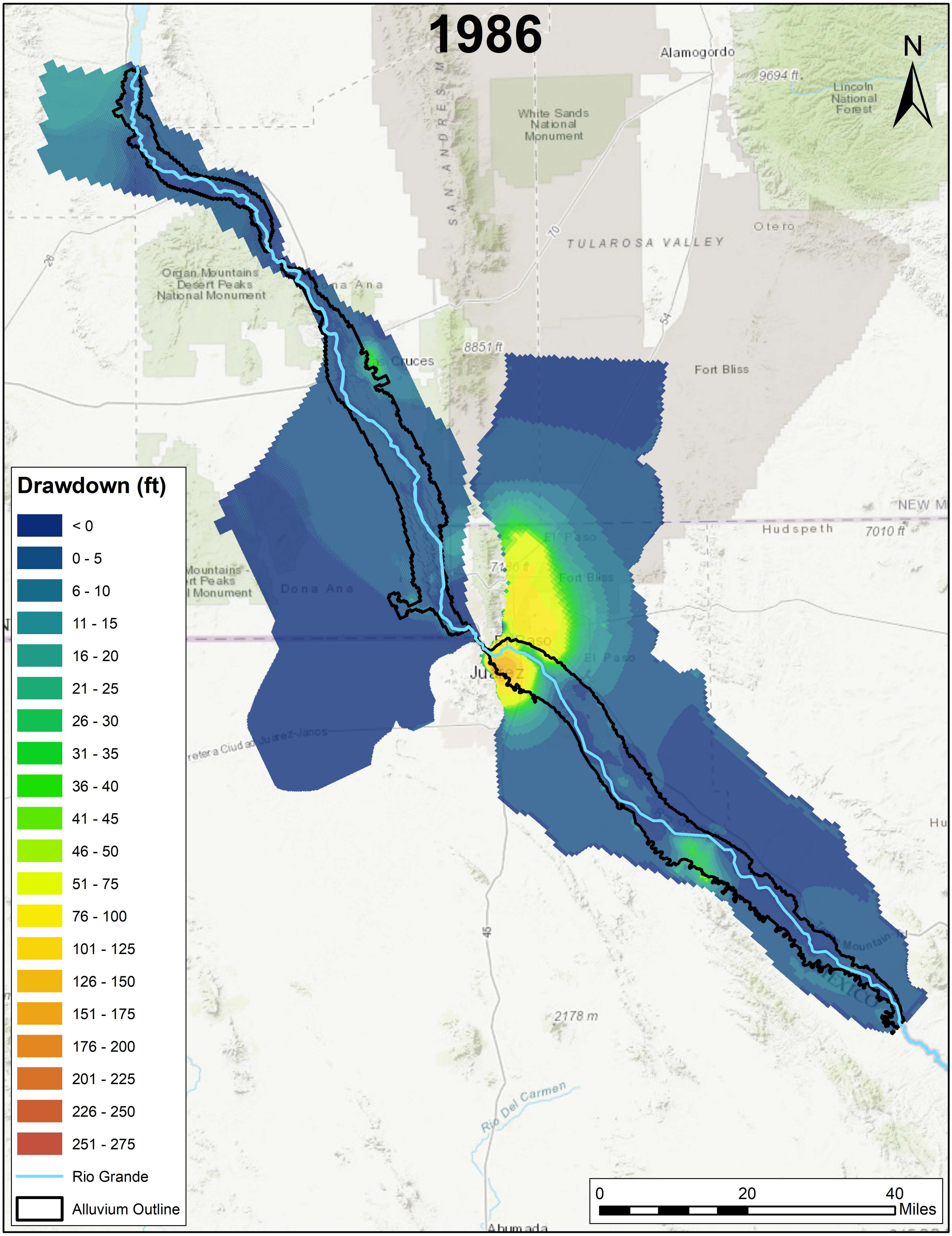

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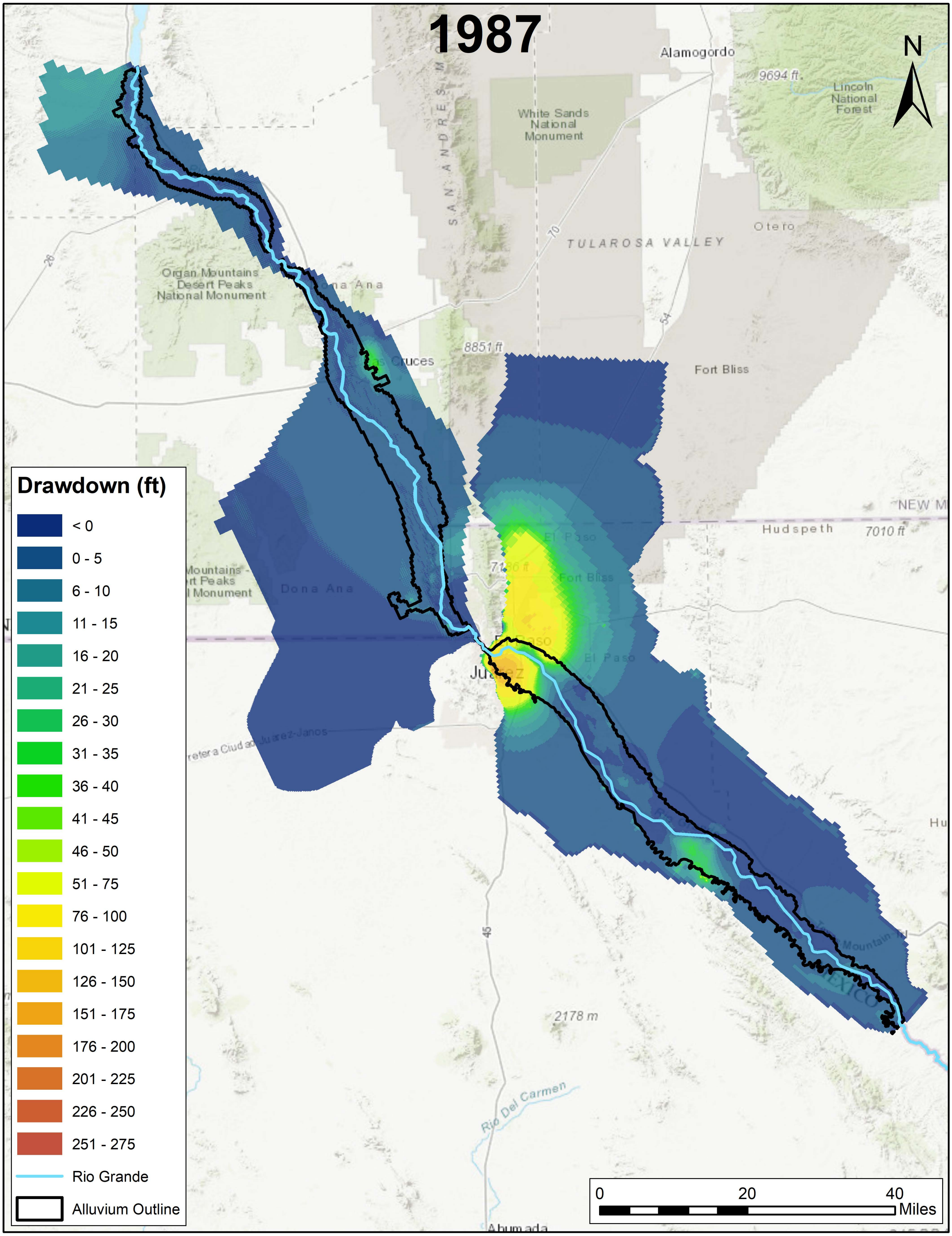

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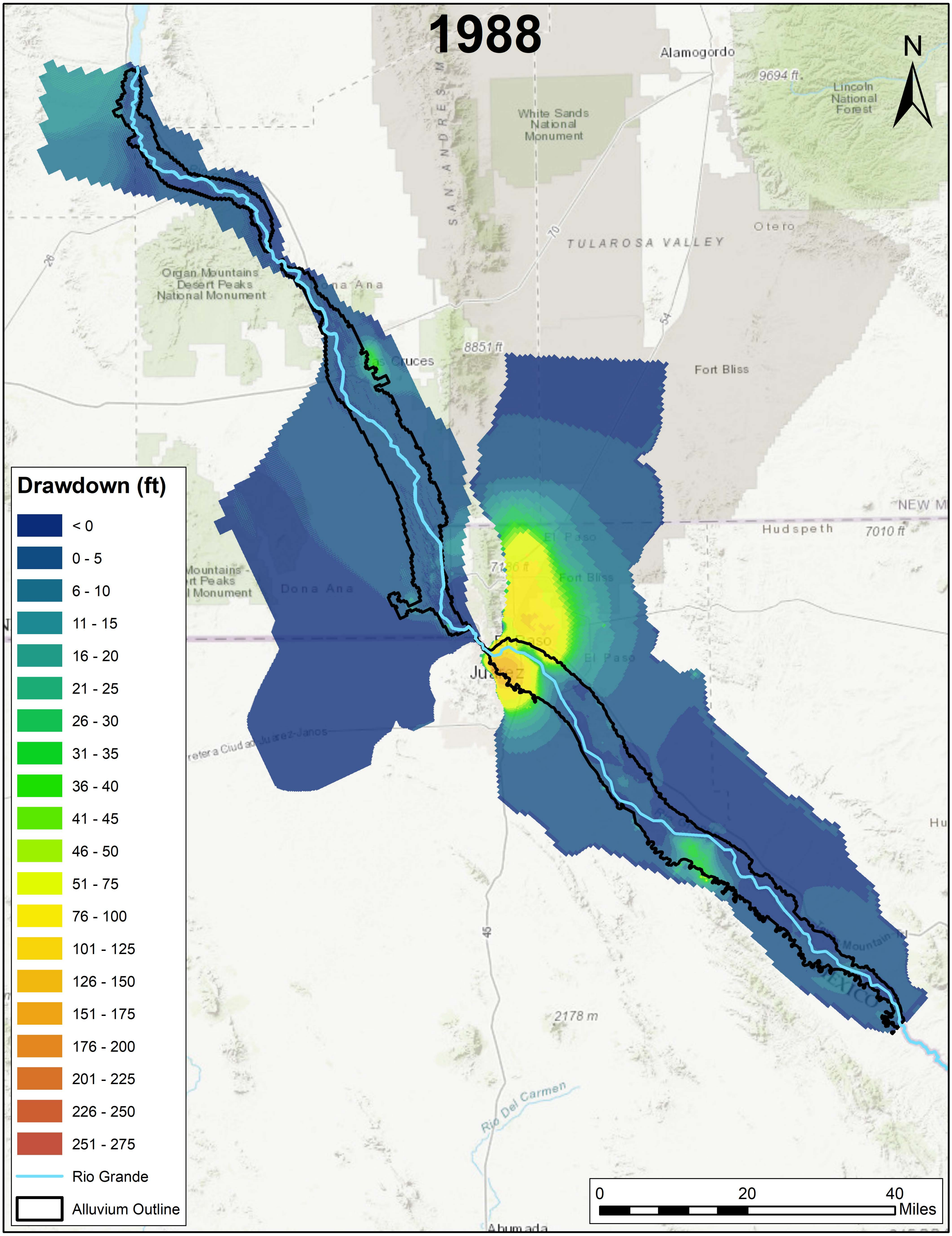

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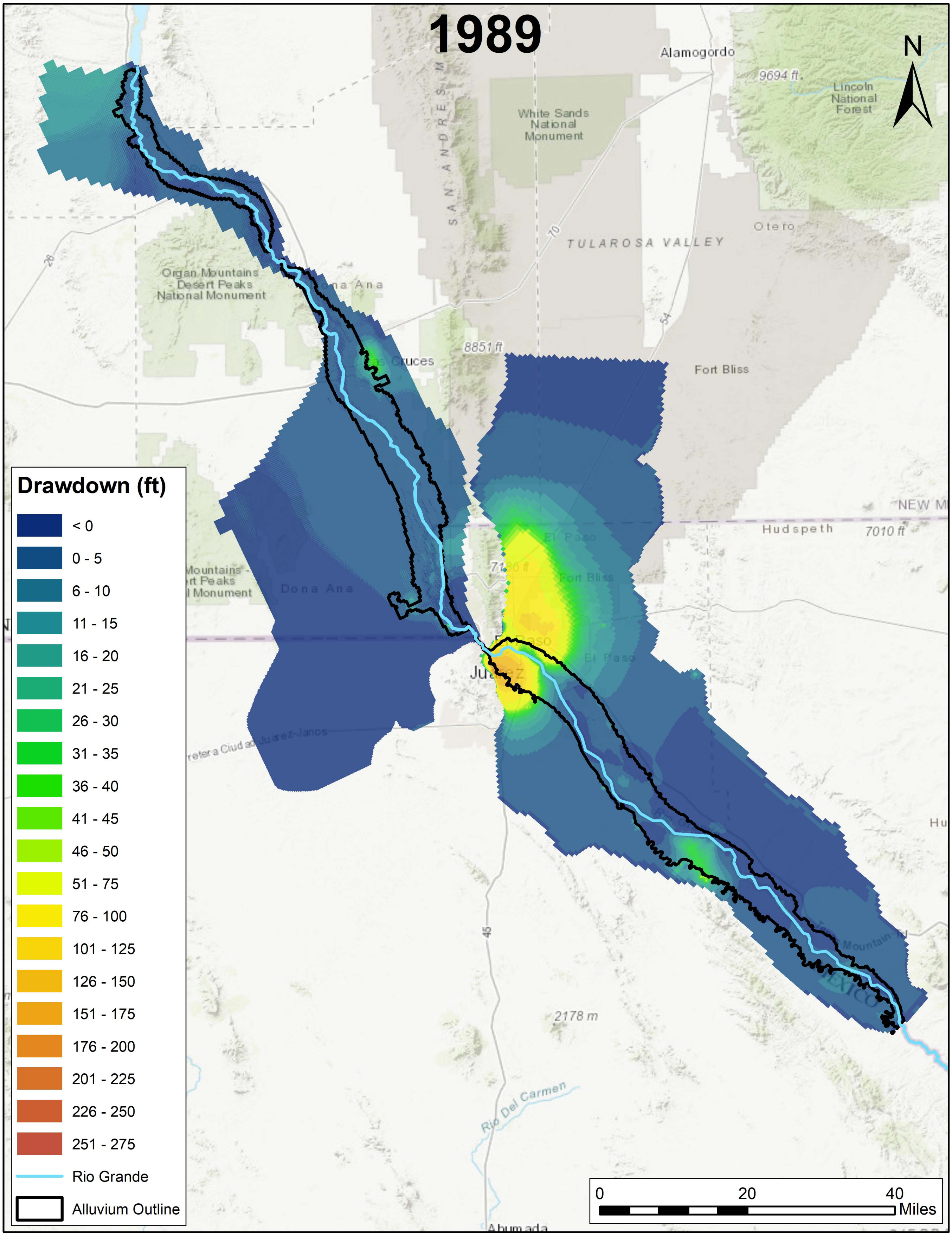

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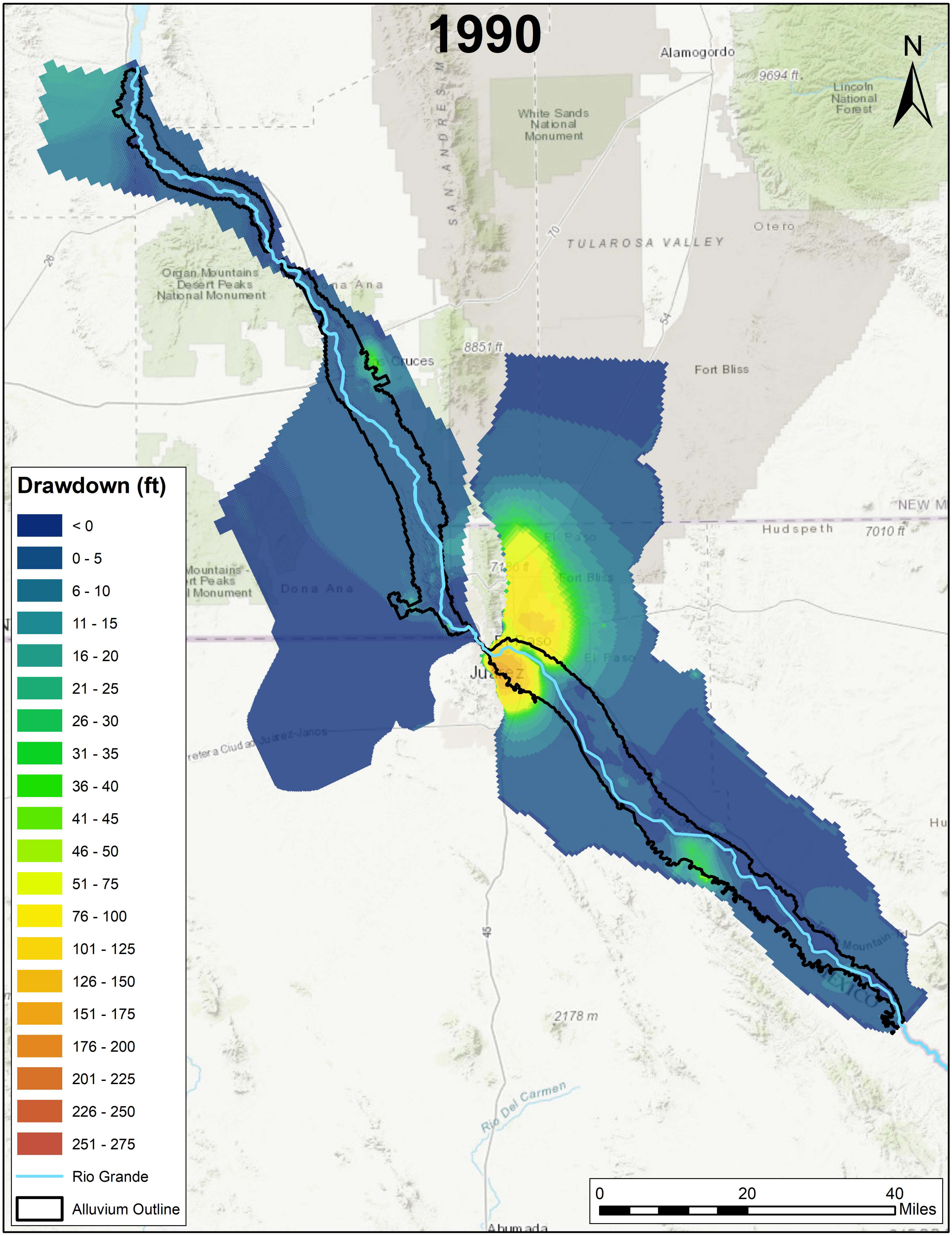

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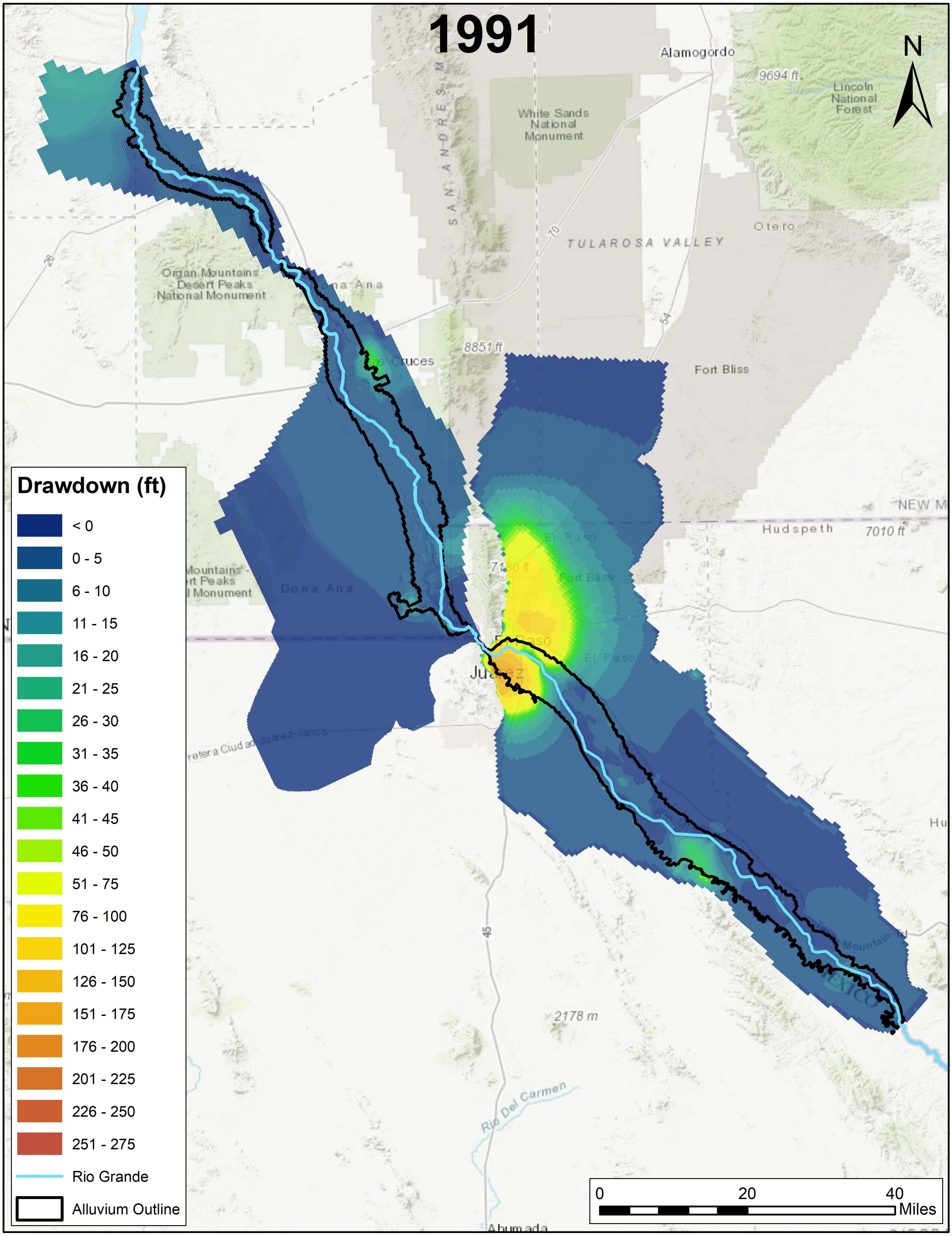

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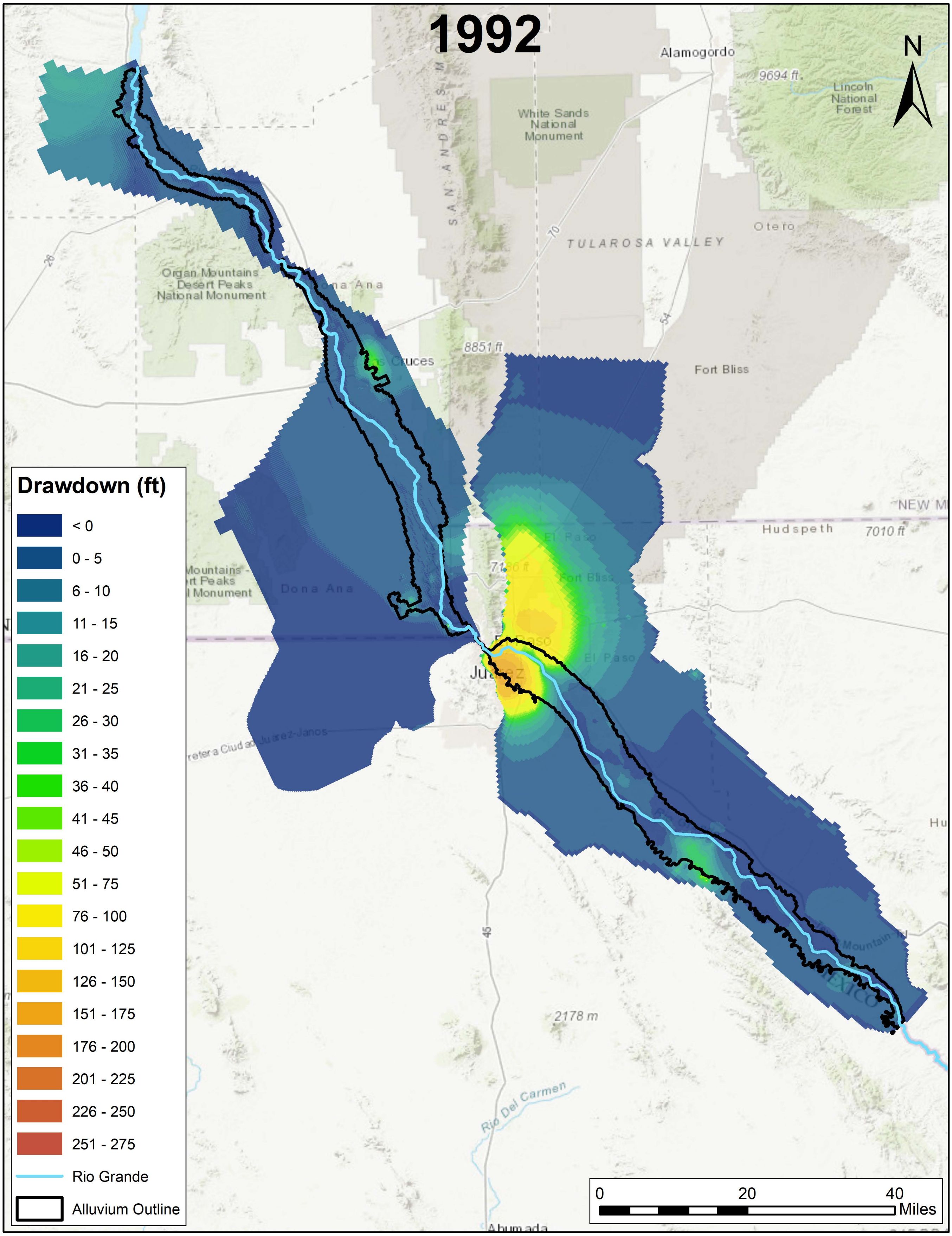

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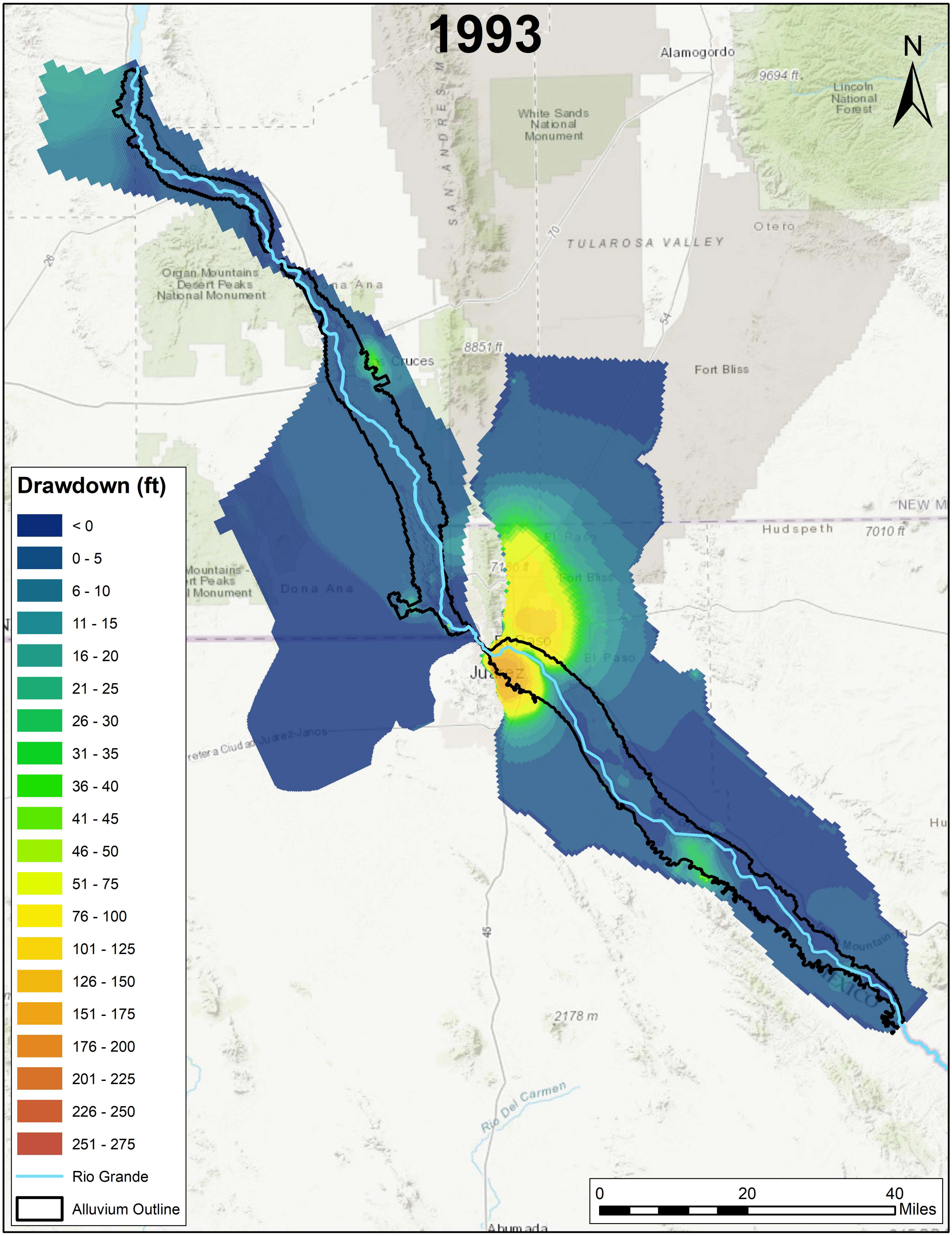

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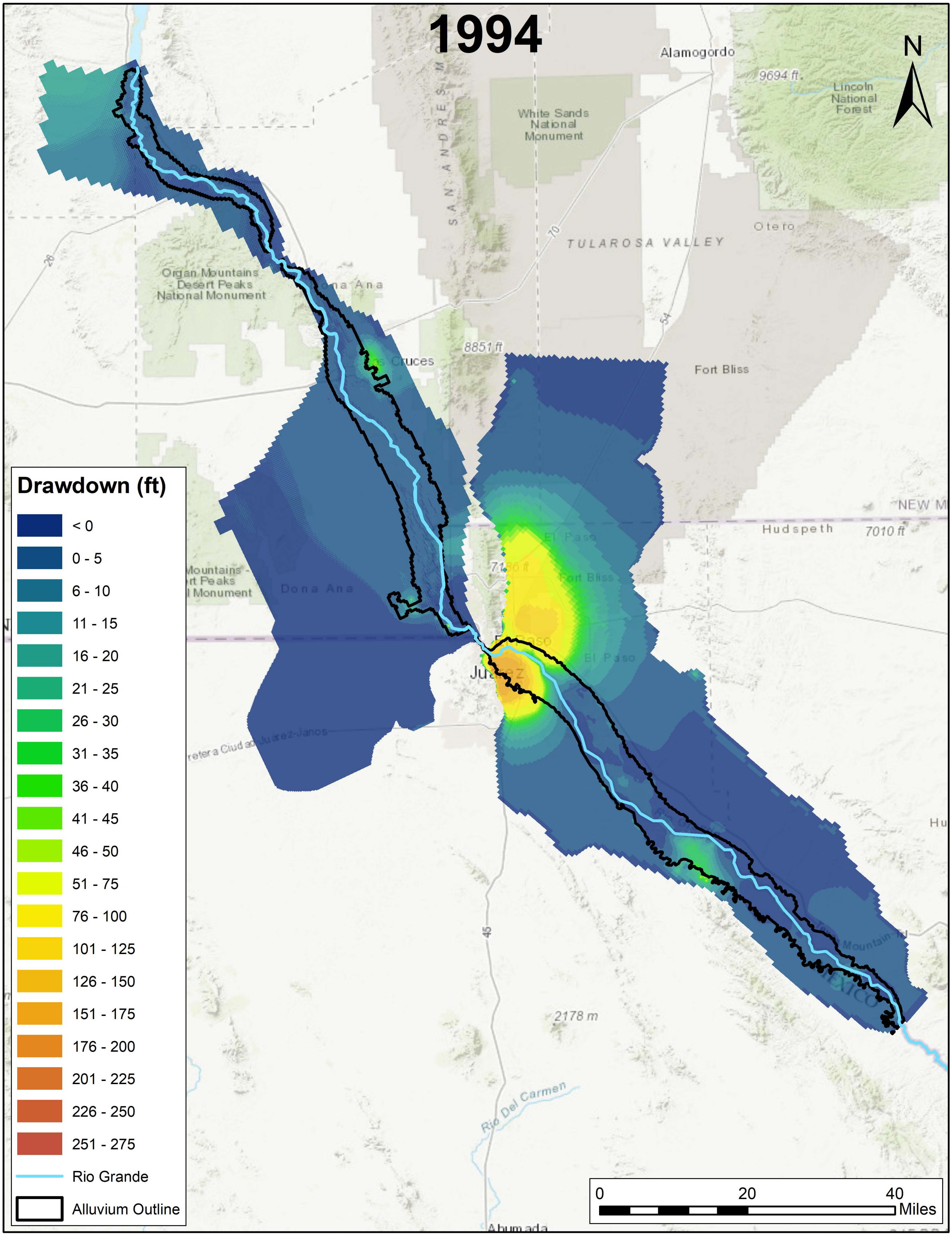

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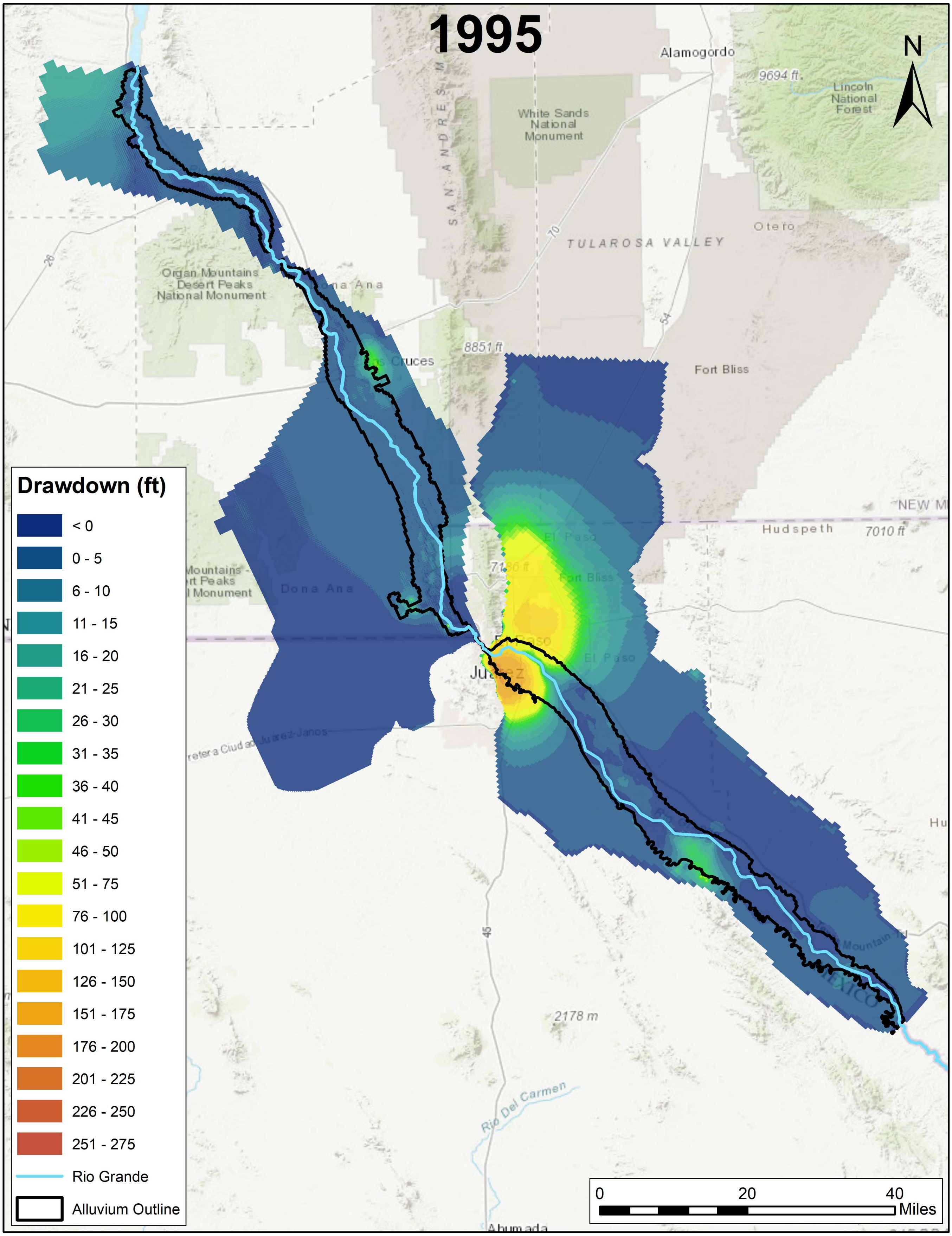

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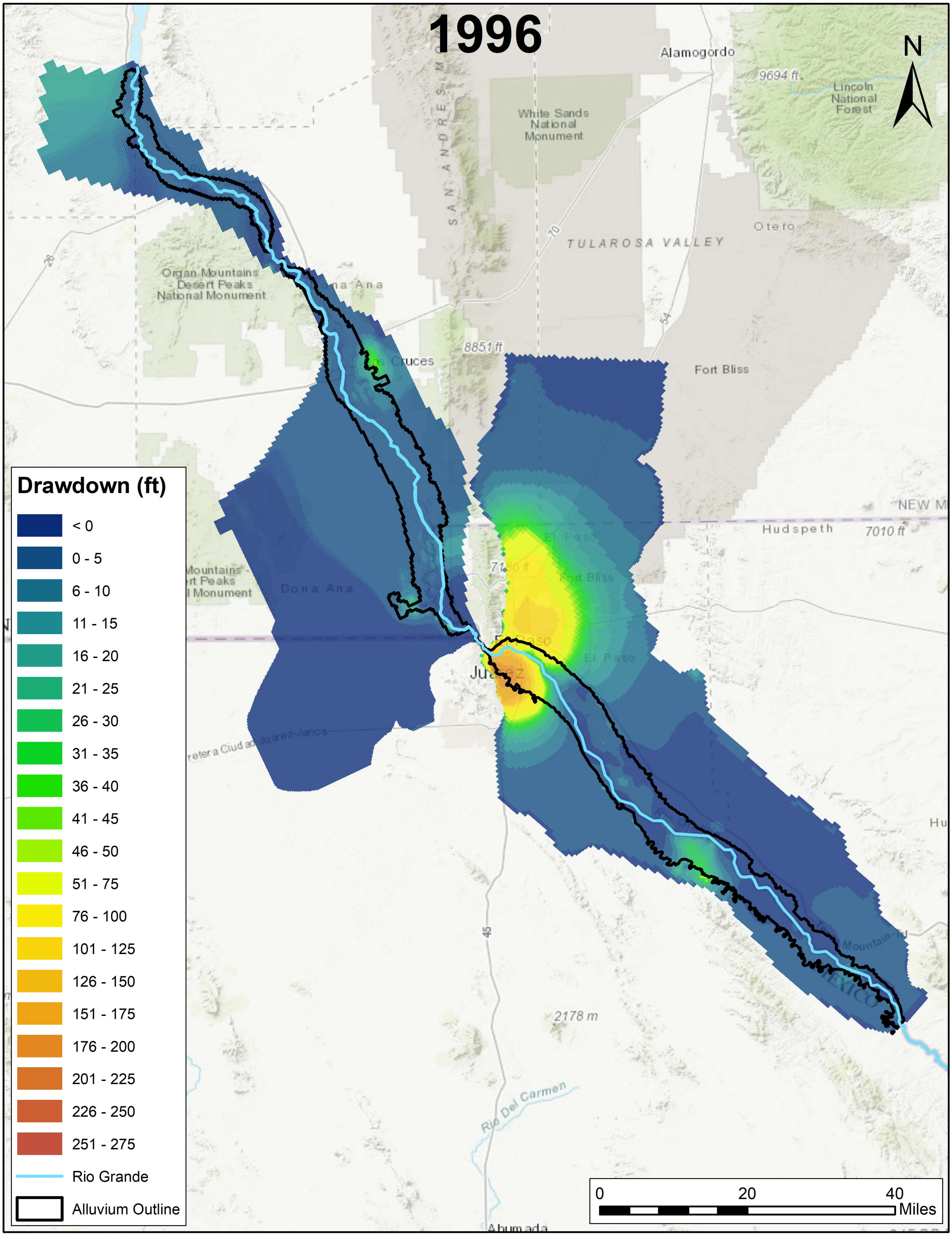

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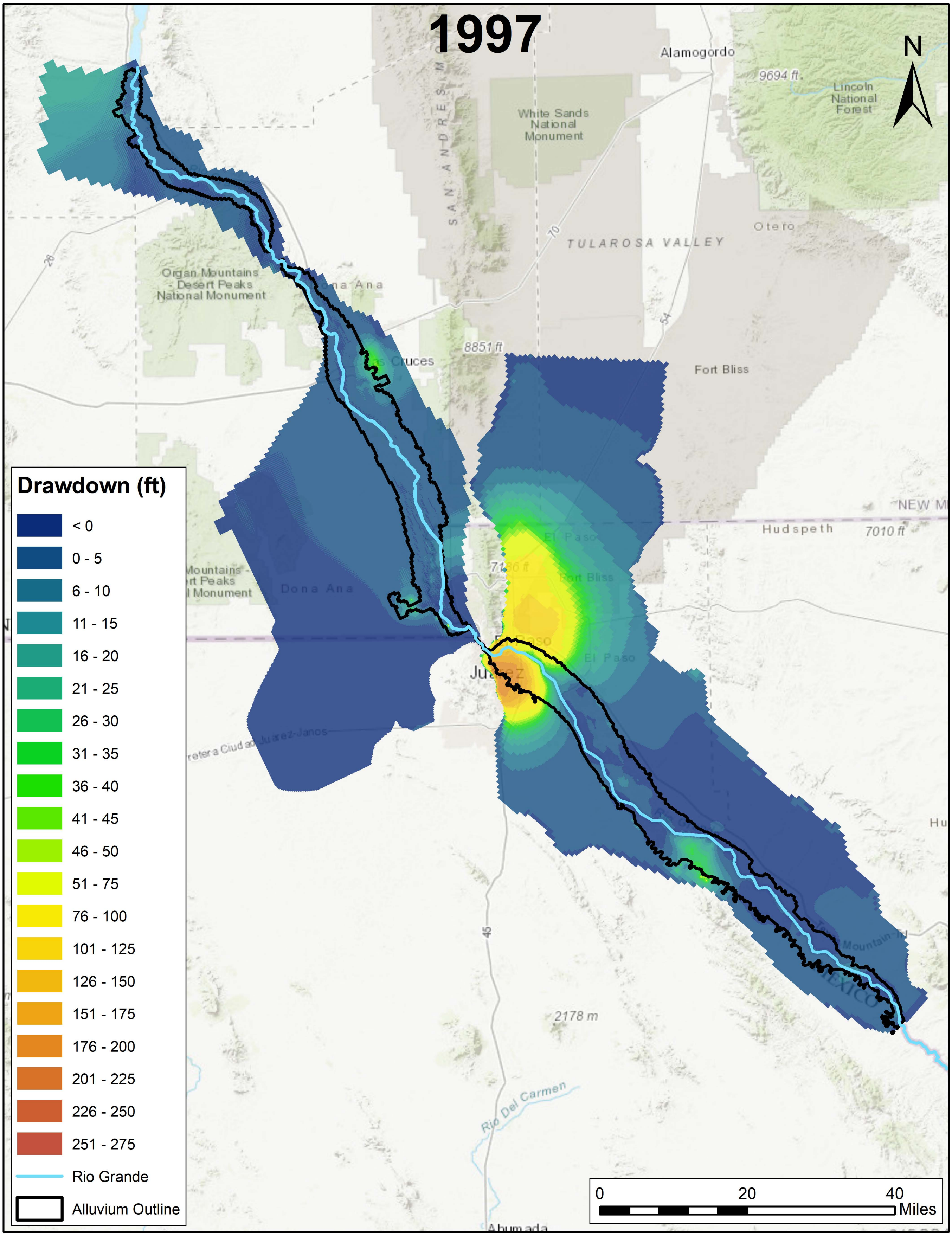

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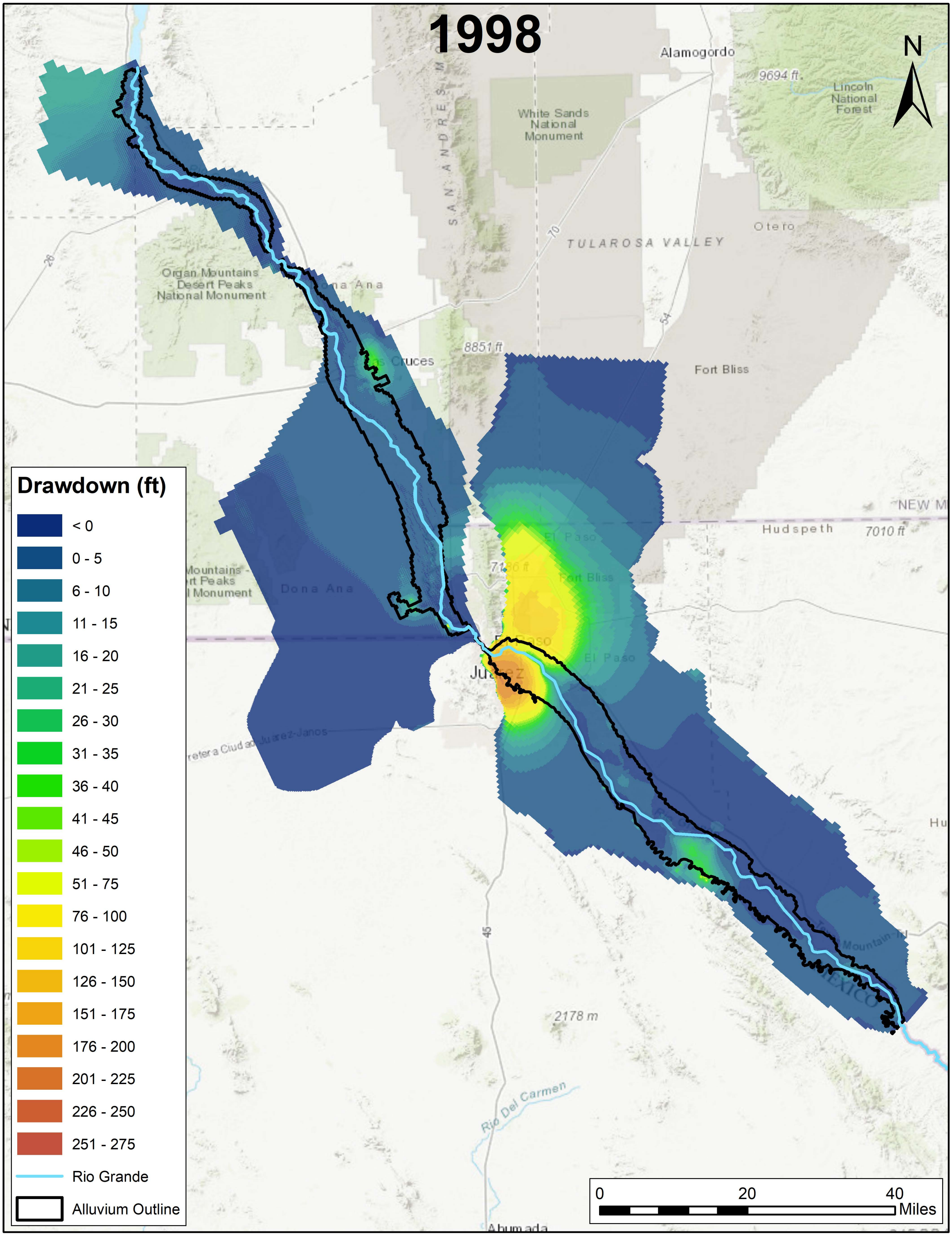

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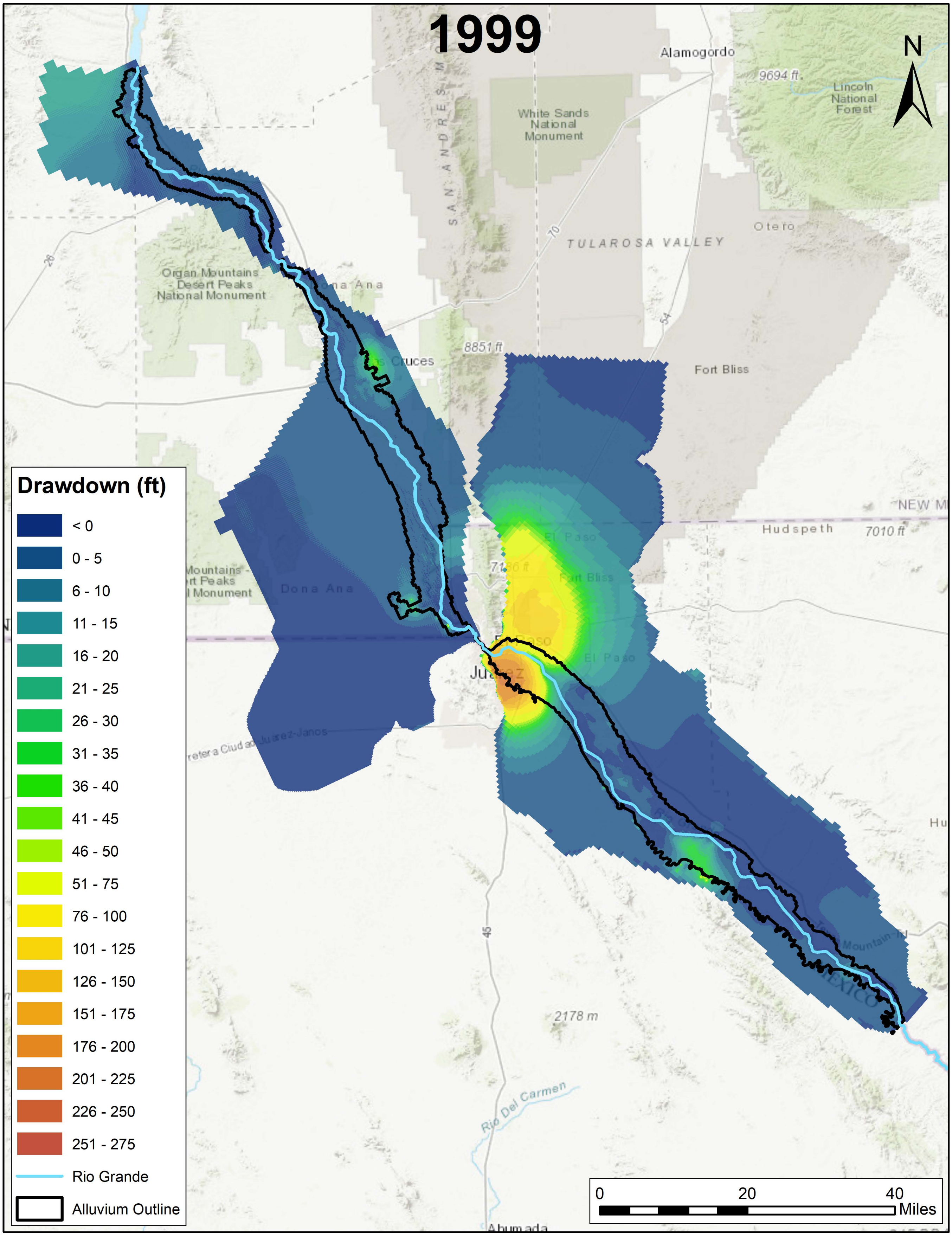

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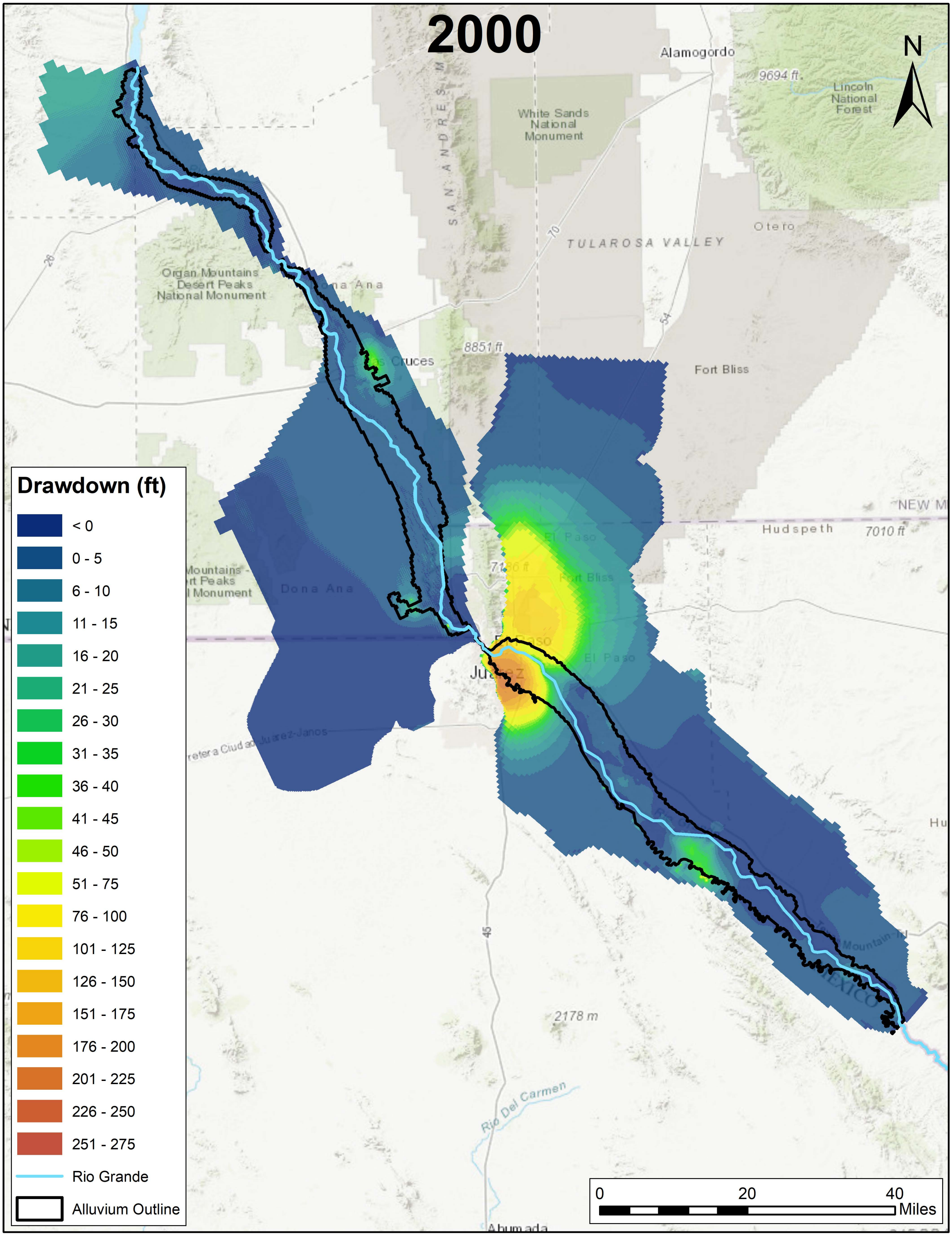

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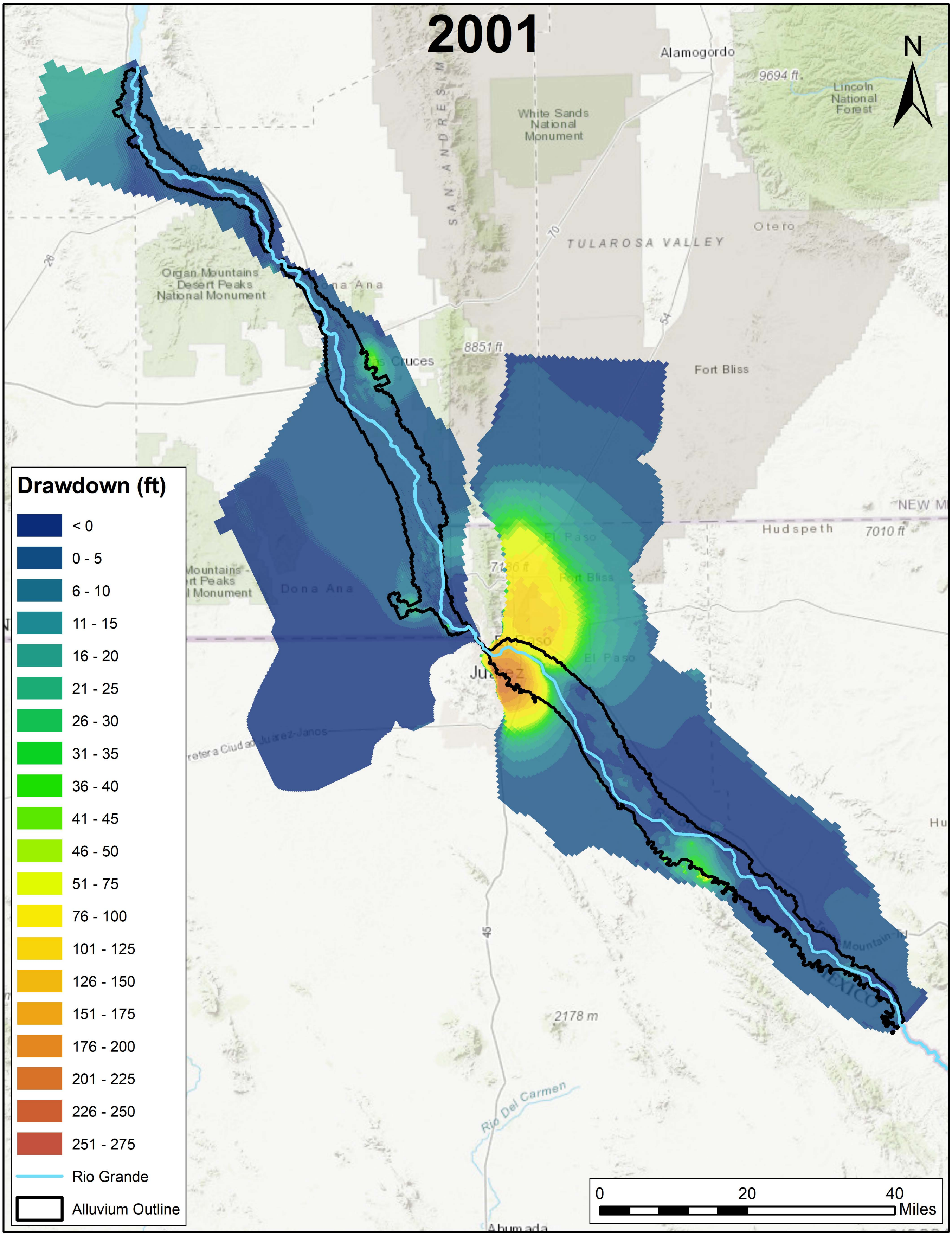

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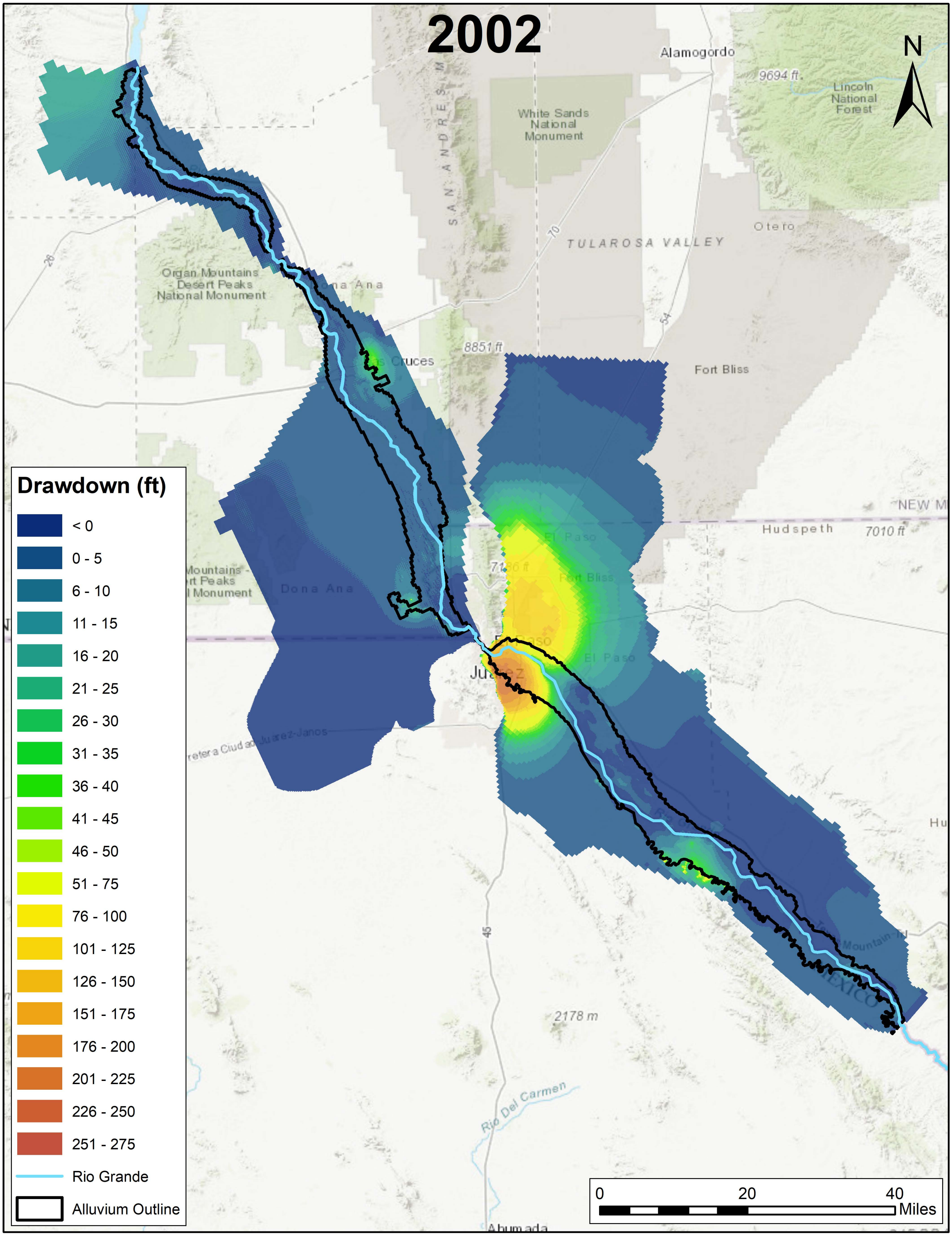

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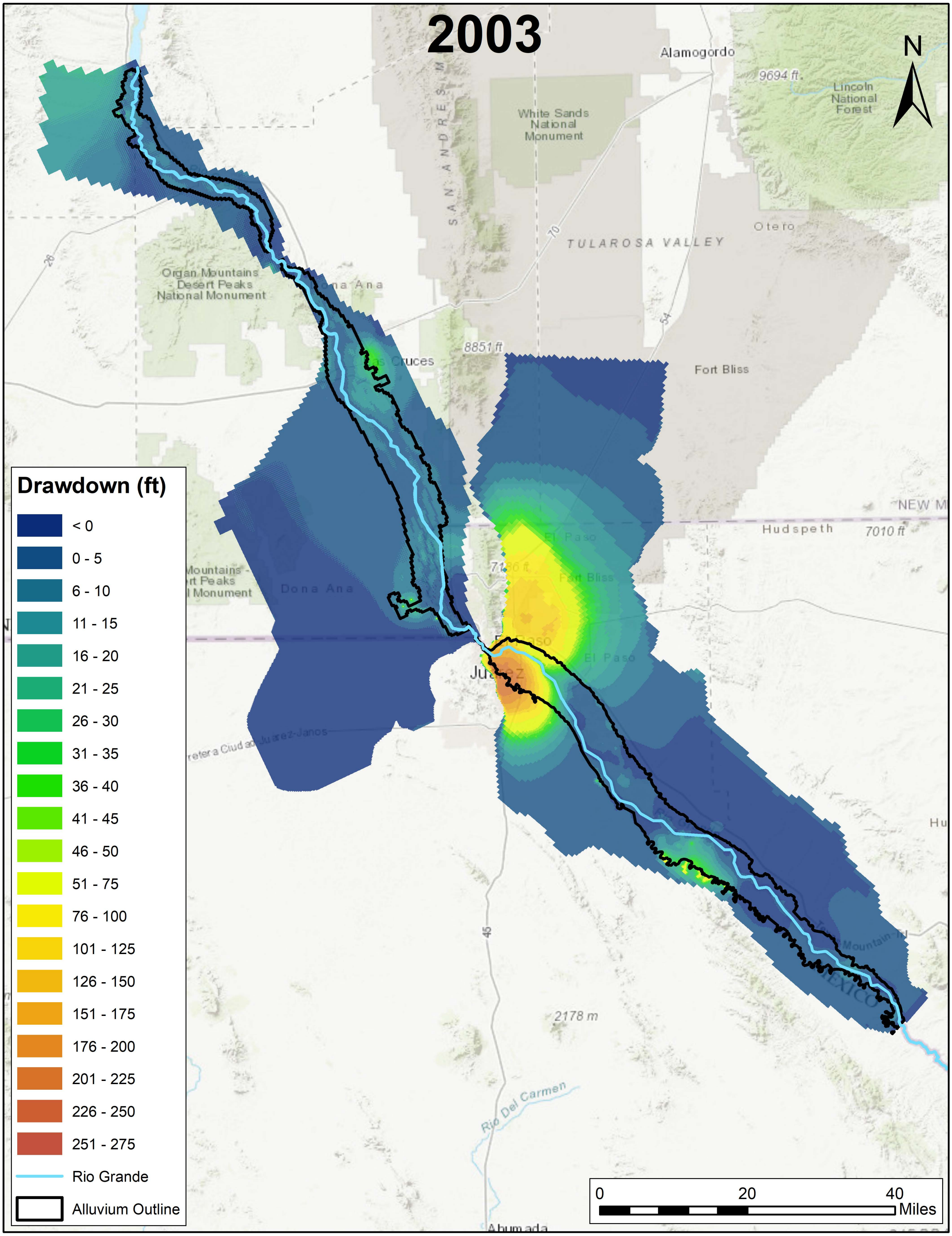

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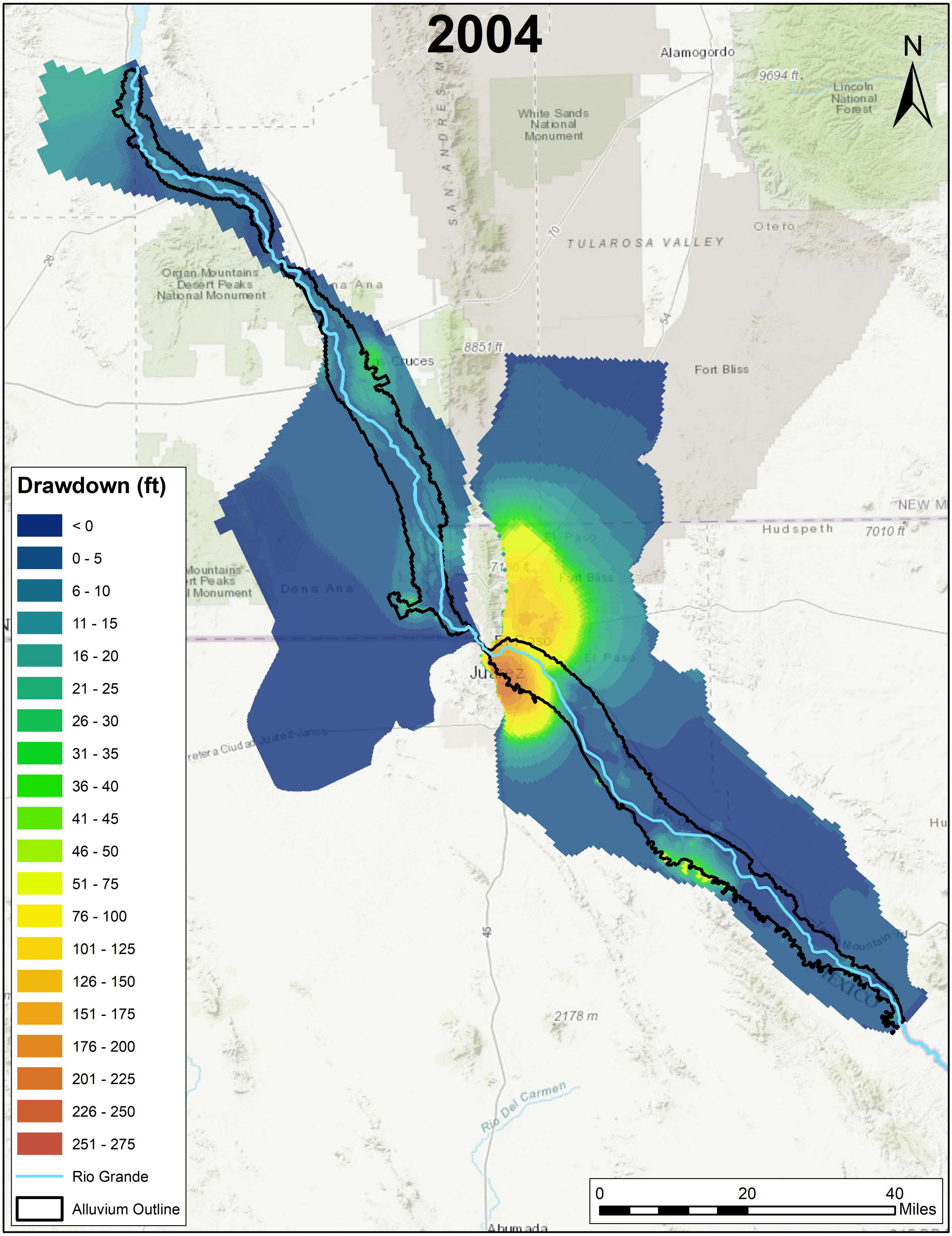

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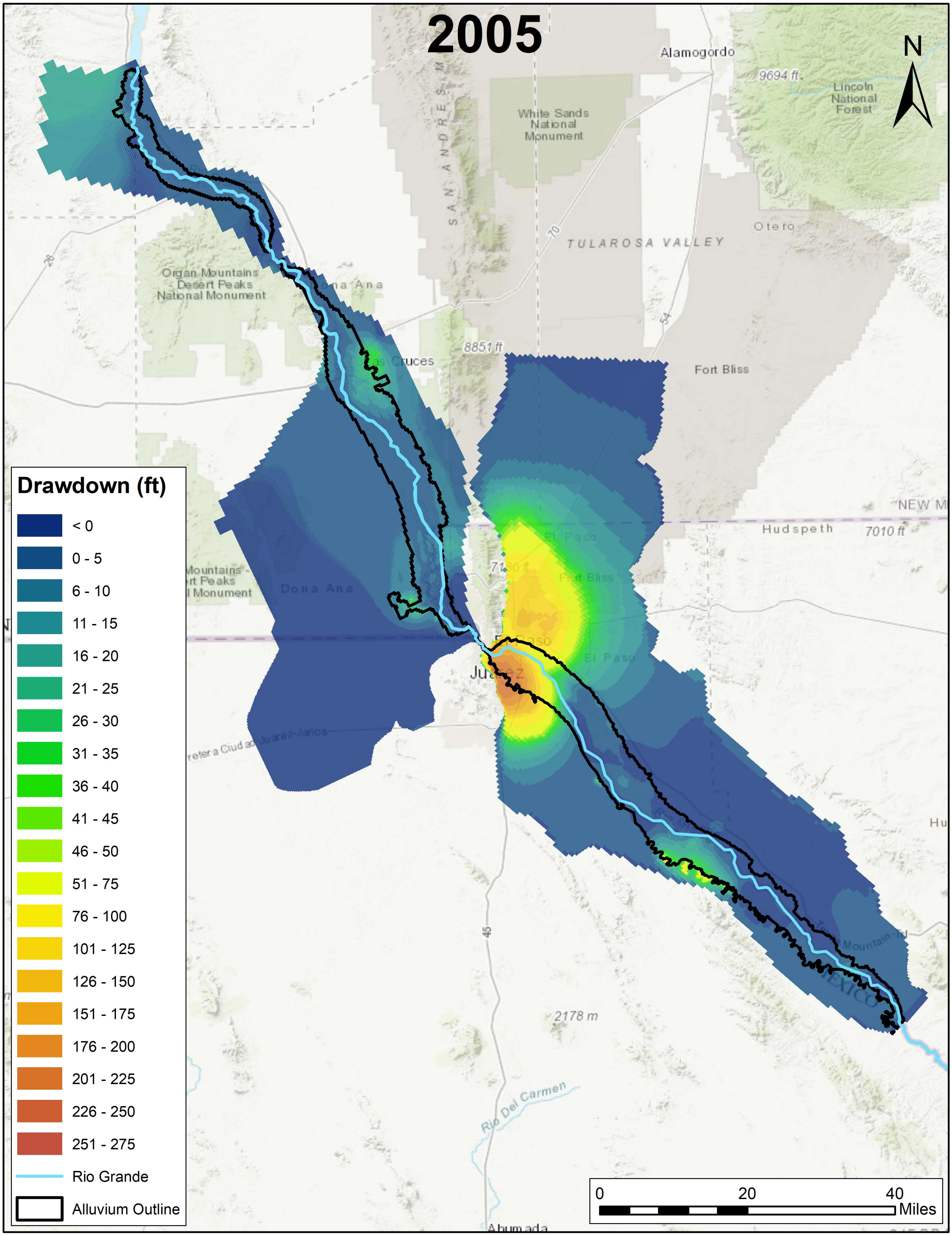

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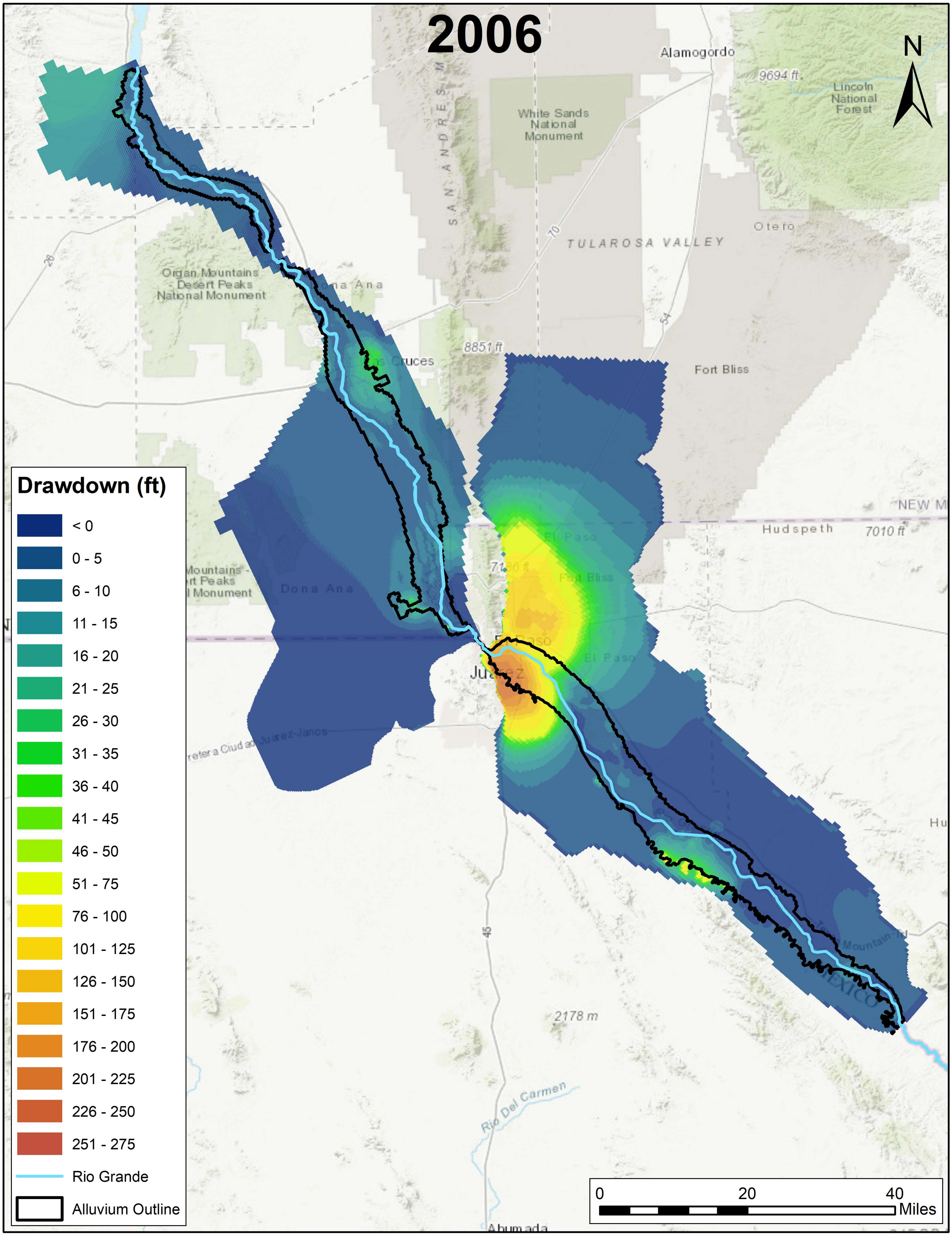

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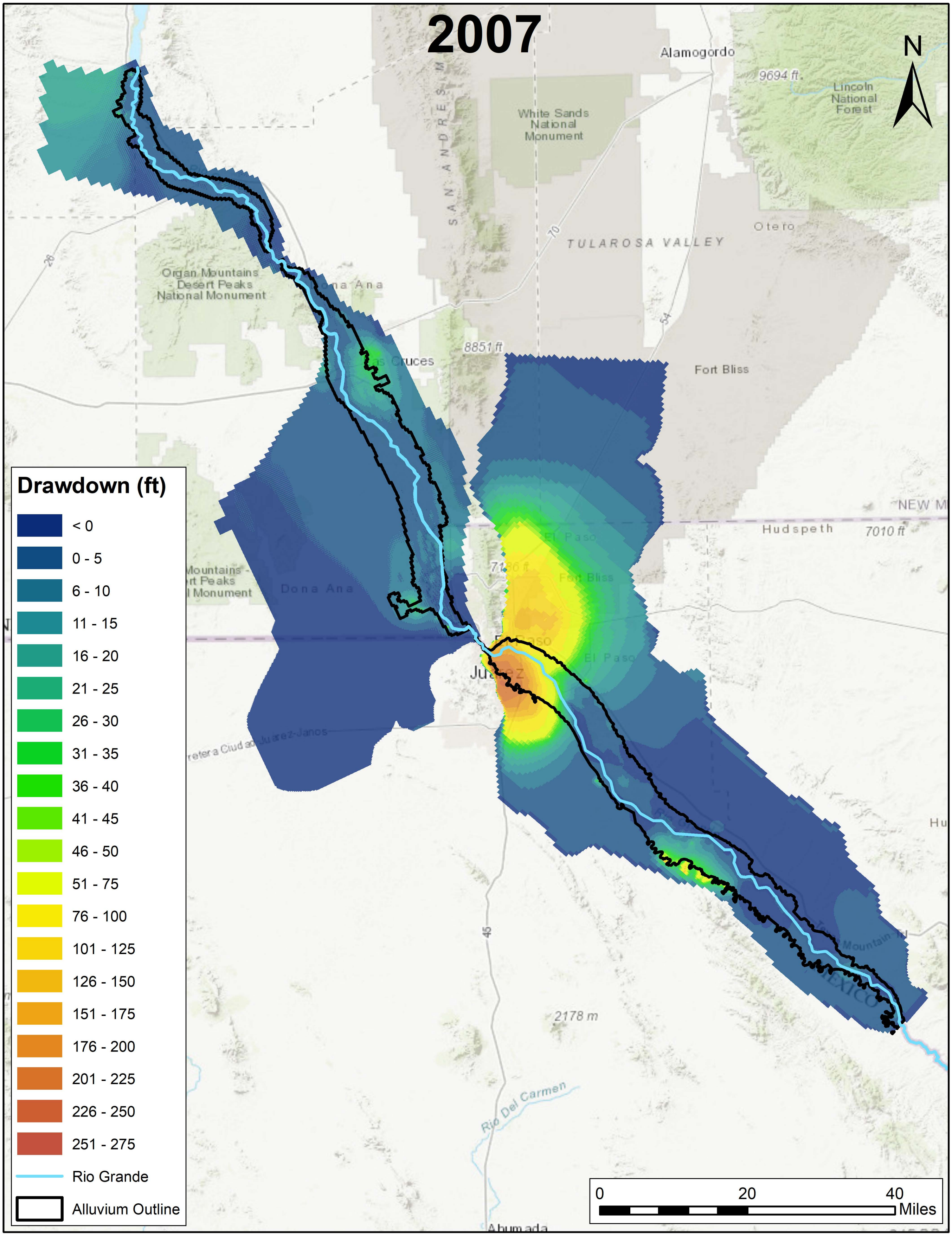

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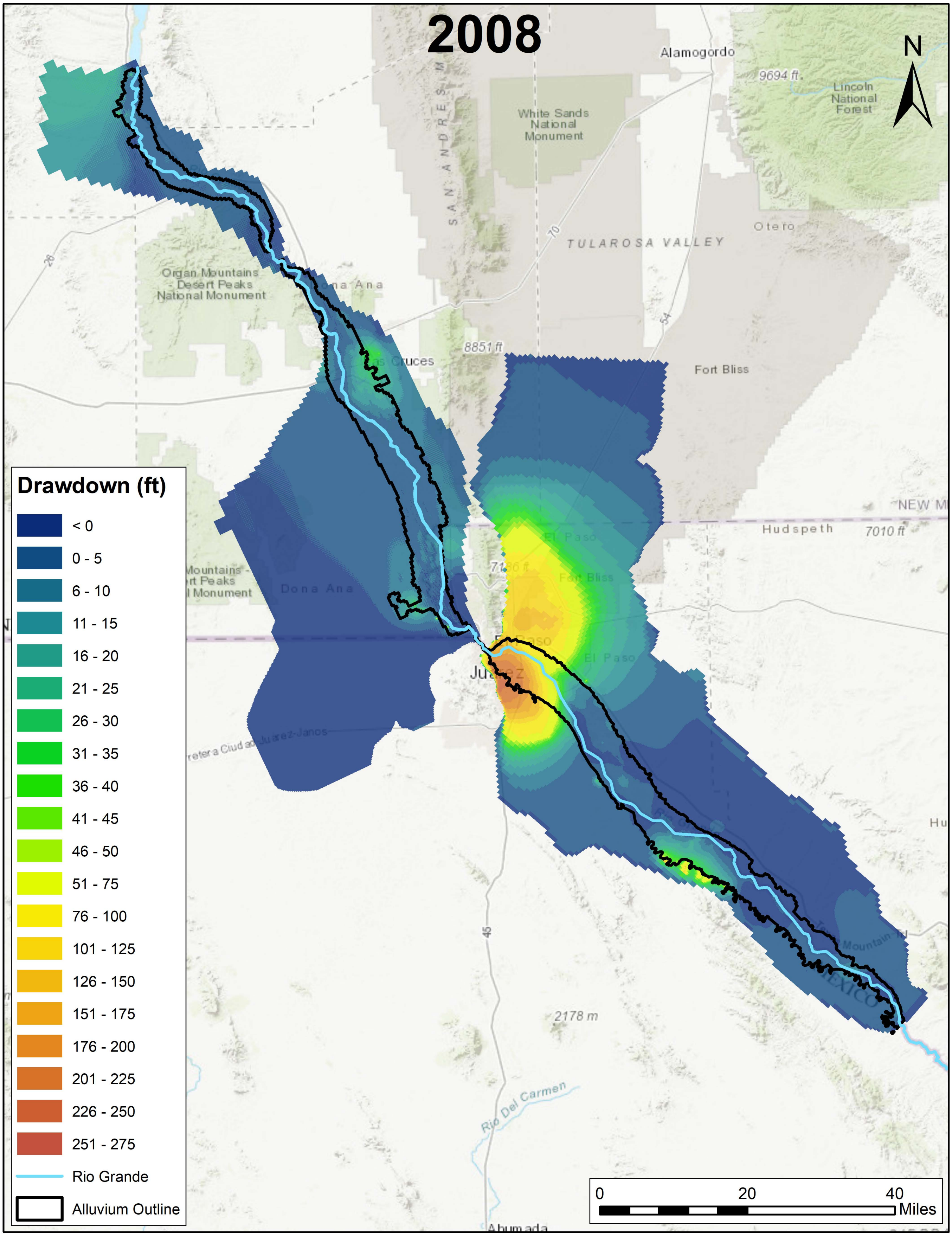

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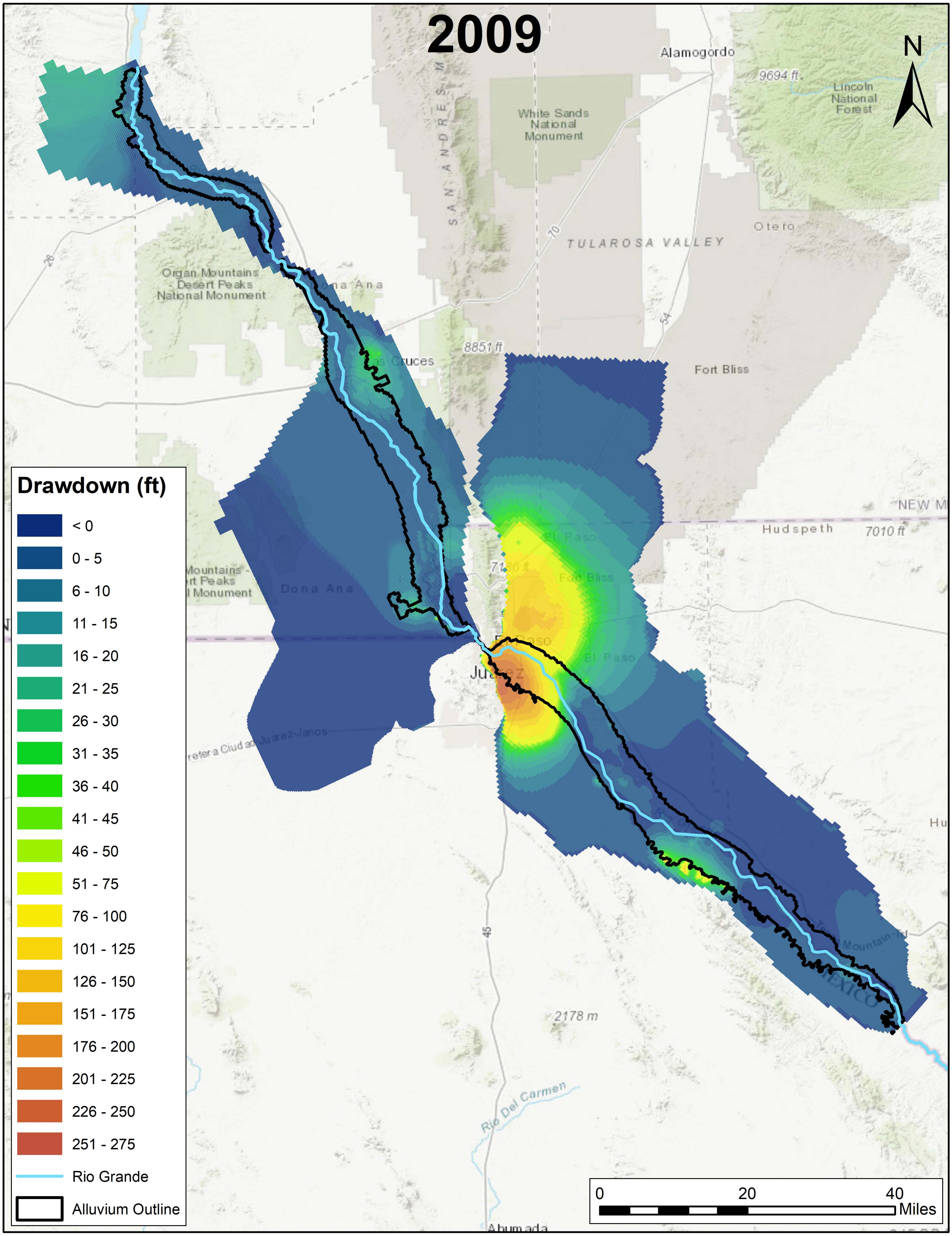

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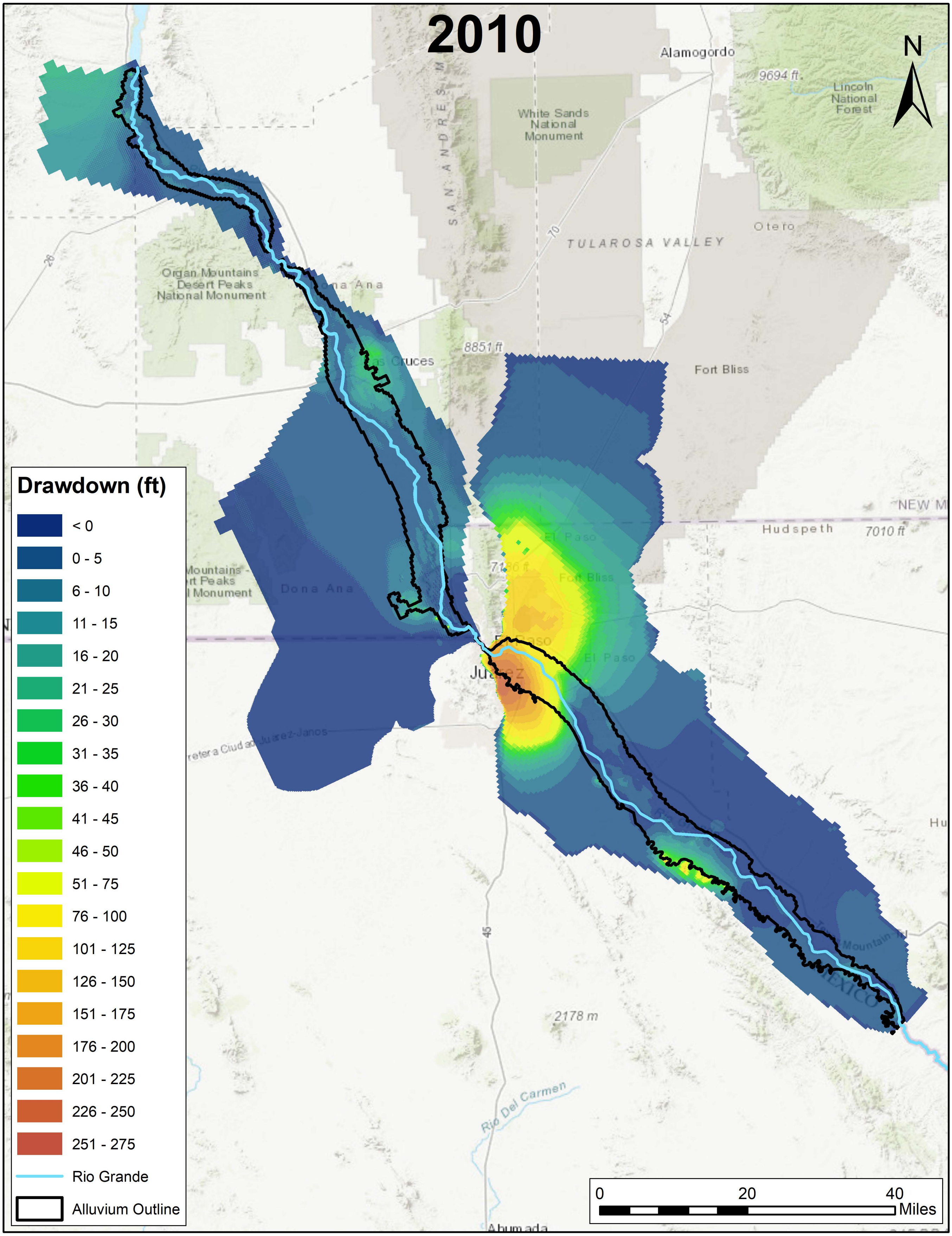

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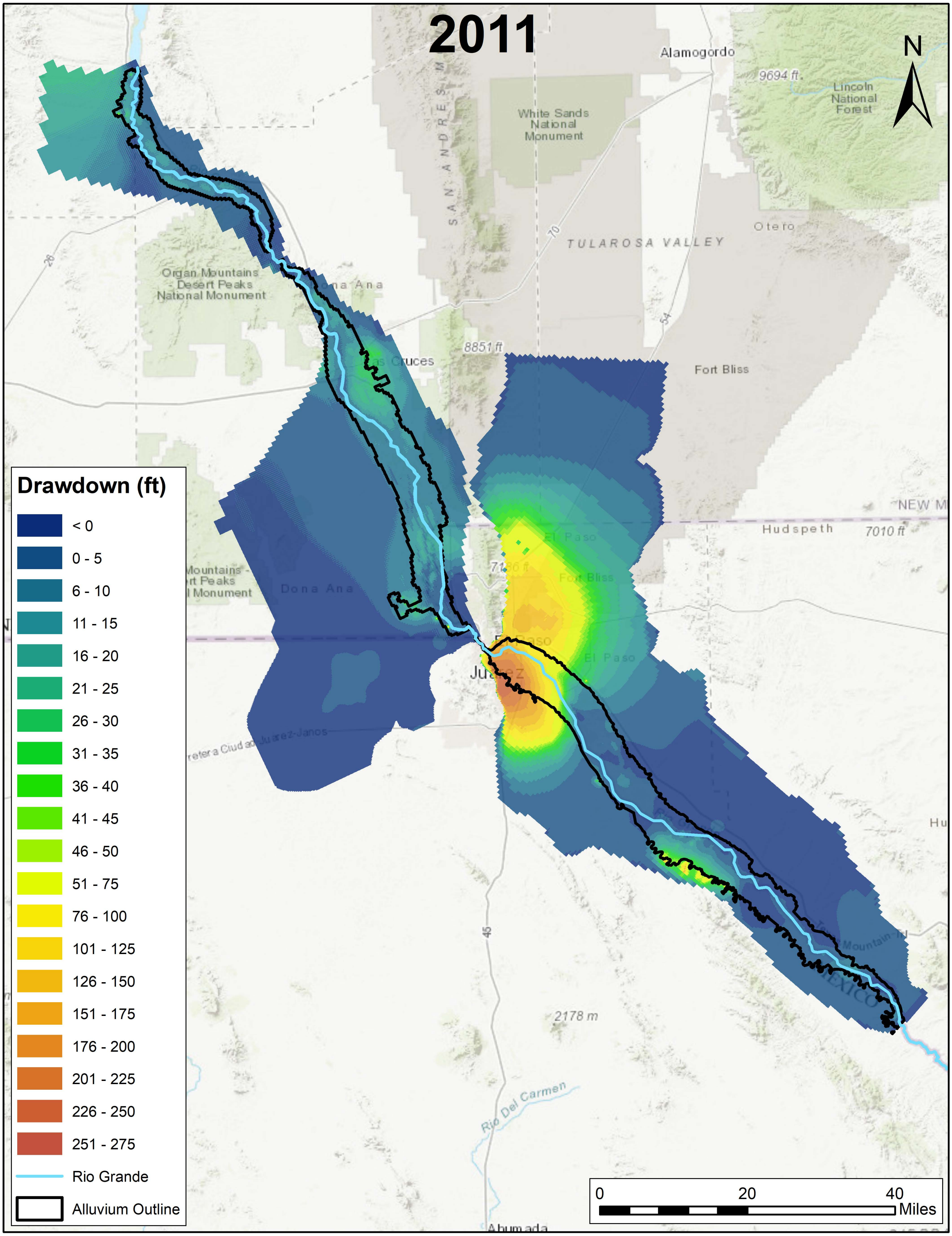

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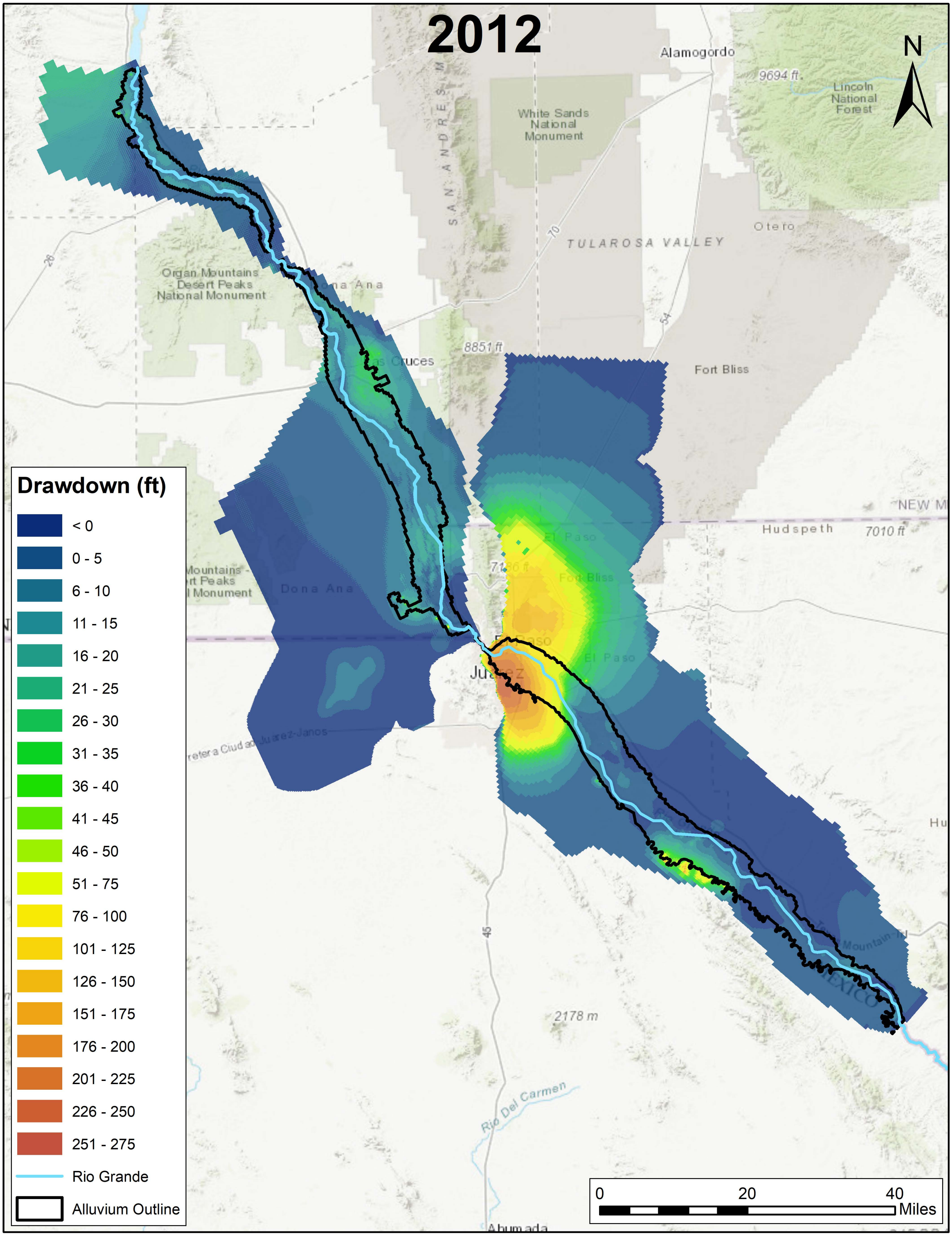

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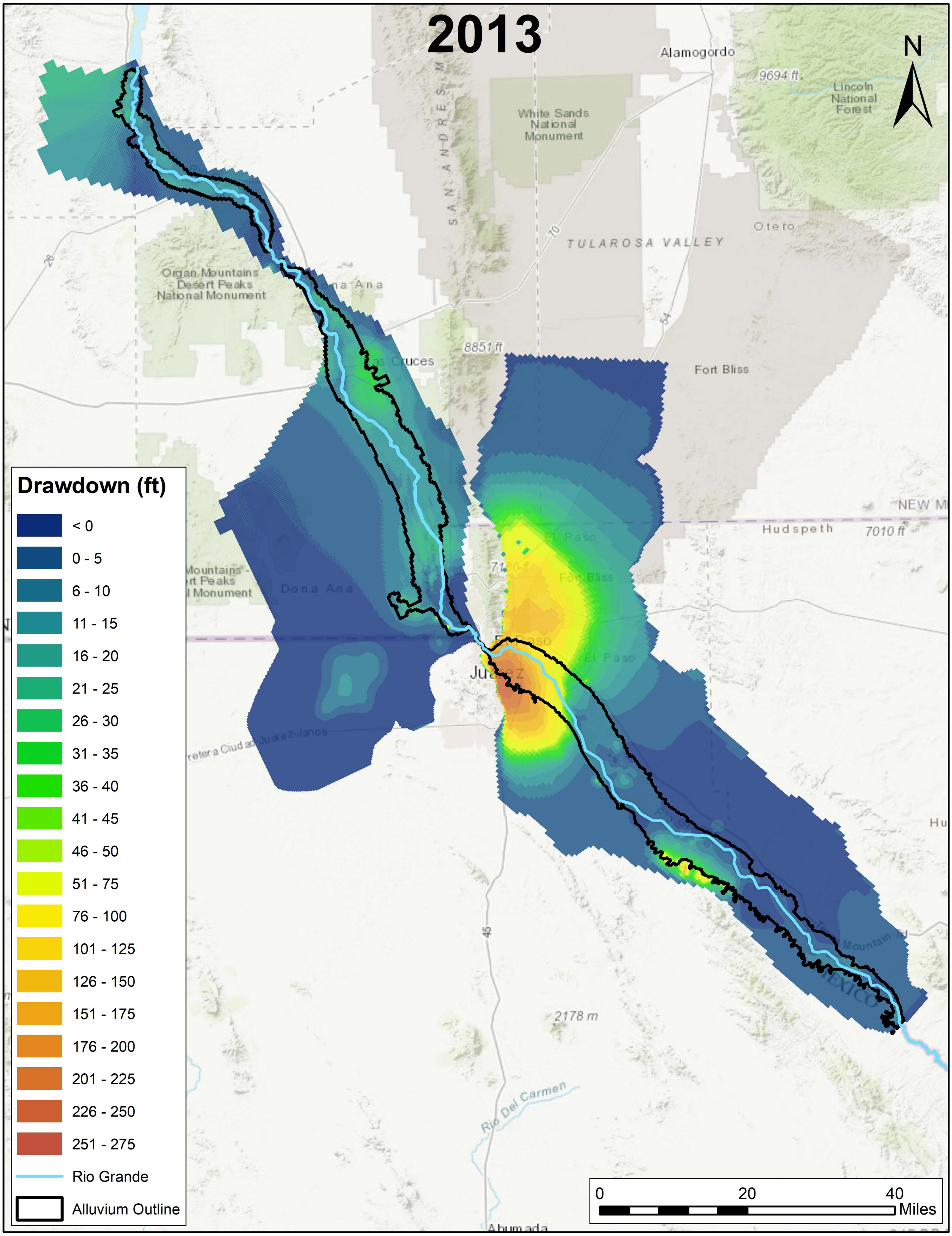

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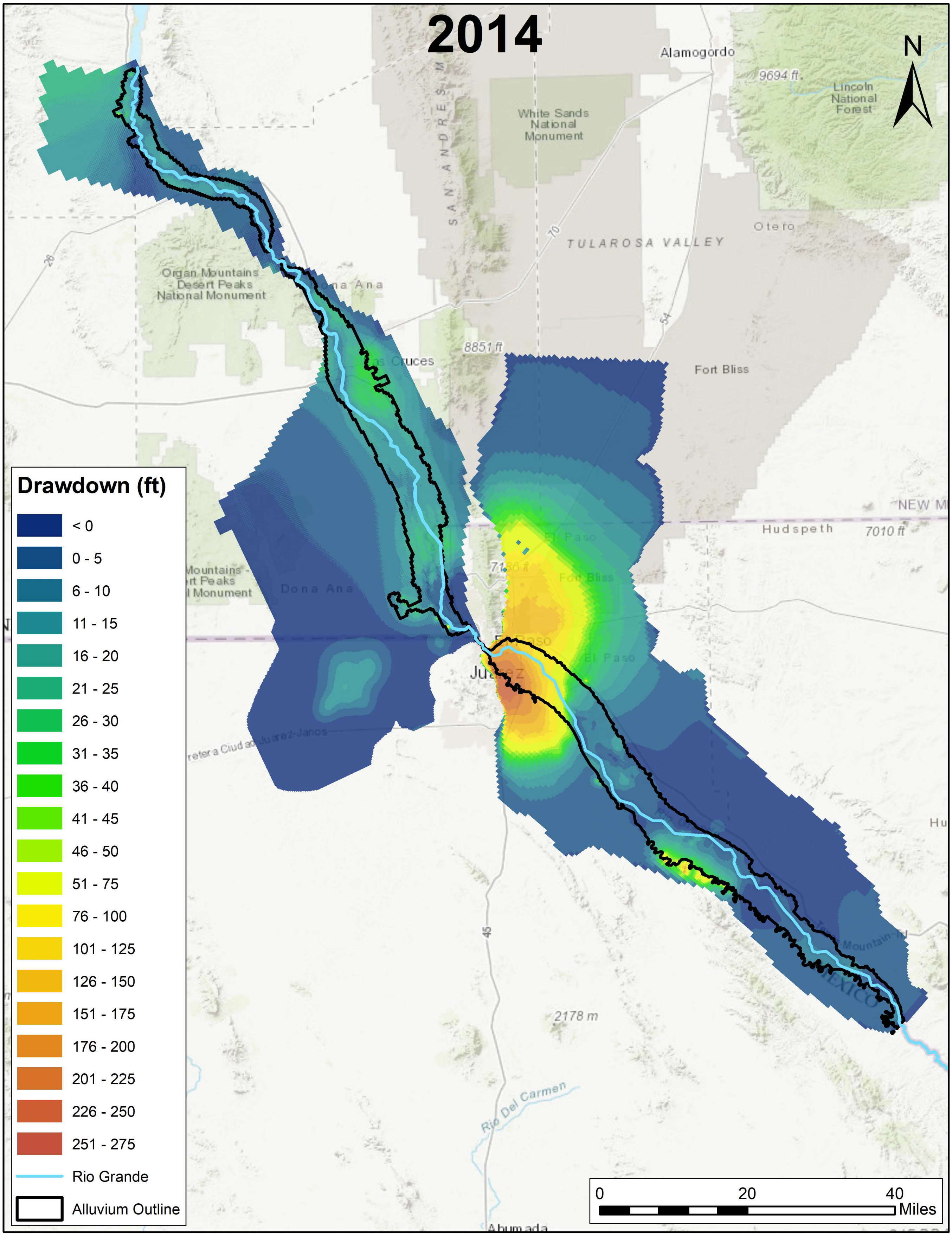

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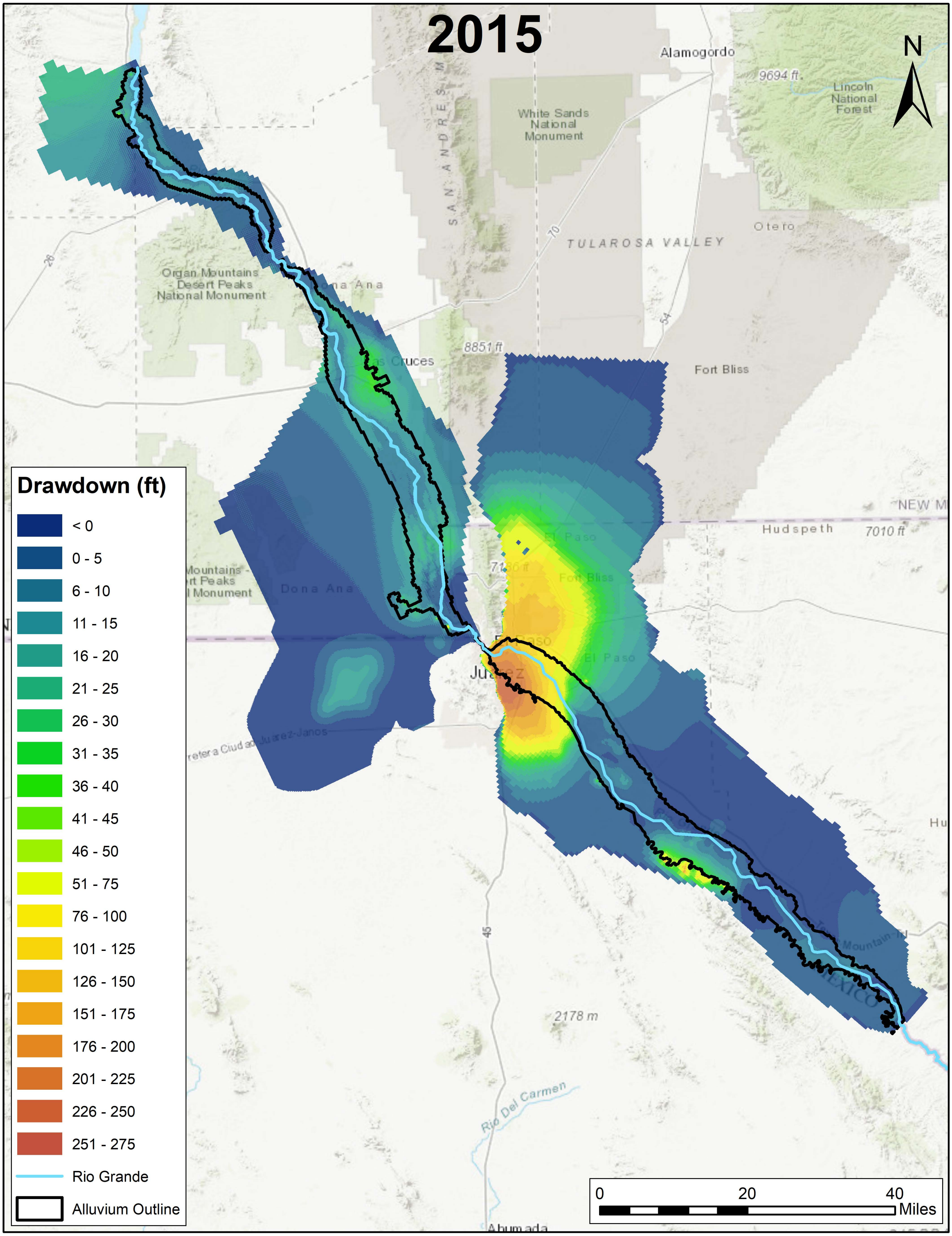

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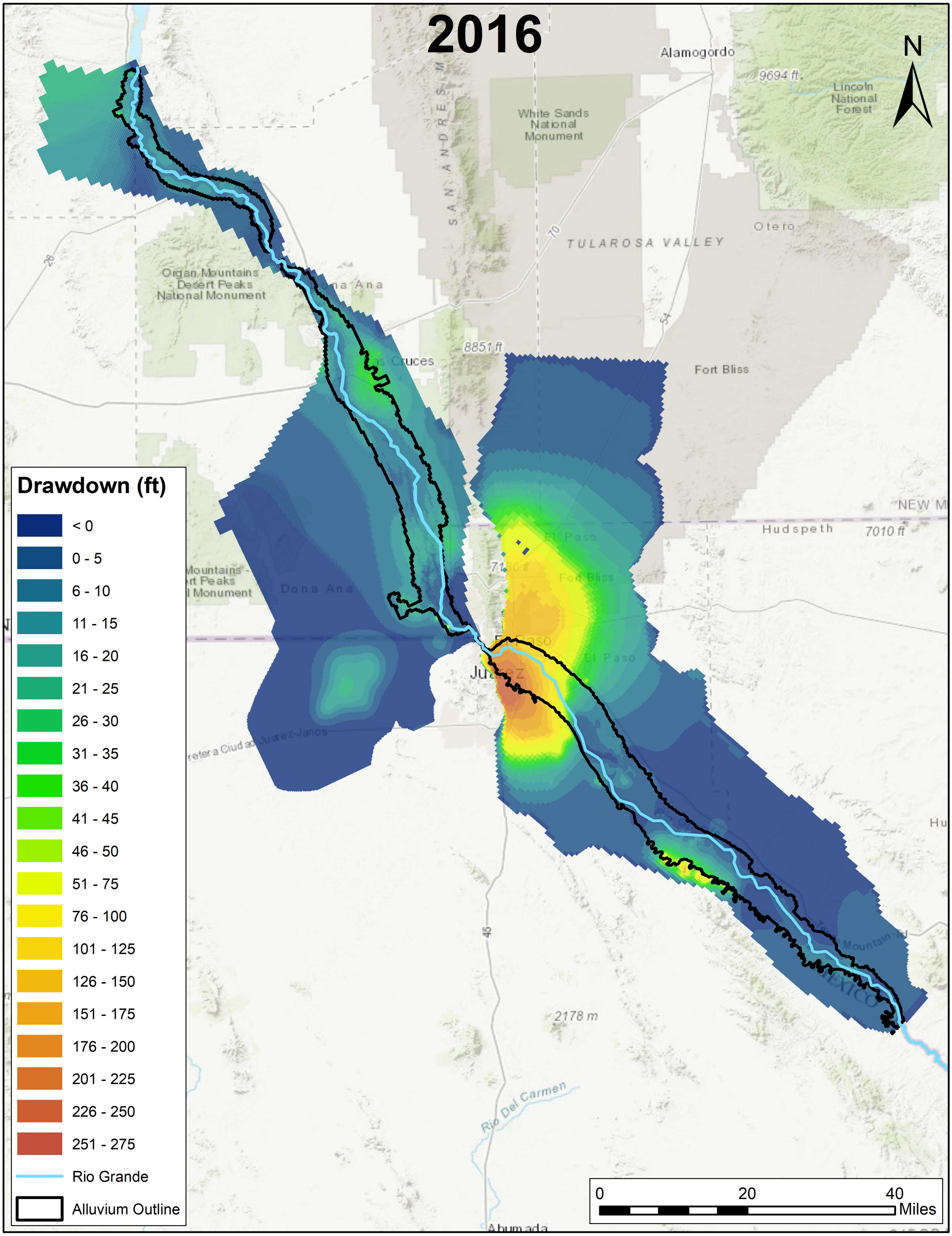

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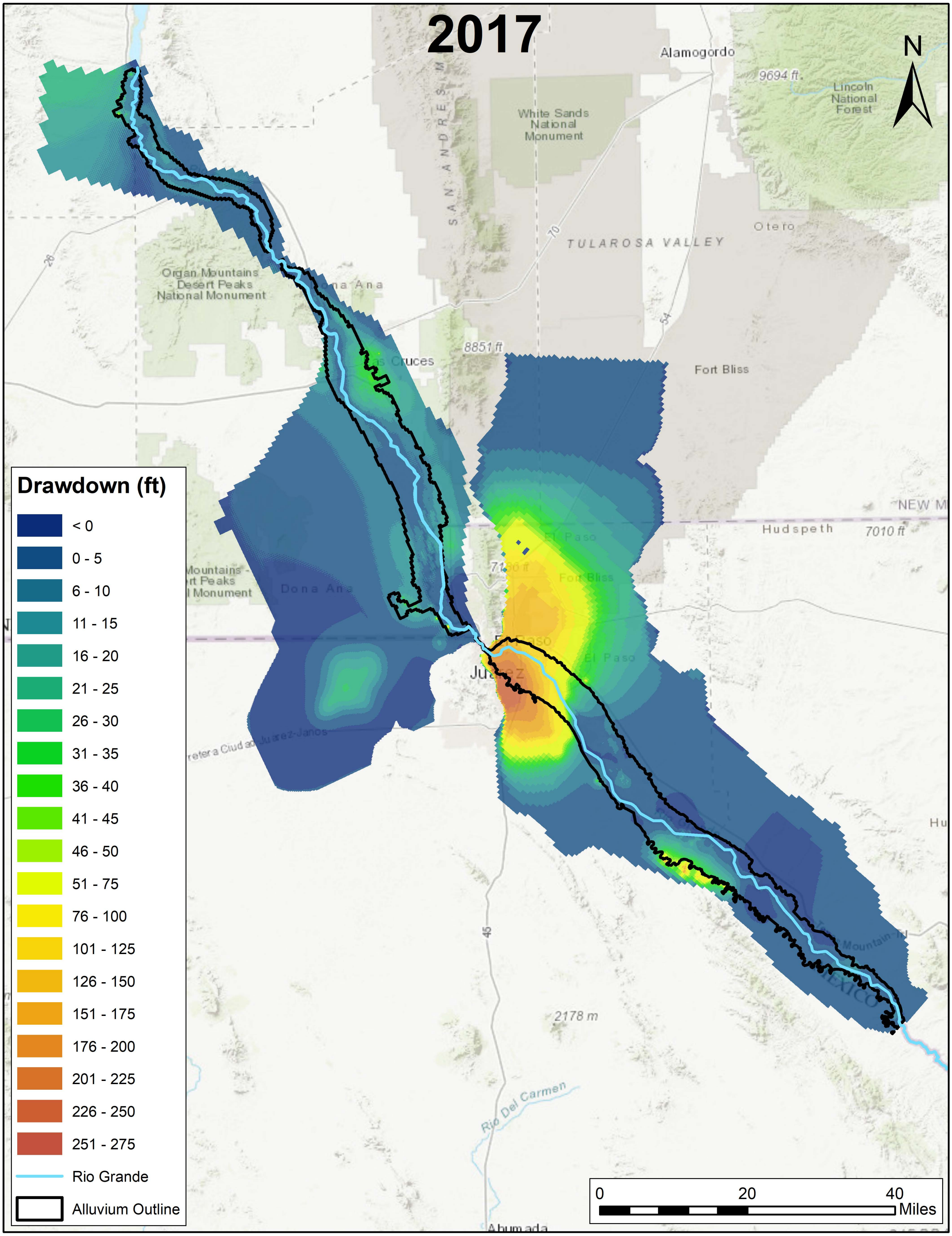

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No. 141, Original

In the
Supreme Court of the United States

Texas v. New Mexico and Colorado

Expert Report of
Gregory K. Sullivan, P.E.
and
Heidi M. Welsh

Prepared for:

State of New Mexico

Prepared by:

GREGORY KEVIN SULLIVAN
22620
7/15/20

Heidi Welsh

Gregory K. Sullivan, P.E.

Adelheid M. Welsh

October 31, 2019

(Revised July 15, 2020)

Spronk Water Engineers, Inc.

TX v. NM # 141
New Mexico Exhibit
NM_EX-122

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FIGURES

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APPENDICES

LIST OF ABBREVIATIONS

2008 OA	2008 Operating Agreement
ACE	American Canal Extension
AF	Acre-feet
Reclamation	Bureau of Reclamation
CFB Model	Canal and Farm Budget Model
cfs	Cubic feet per second
CIR	Crop irrigation requirement
cms	Cubic meters per second
Compact	Rio Grande Compact
DCMI	Domestic, commercial, municipal, and industrial
DE	David's Engineering
DP	Deep percolation
EBID	Elephant Butte Irrigation District
EPA	Environmental Protection Agency
EPCWID	El Paso County Water Improvement District No. 1
EPW	El Paso Water
ET	Evapotranspiration
FHG	Farm headgate
Ft. Quitman	Fort Quitman, Texas
gpm	Gallons per minute
GPS	Global positioning system
HCCRD	Hudspeth County Conservation and Reclamation District No. 1
Hueco Model	Hueco Ground Water Model
Hydros	Hydros Consulting
IBWC	International Boundary and Water Commission
ILRG Model	Integrated Lower Rio Grande Model
JID	Juarez Irrigation District
JMAS	Junta Municipal de Aqua y Saneamiento (water utility for Ciudad Juarez)
LRG	Lower Rio Grande
LRG Area	Area of irrigation and non-irrigation water use in the Rincon, Mesilla, El Paso, and Juarez Valleys between Caballo Reservoir and Ft. Quitman Texas
M&A	Montgomery & Associates
MAD	Management allowable depletion
MFE	Maximum farm irrigation efficiency
MMA	McDonald-Morrisey Associates, LLC
MX-IBWC	Mexican section of the International Boundary and Water Commission
NMAGO	New Mexico Office of the Attorney General
NMISC	New Mexico Interstate Stream Commission
NMOSE	New Mexico Office of the State Engineer
NMR-M Model	New Mexico Rincon-Mesilla Ground Water Model
NPDES	National Pollutant Discharge Elimination System

PET	Potential evapotranspiration
QA/QC	Quality assurance and quality control
RGCC	Rio Grande Compact Commission
RGJI	Rio Grande Joint Investigation
RiverWare	RiverWare simulation model
RHG	River headgate
SSPA	S.S. Papadopulos & Associates
SWDataSet	Surface Water Dataset prepared by SWE
SWE	Spronk Water Engineers, Inc.
URGWOM	Upper Rio Grande Water Operations Model
USGS	United States Geological Survey
US-IBWC	United States section of the International Boundary and Water Commission
WDR	Water Distribution Report
WTP	Water Treatment Plant
WWTP	Wastewater Treatment Plant

1.0 QUALIFICATIONS AND SUMMARY OF OPINIONS

1.1 Overview of Qualifications of Gregory K. Sullivan, P.E.

My name is Gregory K. Sullivan, and I am a principal and senior water resources engineer at Spronk Water Engineers, Inc. ("SWE") in Denver, Colorado. I have Bachelors of Science degree in Civil Engineering from Colorado State University (1985) and a Master of Science Degree in Civil Engineering from the University of Colorado (1990). I am a registered professional engineer in Colorado, New Mexico, Idaho, and Nevada.

After receiving my undergraduate degree in 1985, I took a job with J.W. Patterson & Associates in Denver where I performed work in water supply planning, water rights analysis, surface water and ground water analysis and modeling, and hydrology. In 1990, I accepted a position at SWE as a staff engineer, became a shareholder in 1992, and am currently one of two majority shareholders. SWE is a consulting firm in areas of water resources engineering and water rights. We work for federal, state, and local governments and other water providers; commercial and industrial water users; and farmers, ranchers and other individuals. Most of our work is in the areas of water supply planning, municipal water supply modeling, surface water and ground water modeling, water rights engineering, and conjunctive management of ground water and surface water.

During my 35-year career in water resources and water rights engineering I have worked on numerous projects involving analyses of historical irrigation water use, municipal water use, and surface water and ground water modeling, primarily in Colorado, Idaho, and New Mexico. Among these efforts was my work in the use and modification of the H-I Model of the Arkansas River in Colorado that was used in the original jurisdiction lawsuit filed in 1985 by the State of Kansas against the State of Colorado in the U.S. Supreme Court. The model simulates daily operation of irrigation water uses under approximately two dozen canal systems along the Arkansas River in Colorado between the City of Pueblo and the Colorado-Kansas state line from 1950 to the present. I testified as expert in the case on several occasions before Special Master Littleworth.

My work on the Rio Grande in New Mexico began in 1999 when I assisted in the development of the original farm budget model of the Rincon and Mesilla basins that was later used in development of the 2007 S.S. Papadopulos & Associates ("SSPA") ground water model of those basins. Since that time, I have worked on various Rio Grande matters leading up to the development and application of the models described in this report.

My professional resume is provided in **Appendix 1A** to this report along with a list of cases in which I have testified as an expert during the past four years. SWE is being compensated at a rate of $200 per hour for my work on this case, and this compensation is not dependent on the outcome of the case.

1.2 Overview of Qualifications of Adelheid M. Welsh

My name is Adelheid (Heidi) M. Welsh. I am a senior watershed scientist and partner at Spronk Water Engineers, Inc. (“SWE”) in Denver, Colorado. I have Bachelors of Science degree in Watershed Science from Colorado State University (2007). I am a registered professional hydrologist through the American Institute of Hydrology.

During college, I took a hydrology internship at the Teton Science School (summer 2006) and worked for the U.S. Forest Service Arapahoe-Roosevelt National Forest (Fall 2006 - Spring 2007) in Fort Collins. After receiving my undergraduate degree in 2007, I worked for the U.S. Forest Service Back Hills National Forest in Sundance, WY. In Fall 2007, I took a job with AATA, Inc. in Denver, where I conducted work in environmental consulting which included data analysis, report writing, and GIS applications.

In 2009, I took a job at SWE as a watershed scientist and became a shareholder in 2017. During my 10-year career in water resources and water rights engineering I have worked on numerous projects involving analyses of historical water use, surface water and ground water modeling, and water accounting. I have extensive experience in compilation and analysis of hydrologic and spatial data.

My work on the Rio Grande in New Mexico began in the 2012 when I assisted in the development of the surface water and accounting dataset and the updated farm budget model of the Lower Rio Grande basin, including the Rio Grande Project, Juarez Valley, and Hudspeth.

My professional resume is provided in **Appendix 1B** to this report. SWE is being compensated at a rate of $150 per hour for my work on this case, and this compensation is not dependent on the outcome of the case.

1.3 Assignments

SWE has contracted for its consulting work on this case through the New Mexico Interstate Stream Commission (“NMISC”) and the New Mexico Office of the Attorney General (“NMAGO”). Our assignments on this case were developed in discussions with legal counsel for the State of New Mexico. We were asked by legal counsel to develop analyses and expert opinions in the following areas:

- Compilation and analysis of historical records on the hydrology and use of water under the Rio Grande Project ("Project") and nearby areas.
- Development of Canal and Farm Budget Models ("CFB Models") of the major irrigation users between Elephant Butte Reservoir and Fort Quitman Texas, including the Elephant Butte Irrigation District ("EBID"), the El Paso County Water Improvement District No. 1 ("EPCWID"), the Hudspeth County Conservation and Reclamation District No. 1 ("HCCRD"), and the Juarez Irrigation District ("JID").
- Coordination of development of integrated surface water and ground water models of the area along the Rio Grande from San Marcial, New Mexico ("San Marcial") to Fort Quitman, Texas ("Ft. Quitman").
- Analysis of historical Project operations.
- Analysis of the impacts of ground water pumping in New Mexico, Texas, and Mexico on streamflows and water deliveries to the major irrigation water users and El Paso Water ("EPW" a.k.a. "EPWU") in the study area.
- Analysis of the impacts of the 2008 Operating Agreement ("2008 OA") on deliveries of water to the major irrigation water users.
- Review of expert reports and supporting data, analyses, and modeling submitted by experts for the State of Texas and the United States.

Summaries of the opinions that were developed by Ms. Welsh and Mr. Sullivan for this case follow.

1.4 Summary of Opinions of Adelheid M. Welsh

Ms. Welsh prepared and is responsible for the opinions in Section 3 and Section 4 which are summarized below. In addition, she was also involved in compiling the data used in the CFB Models described in Section 6, disseminating data for use in the New Mexico models, and in post-processing the model output files into summary tables and graphs.

<u>Section 3 – Lower Rio Grande Hydrologic Data</u>

1. Data from various sources were reviewed and compiled into an Excel database identified as the SWDataSet. The data in the SWDataSet are organized by flow type and annotated with site information such as the location information, period of record, and metadata reference.

2. The data in the SWDataSet are well documented. Detailed metadata has been prepared and is provided with each data entry and includes contact names, originator

information, supporting files, descriptions, processing notes, spatial domain, data quality, time period of content, and other information.

3. The SWDataSet is the best available compilation of surface water and other data for the Lower Rio Grande Area ("LRG Area"), and the information contained in the database is suitable for use in hydrologic modeling and analyses.

4. The data in the SWDataSet have undergone extensive review and quality assurance and quality control ("QA/QC") consistent with industry standards. This includes double checking all data entry against the source information and preparation of tabular, graphical, and statistical summaries that were prepared for each data site to assess the data for consistency.

5. Despite extensive efforts over several years to obtain all available flow records in the Lower Rio Grande basin, there remained missing data that needed to be estimated for technical analysis and modeling purposes. Over a relevant time period, correlations were derived from two sets of available data. The missing data were estimated using the correlation equation and available data. The estimates of these missing data in the SWDataSet are reasonable and suitable for use in modeling and analysis.

Section 4 – Rio Grande Project Accounting Data

6. The Project records, including Water Distribution Reports, Bureau of Reclamation ("Reclamation") tables, accounting reports, and allocation records, were compiled. Information from these reports was added into two Excel spreadsheets that comprise the Accounting DataSet.

7. The Accounting DataSet is comprehensive and is comprised of the best available Project data. In addition to our review, these data have been reviewed by employees in the New Mexico Office of the State Engineer ("NMOSE") and/or the NMISC for consistency and accuracy. All the data in the Accounting DataSet have undergone QA/QC by two or more water resources professionals.

1.5 Summary of Opinions of Gregory K. Sullivan

Mr. Sullivan prepared Section 2 and Sections 5 through 15, and is responsible for the opinions presented in those sections, which are summarized below.

Section 5 – Historical Water Supply and Water Use

8. Most of the water supply for the Lower Rio Grande below Caballo Reservoir originates as Rio Grande flow passing the San Marcial gage and entering Elephant Butte Reservoir. Annual San Marcial gage flows averaged approximately 890,000 AF during the 1890 - 2017 period of record. The flows have been cyclical, with 10-year average flows generally above average through the 1940s, below average during the 1950s - 1970s, above average in the 1980s and 1990s, and below average thereafter. (Figure 5-1).

9. The average annual inflow available to the Project at San Marcial was estimated in the Rio Grande Joint Investigation ("RGJI") as 1,031,000 AF based on flows for the period from 1890 - 1935 adjusted for upstream development. Annual San Marcial flow since that time has averaged 754,000 AF. (Table 5-1).

10. The annual reservoir release necessary to supply the Project was estimated in the RGJI as 773,000 AF. This was increased to the "normal annual release" of 790,000 AF described in Rio Grande Compact ("Compact"). In the generally wet period following the RGJI analysis (1936 - 1950) annual reservoir releases averaged 845,000 AF. Since then annual reservoir releases have averaged only 607,000 AF (1951-2017). (Table 5-1).

11. Average annual depletions of Rio Grande flow between the Caballo Reservoir outlet and the El Paso gage are at approximately the same level now as they were at the time of the Compact (250,000 AF/y). (Figure 5-2).

12. The total annual Project irrigated area contemplated in the RGJI totaled 145,000 acres, while acres that were actually authorized to be irrigated totaled 159,650 acres (155,000 acres plus an additional 3%). The reported actual irrigated area peaked at approximately 160,000 acres in the early 1950s. Since then, the irrigated area has declined, largely due to urbanization, and currently stands at approximately 105,000 acres. (Figure 5-4).

13. Average annual farm headgate deliveries ("FHG deliveries") of Project water were relatively steady from the 1950s - 1970s, increased during the 1980s and 1990s, and have declined since then due to the recent drought. (Figure 5-10, Figure 5-12, Figure 5-14).

14. The total applied water in EBID, including deliveries of Project water and supplemental pumping, has declined slightly since the 1980s. Conversely, the total

applied water in EPCWID, including deliveries to EPW, has remained steady through time. (Figure 5-15 and Figure 5-19).

15. Project operational waste in EBID typically comprised roughly 10% of canal heading diversions from the 1940s and 1950s and thereafter declined to less than 10% in most years. Operational waste in EPCWID followed a similar pattern in the early years with the waste exceeding 10% in the 1940s, and then declining to roughly 10% or less during the 1950s - 1970s. However, when EPCWID took over water distribution within the district in 1980, operational waste increased substantially to an average of approximately 25% of canal diversions until the recent drought. The increased EPCWID waste has resulted in a substantial increase in flows to HCCRD. The excess waste in EPCWID has impacted Project water allocations and deliveries to EBID. (Figure 5-20 through Figure 5-24).

16. The NMOSE has required all well users in the LRG basin within New Mexico to measure and report ground water pumping since 2009. During the relatively dry decade that the measuring requirement has been in effect (2009-2018), annual LRG irrigation pumping in New Mexico has averaged 219,000 AF. New Mexico pumping during this period has been affected by the reduction in Project water allocations to EBID as a result of the 2008 OA. Unlike in New Mexico, there reportedly are no requirements in Texas or Mexico to measure and report pumping, and no records of LRG irrigation pumping are available for those areas. (Figure 5-25).

17. Non-irrigation pumping, primarily for municipal uses, has increased substantially throughout the LRG Area, most notably in the El Paso and Juarez areas. Annual non-irrigation pumping in New Mexico increased to an average of approximately 38,000 AF during the last ten years. This is much less than the non-irrigation pumping that has averaged approximately 82,000 AF in Texas and 144,000 AF in Mexico during the last ten years. (Figure 5-26 through Figure 5-28).

Section 6 – Lower Rio Grande Canal and Farm Budget Models

18. Monthly CFB Models were prepared to simulate irrigation water use in LRG Area during the period from 1938 - 2017. The models were developed to assess the historical use of surface water and ground water in the LRG Area, and specifically to compute:

    - Crop-weighted consumptive use of applied water for the irrigation units in the LRG Area;
    - FHG deliveries for periods when records were not available; and

- Supplemental pumping for all areas, and the primary (ground water only) pumping in New Mexico.

Separate models were developed for four subareas in EBID (Rincon, Leasburg, Mesilla Westside, and Mesilla Eastside), three subareas in Texas (Mesilla Westside, Mesilla Eastside, and El Paso Valley), three subareas in Mexico (JID Units 1, 2, and 3), and the HCCRD.

19. Annual CFB Models were prepared for the portions of the Texas and Mexico irrigation districts that overlie the Hueco Bolson during 1903 - 1939 for the purpose of developing certain input data used in the Hueco Ground Water Model ("Hueco Model") developed by McDonald-Morrisey Associates, LLC ("MMA").

20. The monthly and annual CFB Models that were developed to simulate irrigation water use in the LRG Area are based on commonly used water budget analysis techniques and procedures. Similar water budget analyses are routinely used in the analysis of historical use for changes of irrigation water rights before the Colorado Water Courts.

21. The monthly CFB Models for the LRG Area irrigation units are reasonable representations of the historical irrigation operations during the 1938 - 2017 study period. The simulated consumptive use of applied surface water and ground water, conveyance losses, and on-farm losses are reasonable and representative of the variable water supply and hydrologic conditions that occurred over the 80-year study period.

22. The monthly supplemental ground water pumping and primary ground water pumping computed in the CFB Models are reasonable estimates of the amounts of pumping that were historically required to meet the unmet irrigation demands considering the historical surface water supplies. The simulated pumping for EBID during 2009 - 2017 was within 1% of the reported values. (Figure 6-5).

Section 7 – Need for Modeling Analysis of Claims and Counterclaims

23. Due to the complex effects that Project operations and LRG Area irrigation operations have on the amount and timing of surface water flows, ground water flows and their interaction, a simulation model is useful and necessary to understand and quantify these effects. The model should be reasonably calibrated over a representative historical period and be capable of simulating appropriate dynamic responses of Project and irrigation operations to variations in water supply in historical and alternative scenarios.

24. A simulation model of the LRG Area should reasonably simulate important physical processes and management processes that affect the occurrence, movement, and use of ground water and surface water. Important physical processes include surface water flow, ground water flow, surface water and ground water interactions, evaporation, and evapotranspiration. Important management processes include Project water allocation, reservoir operations, canal operations, and on-farm irrigation operations. (Table 7-1).

Section 8 – Overview and Assessment of Integrated LRG Model

25. The Integrated LRG Model ("ILRG Model") consists of a RiverWare Model that simulates the LRG Area from the Rio Grande at San Marcial gage upstream of Elephant Butte Reservoir to the Rio Grande at Ft. Quitman Gage in Texas. The RiverWare Model is linked to two ground water models - the New Mexico Rincon-Mesilla Ground Water Model ("NMR-M Model") that simulates ground water flow in the Rincon and Mesilla basins between the Caballo Reservoir outlet and the El Paso Narrows, and the Hueco Model that simulates ground water flow in the El Paso and Juarez Valleys from the El Paso Narrows to Ft. Quitman. The ILRG Model simulates the period from 1940 - 2017 and operates using monthly stress periods.

26. The RiverWare Model component of the ILRG Model simulates the surface water and shallow ground water systems of the LRG Area and is the principal vehicle for computing the impacts of pumping and the effects of operational changes on surface water flows. It employs rule-based processes that simulate the essential functions of the Project and operations of the LRG Area irrigation systems. It is through these rule-based processes that the simulated systems are re-operated in alternative scenarios in a manner that reflects the real-world response to changes in conditions.

27. The NMR-M Model and the Hueco Model simulate the hydraulic effect of ground water pumping on surface flows and the effect of drains on ground water flows. The ground water models are linked to the RiverWare Model through certain data that are passed between the models in successive iterations.

28. The RiverWare Model and the ground water models of the ILRG Model have been calibrated to simulate historical surface water and ground water flows during the 1940 - 2017 study period using historical data for reservoir releases, canal operations, and FHG deliveries. The calibrated models reasonably replicate the seasonal, annual, and inter-annual variations in surface water and ground water flows.

29. In order to simulate the human-influenced management processes of the Project and LRG Area irrigation systems, the ILRG Model employs rule-based simulation processes

to simulate reservoir operations, canal diversions, FHG deliveries, and other processes. These rules were tuned in a calibration-like process to reasonably match historical records of reservoir releases, canal diversions, FHG deliveries, streamflows, and the simulated pumping in the calibration run.

30. The calibrated and tuned ILRG Model is the best available tool for evaluating claims, counterclaims, and answering questions about the effects of certain actions on Project operations and deliveries of water to LRG water users. The ILRG Model is superior to the ground water model of the Rincon and Mesilla basins developed by the Texas experts ("Texas Model") for use in the litigation because (a) it simulates the entire LRG Area between the El Paso Gage and Fort Quitman, (b) it employs monthly stress periods that allow it to simulate the important seasonal variations in ground water and surface water flows, and (c) it is capable of simulating the dynamic response of Project operations to changes in flow through rule-based simulation processes.

31. Post-processing spreadsheets were prepared to summarize outputs from the ILRG Model to illustrate the model results and to verify the models are correctly functioning. Tables and charts depicting the model results are presented in Section 9 for the Historical Base Run, in Section 10 for the Alternate Scenario Runs, in Section 13 in responses to the Hutchison Report, and in Section 14 in the responses to the Dorrance Report.

Section 9 – Historical Base Run of Integrated LRG Model

32. The tuned version of the ILRG Model was used to simulate the historical period from 1940 - 2017, including Project operations, to develop the Historical Base Run. The Historical Base Run was compared to alternative runs of the tuned model that simulated various no-pumping and alternative operating scenarios. Project water allocations were simulated using the D1/D2 allocation procedure from 1951 - 2005, the D3 allocation procedure without carryover in 2006 and 2007, and the D3+Carryover procedure in the 2008 OA from 2008 - 2017. Irrigation pumping coverage in EBID, EPCWID, HCCRD, and JID Units 2 and 3 was specified to increase linearly from 0% in 1947 to 100% in 1955, and in JID Unit 1 from 0% in 1939 to 100% in 1954. Non-irrigation pumping and return flows were specified and simulated based on historical records and estimates.

33. The simulated outputs for the Historical Base Run reasonably match the results from the historical records and the historical calibration run of the ILRG Model. Based on this match and the dynamic functionality of the ILRG Model, the Historical Base Run represents a reasonable baseline for comparison to alternative scenarios with reduced pumping, or other changes in model inputs.

Section 10 – Alternative Runs of Integrated LRG Model

34. Thirteen runs were made of the ILRG Model including the Historical Base Run (Run 1), nine no-pumping runs (Runs 2 - 10), and three alternative operations runs (Runs 11 - 13). All runs were made with the tuned version of the ILRG Model in which rules are used to compute Project water allocations, reservoir releases, canal diversions, and FHG deliveries. Changes in model inputs cause dynamic responses of all simulated processes as the changed conditions ripple spatially and temporally through the model, just as they would in the real world. Model outputs from the alternative scenarios were compared to the outputs from the Historical Base Run or another scenario and the differences were computed and summarized in tables and charts.

35. In the no-pumping runs, all pumping or just non-irrigation pumping was turned off in all areas (Run 2) or in certain geographic areas (Runs 3 - 10). When non-irrigation pumping was turned off, so were the associated wastewater treatment plant discharges and urban deep percolation. Because the Project is operated as a single system, any effects of pumping on surface water supplies that are upstream of points of delivery affect Project operations. The model results show that pumping in Texas and Mexico affects Project water deliveries to EBID water users in New Mexico.

36. A run of the ILRG Model was made in which all irrigation and non-irrigation pumping in the Rincon and Mesilla basins in New Mexico was turned off (Run 3). Comparison of the results from this run against the Historical Base Run show that without New Mexico pumping, annual FHG deliveries during the period from 1985 - 2016 would increase by an average of 26,200 AF to EBID and 8,200 AF to EPCWID. (Table 10A-3a).

37. A run of the ILRG Model was made in which all irrigation and non-irrigation pumping in Texas was turned off (Run 4). Comparison of the results from this run against the Historical Base Run show that without Texas pumping, annual FHG deliveries to EBID during the period from 1985 - 2016 would increase by an average of 5,100 AF, with a maximum annual increase of 32,500 AF. (Table 10A-4a and Table 10A-4b).

38. A run of the ILRG Model was made in which all irrigation and non-irrigation pumping in Mexico was turned off (Run 5). Comparison of the results from this run against the Historical Base Run show that without Mexico pumping, annual FHG deliveries during the period from 1985 - 2016 would increase by a maximum of 3,900 AF to EBID, 3,400 AF to EPCWID, and 9,400 AF to HCCRD. (Table 10A-5b).

39. In addition to the simulated effects on FHG deliveries in the no-pumping runs, turning off pumping in the ILRG Model results in simulated impacts to Project storage (including releases, evaporation, and spills), riparian evapotranspiration, river and

canal evaporation, incidental canal losses, and ground water storage. These impacts are reasonable and consistent with the interconnected nature of the Project and the LRG Area irrigation systems.

40. Two runs of the ILRG Model were made to evaluate the effect of the 2008 OA on Project operations. In Run 11, the D1/D2 allocation procedure was simulated to allocate Project water during the period from 1951 - 2017, and in Run 12 the D3+Carryover accounting was simulated during this 70-year period. Comparison of the results showed that the 2008 OA caused annual EBID FHG deliveries to be (a) reduced by an average of approximately 69,100 AF during periods with low diversion ratios (55 years) and (b) increased by an average of 56,900 AF during periods with high diversion ratios (15 years), for an overall decrease in annual EBID FHG deliveries over the 70-year period averaging 42,100 AF. The results also showed that the 2008 OA increased FHG deliveries to EPCWID in most years with an overall average annual increase of 14,700 AF. (Table 10A-12b).

41. A run of the ILRG Model was made to evaluate the effects of reducing Project operational waste. Run 13 limits waste in EBID and in EPCWID to the lesser of the historical amounts or 10% of diversions. The results show that reducing excess operational waste would have resulted in increases in annual Project water deliveries during 1985 - 2016 averaging 28,600 AF to EBID and 12,700 AF to EPCWID. (Table 10A-13).

Section 11 – Response to Brandes Report

42. Based on review of the expert report by Dr. Robert Brandes, his backup files and references, and attending his deposition, I developed the responses to his report that are presented in Section 11. The following is a summary of certain of the responses:

    a. Dr. Brandes attributed all changes in flows after 1950 to pumping in the Rincon basin and Mesilla basin based on single- and double-mass curve analyses. These simple graphical techniques can be useful in identifying changes in flows, but they are not useful or reliable in determining what caused the changes in flows. For complex interconnected systems like the Rio Grande Project and LRG Area, a robust simulation model capable of simulating the dynamic responses of the simulated systems to changes in conditions is needed to reasonably determine the effects of certain actions, like the effects of pumping, on Project operations and deliveries to LRG Area water users; and to distinguish these effects from other factors that may have contributed to changes in flows or deliveries.

b. The annual changes in El Paso gage flows and deliveries to Texas and New Mexico water users that are computed by Dr. Brandes occur in virtually all years, including years of full Project water allocations. This does not make sense considering how the Project operates in years with full allocations. In these years, if there was an increase in supply because pumping was reduced, then Reclamation would adjust reservoir releases in order to deliver the same amounts of water to the Project water users, and therefore no significant changes in irrigation season flows and deliveries would be expected to occur in these years.

c. Dr. Brandes' analyses of changes in the flow of the Rio Grande at El Paso are not relevant to this litigation because this is neither a point of compliance for the Compact, nor a point of delivery for the Project.

d. Dr. Brandes incorrectly states that the available Project supply is solely determined by the volume of water either in or projected to be in Project storage each year. In reality, Project releases are affected by (i) the amount of water available in storage at the beginning of the irrigation season, (ii) the inflows to storage during the irrigation season, (iii) the gains and losses between the Caballo outlet and the downstream delivery points, and (iv) the demands of the Project water users.

Section 12 – Response to Montgomery and Associates Report

43. Based on review of the expert report by Mr. Staffan Schorr and Dr. Colin Kikuchi of Montgomery and Associates ("M&A"), their backup files and references, and attending their depositions, I developed the responses to their report that are presented in Section 12. The following is a summary of certain of the responses:

a. While M&A developed comprehensive surface water and ground water budgets for the LRG Area, only a few of the outputs from those analyses were used in the Texas Model and in the Texas analyses of impacts from pumping.

b. M&A performed monthly historical farm budget analyses to (i) estimate supplemental pumping and deep percolation in the Rincon and Mesilla basins for use in the Texas Model, and (ii) to estimate pumping in the El Paso Valley and HCCRD for Texas' analysis of damages from New Mexico pumping. The results from these analyses are unreliable because the soil-water balance model that is central to the farm budget analyses is deeply flawed and produces nonsensical results that are physically impossible and contrary to conditions that would be expected to exist in productive and generally well-managed irrigation districts.

c. Notwithstanding the flaws in M&A's farm budget analysis procedures, the estimates of pumping computed by the M&A analysis in New Mexico and Texas appear to be overstated, largely because of because of differences in irrigated area, crop ET, and FHG deliveries compared to the data used in in SWE's CFB Models

<u>Section 13 – Response to Hutchison Report</u>

44. Based on review of the expert report by Dr. William Hutchison, his backup files and references, and review of portions of his deposition transcript, I developed the responses to his report that are presented in Section 13. The following is a summary of certain of the responses:

    a. New Mexico's legal counsel have advised that Dr. Hutchison's definition of a 1938 condition is not appropriate for characterizing the water entitlements of the states. Moreover, it would be inappropriate to define a 1938 condition on the basis of historical operations in a single year as Dr. Hutchison did in his analyses.

    b. The Texas Model developed by Dr. Hutchison is inappropriate for use in analyzing the effects of pumping on Project operations and deliveries of water to LRG water users because:

        i. The model does not employ rule-based simulation processes that allow the model to appropriately respond to changes in surface water flows when pumping is reduced.

        ii. The model does not simulate Project operations and uses of water between the El Paso gage and Ft. Quitman.

        iii. The annual stress periods in the model do not allow distinction of the significant differences in Project operations and river conditions between the irrigation season and non-irrigation season.

    c. The lack of re-operation in the Texas Model is evident in the relatively steady computed annual impacts of Rincon-Mesilla pumping on Rio Grande at El Paso flows, including in years of full Project water allocations. In years with full Project water allocations, it is expected that the irrigation season flow at El Paso would not be appreciably different without pumping because

Reclamation would adjust Project releases to deliver the same amount of water to Project water users.

d. Dr. Hutchison's modeling analyses of Alternative Consumptive Use scenarios and Conjunctive Use scenarios are of little use because the Texas Model lacks any capability to simulate the Project re-operation that would occur in these scenarios.

Section 14 – Response to Dorrance Report

45. Based on review of the expert report by Dr. Lydia Dorrance, and her backup files and references, I developed the responses to her report that are presented in Section 14. The following is a summary of certain of the responses:

a. Dr. Dorrance's analysis to disaggregate the changes in El Paso gage flow simulated by the Texas Model is oversimplified and not a substitute for a fully functional dynamic simulation model of the area between the El Paso gage and Ft. Quitman.

b. Dr. Dorrance's disaggregation analysis is flawed and inappropriate because (i) it relies on results from a flawed model, (ii) it assumes the increased flows would occur in historical monthly proportions, and (iii) all of the increased flow is assumed available for allocation to Texas water users without diminishment by transit losses or operational inefficiencies.

c. Dr. Dorrance's flawed disaggregation analysis resulted in incorrect and inflated estimates of the effects of New Mexico pumping on deliveries to Texas water users.

Section 15 – Response to Sunding Report

46. Based on review of the expert report by Dr. David Sunding, and his backup files and references, I developed the responses to his report that are presented in Section 15. The following is a summary of certain of the responses:

a. Dr. Sunding's analyses are flawed because they rely on unreasonable and unreliable analyses by Dr. Hutchison and Dr. Dorrance of the effects of New Mexico pumping on Texas water users.

b. Dr. Sunding unreasonably assumes that shortages in EPW surface water supply were caused solely by New Mexico pumping and not by other factors, including drought.

c. The damages analysis by Dr. Sunding is based on simulated impacts on El Paso gage flows from all pumping throughout the Rincon and Mesilla basins and therefore implicitly includes impacts of pumping in the Texas portion of the Mesilla basin.

2.0 BACKGROUND

2.1 Study Area

The Rio Grande begins in headwaters in the San Juan Mountains in Colorado that flow east and join other tributaries in the broad and agriculturally productive San Luis Valley of Colorado. The river flows south out of the San Luis Valley and into New Mexico where it picks up considerable flow from the mountains of northern New Mexico and continues in a generally southerly direction through mostly incised canyons past Taos and Santa Fe before reaching the Middle Rio Grande Valley that extends from Cochiti Lake to San Marcial, about 25 miles south of Socorro.

San Marcial is situated at the northern end of Elephant Butte Reservoir, the primary source of water for the Project that serves lands in the Rincon, Mesilla, and El Paso Valleys in southern New Mexico and western Texas. Additional lands are irrigated west of the Rio Grande in the Juarez Irrigation District in Mexico and further to the southeast in Hudspeth County, Texas down to Ft. Quitman.

The study area for this report is primarily the areas tributary to or hydraulically connected to the Rio Grande between San Marcial and Ft. Quitman. This includes the ground and surface water irrigated lands that are part of the Project, the JID, the HCCRD, and the non-irrigation water uses for the towns and cities in the study area. A map depicting the study area is included as **Figure 2-1**.

2.2 Rio Grande Compact

This section provides a brief overview of certain aspects of the Rio Grande Compact (“Compact”). More detailed information on the Compact is provided in the report of Estevan Lopez (2019). The States of Colorado, New Mexico, and Texas agreed to the Compact in March 1938 to equitably apportion the Rio Grande upstream of Ft. Quitman. The Compact was ratified by Congress and became effective on May 31, 1939.

The annual delivery obligations for Colorado are provided in Article III and New Mexico’s delivery obligations are provided under Article IV. In 1948, the Rio Grande Compact Commission (“RGCC”) changed New Mexico’s Article IV delivery obligation from a nine-month schedule of delivery at San Marcial to an annual delivery determined based on the computed annual inflow to Elephant Butte Reservoir. The RGCC also adopted a new Otowi Gage index table for computing New Mexico’s delivery obligation.

Article VI sets out long-term average delivery requirements through a system of debits and credits that allow the states to deviate from the annual obligations based on certain criteria. Annual compact accounting, including these debits and credits, commenced in 1940. The Compact is administered by the RGCC, which is comprised of one voting representative from each of the three States, and a non-voting representative from the United States acting as chair of the Commission.

2.3 Rio Grande Project

The remainder of this section provides an overview of the Rio Grande Project and its operation. More detailed descriptions of the historical operation of the Project and its water allocation and accounting mechanisms is provided in the Barroll Report (2019).

The Rio Grande Project is one of the first large-scale irrigation project developed by Reclamation. It was authorized by Congress in 1905 and construction commenced in 1907 (USNRC, 1938). The Project was developed to improve and expand the existing irrigation systems in the Rincon, Mesilla, and El Paso Valleys, as well as deliver water to Mexico. Elephant Butte Reservoir began storing water in 1915 and was completed in 1916. The major diversion dams and canals for the Project were completed by 1919, and most of the lateral distribution systems and irrigated lands were developed by 1929. High water table conditions caused by irrigation necessitated construction of drainage systems that were largely completed by 1925 (USNRC, 1938). Caballo Reservoir was constructed downstream of Elephant Butte Reservoir for flood control and to conserve winter hydropower releases from Elephant Butte Reservoir for subsequent irrigation use, and the reservoir began operation in 1938. This work, as well as construction of the American Diversion Dam and American Canal, was done as part of the International Boundary and Water Commission's ("IBWC") Canalization Project, which, along with the IBWC's Rectification Project, also realigned the river and adjacent irrigation infrastructure in many areas between Caballo Dam to Fort Quitman (IBWC, 1938; Reclamation, 1938; and IBWC, 1943).

The total irrigated area under the Project was originally planned to total 155,000 acres with 88,000 acres (57%) within EBID in New Mexico and 67,000 acres (43%) within EPCWID in Texas (USNRC, 1938). Of these amounts, about 16,000 acres were in the Rincon Valley, 82,000 acres were in the Mesilla Valley (10,000 acres in Texas), and 57,000 acres were in the El Paso Valley. A 1938 contract between EBID and EPCWID approved by the United States increased the original acreage allotted to the two districts by 3% resulting in a total area authorized to be irrigated of 90,640 acres in EBID and 69,010 acres in EPCWID (EBID, 1938).

The reported actual irrigated area varied through the years as lands were brought in and out of production. The reported actual irrigated area peaked at approximately 160,000 acres in the early 1950s and has generally declined since that time due mainly to urbanization, largely in and around Las Cruces and El Paso. The normal annual release from Project storage to satisfy Project irrigation demands was specified in the Compact as 790,000 AF, including 60,000 AF delivered to the Republic of Mexico at Juarez to satisfy a 1906 Treaty obligation (Reclamation, 1985).

Prior to construction of Elephant Butte Reservoir, the Rio Grande flow available for irrigation in southern New Mexico and western Texas was characterized by highly variable annual and seasonal flows depending mostly on the snowpack accumulation and subsequent snowmelt runoff from the upper portions of the Rio Grande watershed in southern Colorado and northern New Mexico. The original storage capacity in Elephant Butte Reservoir was about 2,274,000 AF, which was sufficient to store almost three years of the normal annual Project release and was essential for controlling and regulating the large fluctuations in Rio Grande flow (USNRC, 1938).

Completion of Caballo Reservoir in 1938 added 346,000 AF of Project storage, however the total Project storage capacity has declined through time due to silt accumulation in the reservoirs. The total combined storage capacity in Elephant Butte Reservoir and Caballo Reservoir declined from 2,570,000 AF in 1940 (Reclamation, 1940) to about 2,000,000 AF in the late 2000’s (RGCC, 2017).

The current major diversion structures for the Project include the following:

Diversions Structures
Rio Grande Project

Region	Dam	Canal(s)
Rincon Basin	Percha Dam	Arrey Canal
Mesilla Basin (NM & TX)	Leasburg Dam	Leasburg Canal
	Mesilla Dam	Eastside Canal Westside Canal
El Paso Valley	American Dam	Franklin Canal Riverside Canal Tornillo Canal
Juarez Valley	International Dam	Acequia Madre

Portions of the southern Mesilla basin extend into Texas, and diversions at the Mesilla Dam into the Eastside Canal and Westside Canal are delivered to Project lands in both New Mexico and Texas.

At present, all Project water deliveries to Project lands in the El Paso Valley originate as diversions from the Rio Grande at the American Dam into the American Canal which delivers water to the Franklin Canal and Riverside Canal headings. Prior to 1999, there was a separate diversion from the Rio Grande at the Riverside Canal heading. In 1999, the American Canal Extension ("ACE") was completed so that all diversions at American Dam could be delivered through a concrete-lined channel to the Franklin Canal and Riverside Canal headings. Until 1938, there was another diversion from the Rio Grande further downstream that supplied the Tornillo Canal. Reconfiguration of the river alignment in the Fabens area and adjacent irrigation infrastructure as part of the Rio Grande Rectification Project eliminated the river diversion for the Tornillo Canal, and since that time the supply for the Tornillo Canal has been derived from water tailing out of the Franklin Canal and Riverside Canal. Periodically, water has been diverted at times from drains to supply water to the Tornillo Canal.

Deliveries of treaty water to Mexico are made at the International Dam located downstream of the American Dam. Following completion of the American Dam in the 1930s, all of the Rio Grande flow has typically been diverted into the American Canal, except for the water that is left in the river to meet the delivery obligation to Mexico at the Acequia Madre. Prior to construction of the ACE, Project water that was destined for the Riverside Canal was diverted into the American Canal and then released back to the Rio Grande downstream of the International Dam through the Leon Street Wasteway or the Ascarate Wasteway where it flowed down the river channel to the Riverside Dam.

The HCCRD is located in Hudspeth County and receives its supply as waste and irrigation return flows from the Project. The Project is not supposed to be operated to intentionally or directly deliver water to the HCCRD.

2.4 Rio Grande Project Operating Procedures

Project lands are distributed along the Rio Grande in the relatively narrow Rincon, Mesilla, and El Paso Valleys. The first Project diversion occurs at Percha Dam approximately two miles below the Caballo Reservoir outlet and the last river diversion is at the International Dam approximately 110 miles downstream. As described above, other Project diversions from the river existed further downstream at Riverside Dam until 1999 and at the Tornillo Canal until 1938.

Due to the long and narrow configuration of the Project lands along with Rio Grande, irrigation return flows to the river from each canal service area as well as any other inflows are available as part of the supply for downstream Project diversions. This can result in efficient Project operation with full reuse of most or all of the irrigation return flows and other flows except those that accrue to the drains or river below the last Project diversion point. Originally, reuse of return flows within the Project occurred downstream of American Dam by means of major diversions from the Rio Grande at the canal headings for Riverside Canal and Tornillo Canal. When these canal headings were removed in 1938 (Tornillo Canal) and the 1999 (Riverside Canal) the opportunity to reuse return flows within EPCWID become more limited. However, reuse of return flows was still possible by diversion and use of drain flows for irrigation of the lower portions of the EPCWID service area. This use of drain flows within EPCWID is reflected in the Project records in many years from 1945 - 1982 (USBR, 1992 and NMSU, 2004). Additional details and discussion of the use of drain water is provided in both the Barroll Report (2019) and the MMA Report (2019).

The normal annual Project release of 790,000 AF described in the Compact appears to be largely based on an analysis in the RGJI that showed that the total supply diverted at the Project canal headings was comprised of varying amounts of storage releases, returns flows and seepage, and a small amount of tributary inflows. The RGJI describes a required annual storage release of 773,000 AF. This figure appears to have been increased to 790,000 AF during the Compact negotiations.

Historical descriptions of the day-to-day Project operations reinforce how the drain flows, wasteway flows, and other river gains or losses are considered in determining the reservoir releases necessary to meet orders for Project water. The following description from the 1936 Project History report is typical:

> *Water releases at the reservoir are changed twice a week to meet the irrigation requirements. The amount to be released is determined by advance orders to ditchriders by water users. These orders are summed for the different divisions and an allowance made for drain and waste return to arrive at the amount to be released. Under normal conditions this can be done very accurately with a small waste below the project limits. (Reclamation, 1936)*

More detailed descriptions of how the reservoir releases were determined are contained in certain versions of the annual Project History reports. A particularly detailed description is provided in the 1943 Project History report (Reclamation, 1943). It describes how the amount of flow needed in the Rio Grande at El Paso is computed by first tabulating the water orders for users in the El Paso Valley and Juarez with allowances for drain returns, waste returns and transmission losses. This figure is then used as a starting point for computations that systematically proceed upstream adding diversion demands and transmission losses and subtracting returns to arrive at the reservoir release that, when combined with the available return flows, is sufficient to meet the Project water demands.

While there have been changes in water allocation procedures through the years (e.g., the D1/D2 operation and the 2008 OA), the process for determining reservoir releases is similar today as it was at the time of the Compact. This is reflected in the following statement contained in the September 16, 2019 Supplemental Disclosure of Dr. Ian Ferguson:

> *Under the Operating Agreement, Reclamation releases Project water from Caballo Dam in accordance with water orders from EBID, EPCWID, and the United States section of the International Boundary and Water Commission ("US-IBWC") on behalf of Mexico. Water orders for Mexico are determined by the Mexican Section of IBWC ("MX-IBWC") and provided to Reclamation by US-IBWC. Water orders for EBID and EPCWID are determined and provided by each district, respectively. Water orders are limited by the allocation balance remaining on each entity's respective Project water account. The quantity of water released from Caballo Dam to satisfy Project water orders is determined by EBID and EPCWID, in consultation with Reclamation, based on the total amount of water ordered and anticipated gains and losses to the Rio Grande between Caballo Dam and Project diversion points. Project diversion dams and canal headings are subsequently operated to execute diversions and deliveries in accordance with water orders placed by EBID, EPCWID, and by US-IBWC for delivery to Mexico.*

The foregoing descriptions show how the amount of irrigation return flows and other flows entering the river are carefully considered in determining how much water to release from Project storage. For a particular aggregate demand, the more return flows that are entering the river, the less water that needs to be released from storage to meet that demand.

The term "diversion ratio" is used in characterizing the relative amount of reservoir release that is needed to meet downstream water demands. The diversion ratio may be computed as the sum of the river heading diversions divided by the reservoir release[1]. The lower the diversion ratio, the higher the reservoir release needs to be to meet downstream water demands. On an annual basis, the diversion ratio can range from 0.6 or less in dry years to over 1.0 in full supply years. The diversion ratio also varies throughout the year depending on river conditions. It is typically low at the beginning of the season when drain flows are low and river seepage losses are high. Drain flows and

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[1] In the accounting under the 2008 Operating Agreement, the diversion ratio is computed as the sum of charged diversions divided by the reservoir release.

river seepage fluctuate through the irrigation season in response to surface water irrigation and pumping, and this impacts the diversion ratio throughout the year.

2.5 Rio Grande Project Water Allocation

The allocation of Project water to Project water users has consistently been based on equal delivery of water per acre until the 2008 OA, as discussed below.

2.5.1 Equal Allotment Per Acre (Inception - 1978)

Reclamation operated all Project facilities through 1978 including the canals and laterals that delivered water to the Project water users. During this time Reclamation attempted to make available to all Project water users an equal amount of water per acre irrigated. There were no significant shortages during the first several decades of the Project operation and Reclamation did not impose any full-season Project water allotments until 1951 when the first significant drought following the completion of Elephant Butte Reservoir in 1915 occurred. Prior to 1951, there were often years when the releases from Project storage exceeded the normal annual release of 790,000 AF described in the Compact.

2.5.2 D1/D2 Allocation Procedure (1979 - 2007)

When the Project water users completed payments under their repayment contracts, Reclamation contracted with EBID (1979) and EPCWID (1980) to take over operation of the canal facilities and deliveries to the water users under each canal. This necessitated accounting for Project deliveries at canal headings rather than at the farm headgates. After this accounting adjustment, there still was equal delivery of water per acre to the Project water users, however, the districts became responsible for these deliveries rather than Reclamation.

To facilitate the delivery change to canal headings, Reclamation analyzed records of historical Project operations from 1951 - 1978 and developed relationships between Project releases and Project diversions and deliveries based on linear regression. The D1 Curve defined the relationship between Project releases and the sum of deliveries to U.S. farms and deliveries to Mexico at the head of the Acequia Madre. The D2 Curve defined the relationship between Project releases and the sum of diversions at all U.S. canal headings and at the Acequia Madre heading.

From 1979 - 2005, the D1 Curve was used to compute the allocation to Mexico based on the usable water available in Project storage and the D2 Curve was used to compute the diversion allocation to EBID and EPCWID. The districts were responsible for distributing water from their canal headings to the water users in their respective service areas.

An accounting system was established by Reclamation to track diversions by each district against their annual allocations. In general, the districts are charged against their allocations for the water they divert and use, but receive credits for certain operations. These credits are described in detail in the Barroll Report (2019).

2.5.3 2008 Operating Agreement (2006 - Present)

Reclamation, EBID, and EPCWID entered into an Operating Agreement for the Rio Grande Project on March 10, 2008 ("2008 OA"). Under the 2008 OA, the annual allocation to Mexico and EPCWID continued to be computed using the D1/D2 Procedure, while the allocation to EBID was modified to be based on the diversion ratio. In years when the diversion ratio is low, the EBID allocation is lower than the D1/D2 allocation that it previously received. In years when the diversion ratio is high, EBID could potentially receive an allocation greater than a D1/D2 allocation, although this has not happened since 2008 OA has been in effect. The revised allocation procedure, referred to as the D3 Procedure, was implemented informally beginning in 2006.

The other significant change in the 2008 OA was that each district was allowed to carry over any unused allocation that remained at the end of the year to add to the allocation it received in the subsequent year. Prior to the 2008 OA, the Project was operated on an annual basis and any unused allocation at the end of the year became part of the supply that was reallocated in the next year 57%/43% to EBID and EPCWID after determining the Mexico allocation under the D1 curve.

3.0 LOWER RIO GRANDE HYDROLOGIC DATA

Surface water data in the Lower Rio Grande have been collected by various agencies since the late 1880s. SWE compiled much of the available data into the Rio Grande Project Surface Water Dataset ("SWDataSet"). The SWDataSet is a compilation of flow and reservoir storage data that are used in various analyses and models by New Mexico representatives and consultants. The purpose of the SWDataSet is to provide a central data repository to ensure data integrity and consistency in the data that are used in the various analyses and models developed on behalf of New Mexico for this case. As more data become available through discovery or other means, these additional data will be added to the SWDataSet collection. The SWDataSet spreadsheet, original data, and metadata are being disclosed along with this report.

Most of the data in the SWDataSet fall into the following data categories:

- Streamflows
- Reservoir storage
- Diversions
- Drain flows
- Wasteway flows
- Municipal flows
- Metered ground water pumping

A list of all the flow data compiled in the SWDataSet is shown in **Table 3-1**. The measurement sites are listed by flow data type and location. The available period of record is also provided in the table. The earliest flow data are from 1889 and all available flow data have been compiled through 2017. All measurements sites with location information are shown in **Figure 3-1** through **Figure 3-5**.

3.1 SWDataSet Description

3.1.1 Organization of SWDataSet

The flow data have been imported into a single Excel spreadsheet and are organized by type, including river flows, canal flows, wasteway flows, drain flows, municipal flows, reservoir data, and metered irrigation pumping data.

3.1.2 Data Sources

The following is a summary of the major data sources used in the SWDataSet. A list of the data sources is provided in **Table 3-2.**

- EBID
- EPCWID
- Environmental Protection Agency (“EPA”)
- IBWC
- RGCC
- Reclamation
- United States Geological Survey (“USGS”)

3.1.3 Time-step

Most of the data in the SWDataSet are monthly data consistent with the monthly stress periods or time-steps used in the modeling and other analyses. Certain of the data that originated as daily data were aggregated and converted to monthly volumes, and these aggregation operations are contained in separate worksheets in the data backup folders.

Annual totals and monthly averages are generally provided below the monthly data. In cases where there are only annual data available, these values are shown in the annual total section and noted in the comments under the period of record. As needed for input into modeling or analysis, these annual data were converted to monthly volumes.

3.1.4 Period of Record

The SWDataSet includes all available flow data for the measurement sites from the earliest record available through 2017. The earliest compiled river flow records are for the Rio Grande at El Paso which date back to 1889. The earliest canal diversion records are for the Leasburg Canal which date back to 1908.

For certain data, there are missing months or years within the period of record. These data gaps are shown in two data matrices provided in the SWDataSet - one showing the monthly data availability and the other showing annual data availability. The monthly and annual data availability matrices are included in **Appendix 3A**.

3.1.5 Data Column Heading

The heading of the column for each measurement site contains the following information:

- District
    - EPCWID, EBID, HCCRD, and JID.
- Region
    - The region refers to the irrigation basin or main canal system (Rincon, Leasburg, Mesilla (NM), Mesilla (TX), El Paso, Hudspeth, and Mexico).
- Location
    - The location information is sourced to a worksheet (“Loc_info”). The location information is an export from an ArcGIS shapefile and in decimal degrees (1983 datum).
- Units
    - Data are in units of monthly AF and are typically rounded to the nearest AF.
- Site Code or other codes/gages numbers
    - The site code is from NMOSE.
        - The site code is based on the basin, type of gage, and miles downstream from Elephant Butte Dam. For example, the site code Westside Canal is 4C95.8A, the “4” is for the Mesilla basin below Leasburg, the “C” is for canal, the “95.8” is the miles downstream of Elephant Butte Dam, and the “A” is needed since there are three canal diversions from the Mesilla Dam (note that Eastside Canal is “B” and Del Rio Lateral is “C”).
    - The other site codes include USGS gage numbers, Reclamation 2008 Operating agreement codes, and EPA National Pollutant Discharge Elimination System (“NPDES”) permit numbers.

- Period of record
    - The period of record contains the year of the earliest record to the year of the latest record. Missing data are documented in the "Data_List" worksheet and are shown in the data matrices. As described above, some the records may be annual only and are noted in a comment.
    - Any estimated data are also noted in a comment.
- Name of measurement site/structure.

3.1.6 Backup Data Folders

The SWDataSet contains a series of backup folders that include the original data and metadata. The backup folders are named based on a source code (i.e., LRG.Doc.SWXXX). Each monthly data entry has a corresponding source code that references the source of the data/backup folder. The source code for each monthly data entry is located in the same worksheet as the monthly data in a parallel table labeled "Source Files." The table of source codes is located to the right of the data table. A summary of the backup data folders and various data sources is provided in **Table 3-2**.

Certain records in the SWDataSet are sourced to LRG.Doc.SW025. The source LRG.Doc.SW025 refers to a compilation of monthly data and not the original source data. Therefore, when data are sourced to the LRG.Doc.SW025, there is an additional source column adjacent to the LRG.Doc.SW025 column that lists the original source. An example of this is shown in the table below.

		DATA	SOURCE FILES	
District:		**EBID**	EBID	
Region:		**Rincon**	Rincon	
Location Lat (dd):		32.869	32.86912627	32.86912627
Location Long (dd):		-107.305	-107.305247	-107.305247
Units:		(af)	(af)	(af)
BOR 2008 OA Code:		R2	R2	R2
Site Code:		2C29.5A	2C29.5A	2C29.5A
Extent of Record:		1918-2017	1918-2017	1918-2017
Year	Month	Arrey Canal	Data Source - Arrey Canal	SW25 Source - Arrey Canal
1938	1	0	LRG.Doc.SW025	LRG.Doc.SW016
1938	2	1,698	LRG.Doc.SW025	LRG.Doc.SW016
1938	3	7,234	LRG.Doc.SW025	LRG.Doc.SW007
1938	4	12,294	LRG.Doc.SW025	LRG.Doc.SW007

In the above example, the data can be found in both source folders (SW025 and SW016 or SW007), but the original data are in the SW016 or SW007 folders.

3.1.7 Metadata

Metadata documentation for each data source is contained in the backup data folders in a Word document. The metadata documents native units, conversion factors, data quality, period of record, contacts for the data, compilation notes, links to online data, etc.

3.1.8 Conversion Units

The following conversion factors were used to convert the measurement units of certain data in the SWDataSet:

- 1 cubic meter per second = 35.31467 cubic feet per second
- 1 cubic foot per second = 1.98345 acre-feet per day
- 1 million gallons = 3.0689 acre-feet

3.1.9 Gage Location Information

Reasonable efforts have been made to compile the geographic coordinates of all measurement sites. Location data include confirmed gage locations and approximate gage locations. Confirmed gage locations are those in which the publishing entity (USGS, EBID, IBWC, etc.) provides coordinates, there are ArcGIS shapefiles associated with the measurement site, or the site has been field verified using a Global Positioning System ("GPS") device. Approximate locations include sites in which the location of the feature (i.e., wasteway) is generally known, but the exact location of the gage is unknown. Schematic diagrams from Reclamation and IBWC and high-resolution imagery from Google Earth were used to approximate gage locations. The source of the location information is described in the "Loc_info" worksheet in the SWDataSet.

3.1.10 Quality Assurance and Quality Control ("QA/QC")

The general QA/QC process of data entry into the SWDataSet is double-checking the data after they are entered into a spreadsheet. For example, after data are copied in, the data are totaled and checked against the totals of the corresponding data in the original source files. Details of the QA/QC process for each data source are included in the metadata.

3.1.11 Data Summaries

For each type of data, there are data summary tabs that include a table generator and a generator for a several summary charts. The summary table and charts show monthly and annual data from 1889 or 1903 through 2017. Example summary tables and charts for each data type is provided in **Appendix 3B.**

Worksheets "ToFarmBudget" and "ToRiverWare" were added to the SWDataSet to facilitate export of certain data for use in modeling.

3.2 Missing Data

Certain of the missing surface water data were estimated to provide complete datasets for modeling or other analyses. Procedures were developed to estimate missing data based on averages, correlations, and other statistical approaches involving comparison to other measured data such as Rio Grande flow data. Municipal wastewater discharges were largely estimated using correlations of annual wastewater discharge and total municipal pumping. Details for how the missing data were estimated are in shown in **Table 3-3**.

The SWDataSet has two worksheet tabs for certain data types that have missing data that were estimated. One worksheet tab contains the raw data and is indicated with an "X" (i.e, "CanalsX"). The other worksheet contains estimates of the missing data and is named without the "X" (i.e., "Canals"). In the worksheets with missing data estimates, the estimated data are noted with a comment in the "Period of Record," and a note in the data source referencing the backup folder with the missing data calculations.

3.2.1 Rincon and Mesilla Basin Data Gaps

The datasets for the Rincon and Mesilla basins are mostly complete. Estimates of wastewater treatment plant ("WWTP") discharges prior to the late 1990s were made and are summarized in **Table 3-3**.

Missing months of data within a year were estimated using an average for that month from the prior and subsequent year. For years with no data, the WWTP was estimated using an average annual percentage of pumping. Ground water pumping from municipalities contributing to the WWTPs were obtained from SSPA. The annual estimated WWTP discharge was distributed evenly into each month (divided by 12). There are two exceptions to this method described below.

For El Paso Electric, a wastewater discharge of 53% was used based on a report from NREL (2004). This reported percentage is comparable to the average percentage computed from the records.

The Village of Hatch receives water supplies from outside of the Lower Rio Grande area for which records are not available. For this town, a relationship between WWTP discharge and population was developed to estimate the WWTP discharge back in time.

3.2.2 Hueco Basin Data Gaps

NMOSE/ISC staff, MMA, and SWE coordinated to identify missing data needed for the Hueco Model back to 1903 when the simulation period commences. A majority of the missing data that needed to be estimated for the Hueco Model was for Mexico from 1903 - 1939. A summary of the missing data for the Hueco Model area and data estimation techniques are summarized in **Table 3-3**.

For Ciudad Juarez, there are no data available for sewage/WWTP production. Estimates made by IBWC (1989) were used for 1950 - 1984. For the rest of the years, the sewage/WWTP production was estimated as 49 percent of the total Ciudad pumping based on an average derived from the IBWC estimates.

For EPW, discharge from the Northwest WWTP, Socorro WWTP, and Bustamante WWTP were estimated back in time. Northwest WWTP estimates from 1987 to August 2002 were based on data used in the Upper Rio Grande Water Operations Model ("URGWOM") model and these data were provided by the NMOSE.

There are EPA discharge data for Socorro WWTP available from 1989 - 1993. The annual Socorro WWTP discharge decreased from 28,000 AF in 1990 to 500 AF in 1993 (zero by 1994). The Bustamante WWTP discharge first began in 1991 and the first record of Bustamante WWTP discharge is 31,000 AF in 1995. It was assumed that the Bustamante WWTP increased from 1991 - 1993 as the Socorro WWTP discharge decreased. To estimate the annual total Socorro/Bustamante WWTP discharge, the unit waste flows from Bustamante WWTP (gallons per day per capita) were multiplied by the percentage of the total City of El Paso population served by the Bustamante WWTP (Brown and Caldwell, 1997). The City of El Paso population was obtained from the El Paso County website (El Paso County, 2016).

The Socorro WWTP had several treatment ponds known as the Socorro Ponds located south of the current location of Bustamante WWTP. Based on appearance of these ponds in a 1967 aerial photo, it was assumed that the Socorro WWTP began operating in 1967. The Socorro WWTP discharge was estimated from 1967 - 1988. From 1991 - 1994, the Bustamante WWTP discharge was estimated as the total Socorro/Bustamante WWTP minus the reported Socorro WWTP discharge.

There are no data for the JID diversions downstream of Acequia Madre. However, there are estimates from various sources from USNRC (1938), Carreno (1957), and IBWC (1989) for 1930 - 1936, 1938 - 1947, and 1950 - 1984, respectively. The IBWC estimates of lower river diversions by JID were based on analysis of gaged river flows. This procedure was used to estimate diversions before 1984 in the years that estimates from others were not available. The lower river gages were discontinued in 1984, and no estimates of lower river JID diversions were made after that time.

3.3 Urban Deep Percolation

Urban deep percolation represents the ground water returns from municipal water use and includes systems losses and deep percolation from lawn irrigation. No records of urban deep percolation volumes were available and therefore values were estimated as described below.

System losses represent leakage from municipal water conveyance systems. Estimates of total system losses for Las Cruces and El Paso are published in various reports. Based on these reports, the system loss to ground water was estimated as the lower end of the reported range of the total system loss, which may include measurement and billing errors. The system loss for EPW was estimated as 7% of the total water use (EPW, 2014 and EPW, 2019). For Las Cruces and all other municipalities, as system loss of 10% was assumed (Shoemaker, 2008).

Lawn irrigation deep percolation was estimated as a percentage of the computed outdoor use of municipal water. The outdoor use was computed as the total monthly water use (total diversion less system loss) minus the monthly indoor use which was estimated as the average monthly water use during December through February. Monthly lawn irrigation deep percolation was computed as 15% of the total monthly outdoor use. This assumes an average irrigation efficiency of 80% (Barta, 2004 and Rogers, 1997) and a spray loss of 5% (Kincaid, 1987).

Urban deep percolation was computed for the following municipal areas:

- Mesilla Basin
    - Las Cruces
    - Santa Teresa
    - Anthony
    - Mesquite
    - Berino
    - Garfield
    - Radium Springs
- El Paso Valley
    - El Paso

The total monthly municipal water use was based on reported total pumping and use of Project water by EPW. Pumping data for the municipal users in the Rincon and Mesilla basins were provided by SSPA and pumping data for EPW were provided by MMA.

Surface water use data were obtained from the SWDataSet. The resulting urban deep percolation volumes are summarized in Section 5.9.

4.0 RIO GRANDE PROJECT ACCOUNTING DATA

4.1 Introduction

Project accounting is comprised of flow data to track the delivery of water to Project lands and to Mexico. The Project accounting data includes the following three types of data.

- Water Distribution Reports
- Project Water Allocation
- Accounting Records

The accounting dataset is comprised of two Excel spreadsheets. The Project Water Allocation and Accounting Reports data are in one spreadsheet (2019-10-25 Draft RGP Accounting Data – Confidential.xlsx) and the Water Distribution Report data are in the other spreadsheet (2019-10-25 Draft WDR Data – Confidential.xlsx). The following sections describe and summarize the different types of Project accounting data.

4.2 Water Distribution Reports (1918 - 2011)

The Water Distribution Reports ("WDRs") are part of the Rio Grande Project Histories and date back to 1918. The Rio Grande Project Histories are annual published reports from Reclamation that are available from 1912 - 1988. These documents include information on the operation and maintenance of the Project and contain data on crop, irrigation, weather, surface flows, operational costs, etc.

From 1918 - 1978[2], the WDRs report the monthly deliveries of Project water to the farms by unit or major canal system. The units include Rincon, Leasburg, Mesilla, and El Paso (a.k.a. Yselta). There are also total Rio Grande Project WDRs which are a sum of the data for individual units. After the Project operations were transferred to the districts in 1979, the WDRs are reported by district (EBID and EPCWID) and there are records for HCCRD as well. A summary of the available and compiled WDR data is shown in **Figure 4-1**. Examples of the WDRs are shown in **Appendix 4A**.

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[2] For the first couple of years, only the river headgate diversions and irrigated acreages were reported.

The following is a list of the WDR data types:

- Irrigated acres,
- River headgate ("RHG") or canal heading diversions,
- Canal loss,
- Canal waste,
- El Paso Valley carriage,
- Non-agriculture diversions, and
- Farm headgate ("FHG") deliveries.

The RHG diversions or canal heading diversions are measured flows for the major canals. Most of the canals divert from the river, but some canal headings are off other canals. These include the Franklin Canal that diverts from the American Canal, the Riverside Canal that diverts from the ACE (after 1999), and the Mesilla Texas diversions that divert from the Eastside and Westside Canals.

The WDRs include the reported total FHG deliveries to Project water users. Between the canal heading diversion and the farm headgates, a portion of the water seeps into the ground water or is consumed by vegetation in and around the canal ("Canal Loss"). Water is also spilled through various wasteways and returned to the river ("Canal Waste" or "Operational Spill"). To improve the conveyance of water downstream, some water is carried through EBID canals to the El Paso Valley ("El Paso Valley Carriage"). The non-agricultural diversions by EPW in the El Paso Valley are also reported.

The calculations for the reported canal heading diversions and Canal Waste in the WDRs for the El Paso Valley vary from year-to-year. Some of the El Paso Valley WDRs have notes indicating how these values were calculated, and these have been compiled and are shown in **Appendix 4B.**

4.2.1 FHG Deliveries (1920 - 2016)

FHG delivery records reported by unit are available from 1920 - 1978 and include Rincon, Leasburg, Mesilla, and El Paso Valley. Since 1979, the FHG deliveries are reported by district. Some EBID records from 1991 - 2010 are reported separately for the Rincon and Mesilla Valleys (including Leasburg). In 2011, there is a separate WDR for the Mesilla Valley only.

In addition to the WDR data, there are annual total EBID FHG deliveries available for 2011 - 2016 reported by the EBID. These records were compiled into the accounting dataset in the WDR spreadsheet.

Within the WDR accounting dataset, the FHG deliveries were disaggregated into units as necessary to have a continuous record of deliveries by unit over time. This was done by pro-rating the monthly district total values using the reported RHG diversions for each unit. For example, the Rincon FHG delivery was computed as the total EBID FHG delivery multiplied by the Rincon diversions (Arrey Canal plus Percha Lateral) divided by the total EBID diversions (Rincon, Leasburg, Mesilla Eastside NM, and Mesilla Westside NM). The diversions to each unit were obtained from the SWDataSet.

Prior to 1979, the total FHG deliveries for the Mesilla Unit were disaggregated into Mesilla Eastside and Mesilla Westside using the canal diversions for the Eastside Canal and Westside Canal. Then, the computed Mesilla Eastside and Mesilla Westside FHG deliveries were further disaggregated into New Mexico and Texas portions using reported irrigated area data.

After 1979, the total district-wide FHG deliveries for EBID and EPCWID were distributed by unit based on reported monthly diversions.

The compiled FHG deliveries by unit and by district from 1938 - 2016 are shown in **Table 4-1.** The values in black are from the records and the values in blue are computed and include the disaggregated values and the totals by district.

The FHG deliveries from the records were used as input into the CFB Models described in Section 6. Some additional adjustments and estimates of missing data were made to the records as needed and as described in that section.

4.3 Allocation Data (1951 - Present)

Prior to the development of the D1/D2 allocation procedures in 1979, Reclamation operated the Project to make available for delivery an equal amount of water per acre to the farm headgates of all Project lands (Reclamation, 2015). The allocation of Project water beginning in 1951 was reported in the Rio Grande Project Histories as an allotment in AF per acre. An initial allotment was made in the beginning of the irrigation season. This allotment was occasionally increased over the runoff season (May - July) based on the amount of runoff accrued in the Project storage. During the 1940s, with ample available Project storage, there were no full season allotments reported in the Project Histories. The initial and final Project allotments from 1951 - 1978 are summarized in **Table 4-2** based on a summary table prepared by Reclamation (2012).

The D1/D2 allocation procedures started in 1979, and the annual allocations were computed as annual diversion volumes for EBID and EPCWID. Distribution of water from the canal headings to the farms was handled by the districts (Reclamation, 2015). Initial and final allocations to the districts are shown in **Table 4-3**. The values from 1979 - 2018 were obtained from Reclamation and district accounting and allocation reports provided by Dr. Peggy Barroll**.** There are some missing allocation data for EBID (1979 - 1983) and EPCWID (1980 - 1982). Also, except for 1984 - 1985, there are no data for the Mexico allocation from 1979 - 2002. Annual allocations for these years were estimated by Dr. Barroll. Examples of the allocation records are shown in **Appendix 4C**.

As described above, the 1940s were wet years with plentiful reservoir supply and the first full-season Project water allotment did not occur until 1951. Therefore, 1940 - 1950 were assumed to be full supply years[3]. From 1951 - 1978, there were a mix of full supply and less than full supply years. Full supply years were assumed to be years with final allotments to the farms of 3.0 AF/acre or more (Reclamation, 1985). From 1979 - 2005, full supply years were assumed to be years with Mexico being allocated 60,000 AF or diverting roughly 60,000 AF or more. After 2005, full supply years were assumed to be years with an annual allocation to EPCWID (not including carryover) of at least 360,000 AF. The 360,000 AF figure was determined in consultation with Dr. Barroll based on review of deliveries and allocations during full supply years from 1984 - 2005.

4.4 Accounting Records (1979 - present)

Accounting records for EBID and EPCWID from 1979 - 2018 have been compiled into the Accounting Dataset. The accounting records track the allocation, diversion charges, credits, and allocation balance for each district. The first available accounting records are reported as irrigation season totals. Monthly accounting records are available beginning in the mid-1980s. The accounting records are in a mostly consistent format throughout the D1/D2 allocation time period (1979 - 2005). Credits to EPCWID were added after the construction of the ACE, and the accounting reports changed after the 2008 OA to reflect changes in the allocation procedures. Below is a list of the type of data in the accounting records:

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[3] The term “full supply” as used herein is synonymous with “full allotment” or “full allocation.”

- Allocation of Project water,
- Delivery charges,
- Credits, and
- Allocation balance/carryover.

Project water is delivered to the districts at canal headings in New Mexico and Texas. Texas lands in the southern Mesilla basin receive Project water that has been diverted by EBID at canal headings in New Mexico. Project water is delivered to the following structures, listed generally in upstream to downstream order. Maps of the accounting points for EBID and EPCWID are shown in **Figure 4-2** and **Figure 4-3.**

Examples of the accounting reports are provided in **Appendix 4D**.

New Mexico Delivery Points	Texas Delivery Points
• Arrey Canal	• La Union West Canal
• Percha Canal	• La Union East Canal
• Leasburg Canal	• Three Saints Lateral
• Westside Canal	• Robertson- Umbenhauer WTP
• Eastside Canal	• Franklin Canal
• Del Rio Lateral	• Jonathan Rogers WTP
• California Lateral	• Riverside Canal
• Various river pumps	

Delivery charges to EBID include the total diversions to EBID at the canal headings listed above minus deliveries to Texas in the Mesilla basin. Credits to EBID include credits for bypass water diverted at Arrey Canal or Leasburg Canal, and credit for flood waters diverted. In addition, there is an adjustment to the EBID delivery charges for diversions that are less than 95 percent of orders. EBID is charged the maximum of 95 percent of its order or the actual diversions.

Delivery charges to EPCWID include the total diversions to EPCWID at the canal headings listed in the above table. In recent years, EPCWID has also been charged for diversions to others including Tigua Pueblo, IBWC, and Yselta del Sur. The largest credits to EPCWID consist of water discharged though the Ascarate Wasteway prior to completion of the ACE in 1999, Haskell WWTP effluent discharges to the ACE, and a credit to the district for unordered and unused water. Since 2003, EPCWID has also received an ACE Conservation Credit that is added to EPCWID's total allocation and not included in the delivery charge.

For both EBID and EPCWID, if one district is ordering water and the other is not, the delivery charge to the district ordering water is equal to the greater of the total Caballo Dam release or the diversions.

Figure 4-4 shows the total allocations to each district, JID, and the total delivery charges to each district from 1979 - 2018. Since 1979, EBID tended to take delivery of most of its allocation. Since 1979, EPCWID took delivery of less than its full allocation in most years. The total EPCWID annual deliveries have decreased since 2005.

5.0 HISTORICAL WATER SUPPLY AND WATER USES

5.1 Introduction

The Rio Grande, like many rivers of the southwestern United States, is characterized by wide swings in annual flow, owing largely to the significant variability in the annual snowpack accumulation and runoff from the headwaters in southern Colorado and northern New Mexico from which most of the Rio Grande flow is derived. Irrigation development in the San Luis Valley of Colorado and later the Middle Rio Grande of New Mexico have long affected the flow of the Rio Grande at San Marcial that is the source of most of the water for the Project. Regulation of upstream water uses in Colorado and New Mexico to meet the annual delivery obligations of Colorado (at the State line) and New Mexico (at San Marcial until 1949 and at Elephant Butte Reservoir thereafter) also have affected the flow available to Lower Rio Grande water users.

Construction of Elephant Butte Reservoir in 1915 and Caballo Reservoir in 1938 were instrumental in regulating the variable supply from upstream for delivery of a more dependable irrigation supply to Project water users. The Project water supply is described in the RGJI as comprised of storage releases, irrigation returns, and, to a minor degree, sporadic tributary inflows.

The average annual demand for irrigation water for the Project and for delivery to Mexico was estimated in the RGJI based on diversion records for the period from 1930 - 1936 and estimates of reuse of return flows and reservoir evaporation losses as follows:

Table 95 – Required Annual diversion demand upon Rio Grande at San Marcial for Rio Grande project and Mexican treaty obligation (USNRC, 1938)

Item	*Annual Demand (acre-feet)*
Net diversions for Rio Grande Project irrigated acreages of 145,000	*600,000*
Rio Grande Project wastes	*65,000*
Riverbed losses above Tornillo Heading	*64,000*
Salinity control in area under Tornillo Canal	*7,000*
Fulfillment of Mexican Treaty obligation	*37,000*
Total reservoir releases	*773,000*
Reservoir evaporation	*120,000*
Reservoir seepage	*60,000*
Total demand on San Marcial	*953,000*

The total release requirement of 773,000 AF/y was increased slightly during the Compact negotiations to the normal annual release of 790,000 AF/y described in the Compact.

The RGJI also included analysis of the flow available at San Marcial. Based on analysis of historical gage records from 1890 - 1935, corrected to account for upstream development that had occurred by the mid-1930s, the average annual flow available at San Marcial for downstream use was estimated at 1,031,000 AF/y. Records of water availability and water use since the mid-1930s indicate that the average available supply has been less than what was estimated in the RGJI and the use of water has been slightly more than what was estimated.

This section summarizes various historical records of water supply and water uses from before the Compact to the present.

5.2 Rio Grande Flows

Rio Grande flow records for the period of available record were compiled for gages between San Marcial and El Paso as follows:

- San Marcial (1890-2017),
- Elephant Butte Reservoir Outlet (1915-2017),
- Caballo Reservoir Outlet (1922-2017, Rio Grande above Percha Dam used for 1922-1937), and
- El Paso (Courchesne) (1895-2017).

Since completion of Caballo Reservoir in 1938, releases from Project storage have been measured below the Caballo Reservoir outlet. Prior to that time Project releases were measured below Elephant Butte Reservoir. From 1922 - 1937 there was a Rio Grande gage upstream of Percha Dam, the first Project diversion located approximately two miles downstream of the Caballo Reservoir outlet. Comparison of the annual releases from Elephant Butte Reservoir to the annual flows in the Rio Grande above Percha Dam during the period of concurrent record shows there was an average annual gain of about 20,000 AF in the 29-mile reach between the Elephant Butte Reservoir outlet and Percha Dam. Therefore, the records for the Rio Grande above Percha Dam are a better representation of the flow available at the upstream end of the Project prior to the time that Caballo Reservoir was constructed.

The upper graph in **Figure 5-1** plots the annual Rio Grande flows at San Marcial since 1890 as well as the 10-year average flow. Annual San Marcial flows averaged approximately 890,000 AF/y during the period of record. The 10-year average line clearly shows the cyclical nature of the flows in the Lower Rio Grande basin during the last almost 130 years. By decade, the flows were above average through the 1940s, below average from the 1950s through the 1970s, above average in the 1980s and 1990s, and below average thereafter.

The middle chart in **Figure 5-1** compares the annual San Marcial flows to the Project releases below Caballo Reservoir since 1922 (Rio Grande at Percha Dam flows used before 1938). The regulating and dampening effect of Project storage is seen by comparing the bars and line in this chart.

Another illustration of the cyclical nature of the Rio Grande flows is presented in the lower chart in **Figure 5-1** that depicts the cumulative departure from average for the San Marcial gage and the Caballo Reservoir releases during the period from 1922 - 2017. The cumulative departure line for the San Marcial gage flows generally increases through

1945, then decreases until 1978, then increases again until 1999, and decreases thereafter. The cumulative departure line for the Caballo Reservoir releases follows a similar pattern, except it is dampened and shifted forward in time by 3-5 years reflecting the storage regulation of the reservoir inflows.

Table 5-1 provides a comparison of the average annual San Marcial inflows and Caballo Reservoir releases for various historical periods and against the comparable planning estimates presented in the RGJI. These comparisons show that the San Marcial flows have been substantially less than were estimated in the RGJI. During the generally wet period until 1950, actual reservoir releases were greater than the estimated releases needed to supply the Project. This was due in part to the Project irrigated area that grew to about 160,000 acres by the early 1950s and well in excess of the 145,000 acres analyzed in the RGJI. The early 1950s also marked the end of the prolonged wet period that had existed for several decades and, as a result, reservoir releases were less than projected in the RGJI due to the drier conditions.

The upper chart in **Figure 5-2** compares the annual Caballo Reservoir releases and El Paso gage flows from 1920 - 2017. The decreases in flow from Caballo Reservoir to El Paso generally reflect the consumptive use of surface water and ground water for irrigation and non-irrigation uses as well as the consumptive use by native vegetation.

The net Rio Grande depletion between the Caballo Reservoir release and El Paso gage, computed as the difference between the lines in the upper chart is plotted as the blue bars in the lower chart in **Figure 5-2**. The 10-year average depletion, plotted as a black line, shows the annual depletions remained relatively steady around 250,000 AF until the wet period of the early 1980s when the average annual depletions increased to over 300,000 AF during the 1990s. With the commencement of the recent dry period in the early 2000s, the average annual depletions have declined back down to around 250,000 AF. **Table 5-1** includes a summary of the average annual Caballo to El Paso depletions for various historical periods.

Figure 5-3 summarizes the annual Rio Grande flows at the Ft. Quitman gage that is located downstream of the HCCRD. Until the mid-1940s, the annual flows often exceeded 200,000 AF. In the following three decades, which were characterized by drier conditions and more careful Project operation to minimize waste, the Ft. Quitman flows averaged less than 40,000 AF. A return of wetter conditions and less efficient Project operation resulted in a significant increase in Ft. Quitman flows that persisted through 2010. Additional discussion of the Project waste is provided in Section 5.6.

5.3 Irrigated Area

The authorized irrigated area for the Project is described in the 1938 contract between EBID and EPCWID and consists of 90,640 acres in New Mexico (57%) and 69,010 acres in Texas (43%). The actual irrigated area in the Project varied through time as new lands were brought into irrigation during the early years of the Project and as lands were taken out of production due to urbanization. In addition, the actual irrigated area fluctuated from year to year as a result of planting and fallowing decisions by farmers in response to forecast water supplies.

The preparers of the RGJI assumed that not all irrigable acres would be irrigated in any one year because of fallowing and other decisions, and they estimated the water requirements for the Project based on a total combined actual irrigated area of 145,000 acres.

The reported annual Project irrigated areas for EBID, EPCWID, and the combined total are plotted in the upper chart in **Figure 5-4** for 1920 - 2017. The Project irrigated area increased rapidly to approximately 140,000 acres in the mid-1920s at which time it leveled out for about 10 years. The irrigated area slowly increased through the 1940s and reached a peak of approximately 160,000 acres in the early 1950s. This is about 15,000 acres greater than the acreage figure used in the RGJI for estimating the average annual reservoir release of 773,000 AF/y.

Since the peak in the early 1950s, the irrigated area steadily declined to the current (2017) value of approximately 105,000 acres. This represents a decline of 55,000 acres or 34% from the peak. The irrigated area in EBID has decreased by 23,000 acres (25%) from a peak of about 93,000 acres to the current 70,000 acres. The decrease in irrigated area in EPCWID has been greater at 32,000 acres (48%), declining from 67,000 acres to 35,000 acres.

As shown in the lower chart in **Figure 5-4**, the reported irrigated area in the HCCRD also increased rapidly during the 1920s reaching almost 15,000 acres in 1930. After declining to about 11,000 acres in 1938, it rose to a peak of 18,000 acres in the early 1950s. As a consequence of the severe drought that affected the Project in the mid-1950s, the irrigated area in the HCCRD, which relies on waste from the Project for its supply, declined precipitously to about 4,000 acres in the late 1950s. Since then, the irrigated area has fluctuated up and down and peaked again in the late 1980s at 17,000 acres, and then declined to the current (2017) 8,000 acres.

The reported irrigated area for the JID is also plotted in the lower chart in **Figure 5-4**. The area increased from about 19,000 acres in 1920 to about 58,000 acres in the mid-1930s and then declined to about 24,000 acres in the mid-1950s. Since then, the JID irrigated area has fluctuated between about 30,000 acres and 45,000 acres, and currently stands at about 32,000 acres (2017).

The decline in irrigated area in the Project and in the JID has been due in part to urbanization, mostly in and around Las Cruces, El Paso, and Juarez. It appears that the fluctuation in the HCCRD irrigated area may have been due to the variability in the water supply for the area.

EPW has reportedly contracted for use of the Project water associated with some of the EPCWID lands that have gone out of production, and this reportedly is the basis for the deliveries of Project water they began receiving in the mid-1940s.

5.4 Diversions

Annual irrigation season (Mar - Oct) diversions at or near the canal headings are plotted in **Figure 5-5** for EBID and EPCWID and **Figure 5-6** for HCCRD and JID during the period from 1920 - 2017. EBID diversions include diversions at the Arrey Canal in the Rincon basin, and the Leasburg Canal, Westside Canal, and Eastside Canal in the Mesilla basin. The Westside Canal and Eastside Canal deliver water to EBID lands in New Mexico and to EPCWID lands in Texas, and the diversions for these canals were pro-rated to EBID and EPCWID based on reported annual irrigated area in each district.

EBID diversions were highest during the wet period that lasted until about 1950. Diversions fluctuated during the 1950s - 1970s as the Project supply cycled through dry and wet periods. Diversions generally increased during the full supply years of the 1980s and 1990s with the 10-year average diversions returning to the level that occurred in the 1940s. Since 2002, diversions have declined dramatically as a result of the drought and enactment of the 2008 OA that has substantially reduced Project water allocations to EBID.

EPCWID diversions include diversions at the Franklin Canal, Riverside Canal (starting in 1928), Tornillo Canal (until 1937), the EPCWID portions of the Westside Canal and Eastside Canal in the Mesilla basin, and EPW diversions. The EPCWID diversions increased rapidly through the 1920s as additional lands were brought into irrigation. Similar to EBID, the EPCWID diversions were at a high level throughout the wet period of the 1930s and 1940s. Diversions plummeted during the early and mid-1950s and then varied up and down through the wet and dry years of the 1960s and 1970s. Diversions during the full supply years of the 1980s and 1990s almost reached the pre-1950 levels with increasing amounts of water delivered to EPW (orange bars in **Figure 5-5**). Commencement of the drought in

2002 resulted in a decline in EPCWID diversions, but because of the 2008 OA diversions did not decline as much as in EBID.

Irrigation season canal heading diversions for the HCCRD are plotted in the upper chart in **Figure 5-6** and include measured or estimated flows in the Tornillo Canal at Alamo Alto, the Hudspeth Feeder Canal, and the Tornillo Drain. Because the HCCRD supply is derived entirely of EPCWID waste and return flows, the HCCRD diversions generally follow the pattern of the EPCWID supply. HCCRD diversions were high in the 1930s and 1940s, and even higher in the 1980s and 1990s. Flows were more variable in the 1950s, 1960s, 1970s and after 2002.

Irrigation season diversions to the JID are plotted in the lower chart in **Figure 5-6**. These include reported diversions at the International Dam to the Acequia Madre and reported and estimated diversions from the Rio Grande downstream of International Dam until 1984. Completion of the American Dam in 1938 allowed the United States to better regulate deliveries to Mexico under the 1906 Treaty. After that time, the United States could divert all flow in the Rio Grande except for the amount being passed a short distance downstream to Mexico for diversion into the Acequia Madre. Diversions into the American Canal could then be delivered to the Franklin Canal heading or returned to the river downstream of the International Dam for delivery to the Riverside Canal heading. Before construction of the American Dam, delivery of flows to the Riverside Canal and the Tornillo Canal had to be delivered in the river past the Acequia Madre and there was no physical way to keep Mexico from diverting in excess of its treaty allotment. This accounts for the large diversions by Mexico until 1938. Since that time, JID diversions have fluctuated in concert with the diversions by the U.S. districts. Reported annual diversions often exceeded the 1906 Treaty limit of 60,000 AF because of the unregulated diversions from the river downstream of the International Dam.

Computed irrigation season canal heading diversions for irrigation in AF per acre are shown in **Figure 5-7** for EBID and EPCWID and in **Figure 5-8** for HCCRD and JID. These figures are based on the actual reported irrigated area in each district. Because of the generally declining acreages in both EBID and EPCWID average per acre diversions for both districts have increased since 1950s. This is especially the case for EPCWID which saw its 10-year average per acre diversions increase from about 3 AF/ac in the early 1960s to about 7 AF/ac in the 1990s. Per acre diversion have declined in recent years due to the prolonged drought.

Average per acre diversions for the HCCRD also increased markedly from about 3 AF/ac in the 1960s to about 8 AF/ac in the 1990s. In the JID, per acre diversions have remained relatively steady since completion of the American Canal in 1938. The per acre diversions are relatively low compared to EBID, EPCWID, and HCCRD because JID has significant additional supply from sewage/WWTP returns and drain flows that are not included in the per acre diversions shown in **Figure 5-8**.

Irrigation season canal heading diversions per authorized acre for EBID and EPCWID are summarized in **Figure 5-9**. The EPCWID diversions include diversions by EPW for municipal use. The authorized Project acres total 90,640 acres in EBID and 69,010 (EBID 1938). The per authorized acre diversions in EBID increased from approximately 4 AF/y in the 1960s to over 5 AF/y in the 1990s before declining in recent years due to the effects of drought and the 2008 OA. Similarly, the per authorized acre diversions in EPCWID increased from about 3 AF/y in the 1960s to about 5 AF/y in the 1990s before declining in recent years. The per authorized acre diversions in EPCWID are generally lower than in EBID because there has been more urbanization in EPCWID resulting in less overall water demand.

5.5 Farm Headgate Deliveries of Surface Water

Similar charts to the canal heading diversion charts were prepared to summarize the reported and estimated FHG deliveries of surface water. Summaries of the annual FHG delivery volumes are shown in **Figure 5-10** for EBID and EPCWID and **Figure 5-11** for HCCRD and JID. The FHG delivery volumes vary widely depending on the Project supply.

EBID FHG deliveries during full supply years of the 1980s and 1990s are slightly greater than during the full supply years of the 1960s and 1970s. EBID FHG deliveries have declined sharply since 2002 due to effects of drought and the 2008 OA.

FHG deliveries for EPCWID are shown as stacked bars for irrigation deliveries (red) and EPW deliveries (yellow). There are 10-year average lines in the EPCWID chart for the irrigation deliveries only and the total deliveries. The EPCWID FHG deliveries during full supply increased from approximately 150,000 AF during the 1960s - 1980s to over 200,000 AF in many years during the 1990s and 2000s.

FHG deliveries to HCCRD varied widely from 1940 to the present but increased from an average of 20,000 AF/y - 30,000 AF/y during the 1960s and 1970s to approximately 50,000 AF/y in the 1990s and early 2000s.

There are no records of FHG deliveries for JID and the values in **Figure 5-11** were estimated based on total diversions minus an estimated total canal loss. The estimated JID FHG deliveries have increased through time due to reported increases in WWTP discharges to the canal system and lining of the JID canals and laterals.

Computed irrigation season farm headgate diversions for irrigation in AF per acre are shown in **Figure 5-12** for EBID and EPCWID and in **Figure 5-13** for HCCRD and JID. These figures are based on the actual reported irrigated area in each district. Because of the generally declining acreages in both EBID and EPCWID average per acre FHG deliveries for both districts have remained steady or slightly increased since the 1950s. Per acre FHG deliveries have declined in recent years due to the prolonged drought. The declines are greater in EBID due to effects of the 2008 OA. Per acre farm deliveries in HCCRD increased from an average of 2 AF/ac in the 1960s to an average of 3.5 AF/ac in the 1990s and 2000s. In JID, FHG deliveries increased from an average of 1 AF/ac in the 1960s almost 2 AF/ac in recent years.

5.6 Farm Headgate Deliveries of Surface Water Plus Pumping

Charts summarizing FHG deliveries of surface water plus supplemental ground water pumping are shown in **Figure 5-15** through **Figure 5-18**. These charts are identical to the charts in **Figure 5-10** through **Figure 5-13** except that the estimated supplemental ground water pumping was added to the FHG deliveries to compute the total applied water. The estimated supplemental ground water pumping was computed as part of the CFB Model analyses that are described in Section 6.

The stabilizing effect of the supplemental pumping is obvious in the total applied volumes for EBID and EPCWID summarized in **Figure 5-15**. The applied water volumes for HCCRD in **Figure 5-16** are more variable due to the large variations in surface water supply and large variations in irrigated area. The total applied water volumes for JID increase substantially through the 1950s and 1960s due to the development of supplemental ground water supplies and increased supply from Ciudad Juarez sewage/WWTP returns.

The computed annual total applied water per actual irrigated acre shown in **Figure 5-17** are relatively stable for EBID and EPCWID throughout the study period with the averages fluctuating between approximately 3 AF/ac and 3.5 AF/ac in both districts.

The annual total applied water for HCCRD shown in **Figure 5-18** has more variability than the EBID and EPCWID values, but the 10-year average also fluctuates in the range of 3 to 3.5 AF/ac. The JID total applied water values also shown in **Figure 5-18** increased from approximately 2 AF/ac in the early 1950s to an average that varies between 3 and 3.5 AF/ac from about 1970 to the present.

The annual total applied water for EBID and EPCWID are shown per authorized acre in **Figure 5-19**. The EBID amounts varied above and below 3 AF/ac throughout the study period. The EPCWID amounts were slightly less averaging about 2.5 AF/ac. The lower average for EPCWID is likely due to greater urbanization in the EPCWID service area and resulting in lower irrigation water demands.

5.7 Waste and Deliveries to HCCRD

Historical data were reviewed to assess how Project operational waste has changed over time. Operational waste is a generally unavoidable part of operating a large irrigation Project. In order to operate without waste, it would be necessary to release the water from storage in the amounts and with the timing that, when combined with the gains and losses between the reservoir outlet and the delivery points, would result in delivery of exactly what was ordered. Such operational perfection is generally not achievable due to the time it takes for releases to reach the farms, the day-to-day variations in gains and losses between the Caballo Reservoir outlet and the delivery points, changes in water orders after releases have been made, and variations in efforts to control and manage the Project supply. Operational waste appears as discharges from canals back to the river or drains through wasteways, and as water tailing out the end of the canals.

Operational waste is not lost to the Project if it can be diverted downstream and used within the Project. Indeed, this is what happens with much of the waste from the EBID canals that returns to the river and is part of the supply that is diverted and used in the EPCWID or the JID. The operational waste that is lost to the Project is the waste that leaves the Project area below the Tornillo Division of the EPCWID.

Reported annual volumes of operational waste for EBID are plotted in **Figure 5-20** along with annual canal heading diversions. The annual EBID operational waste was relatively consistent and trending downward from the 1940s through the 1970s. The operational waste spiked upward during a few years in the late-1980s and early-1990s before declining to the lower levels in the mid-1990s and thereafter. Note that portions of the reported EBID operational waste may have been intentional because water that was destined for downstream delivery below El Paso was reportedly sometimes delivered through EBID canals and wasted back to the river downstream because the conveyance efficiency of the canals was often better than the river during dry conditions.

Figure 5-21 shows the annual EBID waste as a percentage of annual canal diversions. The operational waste fluctuated above and below 10% through the mid-1960s and then declined to around 5% from the mid-1960s through 2001 except during the wet periods in the mid-1980s and mid-1990s. As described above, much of the EBID operational waste would have been diverted and used in the EPCWID and therefore was not lost to the Project.

Similar charts for reported operational waste in the El Paso Valley portion of the EPCWID are provided in **Figure 5-22** and **Figure 5-23**. The reported annual waste volumes in **Figure 5-22** exhibit a somewhat similar pattern to the EBID waste volumes in that the annual volumes were relatively high in the 1930s and 1940s and then lower through the 1970s.

However, beginning in the 1980s, the reported El Paso Valley waste increased substantially over what it was prior to that time, and not just during a few years in the 1980s and 1990s like it did in EBID. It is noteworthy that that increase in waste generally coincided with the EPCWID taking over the water distribution within the district from Reclamation.

Records of operational waste for the El Paso Valley are not available after 2002, so the annual waste volumes after 2002 were estimated based on a linear regression with the reported total annual canal flow to HCCRD (Tornillo Canal at Alamo Alto + Hudspeth Feeder Canal) that is also plotted in **Figure 5-22** and seems to generally follow the pattern of the reported El Paso Valley waste prior to 2002.

Figure 5-23 shows the annual El Paso Valley waste as a percentage of total El Paso Valley diversions (computed as Franklin Canal diversions minus Ascarate Wasteway flows [before completion of the ACE in 2000] plus Riverside Canal diversions plus EPW diversions). When Reclamation tightened up Project operations in the early 1950s, the waste declined from over 20% of diversions to generally less than 10% of diversions where it remained through the late-1970s. Then, inexplicably, the waste increased to an average of approximately 25% of diversions where it remained until the recent drought.

Assuming 10% represents a reasonable upper limit for El Paso Valley operational waste, **Figure 5-24** was prepared to summarize the annual waste volumes that exceeded this threshold. As shown in the table embedded in **Figure 5-24**, the annual El Paso Valley operational waste since 1980 during non-spill years averaged 51,200 AF, and annual operational waste in excess of 10% averaged 28,000 AF. Assuming this operational waste represents water that could have been saved, EBID and EPCWID would have shared in this savings 57%/43%. EBID’s share of the savings would have averaged approximately 16,000 AF/y and this represents a reasonable approximation of the impact that the increase in El Paso Valley waste had on EBID during the period from 1980 - 2017.

5.8 Irrigation Pumping

Since 2009, all wells in the New Mexico part of the LRG basin have been required to be metered by order of the New Mexico State Engineer (with the exception of single-family domestic wells and small stock wells). Many non-irrigation wells were metered long before 2009 under State Engineer permit conditions. All metered ground water uses are reported annually in the LRG Water Master Reports. The total annual metered irrigation pumping volumes in the Rincon basin and Mesilla basin in New Mexico from 2009 - 2018 are shown in **Figure 5-25**. Since 2016, the irrigation pumping has also been reported by subarea (Rincon, Mesilla North/Leasburg, and Mesilla South) and outlying areas. The stacked bars in **Figure 5-25** depict the annual irrigation pumping by subarea starting in 2016.

5.9 Non-Irrigation Water Uses and Return Flows

Water used for non-irrigation purposes in the LRG Area includes domestic, municipal, commercial, and industrial ("DCMI") uses. Most of the non-irrigation water uses are supplied by in-basin ground water pumping with the exception of EPW use of Project water, and ground water imported by Las Cruces from the Jornada basin.

A portion of the non-irrigation water use returns to the Rio Grande, canals, and drains through WWTP discharges and to the ground water system through urban deep percolation. These return flows were tabulated and estimated as described in Section 3.

Summaries of the combined annual non-irrigation water uses and measured and estimated return flows in New Mexico, Texas, and Mexico are shown in **Figure 5-26** through **Figure 5-28**. Annual pumping and return flows have averaged the following volumes during the past five years:

Average Annual Non-Irrigation Pumping and Return Flows
LRG Study Area
2013-2017
(acre-feet)

Region	Pumping	WWTP Discharges	Urban Deep Percolation	Total Returns
New Mexico	36,500	12,900	4,100	16,900
Texas	86,700	52,100*	11,900	64,000
Mexico	150,900	71,400	0	71,400

* NW WWTP (7,100 AF/y), Haskell WWTP (15,500 AF/y), and Bustamante WWTP (29,500 AF/y)

6.0 LOWER RIO GRANDE CANAL AND FARM BUDGET MODELS

Canal and Farm Budget Models ("CFB Models") were prepared to simulate historical irrigation water use in the major irrigation units in New Mexico, Texas, and Mexico between Elephant Butte Reservoir and Ft. Quitman. The models employ typical water balance calculations based on the simple formula:

- Inflows - Outflows = Change in Storage.

The CFB Models simulate use of surface water and ground water to meet the irrigation requirements for the crops that were historically grown in the study areas. The models simulate delivery of water from the canal headings to the farms including conveyance losses to seepage, incidental consumptive losses, wasteway flows, and carriage water operations. Simulated deliveries of surface water to the farms are used to meet crop irrigation water requirements limited by reasonable maximum farm irrigation efficiencies, and the deliveries that are not consumed return as deep percolation or surface runoff. A soil moisture reservoir is simulated in the root zone of the crop to carry over excess surface water applications from one stress period to the next. After development of irrigation wells in the late-1940s and early 1950s, unmet crop water demands are assumed to be met by ground water pumping.

The CFB Models were developed to assess the historical use of surface water and ground water in the LRG Area, and specifically to compute:

- Crop-weighted consumptive use ("CU") of applied water for the irrigation units in the LRG Area;
- FHG deliveries for periods when records were not available;
- Supplemental pumping for all irrigation units, and the primary (ground water only) pumping in New Mexico; and,
- Annual inputs for the Hueco Model simulation of period from 1903 - 1939.

In addition, the CFB Models were used to verify the canal and farm budget simulation process that was implemented in the RiverWare Model.

6.1 Simulated Irrigation Units

Separate CFB Models were developed for distinct irrigation units within the four irrigation districts in the LRG Area (EBID, EPCWID, HCCRD, and JID) based on the geography and availability of input data (e.g., diversion data, irrigated area data, cropping data, etc.). The following tables lists the separate CFB Models that were prepared, and the geographic area for each model is mapped in **Figure 6-1**.

Identification of CFB Models by Irrigation Unit

Irrigation Unit	District	Location
Rincon	EBID	Rincon Valley in Sierra and Dona Ana Counties, New Mexico
Leasburg	EBID	Leasburg Canal service area in the Mesilla Valley in Dona Ana County, New Mexico
Mesilla Westside (NM)	EBID	Westside Mesilla Canal service area in the Mesilla Valley in Dona Ana County, New Mexico
Mesilla Eastside (NM)	EBID	Eastside Mesilla Canal service area in the Mesilla Valley in Dona Ana County, New Mexico
Mesilla Westside (TX)	EPCWID	Westside Mesilla Canal service area in the Mesilla Valley in El Paso County, Texas
Mesilla Eastside (TX)	EPCWID	Eastside Mesilla Canal service area in the Mesilla Valley in El Paso County, Texas
El Paso Valley	EPCWID	El Paso Valley in El Paso County, Texas
HCCRD	HCCRD	Hudspeth County, Texas
JID Unit 1	JID	Northern portion of the JID Irrigation District in Chihuahua, Mexico
JID Unit 2	JID	Middle portion of the JID Irrigation District in Chihuahua, Mexico
JID Unit 3	JID	Southern portion of the JID Irrigation District in Chihuahua, Mexico

6.2 Study Period

The primary CFB Models simulate historical irrigation operations using available historical data from 1938 - 2017 using a monthly time-step. CFB Model simulations for the irrigation units in the El Paso Valley area of the EPCWID, HCCRD, and JID were also prepared for the period from 1903 - 1937 using an annual time-step to compute certain data that were used in the Hueco Model developed by MMA.

6.3 CFB Model Simulation Processes

The equations used in the CFB Models for lands with supplemental ground water are shown on **Table 6-1** and a schematic flow diagram of the computations is shown in **Figure 6-2**. In each time-step, the irrigation demand volume is computed based on the weighted crop irrigation requirement ("CIR") multiplied by irrigated area. Water supplies are simulated to meet the monthly irrigation demand in the following order:

1. Farm headgate deliveries of surface water,
2. Soil moisture carryover from the prior month, and
3. Ground water pumping.

The surface water available to the crop is computed as FHG delivery multiplied by the estimated maximum farm irrigation efficiency ("MFE").

If the available surface water is not sufficient to meet the irrigation demand, stored soil moisture carried over from the prior time-step is used next to meet any unmet irrigation demand. The simulated capacity of the soil moisture reservoir for each irrigation unit is based on the management allowable depletion ("MAD") portion of water holding capacity of the crop root zone.

Ground water pumping is computed as the unmet irrigation demand that remains after simulating the use of surface water and stored soil moisture, and is computed as the unmet CIR demand divided by the MFE and limited by the available ground water pumping capacity. The available ground water pumping capacity is specified by (a) the pumping season, (b) the pumping development, (c) the pumping capacity, and (d) the portion of the unmet demand met by pumping.

If the available surface water supply exceeds the crop irrigation demand, the excess surface water supply is stored in the available capacity in the soil moisture reservoir. Water stored in the soil moisture is available for crop water consumption in subsequent months. If the water available for soil moisture carryover plus the beginning of month soil moisture exceeds the soil moisture reservoir capacity, then the excess supply adds to the on-farm losses.

On-farm losses are computed as the total water delivery to farm (surface water and ground water pumping) multiplied by the on-farm irrigation inefficiency (100% minus MFE) plus the portion of the delivery that exceeds the CIR and the excess soil moisture reservoir capacity. The on-farm losses are divided between surface runoff and deep percolation. Surface runoff is computed as the on-farm loss multiplied by a user-specified surface runoff percentage. Deep percolation is computed as the total on-farm loss minus the surface runoff.

Lands irrigated solely by ground water ("primary ground water lands") have been identified within or near the EBID area and are simulated in the EBID CFB Models. There currently is no simulation of primary ground water lands in the Texas and Mexico CFB Models because there is no available information on lands that may be irrigated solely by ground water in these areas.

The simulation of primary ground water lands in the EBID CFB Models is similar to the CFB Models of the areas with supplemental pumping except there is no simulation of a soil moisture reservoir. Ground water is pumped to meet the weighted irrigation water demand limited by the available pumping capacity as described above. The well development for primary ground water lands is implicit in the specified annual primary ground water acres. The primary ground water pumping is computed as the consumptive use of primary ground water pumping divided by the specified MFE. The total on-farm loss is computed as the primary ground water pumping minus the crop consumptive use. The on-farm losses are split between surface runoff and deep percolation as described above.

The annual CFB Models for the irrigation units in the Hueco Model area for 1903 - 1937 employ the same logic as the monthly CFB Models except they use an annual time-step.

Descriptions of the input data that were used in preparing the monthly CFB Models for the 1938 - 2017 study period are provided below. The input data for the annual CFB Models for the Hueco Model area from 1903 - 1937 are described in **Appendix 6A**.

6.4 CFB Model Inputs

The following is a list of the input data and input parameters that are required for the monthly CFB Models:

- Monthly surface water diversions (AF)
- Irrigated area (acres)
  - Lands that receive both surface water and ground water ("supplemental acres")
  - Lands that receive only ground water ("primary acres")
- Monthly crop irrigation requirement (feet)
- Excess effective precipitation (feet)
- Farm headgate deliveries (AF)
- Conveyance loss, wasteway flows, and carriage water percentages (% of diversions)
- Maximum farm irrigation efficiency (percent)
- Surface runoff percent (% of total on-farm loss)

- Available soil moisture reservoir capacity within the crop root zone of the irrigated crops (feet)
- Supplemental ground water pumping capacity (pumping coverage %, maximum pumping rate, % unmet demand met by pumping, pumping season)
- Primary ground water pumping capacity (maximum pumping rate [gpm], % unmet demand met by pumping, pumping season)

Detailed descriptions of the input data and parameters used in the monthly CFB Models are provided below.

6.4.1 Surface Water Supplies

Monthly surface water diversions for the CFB Models were obtained from the SWDataSet described in Section 3. The following table summarizes the surface water diversions from 1938 - 2017 simulated in each CFB Model.

Surface Water Diversions for Monthly CFB Models

Irrigation Unit	**Surface Water Diversions (1938 - 2017)**
Rincon	Arrey Canal (1938 - 2017) + Percha Lateral (1953 - 2017)
Leasburg	Leasburg Canal (1938 - 2017) + California Extension (1986 - 2017) + Pumped from River (1985 - 2017)
Mesilla Westside (NM)	Westside Canal (1938 - 2017); pro-rated to NM Mesilla lands and TX Mesilla lands based on irrigated area
Mesilla Westside (TX)	
Mesilla Eastside (NM)	Eastside Canal (1938 - 2017) + Del Rio Lateral (1955 - 2017); pro-rated to NM Mesilla lands and TX Mesilla lands based on irrigated area
Mesilla Eastside (TX)	
El Paso Valley	Franklin Canal (1938 - 2017) – Ascarate Wasteway (1938 - 1999) + Riverside Canal (1938 - 2017) + Bustamante WWTP outfall to Riverside Canal (1991 - 2017 in Feb - Nov) + 50% x Socorro WWTP (1967 - 1993 in Feb - Nov) + Drain Water Diverted at Fabens (1945 - 1982)
HCCRD	1938 - 4/1947: Hudspeth Canal (Tornillo End) + Tornillo Drain 5/1947 - 2017: Tornillo Canal (at Alamo Alto) + Tornillo Drain + Hudspeth Feeder Canal
JID Unit 1	2/3 x Acequia Madre (1938 - 2017)
JID Unit 2	1/3 x Acequia Madre (1938 - 2017) + 3/4 x Ciudad Juarez Sewage (1938 - 2017 in Feb - Nov) + 1/2 x River Diversions (1938 - 1984)
JID Unit 3	1/4 x Ciudad Juarez Sewage (1938 - 2017 in Feb - Nov) + 1/2 x River Diversions

There is evidence of reuse of drain water for irrigation in El Paso Valley, HCCRD, and JID (IBWC, 1989; USBR, 1992; NMSU, 2004). There are some limited records of these drain returns to canals in the El Paso Valley from 1945 - 1982 and these are used in the CFB Model for that area (Reclamation, 1992 and NMSU, 2004). There are no records of drain flow use in HCCRD and JID and no drain flow use is simulated for these areas in the CFB Models.

Monthly diversions records for the primary surface water sources used in the Rincon, Leasburg, and Mesilla units are complete for the 1938 - 2017 study period. The diversion data for several small diversion facilities that were developed after 1938 (Percha Lateral, California Extension, Del Rio Lateral, and Pumped from River) are also complete.

Monthly diversion records for the surface water sources used in the El Paso Valley, HCCRD, and JID units are largely complete for the 1938 - 2017 period, but include some estimates as described in Section 3. Additional details regarding the irrigation water supplies for the El Paso Valley, HCCRD, and JID are provided below.

El Paso Valley Surface Water Supplies

A simplified schematic diagram of the El Paso Valley diversion works is shown in **Figure 6-3**. There are two main canals, Franklin Canal and Riverside Canal, that supply the El Paso Valley. All water for the El Paso Valley is diverted at American Dam into the American Canal that conveys water to the Franklin Canal heading. Water is diverted from the American Canal upstream of the Franklin Canal heading to supply EPW's Robertson/Umbenhauer Water Treatment Plant ("WTP"), and a portion of American Canal flow can be wasted back to the Rio Grande through the Leon Street Wasteway. Until 1999, water was returned from the Franklin Canal to the Rio Grande through the Ascarate Wasteway. The discharges from the Leon Street and Ascarate Wasteways were conveyed down the Rio Grande for diversion at Riverside Dam into the Riverside Canal.

The Riverside Dam failed in the late 1980s and a coffer dam was used to continue diverting water into the Riverside Canal until the completion of the ACE in 1999. The ACE extended the American Canal south past the Franklin Canal heading to the Riverside Canal heading. EPW diverts from the Riverside Canal to supply the Jonathan Rogers WTP that was constructed in 1993. The measuring structure of the Riverside Canal is reportedly located downstream of the intake for Jonathan Rogers WTP.

EPW currently has two WWTPs in the El Paso Valley - the Haskell WWTP constructed in 1923 and the Bustamante WWTP constructed in 1991. Prior to the completion of the ACE, the Haskell WWTP discharged to the river upstream of Riverside Dam. Since 1999, the Haskell WWTP has discharged either to the river or to the ACE. Haskell WWTP discharges are included in the measured diversions for the Riverside Canal. The Bustamante WWTP typically discharges into the Riverside Canal downstream of the Riverside Canal heading, and while these discharges are not included in the measured Riverside Canal diversions, they are available for irrigation use by EPCWID farmers. The Bustamante WWTP can also discharge to the Rio Grande or to the Rio Bosque Wetlands Park through the Riverside Drain.

Prior to construction of the Bustamante WWTP, the Socorro WWTP treated wastewater in the area, and reportedly discharged to the Socorro Ponds and canals located downstream of the Bustamante WWTP. There are limited discharge records for the Socorro WWTP and most of the monthly discharges were estimated as described in Section 3. While there is little information available regarding the Socorro WWTP operations, it appears that water was discharged to the ponds and canals in the vicinity, but the outfall locations and portion of discharges to the canals is unknown. Given the absence of information, it was assumed 50% of the Socorro WWTP discharges were discharged to canals and available for irrigation of EPCWID farms in the El Paso Valley. Simulated irrigation use of WWTP discharges in the EPCWID was limited to the months of February - November.

HCCRD Surface Water Supplies

HCCRD primarily receives its water as waste and return flows from EPCWID at the El Paso-Hudspeth County Line. The HCCRD diversion works are shown in **Figure 6-4**. From 1938 to April 1947, water was conveyed to HCCRD through the Hudspeth Canal (Tornillo End) and the Tornillo Drain. In May 1947, the Hudspeth County Regulating Reservoir No. 1 was completed at the El Paso-Hudspeth County Line, and the HCCRD inflow system was reconfigured and thereafter, the surface water supply available to HCCRD is represented by the measured flows in the Tornillo Canal at Alamo Alto, the Hudspeth Feeder Canal, and the Tornillo Drain.

JID Surface Water Supplies

The surface water supplies used in the JID vary among the three JID irrigation units (Units 1, 2 and 3). The following is a summary of how the reported and estimated JID surface water supplies were distributed among the three JID units:

JID Surface Water Supplies (% Source)

Source	Unit 1	Unit 2	Unit 3
Acequia Madre	67%	33%	0%
Sewage/WWTP Flow	0%	75%	25%
River Diversions	0%	50%	50%

Unit 1 is allocated two-thirds of the Acequia Madre diversion and Unit 2 is allocated the remaining one-third (IBWC, 1989). Based on location, the Juarez sewage/WWTP discharges are available to Units 2 and 3, and it was assumed that the Unit 2 receives 75% and Unit 3 receives the remaining 25%. There are two diversions from the Rio Grande downstream of the Acequia Madre heading at the International Dam. One is located near the El Paso-Hudspeth County Line and can supply water to Unit 2 and the other is located near the Alamo Arroyo in Hudspeth County and can supply water to Unit 3. The total river diversions were assumed split equally between Unit 2 and Unit 3.

The diversion records of Acequia Madre are mostly complete during the 1938-2017 study period, and missing records were estimated as described in Section 3. The estimates of JID river diversions downstream of the Acequia Madre, and Juarez sewage/WWTP discharges described in Section 3 were used.

6.4.2 Irrigated Area

The CFB Models require input of annual values for the irrigated area that receives surface water and supplemental ground water (supplemental acres), and the irrigated area that receives only ground water (primary acres).

The annual irrigated areas values used in the monthly CFB Models for 1938 - 2017 were provided by David's Engineering ("DE") for each irrigation unit, with the exception of the Mexico irrigated area from 1938 - 1949 which are from Carreno (1957). The following is a summary of the irrigated area data from 1938 - 2017.

Irrigated Area Data for CFB Models

District	Supplemental Acres 1938 - 2017	Primary Acres 1938 - 2017
EBID	1938 - 1975: Reclamation reports 1976 - 2017: Intera Normalized Difference Vegetation Index ("NDVI") analysis	New Mexico Hydrographic Survey
EPCWID		There are no data on primary ground water acres in EPCWID, HCCRD, and JID and therefore the primary ground water acres were set to zero.
HCCRD	1938 - 1975: Reclamation reports and Intera NDVI analysis 1976 - 2017: Intera NDVI analysis	
JID	1938 - 1949: Carreno (1957) 1950 - 1975: IBWC (1989) 1976 - 2017: Intera NDVI analysis	

6.4.3 Crop Irrigation Requirements

The CFB Models require the monthly crop-weighted CIR in feet (AF/ac) for each irrigation unit (including during the winter months). The CIR is the total crop evapotranspiration less effective precipitation. Monthly crop-weighted CIR values for each irrigation unit were developed by DE (2019). Separate CIR values were provided for the primary ground water lands in the EBID irrigation units based on determination that these areas had slightly different cropping patterns than the lands with surface water and supplemental ground water.

The crop-weighted CIR values provided by DE were adjusted downward in the CFB Models from 1938 - 1970 at the direction of DE. The crop weighted CIR values were reduced by 5% from 1938 - 1953, followed by a linear reduction in the adjustment each year until it reached 0% in 1970.

6.4.4 Excess Effective Precipitation

Excess effective precipitation is the monthly effective precipitation in excess of the monthly crop evapotranspiration that is available for storage in the soil moisture reservoir. The monthly excess effective precipitation was computed by DE for each irrigation unit as the effective precipitation minus surface runoff minus CIR (DE, 2019). The monthly excess effective precipitation was added to the soil moisture reservoir in the CFB Models.

6.4.5 Farm Headgate Deliveries

Monthly records of FHG deliveries are published by Reclamation in the WDRs. These records were disaggregated as necessary to the irrigation units simulated in the CFB Models as described in Section 4.2. There were limited adjustments made to the reported FHG deliveries when the reported values were greater than the reported RHG diversions or when the reported canal loss was negative. For example, in 2010 there are several months that the reported El Paso Valley RHG diversion is less than the reported El Paso Valley FHG deliveries. In months such as these, the FHG delivery was computed as the minimum of the reported FHG delivery or the RHG diversion minus the estimated canal loss, and the waste was set to zero.

When FHG delivery records were not available, they were estimated as the monthly surface water diversions minus the reported or estimated monthly canal loss, waste, and carriage water. Descriptions of the methods used to make these estimates are provided in the following section. Annual summaries of the reported and estimated FHG deliveries that were used in the CFB Models are provided in **Table 6-2**.

6.4.6 Canal Loss, Operational Waste, and Carriage Water

The CFB Models simulate the losses and bypasses (carriage deliveries) that historically occurred in delivering water from the canal headings to the farms. There are records of monthly conveyances losses and carriage deliveries published by Reclamation in the WDRs for EBID and EPCWID. The following is a summary of the different types of losses and carriage water that are contained in the WDRs.

- Canal Loss – Canal diversions lost to seepage and incidental consumptive use.
- Waste / Operational Spills – Canal diversions returned to the river via wasteways.
- El Paso Valley Carriage – Canal diversions conveyed to El Paso Valley in the EBID canals instead of the river to reduce transit losses.
- To Eastside Canal – Leasburg Canal diversions delivered to Eastside Canal.

Monthly average canal loss and waste percentages were computed from the 1951 - 1978 WDR records for EBID and EPCWID as a percentage of the monthly canal heading diversions for the months of March - October. Seasonal average loss percentages were computed for the winter months (November - February). These monthly and seasonal percentages were used to compute the canal loss and waste when records were not available. While there reportedly has been some canal lining in EPCWID during recent decades, there were no adjustments made to the percentages for estimated canal loss in recent years.

There are no records of El Paso Valley Carriage after 1978, and it was assumed there was no El Paso Valley carriage thereafter.

There are no records of Leasburg diversions delivered to the Eastside Canal after 1978, however it was assumed these operations continued and the To Eastside Canal flow was estimated as 1.5% of the total Leasburg diversion.

The canal loss for HCCRD was based on reported values when available and estimated as 50% of diversions when records were not available based on the historical data. There are no records of waste for HCCRD and it was assumed to be zero.

There are no data for the JID waste and canal loss, and the waste was assumed to be zero. JID canal losses were estimated as 40% of diversions before canal lining that reportedly began in 1970. This is based on the approximate average of conveyance losses in the El Paso Valley.

Based on reports regarding JID operations obtained and translated by MMA, significant canal lining occurred in the JID between about 1970 and 1987. MMA provided information on lengths and widths of the primary and secondary JID canals that were lined between 1970 and 1987. Assuming that fully unlined canals would lose 40% of diversions and fully lined canals would lose 5% of diversions, weighted average annual conveyance losses were estimated based on the proportion of the total canal area in each unit that was lined. The resulting adjusted canal losses ranged from 40% in 1970 to 33% for Unit 1, 20% for Unit 2, and 21% for Unit 3 in 1987.

6.4.7 Incidental Canal Loss and Canal Seepage

The incidental canal loss is the portion of the total canal loss that is lost to evaporation and evapotranspiration from vegetation along the canals. The incidental canal loss was computed as 6% of the total reported or estimated canal loss (LRGGWMCC, 2005). The canal seepage is computed as the total canal loss minus the incidental canal loss.

6.4.8 Maximum Farm Irrigation Efficiency

The CFB Models require input of an MFE that limits the percentage of the farm water supply (FHG deliveries surface water plus ground water pumping) that is available for crop consumptive use. The MFE functions as an upper limit on the portion of the applied water that is either consumed within the current time-step or stored in the soil moisture reservoir for later use.

The MFE values used in the CFB Models were provided by DE and were developed based on the estimated achievable unit-wide average efficiencies that would occur under water short conditions given the soil types, field configurations and slopes, irrigation practices, and assuming a reasonably high level of management. The MFE values provided by DE started at 65% for 1938-1950 and transitioned upward to 75% for 1984-2017. The same time varying MFE values were used for all CFB Models.

6.4.9 On-Farm Surface Runoff

The simulated on-farm losses were split between deep percolation and surface runoff.

DE provided annual surface runoff percentages that decrease through time due to improved irrigation and water management practices, laser land leveling, and increased use of border irrigation. The surface runoff percentages provided by DE varied from approximately 6% of the on-farm loss for 1938-1950 to approximately 1% of the on-farm loss for 1984-2017. The same time-varying surface runoff percentages were used in all CFB Models.

6.4.10 Soil Moisture Reservoir

The CFB Models simulate a soil moisture reservoir that can be used to store excess irrigation water in the current month for carryover and use in subsequent month(s). The simulated soil moisture reservoir is limited to the soil moisture reservoir capacity within the crop root zone. The following equation was used to compute the capacity of the soil moisture reservoir

SM Cap = AWC x Root Depth x MAD% x Irr Area

where

SM Cap = Soil Moisture Reservoir Capacity in (AF)

AWC = Weighted available soil moisture holding capacity of the soils (field capacity minus wilting point) in inches/foot of soil depth. (feet/feet)

Root Depth = Crop weighted average maximum rooting depth (feet)

MAD%= Crop-weighted MAD that defines the portion of the AWC in which irrigated fields are maintained to avoid significant moisture stress to the crop (%)

Irr Area = Irrigated area (acres)

All of the soil moisture reservoir input parameters were provided by DE. A value of 1.74 inches per foot was specified as the AWC for all irrigation units. Separate crop weighted average Root Depth and MAD values were provided for EBID, EPCWID, HCCRD, and JID.

6.4.11 Supplemental Pumping

Supplemental ground water pumping was computed in the CFB Model based on all or a specified percentage of the unmet crop demand on the supplemental acres after consideration of the available surface water supplies as follows:

SupplCU = min (UnmetCIR x %SupplCIR, SupplMax x %PumpDevelop) x Pump SeasonFlag

where

SupplCU = CU of supplemental ground water (AF)

UnmetCIR = Unmet CIR after surface water supplies (AF)

%SupplCIR = % of unmet CIR met by pumping (%)

%PumpDevelop = % irrigated area with wells (%)

SupplMax = Maximum monthly supplemental pumping rate (AF/month)

PumpFlag = Start and end month flag for pumping

The UnmetCIR is computed as the total CIR minus the CIR met from surface water deliveries in the current month and the available soil moisture carryover from prior the month.

The %SupplCIR provides the ability to limit pumping to less than the amount needed to meet the full unmet demand, after applying the surface water supply. The %SupplCIR is currently assumed to be 100%

The %PumpDevelop describes the portion of the study area served by wells. Well development proceeded rapidly during the early 1950s into the mid-1950s in response to the multi-year drought that resulted in the first significant water shortages in the history of the Project. The specified pumping development is based on a well development timeline developed by Dr. Barroll (NMOSE 2015) for New Mexico and Texas. MMA provided information on well development in JID. For all units except JID Unit 1, the %PumpDevelop is specified to increase linearly from 0% in 1947 to 100% in 1955. For JID Unit 1, the %PumpDevelop is specified to increase linearly from 0% in 1939 to 100% 1954.

The SupplMax is the upper limit on the maximum available well pumping capacity in AF/month that would limit pumping in peak demand months. There were no SupplMax limits imposed in the CFB Models.

The PumpFlag specifies the months in which pumping is allowed to occur to meet unmet irrigation demands. The pumping season in all CFB Models was set as February - November.

6.4.12 Primary Pumping

Primary ground water pumping occurs on irrigated lands that have no access to surface water. The irrigated area data for the primary ground water lands are available for New Mexico based on Hydrographic Survey information, and these data were provided by DE and used in the CFB Models of irrigation units in New Mexico.

There are placeholders for primary ground water acres in the Texas and Mexico CFB Models, but no information is presently available to specify the primary ground water acres in these areas.

The primary ground water pumping is computed in the CFB Models based on the crop irrigation demand on the primary acres as follows:

PrimaryCU = min (PrimaryCIR x %PrimaryCIR, PrimMax)

where

PrimaryCU = CU of primary ground water (AF)

PrimaryCIR =CIR on primary acres (AF)

%PrimaryCIR = % of CIR that can be met by pumping

PrimMax = Maximum monthly primary pumping rate (AF/month)

The PrimaryCIR is the weighted average CIR for the crops grown on the lands irrigated solely by ground water. DE developed different cropping patterns from the primary acres compared to the supplemental acres, and therefore the weight average CIR is different between the primary and supplemental lands. There is no soil moisture simulated on the primary acres because it is assumed that pumping occurs to meet the crop CIR and not to carryover additional water in the soil moisture reservoir for later use.

The %PrimaryCIR can be specified to limit the percent of demand met by pumping on primary ground water lands. This input parameter is set at 100% in the current CFB Models.

The PrimMax parameter can be set to limit primary ground water pumping based on the available pumping capacity of the well. There is no upper limit on the well pumping capacity specified in CFB Models.

There is no pumping development percentage for the primary ground water acres like there is for the supplemental ground water pumping. It is assumed sufficient pumping capacity exists to irrigate the specified primary ground water acres.

6.5 Simulation of Historical Irrigation Operations

6.5.1 EBID CFB Models

There are four EBID CFB Models, including the Rincon, Leasburg, Mesilla East (EBID), and Mesilla West (EBID). The Rincon CFB Model simulates all lands irrigated in the Rincon basin. The Leasburg CFB Model simulates lands irrigated in the northern portion of the Mesilla basin from the Leasburg Canal. A portion of the Leasburg Canal diversions are conveyed to the Mesilla East CFB Model. Mesilla East (EBID) Model simulates lands in the southern portion of the Mesilla basin under the Eastside Canal, and the Mesilla West (EBID) Model simulates lands under the Westside Canal. The surface water supplies for the Eastside Canal and Westside Canal are distributed between EBID and EPCWID proportionally based on irrigated acreage. The boundaries of the CFB Models for EBID are illustrated in **Figure 6-1**.

6.5.2 EPCWID CFB Models

There are three EPCWID CFB Models, including Mesilla East (EPCWID), Mesilla West (EPCWID), and El Paso Valley. As described above, the surface water supplies for the Eastside Canal and Westside Canal are distributed proportionally between EBID and EPCWID based on irrigated area. The lands in the El Paso Valley Model consist of all areas served by the Franklin, Riverside, and Tornillo Canals simulated as a single unit. This is reasonable because the Project is reported operated to make available water on an equal per acre basis. The boundaries of the CFB Models for EPCWID are shown in **Figures 6-1.**

6.5.3 HCCRD CFB Models

There is little information available on the historical operation of HCCRD, and the area is simulated with a single CFB Model assuming that the HCCRD operates to equalize the supply made available to all district lands. The boundaries of the HCCRD CFB Model are shown in **Figure 6-1.**

Based on review of aerial photographs, it was determined that HCCRD Regulating Reservoir No. 1 and HCCRD Regulating Reservoir No. 2 (aka Clayton Reservoir) were constructed in 1947, and HCCRD Regulating Reservoir No. 3 (aka McKinney Reservoir) was constructed in 1996. The HCCRD CFB Model includes the capability to simulate the operation of the three HCCRD reservoirs as a single reservoir to regulate the sometimes erratic HCCRD supply.

There is little data on the HCCRD reservoirs and operations. The composite reservoir capacity was set at 2,600 AF (estimated capacity for HCCRD Reservoir Nos. 1 and 2) until

1995 and was increased by 1,000 AF (estimated capacity for HCCRD Reservoir No. 3) to 3,600 AF in 1996. Reservoir evaporation is computed in the HCCRD CFB Model as the net monthly evaporation provided by DE multiplied by the surface area of the reservoirs. The surface area was assumed to be 257 acres from 1947 - 1955 and 541 acres from 1996 - 2019 based on delineation of the reservoir surface areas from aerial photos. The simulated operation of the HCCRD reservoirs was disabled in the runs of the CFB Model that are provided with this report. This was determined to have less than 5% impact on the simulated historical HCCRD pumping.

6.5.4 JID CFB Models

The surface water supplies and other information for the JID CFB Models are based on limited information that is available for the JID operation. There are three CFB Models for JID that simulate the operations in JID Units 1, 2, and 3. The boundaries of the JID CFB Models are shown in **Figure 6-1**.

The JID surface water supplies were distributed to the JID irrigation units as described above in Section 6.5.1. It is assumed that all JID irrigation units supplement the available surface supplies with ground water pumping. It is suspected based on review of aerial images that drain water is used for irrigation in Unit 2 and Unit 3, but such use is not simulated in the CFB Models, except to the extent that the drain flows are present in the simulated River Diversions.

6.6 Results

The Excel spreadsheet for the CFB Models contains numerous tables and charts to present monthly and annual results. District-wide summaries of the CFB Model results are provided in **Appendix 6B** and include the following tables and charts:

- Monthly charts of on-farm CU (1938 - 2017),
- Annual charts of farm deliveries, CU, losses, irrigated acres, and loss and efficiency percentages (1938 - 2017),
- Annual and average monthly charts of pumping and deep percolation (1938 - 2017),
- Average monthly tables of the inflows, outflows, and changes in storage (1938 - 2017), and
- Annual tables of the inflows, outflows, and changes in storage (1938 - 2017).

Annual tables and charts summarizing the simulated 1903 - 1937 results for the annual CFB Models developed to provide inputs to the Hueco Model are also available in the CFB Model spreadsheet.

Among the results provided in the CFB Model spreadsheet are the computed supplemental pumping and primary pumping (EBID only) volumes. Records of annual ground water pumping are available for EBID from 2009 - 2017. Comparisons of computed vs. actual annual ground water pumping for the EBID CFB Models are shown in **Figure 6-5**. In general, there is good agreement between the computed and actual pumping from 2009 - 2017.

The results from the CFB Models are referenced in Section 12 in the responses to the M&A expert report.

7.0 NEED FOR MODELING ANALYSIS OF CLAIMS AND COUNTERCLAIMS

The Rio Grande between Elephant Butte Reservoir and Fort Quitman is a highly developed working river system that is the life blood to the region in sustaining local economies and natural ecosystems. The historical time-series data in Section 5 show there have been changes and/or fluctuations in Rio Grande flows and Project diversions and deliveries prior to and since the Rio Compact was entered in 1938. The Rio Grande flow and water supply available for use is affected by numerous natural and man-caused factors including the following:

- Precipitation runoff,
- Water surface evaporation,
- Evapotranspiration of native vegetation,
- Project operations,
- Irrigation operations,
- Municipal water supply operations,
- Ground water pumping, and
- Surface and ground water interaction.

The claims and counterclaims filed in the pending lawsuit assert that certain actions such as pumping and changes in Project operating procedures have impacted Rio Grande flows and deliveries of Project water. Due to the complex interactions between the above factors and surface and ground water flows, it is not possible to reliably quantify and differentiate the effect of a certain action (e.g., pumping) on a certain outcome (e.g. changes in El Paso flow) using historical data alone. The mere presence of a correlation between two quantities does not mean there is a cause-and-effect relationship between them. The correlation may be spurious, or there may be multiple factors causing a change in some quantity.

Texas has claimed that changes in the Rio Grande flow at El Paso are due to the development of upstream ground water pumping. The double-mass curve analysis presented in the Texas expert report by Robert J. Brandes is based on an alleged cause and effect relationship evidenced by a correlation.

While pumping has certainly impacted Rio Grande flows, there are likely other factors that have contributed to the changes in flow including the following:

- Reduction in inflows to Project storage,
- Changes in irrigated area and crop selection,
- Changes in irrigation practices,
- Increases in downstream pumping, and
- Changes in Project operations.

While changes in the flow of the Rio Grande at El Paso may be of historical interest, flow changes at any single river gage are irrelevant to this case, to the Compact, and to the operation of the Project. Of more relevance are changes in the deliveries of Project water for beneficial use.

For complex water systems like the Lower Rio Grande, it is necessary to develop simulation model(s) to better understand and quantify the interrelationships among natural and man-influenced processes, and to isolate and compute the effects of actions relevant to the claims and counterclaims in this case. The reliability of predictions from a simulation model is enhanced if (a) the model is reasonably calibrated over a representative historical period, and (b) the simulated processes reflect reasonable and appropriate dynamic responses to simulated changes to historical conditions.

The modeling requirements in this case are more complex than in a typical ground water modeling project that might, for example, involve determining the amount, timing, and location of impacts on ground water levels and surface water flows resulting from ground water pumping. In typical ground water pumping evaluations, the objective in constructing the model is to reasonably simulate the relevant physical process so that the model produces reasonable estimates of stream depletions and changes in ground water levels given the simulated pumping volumes. Model calibration in this instance would be focused on adjusting aquifer characteristics, boundary conditions, and other physical parameters so that the simulated historical conditions (e.g., water levels and streamflows) reasonably match historical values.

The Lower Rio Grande system is more complicated because of the need to simulate the operations of the Project and the LRG irrigation systems. The Project facilities and irrigation systems are operated and managed to respond to changes in the available water supply, and this introduces a human element that needs to be incorporated in the model processes. Not only do the physical processes need to reasonably respond to changes in inflows and modeled stresses, but so do the Project operations. For example, simulating a reduction in pumping within the Project area would be expected to cause the following responses:

- Reduced on-farm consumptive use, deep percolation, and surface runoff from pumping.
- Increased ground water levels and drain flows.
- Increased riparian evapotranspiration due to shallower ground water levels.
- Increased ground water flow to the Rio Grande and/or reduced Rio Grande flows to the ground water system.
- The above responses would generally increase Rio Grande flows which in turn would affect Project operations depending on the Project supply at the time.
    - During full supply periods, the increased river flows would prompt reductions in reservoir releases to deliver the same amounts to Project water users. This in turn would accumulate additional water in storage that would be carried forward and used in subsequent non-full supply periods.
    - During non-full supply periods, the additional flow in the river and additional water carried over in reservoir storage would increase the supply available for delivery to New Mexico, Texas, and Mexico water users.
- Increased deliveries for irrigation would increase surface water consumptive use, deep percolation, and surface runoff. If pumping in only certain areas was reduced or turned off, then the changes in surface water supplies to other areas would result in corresponding changes in pumping to meet unmet demands in those areas.
- Increased reservoir storage would increase reservoir evaporation and increase reservoir spills.
- During the non-irrigation season, much of the additional river flow would exit from the downstream end of the system unconsumed.

The foregoing list of expected responses to simulated changes in pumping are the same types of responses that historically occurred when the surface water supplies and pumping varied between historical wet and dry periods.

7.1 Required Model Features

In order to fully evaluate the claims and counterclaims in this case, a robust model of the hydrologic and water use systems between San Marcial and Fort Quitman is needed. The model should generally simulate the following features:

- Inflows
- Reservoir operations

- River routing
- Irrigation operations and pumping
- Non-irrigation operations and pumping
- Non-beneficial ET
- Ground water flow
- Ground water/surface water interaction

The model features listed above should not be simulated based on fixed inputs that cannot change in alternative scenarios. A model based on fixed inputs rather than dynamic processes has little or no ability to dynamically respond to changes in the modeled stresses. For example, if reservoir releases and canal diversions are fixed at historical levels in simulation of alternative scenarios (e.g., reduced pumping), then the model has no functionality to adjust to changes in river flow, and most or all of the changes in river flow will unreasonably accumulate as changes in Rio Grande outflows from the study area.

The manner of dynamic simulation of model processes depends on whether the processes are physically-based or management-based as described below. **Table 7-1** contains a list of the required simulation processes, including whether they are physical or management processes.

7.2 Physical Processes

Physical processes move water based on physical relationships or mass balance calculations that are not dependent on human decisions or management. For example, reservoir evaporation is a physical process that depends on evaporation rates and reservoir surface area. It may be dynamically simulated in a model using a time-series input of evaporation rates and reservoir surface area computed based on the simulated reservoir storage contents and the surface area-volume relationship for the reservoir. Another example of a physical process is river seepage computed based on the simulated head difference between the river surface and the connected ground water system, and the conductance of the riverbed materials through which the seepage travels. In the foregoing examples, there obviously are human decisions that affect the reservoir contents or river flows, but the physical processes involved in evaporating water from the reservoir surface or seeping water from a river are independent of those human decisions.

Physical processes may be calibrated by adjusting input parameters in the simulation equations within reasonable bounds to match simulated values to observed values. In the calibration process, reservoir releases, diversions, and FHG deliveries are set at historical values and the model parameters are adjusted to match streamflows, drain flows, and ground water levels.

7.3 Management Processes

Project and irrigation operations involve management decisions that need to be translated into rule-based simulation processes appropriate for the spatial and temporal scales of the model. For example, rules can be developed to simulate farm headgate demands as a function of irrigated area and crop irrigation requirements. Farm headgate deliveries can then be simulated as the lesser of the demand or the available supply. Such rules allow the model simulation to dynamically adjust farm headgate deliveries in alternative scenarios in response to changes in the available water supply.

Simulation of management processes can also be adjusted to reasonably match simulated and observed values. The process of adjusting the simulated management processes is described in this report as “tuning” to distinguish it from “calibrating” the physical processes. In the tuning process, the simulation rules are adjusted to reasonably match historical reservoir operations, canal diversions, farm headgate deliveries, and other historical data.

8.0 OVERVIEW AND ASSESSMENT OF INTEGRATED LRG MODEL

8.1 Introduction

Three simulation models were developed and integrated for use in assessing certain of the claims and counterclaims in this case. These models consist of a RiverWare Model of the surface water and alluvial ground water systems from San Marcial to Ft. Quitman ("RiverWare Model"), a MODFLOW ground water model of Rincon and Mesilla Valleys located between the Caballo Reservoir outlet and the Rio Grande at El Paso gage, and another MODFLOW ground water model of the El Paso Valley and Juarez Valley located between the El Paso gage and Ft. Quitman. Together, the three models are referred to as the "Integrated LRG Model" or "ILRG Model." A map showing the spatial domains of the three models is provided **Figure 8-1**.

The RiverWare Model is the principal vehicle for computing the impacts of pumping and the effects of operational changes on the surface water system. The ground water models play a supporting role in computing certain inputs to the RiverWare Model including canal seepage, evapotranspiration of native/riparian vegetation, and flux between the shallow Rio Grande alluvial aquifer and the Upper Santa Fe Group and/or Middle Santa Fe Group.

The ILRG Model simulates irrigation and non-irrigation water uses over a study period that extends from January 1940 to December 2017 using monthly stress periods. Integration of the three models occurs through passing of certain information between the RiverWare Model and the ground water models as they are run iteratively until closure.

This section provides on overview of the three models, their suitability for assessing claims and counterclaims in this case, and development of post-processing tools for summarizing and assessing alternative model scenarios. Details regarding the development, calibration, and operation of the three models are provided in the reports of other New Mexico experts.

8.2 RiverWare Model

The RiverWare Model was developed by Hydros Consulting ("Hydros") in Boulder, Colorado. The model simulates the operations of EBID and EPCWID that comprise the Project, the HCCRD system located south of the EPCWID in Hudspeth County, and the JID system located west of Rio Grande in Mexico. A simplified schematic diagram of the flow linkages in the RiverWare Model is shown in **Figure 8-2**.

RiverWare is a full-featured customizable river system modeling package that is well-suited for modeling a river system like the Rio Grande between San Marcial and Fort Quitman. The modeling software is equipped with a rich menu of functions to simulate various flow process and can be customized to simulate other flow processes through development of scripted rule sets.

The RiverWare Model performs the following water budget calculations during each monthly stress period to simulate Project and other irrigation operations within the study area.

- Reservoir Budget,
- River Budget,
- Canal and Farm Budget, and
- Shallow Ground Water Budget.

Schematic diagrams of the RiverWare water budgets are shown in **Figure 8-3** through **Figure 8-7**.

8.2.1 Reservoir Budget

The Reservoir Budget in the RiverWare Model simulates operation of Project storage in Elephant Butte Reservoir and Caballo Reservoir. Inflows to the reservoirs consist of historical Rio Grande at San Marcial gage flows, precipitation, and unmeasured gains/losses derived from water balance analysis of historical reservoir operations data. Releases from storage are simulated to meet Project water demands, a small pre-Project diversion, and to spill water when the reservoir is full.

The simulated usable water in Project storage available for allocation is computed each month from February through July as the usable water in storage plus the reservoir releases to date. The usable Project supply is allocated to EBID, EPCWID, and Mexico in the Historical Base Run using three sets of allocation rules. D1/D2 Rules are used to simulate historical operations from 1948 - 2005. While the D1/D2 Rules did not actually go into operation until 1980, they were judged to reasonably simulate the equal allocation per acre procedure that functioned before that time. The D3+Carryover Rules from the 2008 OA are used to simulate allocation of Project water from 2008 - 2017. The D3 Rules without carryover accounting are used in 2006 and 2007.

During the wet period from 1940 - 1947 when Reclamation did not set any annual Project water allotments, historical records show that the Project water users generally called for and were delivered whatever water they needed and sometimes more. Therefore, the

RiverWare rules during the 1940 - 1947 period were developed to generally match historical operations without the restriction of an annual allocation.

Storage releases to Mexico are made on a set monthly schedule for delivery to the International Dam and diversion into the Acequia Madre. Storage releases to EBID and EPCWID are made based on rules that deliver water to meet the demands of EBID and the combined irrigation and EPW demand of EPCWID, as limited by the computed annual allocations. Water available to HCCRD is comprised of simulated waste and return flows from EPCWID.

8.2.2 River Budget

The River Budget in the RiverWare Model simulates the routing of flows down the Rio Grande. Inflows consist of reservoir releases, drain and wasteway flows, wastewater treatment plant discharges, and on-farm surface runoff. Outflows include canal diversions, river evaporation, and flow past Ft. Quitman. Seepage between the river and alluvial aquifer is computed based on the difference in head between the river water surface and the simulated ground water level and is calibrated using specified riverbed conductance values.

8.2.3 Farm Budget

Irrigation operations within EBID, EPCWID, HCCRD, and JID are simulated in RiverWare Model using a farm budget simulation algorithm similar to one used in the CFB Models described in Section 6. The farm budget calculations in the RiverWare Model are performed using monthly stress periods for the following geographic areas.

Geographic Units for RiverWare Model Farm Budget Calculations[4]

EBID	EPCWID	HCCRD	JID
Rincon	Mesilla Eastside	Unit 1	Unit 1
Leasburg	Mesilla Westside	Unit 2	Unit 2
Mesilla Eastside	El Paso Valley	Unit 3	Unit 3
Mesilla Westside			

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[4] Calculations for the above geographic units are disaggregated to a sub-area level in Riverware to spatially distribute the pumping, and irrigation return flows along the Rio Grande.

Simulated deliveries to the various major canal headings on the Rio Grande are conveyed to farms after being reduced by wasteway discharges back to the river and by canal and lateral conveyance losses. The conveyance loss includes a seepage component computed by the ground water models. The total conveyance loss is computed in the RiverWare Model as the seepage loss from the ground water models divided by 0.94 reflecting an assumed incidental consumptive conveyance loss of 6%.

The monthly crop water demands for each unit are computed as the irrigated area multiplied by the crop-weighted average CIR. The CIR for each crop is computed outside of the RiverWare Model as the potential evapotranspiration ("PET") less the effective precipitation.

The water supply available to meet the crop water demand is computed in the RiverWare Model as the farm headgate delivery multiplied by a specified MFE that increases through time. Available supply in excess of the crop demand may be stored in the root zone of the crop for subsequent use. Until 1948, if the simulated monthly available water supply, including the soil moisture carryover from the prior month, was insufficient to meet the crop water demand, then a shortage was computed. Significant use of ground water for irrigation commenced in 1948 and was fully implemented by 1955, and shortages in crop water demand were assumed alleviated in part by ground water pumping beginning in 1948 and in full by 1955 and beyond.

On-farm losses and excess farm deliveries become surface runoff to the Rio Grande and deep percolation to the alluvial aquifer. Additional irrigation return flows include wasteway discharges to drains or to the river and canal seepage accruals to the alluvial aquifer.

8.2.4 Ground Water Budget

The RiverWare Model includes a ground water object under each water user object that functions like a large cell in a MODFLOW ground water model. Inflows to the ground water object include canal seepage computed in the ground water models, flow between the alluvial aquifer and other aquifers in the ground water model (inflows or outflows to the ground water object), and on-farm deep percolation losses computed in the Farm Budget. Outflows from the ground water object include alluvial ground water pumping and riparian ET computed in the ground water models. Other inflows/outflows are computed based on head differences between the ground water object and surrounding objects including river seepage, drain flows, and lateral flows to other ground water objects.

8.3 New Mexico Rincon-Mesilla Ground Water Model

The New Mexico Rincon-Mesilla Ground Water Model ("NMR-M Model") was developed by SSPA using the USGS MODFLOW software to simulate ground water use in the Rincon Valley and Mesilla Valley between the Caballo Reservoir outlet and the Rio Grande at El Paso. The modelled area includes all of the EBID service area in New Mexico and the Mesilla Valley portion of the EPCWID service area in Texas. The model simulates ground water flow in the Rio Grande alluvium and the deeper and more laterally extensive aquifers of the Upper, Middle, and Lower Santa Fe Groups. Lying over the upper model layers is a surface flow network constructed using the MODFLOW SFR Package that simulates head dependent interaction between the ground water system and the Rio Grande and the Project canals, laterals, and drains. Most of the irrigation pumping is simulated in the alluvial aquifer and most of the non-irrigation pumping is simulated in the aquifers of the Santa Fe Group.

Water budget diagrams illustrating the simulation processes of the NMR-M Model are shown in **Figure 8-8**. Specified time-series inputs to the NMR-M Model are pumping from non-alluvial wells and mountain front recharge. Other inputs to the NMR-M Model are passed from the RiverWare Model and consist of reservoir releases, canal diversions, farm headgate deliveries, wasteway flows, deep percolation, and pumping from the alluvial aquifer for irrigation. Data passed from NMR-M Model to the RiverWare Model include canal seepage, riparian ET, non-irrigation pumping from the alluvial aquifer, flow between alluvial aquifer and Santa Fe Group.

Simulated monthly farm headgate deliveries are removed from NMR-M Model and the corresponding deep percolation and surface runoff from the RiverWare Model are added to the NMR-M Model. The difference between the removed farm headgate deliveries and the added irrigation return flows represents the on-farm consumptive use of applied water in the RiverWare Model.

8.4 Hueco Ground Water Model

The Hueco Model was developed by MMA using USGS MODFLOW software to simulate ground water use in the alluvial aquifer and the Santa Fe Group aquifers of the Hueco Bolson that underlie the El Paso Valley from the Rio Grande at El Paso gage to near Ft. Quitman. The modeled area includes a large portion of El Paso County in Texas including the City of El Paso, Hudspeth County, and the Juarez Valley, including Ciudad Juarez.

The model simulates Irrigation and ground water pumping of EPCWID in the El Paso Valley, the HCRRD, and the JID. Non-irrigation pumping is simulated for EPW, which serves the City of El Paso, other significant M&I water users in the El Paso area, and the water and sanitation utility for Ciudad Juarez, Junta Municipal de Aqua y Saneamiento ("JMAS"). Like the NMR-M Model, surface water features and their interaction with the underlying ground water system are simulating using the MODFLOW SFR Package.

The ground water model water budget diagrams in **Figure 8-8** also apply to the Hueco Model. Specified inflows and information passed between the RiverWare Model and the Hueco Model are the same as for the NMR-M Model.

8.5 Integration of LRG Models

A manual iteration procedure is used to execute runs of the ILRG Model, and a diagram illustrating the procedure is shown in **Figure 8-9**. The major simulation processes are shown on the right side of the diagram in blue for the RiverWare Model and the left side in brown for the ground water models. Information passed between the models is listed in the center with the information passed from the RiverWare Model to the ground water models shown in blue and the information passed from the RiverWare Model to the ground water models shown in brown.

An illustration of the model execution process is provided at the bottom of **Figure 8-9**. The procedure for making an iterated model run starts by running the RiverWare Model with an initial time-series of input data from the ground water model from a prior run. After running the RiverWare Model, the required RiverWare Model outputs are passed to the two ground water models and they are both run. Required outputs from the ground water model are then passed to the RiverWare Model and it is executed again. This iterative process is repeated until the differences in the simulated flows from one iteration to the next is relatively small. Closure typically occurs within several iterations.

8.6 Calibration of LRG Models

As described previously, calibration of the LRG Models is specific to adjustment of the simulation of the physical processes in the model. The models were calibrated by simulating the historical study period using historical data for the following model inputs:

- Reservoir releases,
- River diversions,
- Farm headgate deliveries,
- EPW deliveries,
- Non-irrigation pumping, and
- Non-irrigation return flows.

Selected model input parameters were varied during the calibration process to improve matching of the following simulated outputs to the historical observed values:

- River flows,
- Drain flows,
- Ground water levels in the alluvial aquifer, and
- Ground water levels in the Santa Fe Group (ground water models).

A diagram illustrating the calibration process for the RiverWare Model is shown in **Figure 8-10**. The fixed historical time series inputs are shown in black, the values computed in the RiverWare Model are shown in blue, the values computed in the ground water models and passed to the RiverWare Model are shown in green, and the calibration targets are shown in red.

Summaries of the RiverWare Model calibration results for the Rio Grande at El Paso and the Rio Grande at Ft. Quitman are provided in **Figure 8-11** and **Figure 8-12**, respectively. Each figure contains three charts and several calibration statistics at the bottom of the page.

El Paso Gage

The measured and modeled monthly flows for the Rio Grande at El Paso gage are plotted in the upper graph in **Figure 8-11**. All model error[5] or imperfections in simulating consumptive use, return flows, well pumping depletions, drain flows, and other processes upstream of the El Paso gage accumulate as differences between the modeled and measured flows at the gage. Visual comparison of the two lines in the upper chart indicates generally excellent agreement between the modeled and measured streamflows. The other charts in **Figure 8-11** compare the modeled and measured annual flows (lower left) and the modeled vs. measured flows in a scatter plot (lower right). The mean monthly flow during the calibration run was 31,698 AF compared to a mean measured flow of 31,191 AF. The mean residual or mean error is +506 AF or approximately +1.6% of the measured mean monthly flow. Depictions of modeled and measured flows at El Paso gage were evaluated for model calibration purposes only, and contrary to Texas's position in this case, the El Paso gage is not a Compact delivery point.

Ft. Quitman Gage

The measured and modeled flows at the Rio Grande at Ft. Quitman gage at the downstream end of the ILRG Model are plotted in **Figure 8-12**. Comparison of the measured and modeled flows in the upper chart shows the model performs well in matching the trends and fluctuations in flows, but also shows accumulation of some additional model error in simulating conditions downstream of the El Paso gage in the El Paso Valley and Juarez Valley. This is due in part to the general lack of data regarding water use and water distribution in these areas. The mean monthly modeled flow during the calibration run was 11,030 AF compared to a mean measured flow of 10,345 AF. The mean residual or mean error is +685 AF or approximately +6.6% of the measured mean monthly flow.

8.7 Tuning of LRG Models

After calibrating the physical processes in the RiverWare Model, the historical time series data for reservoir releases, diversions, and farm headgate deliveries were replaced with rules to simulate major management processes of the Project operations and water uses. Tuning of the RiverWare Model refers to adjustment of the rules for these management processes to reasonably match historical operations, specifically the following:

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[5] In modeling parlance, "error" refers to differences between simulated values and observed values. It does not mean or imply a mistake in the model.

- Allocations,
- Reservoir releases,
- River diversions,
- Wasteway flows,
- Farm headgate deliveries, and
- River flows.

A diagram illustrating the tuning process for the RiverWare Model is shown in **Figure 8-13**. The diagram is the same as the calibration diagram in **Figure 8-12** except the tuning targets are highlighted in yellow.

Simulation of Project operations with rules rather than using historical data results in some decline in the agreement between modeled and historical streamflows because of the challenge in developing fixed rules to simulate operations that may include to varying degrees uncertain and ad hoc decision processes. Some decline in agreement between simulated and observed flows is an unavoidable consequence associated with development of a model that appropriately responds to simulated changes in historical conditions.

Further, the errors that are present in the tuned model simulation of historical conditions (i.e., in the historical operations run) are also largely present in alternative simulations using the tuned model (e.g., in no-pumping runs). Therefore, when differences are computed between the output of two runs of the tuned models (e.g., simulated streamflows or farm deliveries), these errors tend to cancel each other out, resulting in changes in outputs that reasonably represent the effects of changes in the simulated model inputs.

Figure 8-14 through **Figure 8-18** provide comparisons of various model outputs from the tuned ILRG Model simulation of historical operations during 1940 - 2017 against the results from the calibration run in which reservoir releases, diversions, and farm headgate deliveries were set at historical values. As described further in Section 9, the tuned model simulation of historical conditions is designated as the Historical Base Run against which simulations of alternative scenarios were compared. Consistent with this, the tuned model results are identified as the Historical Base Run (black line) and compared to the Calibration Run (orange line). The following is a list of the comparisons between the Historical Base Run and the Calibration Run shown in **Figure 8-14** through **Figure 8-18.**

- **Figure 8-14** – Annual Summary of Project Storage and Rio Grande Flows
- **Figure 8-15** – Annual Summary of Irrigation Operations – EBID
- **Figure 8-16** – Annual Summary of Irrigation Operations – EPCWID
- **Figure 8-17** – Annual Summary of Irrigation Operations – HCCRD
- **Figure 8-18** – Annual Summary of Irrigation Operations – JID

The graphical comparisons in the above figures show that the simulated values in Historical Base Run of the tuned ILRG Model reasonably matches the values from the historical Calibration Run. Of particular note is how well the simulated irrigation pumping in the Historical Base Run matches the magnitude and trends in the simulated pumping in the Calibration Run. Differences in the simulated pumping reflect the accumulated differences in all simulated processes that occur between the Project storage and farm headgate deliveries of surface water. Given this, the general agreement between the simulated pumping in the Historical Base Run and the Calibration Run is considered excellent.

The matches between the simulated reservoir storage contents, Caballo Reservoir releases, El Paso flows and Ft. Quitman flows in the Historical Operations Run and the Calibration Run are also excellent.

Additional discussion of the results of the Historical Base Run is found in Section 9 below.

8.8 Model Output and Post-Processing of Results

Post-processing spreadsheets were prepared to summarize output from the ILRG Model. The purpose of the spreadsheets is to help illustrate and explain the model results and to help verify the models are correctly functioning. Post-processing spreadsheets were developed to summarize the following model results:

- Calibration and tuning results,
- Water budgets and balances,
- River point flow diagrams and flow maps, and
- Changes in modeled outputs for alternative scenarios.

Tables and charts from the post-processing spreadsheets are presented in the foregoing subsections on model calibration (Section 8.6) and model tuning (Section 8.7), in Section 9 in the discussion of the Historical Base Run, and in Section 10 in the discussion of the model runs that were made in support of New Mexico’s counterclaims.

8.9 Suitability of ILRG Model for Assessment of Claims and Counterclaims

The ILRG Model was successfully calibrated and tuned over a 78-year study period comprised of a wide variety of hydrologic conditions ranging from the wet periods of the 1940s, 1980s, and 1990s with little or no pumping, to the dry periods of the 1950s and 2010s with substantial pumping. The calibration and tuning results demonstrate that the model reasonably simulates surface and ground water use between Elephant Butte Reservoir and Ft. Quitman as well as the physical interaction between the surface and ground water systems.

In addition, the ILRG Model complies with the objectives described in Section 7 for developing calibrated rule-based models that are capable of reasonably simulating appropriate responses to simulated changes in historical input data and/or operating conditions. This includes dynamic simulation of the substantive real-world processes of allocating Project supplies to the U.S. districts and Mexico, releasing those allocations to meet the Project water demands and the 1906 Treaty obligation to Mexico in combination with the simulated downstream return flows to the river from irrigation and non-irrigation uses.

It is my opinion that the ILRG Model is the best available scientific tool for evaluating the effects of hydrological and institutional changes within the LRG Area on surface water supplies, streamflows, and ground water storage in the Rio Grande basin between Elephant Butte Reservoir and Ft. Quitman.

9.0 HISTORICAL BASE RUN OF INTEGRATED LRG MODEL

9.1 Introduction

The ILRG Model was used to simulate historical conditions over the 1940 - 2017 study period for purposes of calibrating and tuning the model as described above. In addition, the tuned version of the model was used to develop the Historical Base Run that was compared to the results of alternative scenarios that were also simulated with the tuned version of the ILRG Model. This section of the report provides an overview of the operational specifications for the Historical Base Run as well as summaries of the simulated results.

9.2 Key Operational Specifications for Historical Base Run

The following is a summary of the key specifications and rules for simulating Project operations and irrigation and non-irrigation water uses in the Historical Base Run of the ILRG Model:

- <u>Project Water Allocation</u> – The D1/D2 allocation procedure developed by Reclamation and implemented starting in 1979 is used to allocate Project water from 1951 - 2005. While the D1/D2 Procedure was not officially implemented until 1979, it was determined to reasonably approximate the somewhat ad-hoc equal allocation per acre procedure that existed prior to 1979. Annual full supply allocations prior to 1979 were estimated based on maximum allocations reported during that time. The D3 allocation procedure without carryover is simulated in 2006 and 2007. The D3+Carryover allocation procedure is simulated starting in 2008 through the end of the study period. While certain details of the 2008 OA allocation procedure were modified from time to time after 2008, the allocation procedure simulated in the ILRG Model is consistent with the 2017 version of the 2008 OA allocation worksheet.
- <u>Project Accounting</u> – The Project accounting includes tracking the Project diversions to EBID, EPCWID, and JID. Reservoir releases are made from the Project storage to deliver water to the districts and the diversions are limited to the Project water allocations. The EBID diversion charges include Arrey Canal, Leasburg Canal, Eastside Canal, and Westside Canal flows to New Mexico. The EPCWID diversion charges include Eastside Canal and Westside Canal flows to Texas, Franklin Canal minus Ascarate Wasteway (pre-1999), Riverside Canal, and EPW diversions of Project water. Credits against diversion charges are simulated for the ACE credit and the Haskell WWTP credit.

- FHG Demands – Irrigation demands at the farm headgate are computed based on historical irrigated area, historical monthly crop-weighted average CIR values, and specified maximum farm irrigation efficiency values that increase through time. Added to the crop irrigation water demand in the current month is a demand to fill the unfilled portion of the soil moisture reservoir in the crop rootzone.
- Conveyance Losses – Canal conveyance losses are computed in the SFR packages of the NMR-M Model and the Hueco Model. An incidental loss of 6% is added to the computed conveyance loss to represent consumptive use by evaporation and vegetation along the canals and laterals.
- Canal Diversion Demands – Diversion demands at the canal headings are computed as the FHG demands plus the conveyance loss divided by one minus the waste factor and the result is then multiplied by factors developed during the model tuning to match historical diversions.
- Irrigation Pumping – Irrigation pumping coverage is specified to increase linearly from 0% in 1947 to 100% in 1955 and remain at that level for the rest of the study period. Upon reaching full coverage in 1955, it is conservatively assumed that irrigation pumping meets 100% of the unmet irrigation demand after Project water deliveries to Project lands. Pumping on the simulated non-Project lands in EBID that are served only by wells is also conservatively assumed to meet 100% of the simulated irrigation demand.
- Non-irrigation Pumping and Return Flows – Municipal pumping, wastewater treatment plant return flows, and urban deep percolation are based on historical records and estimates. Domestic pumping is set at historical estimated levels.

9.3 Historical Base Run Results

The Historical Base Run simulates historical Project operations and water uses between Elephant Butte Reservoir and Ft. Quitman from 1940 - 2017. The simulated Project operations and water uses generally track the historical records that are summarized in Section 5. However, simulation of the Historical Base Run provides additional information and insight on the hydrologic and water use processes for which comprehensive measurements and records are not available. For example, the model results show estimated historical ground water pumping that was needed to meet the unmet irrigation demands after Project water deliveries, and the various components that contribute to the gains and losses of selected river reaches. The following are selected results and observations from review of the Historical Base Run.

9.3.1 Reservoir Operations

Figure 9-1 summarizes the simulated annual inflows, outflows, and end-of-year storage contents of Elephant Butte Reservoir, Caballo Reservoir, and the two reservoirs combined. Inflows are represented as stacked positive bars and include Rio Grande inflows, local inflows, and precipitation. Outflows are shown as stacked negative bars and consist of releases, evaporation, and storage adjustments (for periodic adjustments to the reservoir stage-capacity table due to siltation). The end-of-year storage contents is plotted as a black line in the figures and the annual changes in the end-of-year storage correspond to differences between the total reservoir inflows and outflows.

Review of the combined reservoir storage chart shows how the reservoir inflows varied through time affecting the reservoir contents and the reservoir releases. Two years of high inflows in the early 1940s caused the reservoirs to spill in 1942. This was followed by a mix of average and below average inflows during the 1940s that resulted in a decline in the simulated reservoir contents. This was followed by six out of seven years with very low inflow that resulted in five consecutive years from 1953 - 1957 with reservoir releases of roughly 500,000 AF or less. Inflow conditions improved in late 1950s resulting in some increases in reservoir contents and Project supply. The 1960s and 1970s were characterized by inflows typically ranging between 400,000 AF and 1,000,000 AF, and reservoir releases fluctuated accordingly between full and partial. The late 1970s ushered in prolonged period of above normal inflows and full water supply conditions for the Project that lasted until the early 2000s when drought again returned to the Rio Grande basin and Project deliveries plummeted. Since that time, Project storage has remained low and reservoir releases have been less than average.

The simulated annual allocations and charges to EBID and EPCWID during the 1940 - 2017 study period are summarized in **Figure 9-2.** These reflect allocations under the D1/D2 Procedure until 2005, the D3 Procedure without carryover in 2006 and 2007, and the D3 + Carryover Procedure thereafter. The full supply conditions during the 1940s and 1980s and 1990s are reflected in the full allocations to the districts during these years. The fluctuations in allocations during the 1950s - 1970s are also evident.

When the recent extended drought commenced in the early 2000s, the allocations to EBID and EPCWID declined together as provided for under the D1/D2 procedure. This changed when the D3 accounting was implemented with the allocations to EBID generally dropping in comparison to the EPCWID allocations which continued to be determined under the D1/D2 methodology. The carryover accounting under the 2008 OA is evident in the simulated EPCWID allocations during the late 2000s that were greater than any time prior.

9.3.2 EBID Operations

Figure 9-3 summarizes the simulated historical diversions, FHG deliveries, pumping, and conveyance losses for EBID. The simulated EBID diversions and FHG deliveries were greatest during the full supply periods of the 1940s, 1980s, and 1990s. Diversions were low during the multi-year droughts of the mid-1950s and 2010s, and during shorter term dry periods in the 1960s, 1970s, and 2000s. Adoption of the 2008 OA also contributed to the relatively low diversions after 2007.

The simulated pumping was generally inversely proportional to the FHG deliveries with low pumping in full supply years and high pumping in low supply years. Simulated annual pumping during recent dry years has ranged between about 200,000 AF and 300,000 AF, which is similar to the simulated annual pumping during the dry years of the 1950s, 1960s, and 1970s.

9.3.3 EPCWID Operations

Figure 9-4 summarizes the simulated historical diversions, FHG deliveries, pumping, and conveyance losses for EPCWID. Similar to EBID, the EPCWID diversions were high during the full supply years of the 1940, 1980s, and 1990s, and low during the non-full supply years of the 1950s, 1960s, 1970s, and during the recent extended drought that began in the early 2000s. The simulated EPCWID diversions did not decline as much as the EBID diversions after 2007 because the 2008 OA allocates water first to EPCWID at the expense of the allocations to EBID.

The simulated annual pumping by EPCWID was greatest during dry years between 1950 and 1980 reaching as much as 154,000 AF. Because of the reduction in irrigated area and enactment of the 2008 OA, simulated annual irrigation pumping in EPCWID during the recent drought topped out at about 70,000 AF. The modeling shows little unmet irrigation water demand after considering the available surface water supply during the 1980s and 1990s and therefore little simulated supplemental pumping.

9.3.4 Hudspeth Operations

Figure 9-5 summarizes the simulated historical diversions, FHG deliveries, pumping, and conveyance losses for HCCRD. Because HCCRD relies on waste from EPCWID, the pattern of its supply generally mirrors the supply of EPCWID, rising in wet years and falling in dry years. Most of the simulated supplemental pumping to meet unmet demand occurred prior to 1980, with the simulated maximum annual pumping of 32,000 AF in 1954. The simulated surface water supply after 1980 was generally adequate to meet irrigation demands without much supplemental pumping.

9.3.5 Juarez Operations

Figure 9-6 summarizes the simulated historical diversions, FHG deliveries, pumping, and conveyance losses for Juarez. Pursuant to the 1906 Treaty, 60,000 AF are delivered to the headgate of the Acequia Madre in full supply years. Deliveries to Juarez are reduced in non-full supply years in proportion to the reduction in deliveries to the districts. The simulated farm headgate deliveries have steadily increased since 1980 due to simulated increases in wastewater discharges to the Acequia Madre and increased use of irrigation return flows. However, because of gradual increases in irrigated area through time, the annual supplemental pumping has generally fluctuated between 50,000 AF and 100,000 AF during most years since ground water use became widespread in the early 1950s.

9.3.6 River Flows

Annual water budget summaries of river inflows and outflows are shown in **Figure 9-7** for Rincon and Mesilla basins upstream of El Paso and in **Figure 9-8** for the El Paso Valley down to Ft. Quitman. The stacked positive bars represent inflows to the river and the stacked negative bars represent outflows from the river. The black line represents the net difference between the sum of the inflow bars and the sum of the outflow bars. The black line also is equal the difference between the Rio Grande inflows entering the top of the reach and the Rio Grande outflows existing the bottom of the reach, which are not shown on the graph.

In the Caballo to El Paso reach, the largest inflows are wasteway and drain returns. The primary outflows are canal diversion. The simulated annual river seepage is positive during the wet periods of the 1940s and 1990s indicating that the river is gaining flow from the ground water system. During most of the remainder of the simulation period the river seepage is negative indicating the river is losing water to the ground water system. Within each year, the river gains and losses vary monthly and seasonally.

In the El Paso to Ft. Quitman reach, the largest inflows are wasteway returns (mostly discharges from the American Canal below International Dam that are rediverted at the Riverside Canal prior to construction of the American Canal Extension in 1999). The next largest inflows are the canal returns at the lower end of the HCCRD. Other relatively minor inflows are drain returns and wastewater treatment plant discharges. The largest outflows are the canal diversions at American Dam and at the Riverside Dam when it was in operation. The other outflow is the net river seepage from the river to the ground water system.

Figure 9-9 summarizes the annual flow at different points between Caballo Reservoir and Ft. Quitman. The difference in reservoir releases between wet years and dry years is evident in the point flow charts. The point flows generally decrease in the downstream direction as water is diverted for irrigation. There is a characteristic increase in flows downstream of the Mesilla Dam that represent the simulated flows of the La Mesa Drain and other drains in the area. River flows are typically depleted to at or near zero below International Dam followed by an increase in flow as water was discharged from American Dam back to the Rio Grande to deliver water for diversion at Riverside Dam until completion of the American Canal Extension in 1999. Some increase in flow at the County Line and at Ft. Quitman is also evident in many years as the river is replenished by irrigation return flows.

A different depiction of the historical river flows is provided in the monthly flow maps **Figure 9-10** that show the simulated monthly average flow in cubic feet per second at various locations between Caballo Reservoir and Ft. Quitman. The flows are color coded in ranges to aid in interpretation ranging from dark blue for flows greater than 500 cfs through lighter shades of blue then green and finally white flow flows less than 10 cfs. The characteristic pattern of flows is for large releases from Caballo during the irrigation season and these flows are gradually depleted to zero at some point downstream, typically at American Dam and/or International Dam. The flows are modestly restored in the downstream reaches down to Ft. Quitman. During the non-irrigation season, there are no simulated releases from Caballo, the simulated flows increase through return flows in varying amounts depending on whether conditions are relatively wet or relatively dry.

10.0 ALTERNATIVE RUNS OF INTEGRATED LRG MODEL

10.1 Introduction

The ILRG Model was used to simulate alternative scenarios in response to certain of the Texas claims and to support certain of the New Mexico counterclaims. All alternative scenarios were simulated with the tuned version of the ILRG Model that was used to produce the Historical Base Run described in Section 9. The simulated alternative scenarios fall into two categories as follows:

- No-Pumping Scenarios – Most of the alternative scenarios involved turning off pumping in certain geographic areas or turning off certain types of pumping.
- Operations Scenarios – Other alternative scenarios involved simulation of changes in certain rules for Project operations or irrigation operations.

A list of the model runs that were performed for this report is provided in **Table 10-1**. The no-pumping scenario runs are described in Section 10.2 and the operations scenario runs are described in Section 10.3.

10.2 No-Pumping Scenarios

The purpose of simulating no-pumping scenarios was to evaluate the effects that pumping in New Mexico, Texas, and Mexico has on Project operations and deliveries of Project water. The no-pumping scenarios were simulated by running the ILRG Model with changes in rules or input data depending on the type of pumping that was turned off. For irrigation pumping, the RiverWare Model rule that computes pumping based on the unmet crop irrigation demand is switched off. Reductions in surface runoff and deep percolation return flows that result from turning off the irrigation pumping are simulated as part of the farm budget algorithm in the RiverWare Model.

As previously described, non-irrigation pumping and the corresponding WWTP returns and urban deep percolation returns are simulated in the ILRG Model based on external input of data to the model. Therefore, turning off non-irrigation pumping requires modifying these model inputs to set the pumping and corresponding return flows to zero.

After modifying the irrigation pumping switch and/or the non-irrigation pumping and return flow input data sets, the ILRG Model is executed using the same iterative procedure involving alternating runs of the RiverWare Model and the ground water models until closure is reached (typically 3 to 5 iterations). Turning off pumping results in increased in ground water levels, increased drain flows, and reduced river seepage. This in turn causes the RiverWare Model to adjust Project water allocations, reservoir releases, canal diversions, and FHG deliveries to adjust to the change in water supply. The simulated changes in water supply and system responses ripple spatially and temporally through the model linkages.

Output data from the alternative scenario run are tabulated and compared to the results from the Historical Base Run or another run to quantify what changed between the runs.

Appendix 10A contains two tables and one figure that compare results from each no-pumping run to the Historical Base Run for the period from 1985 - 2016. This period was selected for summarizing the results of the no-pumping runs because it is the period for which Texas is claiming damages from New Mexico pumping. The following is an explanation the summary tables and figure in **Appendix 10A** for the All Pumping Off run (Run 2) (**Table 10A-2a**, **Table 10-A2b**, and **Figure 10A-2**). These explanations are also applicable to the summary tables and figure for the other no-pumping runs summarized in **Appendix 10A**.

Table 10A-2a tabulates average annual differences in certain model inputs and outputs during the 1985 - 2016 period. The first several rows tabulate the “Change in Pumping Stress” which summarizes the differences in model inputs between the no-pumping run and the Historical Base Run. The change in pumping stress consists of the irrigation pumping and/or net non-irrigation pumping (total non-irrigation pumping minus corresponding WWTP returns and urban deep percolation returns) that are turned off.

The remaining rows in **Table 10A-2a** under “Effects of Change in Pumping Stress” show the simulated effects of the changes in input stresses on the following model outputs:

- Farm Headgate Deliveries (Mar-Oct)
- Farm Headgate Deliveries (Nov-Feb)
- Irrigation Pumping
- Reservoir Evaporation
- Riparian ET
- River Evaporation and Incidental Canal Loss
- Rio Grande at Ft. Quitman Flows
- Changes in Storage (Reservoir, Ground Water, Soil Moisture)
- Sum of the above effects.

The first two columns in **Table 10A-2a** summarize annual averages for the Historical Base Run and the All Pumping Off Run, respectively. The third column presents the annual average differences between the two runs. The last two columns show percentage changes computed in two different ways; the first computes the differences between the model runs as a percentage of the simulated change in stress, and the second computes the percentage change of each quantity from the average in the Historical Base Run. The sum of the annual changes does not equal the total change in the simulated stress because certain of the model outputs are not independent quantities (e.g., pumping and FHG deliveries).

The results summarized in **Table 10A-2a** generally illustrate how the model simulates the real-world response of the Project operation and LRG Area irrigation systems to the changes in water supply that would have resulted if the historical pumping had not occurred. These responses are described in more detail below for certain of the no-pumping runs.

Note that for discussion purposes, the results of the no-pumping runs are described in terms of the effect of turning off pumping and the resulting increases in various simulated quantities (e.g., Project water deliveries, reservoir storage, ground water storage, Rio Grande flows, etc.) However, by changing the algebraic sign, the results can also be interpreted as the effects of pumping on the simulated results.

Table 10A-2b presents the change in each year from 1985 - 2016 for certain of the model outputs that are summarized in **Table 10A-2**. Specifically, the annual outputs summarized in **Table 10A-2** include changes in farm headgate deliveries, reservoir evaporation, riparian ET, river evaporation plus incidental canal loss, Rio Grande flows at El Paso and Ft. Quitman.

Figure 10A-2 contains bar charts showing the simulated change in FHG deliveries to EBID, EPCWID (including deliveries to EPW), and HCCRD. The blue bars illustrate the change in FHG deliveries during March - October and the orange bars show the change in FHG deliveries during November - February.

10.2.1 No New Mexico Pumping Scenario (Run 3)

In response to the analyses of impacts of New Mexico pumping described in the Texas expert reports, the No New Mexico Pumping Scenario was simulated with the ILRG Model to analyze the Project operations that would occur in the absence of New Mexico pumping, including the re-operation of the Project that would occur with the changes in drain flows, and river gains and losses without pumping. The results described in this section show that the simulated effects of New Mexico pumping on deliveries to Texas water users are far less than the impacts computed by the Texas experts.

In the No New Mexico Pumping Scenario, the RiverWare Model rule that simulates irrigation pumping to meet the unmet monthly irrigation demand that remains after the simulated use of surface water and soil moisture is switched off. This results in simulated irrigation shortages in EBID during all years. The magnitude of the shortage varies depending on the Project supply. In wet years with full allocations, the shortages to Project lands are relatively small, while in dry years with low allocations, the shortages are substantial.

The simulated effects of turning off New Mexico pumping in the ILRG Model during the 1985 - 2016 study period are summarized in in **Table 10A-3a**, **Table 10A-3b**, and **Figure 10A-3** in **Appendix 10A**.

The average annual effects of turning off New Mexico pumping on river flows, diversions, storage, and other simulated processes are summarized in **Table 10A-3** for 1985 - 2016 period. The simulated effect of turning off irrigation and non-irrigation pumping in New Mexico results in year-round increases in drain flows, and reductions in river losses and/or increases in river gains. These changes in flow in turn result in changes in reservoir operations and deliveries of Project water depending largely on the simulated allocation of Project water. In full allocation years there is relatively little change in FHG deliveries while in non-full allocation years there are much larger changes. The simulated effects on reservoir operations from pumping include (a) increases in reservoir evaporation, (b) increases in allocations in non-full supply years, and (c) increases in spills.

The increased river flows without New Mexico pumping that would either increase Project water deliveries in the current year or would be carried over in Project storage and allocated and delivered in subsequent years both show up in the simulations as impacts to the Project supply delivered to both New Mexico and Texas. This is reflected in the results in **Table 10A-3a** that show that New Mexico pumping impacts on March - October FHG deliveries average 26,200 AF/y to EBID and 8,200 AF/y to EPCWID.

Without New Mexico pumping, there would be increased reservoir evaporation due to the reduction in reservoir releases necessary to make deliveries to Project water users, increased river and canal evaporation due to the general increase in the surface water supply, and more riparian evapotranspiration due to increased ground water levels. Together, these effects would have averaged 11,600 AF/y during 1985 - 2016, or approximately 8% percent of the net pumping stress. This can be characterized as the salvage effect of New Mexico pumping.

Turning off pumping in New Mexico would also increase the flow of the Rio Grande at Ft. Quitman. The simulated increase in annual Ft. Quitman flows averaged 66,600 AF during the 1985 - 2016 period and is comprised of increased spills from Project storage, increased winter flows, and return flows from the additional Project water deliveries to EPCWID, HCCRD, and JID.

Finally, the ILRG Model shows that if there had been no New Mexico pumping then alluvial ground water storage would have increased by an average of 10,500 AF/y and non-alluvial ground water storage would have increased by an average of 12,100 AF/y over the 1985 - 2016 period.

The annual volumes of impacts from New Mexico pumping that correspond to the averages in **Table 10A-3a** are presented in **Table 10A-3b**. The impacts on seasonal and annual FHG deliveries to EBID, EPCWID, and HCCRD are summarized in **Figure 10A-3**.

Additional comparisons of the model outputs for the Historical Base Run and the No New Mexico Pumping Scenario are provided in **Appendix 10B** for the entire 1940 - 2017 study period to illustrate the ILRG Model responses to turning off New Mexico pumping. Comparisons of annual storage and Rio Grande flows are shown in **Figure 10B-1**. Comparisons of annual diversions, FHG deliveries, pumping, and conveyance losses are presented in **Figure 10B-2** for EBID, **Figure 10B-3** for EPCWID, and **Figure 10B-5** for HCCRD. The results in these figures illustrate that diversions by EBID and EPCWID are not appreciably different with or without pumping in full supply years. The impacts of pumping are concentrated in the non-full supply years with additional diversions and deliveries of water in the no-pumping run to EBID, EPCWID, and HCCRD.

More detailed depictions of the simulated Project storage, river flows, and deliveries or Project water are presented in **Figure 10B-5** through **Figure 10B-17**. These figures compare the simulated monthly volumes from the Historical Base Run (black line) and No New Mexico Pumping Scenario (orange line). In these figures, the differences in Project operations during full supply years and non-full supply years are evident. In addition, the differences in flows during the irrigation and non-irrigation seasons are also evident.

The results of the No New Mexico Pumping Scenario show that the effects of New Mexico pumping on deliveries to Texas water users are much smaller than computed in the analyses performed by the Texas experts. The summary results in **Appendix 10A** and more detailed results in **Appendix 10B** show that the ILRG Model simulates reasonable and appropriate responses that would result from turning off New Mexico pumping that reflect the real-world response of Project operations to changes in water supply.

Additional comparisons of the ILRG Model results for the No New Mexico Pumping run to the results in the Texas expert reports are provided in Section 13 and Section 14.

10.2.2 No Texas Pumping Scenarios (Runs 4, 7, 8)

Several runs were made of the ILRG Model to evaluate the effect of pumping in Texas on Project operation and the surface water supplies of the LRG water users. The results from these simulations show that pumping in Texas also impacts Project operations and deliveries of Project water to EBID and EPCWID, particularly in non-full supply years.

The No Texas Pumping Scenarios were simulated in the same manner as the No New Mexico Pumping Scenario. Turned off in the No Texas Pumping Scenarios were all or a portion of the supplemental irrigation pumping, and all or a portion of the non-irrigation pumping and the associated WWTP and urban deep percolation return flows. The following are specifications and summaries of the results of the No Texas Pumping Scenarios.

<u>All Texas Pumping Off (Run 4)</u> – In this scenario, all supplemental irrigation pumping and non-irrigation pumping in the Texas portion of the Mesilla basin and the El Paso Valley was turned off. In addition, the urban return flows from the non-irrigation pumping were also turned off, including WWTP discharges and urban deep percolation. On average over the period from 1985 - 2016, 20,500 AF/y of irrigation pumping, 88,900 AF/y of non-irrigation pumping, and 45,600 AF/y of urban return flows were turned off. This was a net change in pumping stress of 63,800 AF/y. The results from the All Texas Pumping Off run are summarized in **Table 10A-4a**, **Table 10A-4b**, and **Figure 10A-4** in **Appendix 10A**. If Texas had not pumped ground water, the EBID farm deliveries during 1985 - 2016 would have increased by an average of 5,100 AF/y with a maximum annual increase of 32,500 AF in 2009. Without Texas pumping, EPCWID and Hudspeth diversions and FHG deliveries would increase in some years and decrease in other years. The reason for the decreases is due to the impacts of pumping on surface flows sometimes being less than the changes in irrigation and non-irrigation return flows. On average, the greatest effect of no Texas pumping would be an increase in ground water storage averaging 49,300 AF/y over the 1985 - 2016 period.

- <u>Texas Mesilla Pumping Off (Run 7)</u> – In this run, all supplemental irrigation pumping and non-irrigation pumping in the Texas portion of the Mesilla basin (including EPW’s Canutillo wells) was turned off. On average over the period from 1985 - 2016, the net change in pumping stress averaged 13,800 AF/y and was comprised of an average of 2,800 AF/y of irrigation pumping, 24,100 AF/y of non-irrigation pumping less 13,200 AF/y of urban return flows. The results of this run are summarized in **Table 10A-7a**, **Table 10-7b**, and **Figure 10-7** in **Appendix 10A**.

- Texas Non-irrigation Pumping Off (Run 8) – In this run, all Texas non-irrigation pumping and associated urban return flows were turned off. On average over the period from 1985 - 2016, the net change in pumping stress totaled 43,300 AF/y and was comprised of an average of 88,900 AF/y of non-irrigation pumping less 45,600 AF/y of urban return flows. The results of this run are summarized in **Table 10A-8a**, **Table 10A-8b**, and **Figure 10A-8** in **Appendix 10A**.

10.2.3 No Mexico Pumping Scenario (Run 5)

In this scenario, all supplemental pumping in JID and all municipal pumping and associated WWTP discharges in Ciudad Juarez were turned off. On average over the period from 1985 - 2016, 59,200 AF/y of irrigation pumping, 115,000 AF/y of municipal pumping, and 57,300 AF/y of WWTP discharges were turned off. The results of these runs are summarized in **Table 10A-5a**, **Table 10A-5b**, and **Figure 10A-5** in **Appendix 10A**. The maximum annual impacts of Mexico pumping on FHG deliveries were 3,900 AF to EBID, 3,400 AF to EPCWID, and 9,400 AF to HCCRD. Mexico pumping had an average annual impact on ground water storage of 89,200 AF/y during 1985 - 2016.

10.2.4 No Rincon-Mesilla Pumping Scenario (Run 6)

A run of the ILRG Model was made to evaluate the effect of turning off all irrigation and non-irrigation pumping in the Rincon basin and Mesilla basin in New Mexico and in the Texas portion of the Mesilla basin. The purpose of this run was to simulate a scenario that was directly comparable to 100% reduced pumping run of Texas Model described in the Hutchison Report. In this scenario, all irrigation pumping and all non-irrigation pumping and urban return flows in the Rincon and Mesilla basins were turned off. This included pumping of the Canutillo wellfield (EPW) and the Conejos-Medanos wellfield (Juarez). On average over the period from 1985 - 2016, 125,800 AF/y of irrigation pumping, 64,900 AF/y of non-irrigation pumping, and 28,100 AF/y of urban return flows were turned off. The results of these runs are summarized in **Table 10A-6a**, **Table 10A-6b**, and **Figure 10-6** in **Appendix 10A**. Without pumping in the Rincon and Mesilla basins, EBID farm deliveries during 1985-2016 would have increased by an average of 30,400 AF/y with the greatest increases being 109,400 AF in 2010. Additional discussion of the No Rincon-Mesilla Pumping scenario is provided in Section 14.

10.3 Operational Scenarios

Three alternative operating scenarios were simulated using the ILRG Model. Two runs were made to evaluate the impacts of the 2008 OA on Project operations. The other run was made to assess the effects on the Project from excess operational waste.

10.3.1 2008 Operating Agreement Scenarios (Runs 11 and 12)

Two runs of the ILRG Model were made to evaluate the effect of the D3+Carryover accounting in the 2008 OA on Project operations and LRG water supplies. In Run 11, the D1/D2 allocation procedure was simulated to allocate Project water during the entire period from 1948 - 2017 period, and in Run 12 the D3+Carryover accounting was simulated during this 70-year period[6]. Otherwise, both runs utilized the same RiverWare Model simulation rules as in the Historical Base Run. Irrigation pumping was simulated based on the unmet irrigation demand and the non-irrigation pumping and associated return flows were set at historical levels.

The simulated effects of the D3+Carryover accounting from the 2008 OA are illustrated by the simulated differences in the ILRG Model outputs computed as the Run 12 minus Run 11 during the 1948 - 2017 period. The differences between these runs are summarized in **Table 10A-12** in **Appendix 10A** and in **Table 10B-12** in **Appendix 10B**. The impact of the 2008 OA was to reduce EBID farm deliveries by an average of 42,100 AF/y during 1948 - 2017 and increase EPCWID deliveries by an average of 16,100 AF/y during the same period. The annual results summarized in **Table 10B-12** show that the effect of the 2008 OA on EBID FHG deliveries varies significantly depending on the hydrologic state of the basin. The following is a summary of the average annual effect on EBID and EPCWID FHG deliveries in three intervals of the 1948-2017 period.

**Average Effect of 2008 Operating Agreement
on March - October FHG Deliveries
In Wet and Dry Periods**

Period	Wet/Dry	EBID	EPCWID
1948 - 1985	Dry	-68,700	13,400
1986 - 2000	Wet	56,900	23,300
2001 - 2017	Dry	-70,000	15,600
1948 - 2017	All Years	-42,100	16,100

In the two historical dry periods with a relatively low diversion ratios (55 years), annual EBID FHG deliveries are substantially reduced by an average of approximately 68,700 AF while in the wet period from 1986-2000 (15 years) with a relatively high diversion ratios, annual EBID FHG deliveries increased by an average 56,900 AF. The effect of the 2008 OA

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[6] As described in Section 8.2.1, the RiverWare rules do not simulate annual allocations during the wet period from 1940 – 1947.

on EPCWID is more consistent with increased FHG deliveries in most years with an average annual increase of 16,100 AF.

10.3.2 Reduced Waste Scenario (Run 13)

As discussed in Section 5, beginning with the 1950s drought and continuing through the 1970s, Reclamation was able to operate the Project with operational waste below 10% during most years. In a few years during the wet periods of the mid-1980s and mid-1990s, the EBID waste increased to approximately 20%. The situation in EPCWID was markedly different than in EBID from the 1980s through the 2000s (after EPCWID took over operations) with the operational waste consistently in the range of 20% to 30%.

A run of the ILRG Model was made to evaluate the benefit to the Project from reducing the operational waste. The RiverWare operational rules were modified so that the operational waste was limited to the lesser of the historical amounts or 10% of the simulated diversions. The differences between this run and the Historical Base Run are summarized in **Table 10A-13** in **Appendix 10A** The results show that reducing excess operational waste would have resulted in increases in annual Project water deliveries during 1985 - 2016 averaging 28,600 AF to EBID and 12,700 AF to EPCWID.

11.0 RESPONSE TO BRANDES REPORT

Robert J. Brandes, Ph.D., P.E. prepared a May 31, 2019 expert report on behalf of the State of Texas ("Brandes Report"). The subjects of the Brandes Report generally included the following:

- New Mexico Ground Water Development
- Historical Changes in Rio Grande Flows
- Project Operations
- Effect of Ground Water Pumping on Project Deliveries

SWE was asked by legal counsel for New Mexico to review the Brandes Report to identify information or opinions with which we disagreed, and to prepare expert opinions to respond to these issues. We attempted to identify and respond to all substantive issues in which there appeared to be differences of opinion, however a lack of response to a particular issue should not be interpreted as tacit agreement with Dr. Brandes' opinion(s).

Brandes Opinion 1 *– Extensive ground water development in the Rincon and Mesilla basins of New Mexico that began in the 1950s has depleted drain flows and river flows, and this has altered the Project water budget by reducing flows in the Rio Grande that would reach water users in Texas. (Page 10 paragraph 1).*

Response:

The conceptual discussion of the impacts of pumping on Texas water users in Section 4 implies that New Mexico pumping has caused continuous and unrelenting impacts on Texas water users since the early 1950s. The discussion exaggerates the impacts for the following reasons:

1. Pumping in New Mexico varied substantially since it developed in the early 1950s with higher pumping amounts in low Project supply years and lower pumping amounts in full supply years.
2. In full supply years, Reclamation delivered all water ordered by EPCWID and EBID up to their total allocations. To the extent there were varying Project delivery efficiencies (i.e., diversion ratio), Reclamation could adjust releases from storage to deliver the water that was ordered. Therefore, there would not be shortages of delivered water to EPCWID as a result of New Mexico (or Texas) pumping on Project water deliveries in full supply years.

3. There were full supply years from 1979 through 2002, and Dr. Brandes ignores the full deliveries to Texas during all of these years.
4. Additionally, if ground water pumping caused any reductions in the diversion ratio within the Project areas, this would apply to New Mexico, Texas, and Mexico pumping. Dr. Brandes ignores the impacts of Texas and Mexico pumping on Project operations.
5. Dr. Brandes also ignores that Reclamation operated the Project releases and deliveries, encouraged conjunctive use of ground water by all Project participants to meet the full irrigation demands from 1951 - 1978, and then formalized the needed conjunctive use of surface water and ground water by implementing the D1/D2 allocation procedure in 1980 and operating thereunder until major changes in the operating procedures were initiated in 2006 and then adopted in the 2008 OA. Instead, Dr. Brandes blames all changes in Project water deliveries and Rio Grande flows on New Mexico pumping.
6. The foregoing criticisms apply to all of the analyses of historical river flows, drain flows, and Project water deliveries that are presented in the Brandes Report.

Brandes Opinion 2 *– The estimated annual withdrawals for irrigation in the Rincon and Mesilla basins since 1940 are presented on the bar chart in Figure 4.3. As shown by the bars on the chart in Figure 4.3, annual groundwater withdrawals for irrigation has varied considerably, likely in response to wet/dry conditions, and the annual volume of groundwater pumpage for irrigation was substantial even in the early 1950s, indicating that the groundwater well pumping capacity, and likely the total number of irrigation wells, at that time were significant. The demands for additional supplies of irrigation water during the severe drought of the 1950s and during other dry periods, particularly in the mid-2000s and after 2010, are illustrated by the higher levels of groundwater withdrawals on the chart. (Page 11 paragraph 2).*

Response:

The ground water withdrawals for irrigation in Figure 4.3 in the Brandes Report include a significant amount of pumping in the Texas portion of the Mesilla basin. Since roughly 10% of the total Project irrigated area in the Mesilla basin is in Texas, it is reasonable to assume that roughly 10% of the estimated Mesilla basin irrigation pumping in Figure 4.3 would also be in Texas.

The high pumping in the early 1950s is unrealistic given that significant irrigation well development began in New Mexico in the late 1940s and was not complete until about 1955. The pumping estimates shown in Figure 4.3 indicate that almost all of the pumping capacity developed in a single year, with pumping increased from about 10,000 AF in 1950 to about 200,000 AF in 1951. It is unrealistic to assume that all of the irrigation wells would have been constructed in a single year.

As described in the responses to the M&A Report, the total irrigation water demands are overstated because the crop irrigation water requirements are too high beginning in the mid-1980s. Since the irrigation pumping is estimated based on the unmet irrigation demand, this leads to the irrigation pumping also being overstated.

The estimated irrigation pumping during the full supply years of the 1980s and early 1990s averaging nearly 100,000 AF/y is unrealistically high given the full allocation of surface water during those years.

Brandes Opinion 3 *–The plot in Figure 4.5 shows the total combined groundwater withdrawals for both irrigation and urban uses in the Rincon and Mesilla basins [5]. As indicated, since 1950, the total annual groundwater withdrawals consistently have been above 100,000 AF per year, with peak pumpage in recent dry years in the range of 300,000 to over 400,000 AF. (Page 12 paragraph 2).*

Response:

A substantial portion the annual pumping in Figure 4.5 of the Brandes Report is from irrigation wells in the Texas portion of the Mesilla Valley, from EPW's Canutillo wellfield, and from the Juarez Conejos-Medanos wellfield. Pumping from these non-New Mexico wells contributes to the depletions of Rio Grande flow for which Texas is claiming damages. **Figure 11-1** disaggregates the Texas estimates of the total annual pumping in the Rincon and Mesilla basins between the amounts from wells in New Mexico, Texas, and Mexico.

Brandes Opinion 4 *– A report by an unknown author reportedly prepared in 1982 is cited as evidence of the following impacts from ground water development in the Rincon and Mesilla basins:*

> *This groundwater development has changed the flow regime established prior to 1951 such that a greater release is required from Elephant Butte Reservoir to achieve the same flow at El Paso. This new trend, which was established after the end of the drought of the 1950's, has continued to the present (1982).*
>
> *In conclusion, all four figures used in this analysis show that the effects of the groundwater development below Elephant Butte Dam induced by the drought of the 1950's have significantly affected the amount of water reaching El Paso. The*

> *new relationship is well defined and has been continuous to the present (1982). (Page 14 paragraph 2 and 4).*

Response:

The reliability of conclusions from a 1982 report by an unknown author with unknown affiliation using unsourced data is questionable. Dr. Brandes presents analyses similar to those in his report, and my responses are therefore focused on review of his analyses.

Brandes Opinion 5 *– A 1986 report by Tipton and Kalmbach prepared for the IBWC is described and the following conclusions are cited from the report*

> *1) Depletions of the Rio Grande upstream of the El Paso Narrows have increased. The annual depletions from 1922 through 1950 averaged 237,000 acre-feet per year, from 1951 through 1984 averaged 260,000 acre-feet per year, and from 1980 through 1984 averaged 305,000 acre-feet per year.*
>
> *5) The use of wells in the Rincon Valley and Mesilla Basin for supplemental irrigation water and for municipal, industrial, and domestic uses since 1951 is the principal cause for the increased depletion upstream of the El Paso Narrows. (Page 15 paragraph 1 and 2).*

Response:

The Rio Grande depletions upstream of the El Paso Narrows were reportedly computed as the annual flow at El Paso minus the releases from Project storage. Based on this calculation, the 1986 report concluded that annual Rio Grande depletions increased by an average of 23,000 AF/y after 1950 based on comparison of average depletions during 1922 - 1950 (237,000 AF/y) to average depletions during 1951 - 1984 (260,000 AF)/y).

The 1986 report does not describe the specific sources for the data that were used in the analyses described in the report. Also, the attachments to the report that are the basis for some of the conclusions in the report were not provided. This makes it difficult to review and assess the validity of the report analyses and conclusions.

The report text indicates that the releases from Project storage were a combination of releases from Elephant Reservoir and releases from Caballo Reservoir. Since Caballo Reservoir began operating in 1938, it is assumed that Elephant Butte Reservoir releases were used before 1938. As described previously in Section 5, on average, there was an average gain of about 20,000 AF/y between the Elephant Butte Reservoir outlet and the approximately location of the Caballo Reservoir outlet between 1930 and 1938. Therefore, depletions computed from Elephant Butte Reservoir releases would be expected to be lower than depletions computed from Caballo Reservoir releases before 1938. Using Elephant Butte Reservoir releases for more than half of the 1922 - 1950 period would have depressed the average computed depletions during this period. Comparison of this figure to average depletions after 1950 that are computed entirely based on Caballo Reservoir releases would result in misleading conclusion about differences in average depletions before and after 1950.

As described in Section 5, average depletions from the Caballo Reservoir outlet (or Percha Dam prior to 1938) to El Paso remained relatively steady from the 1930s through the 1970s at about 250,000 AF, increased to around 300,000 AF during the 1990s, and fell back to around 250,000 during the last decade. Therefore, any conclusions about long term persistent trends in depletions are not supported by the available data.

Brandes Opinion 6 *– A 1997 report by a hydrologic task committee appointed by a New Mexico District Court is described and the following conclusion from the report is cited as evidence that ground water pumping causes depletions to Rio Grande flows.*

> *Well withdrawals in the LRGB have been derived partly from stored groundwater, partly from surface-water depletion and partly from capture of evapotranspiration. The fraction derived from the surface water grows through time. The historical portion of well withdrawal from surface-water depletion is estimated to be between 80 and 90 percent. Specific wells may derive water from appreciable different proportions of each source. (Page 15 paragraph 6).*

Response:

The 1997 report describes a ground water model that was developed and used for analysis of basic effects of ground water pumping.

> *Various pumping scenarios were examined using a ground water model to illustrate basic hydrologic relationships. The ground water modeling results are dependent on a number of simplifying assumptions and do not simulate the historical development within the LRGB.*

The 1997 report indicates that the model was used to simulate the effect of pumping of a hypothetical well at a rate of 500 gallons per minute (“gpm”) at various locations in the basin and distances from the river and at various depths to assess the effect that well location had on pumping impacts to (a) ground water storage, (b) river flow, and (c) capture of evapotranspiration (of native vegetation). The report concluded that the location and depth of the well had a significant impact on how much the simulated pumping depleted the river.

Support for the reported conclusion that between 80% and 90% of historical well withdrawals come from surface water depletions was not found in the 1997 report. The results of various model runs in Appendix A of the 1997 report show substantially more variability in the amount of pumping that is derived from the stream after 100 years of pumping (42% - 93%).

Details about the ground water model construction were not provided in the 1997 report and it is unclear whether the model was calibrated. The report includes the following caveats regarding the model results:

> *Although the work presented in this report is based on the most recent technical information available, it should not be considered as a definitive description of the hydrogeologic system or its response to stresses.*
>
> *A cautionary note is in order. Model simulations quantify the impacts of pumping in the LRGB, but are affected by the way that a model is constructed. The simulations are also affected by the assumptions made regarding hydrologic relationships. If an accurate quantification of the effects of ground-water withdrawals is desirable, the key hydrogeologic relationships that are assumed in any model should be subjected to scrutiny and verification.*

Based on stated purpose of the 1997 modeling work, the simplified nature of the model runs, and the caveats regarding the model results, the report conclusions should be interpreted as preliminary, approximate, and conceptual. The NMR-M Model is far more sophisticated and evolved than the relatively simple model described in the 1997 Report. There is no point in relying on results from a model developed over 20 years ago when more capable tools, like the NMR-M Model and the ILRG Model, are available today.

Brandes Opinion 7 *– Dr. Brandes summarizes a 2008 presentation by Gary Esslinger, manager of the EBID concerning the 2008 Operating Agreement. Esslinger explained the development of the D1/D2 Curves that were used to allocate Project water from 1979 - 2007, and which continue to be used to allocate water to Texas and Mexico under the 2008 Operating Agreement, allowed groundwater pumping in New Mexico to be grandfathered at the 1951-1978 levels that are embedded in the D1/D2 Curves. (Page 16 paragraph 5)*

Response:

Figure 4.6 in the Brandes Report illustrates the annual reservoir release and diversion data for 1951 - 1978 (red dots) that were used to develop the D2 Curve (red line). The D2 line is the best fit straight line through the 1951 - 1978 data that are generally scattered above and below the line. More recent data are shown in the plot for two periods from 2003 - 2007 (before full implementation of the 2008 OA) and for 2008 - 2017 (after the 2008 OA). The recent data in Figure 4.6 are charged diversions during Project releases from storage as compared to the 1951 - 1978 data used to develop the D2 Curve which are total annual diversions and include diversions outside of the Project release period. As a result, recent data are biased low compared to the 1951-1978 data.

Additionally, as to the 2003 - 2007 data, all years except 2005 are within the scatter range of the D2 Curve data and therefore do not exhibit unusually low deliveries. Lastly, during the 2006 - 2017 period, Texas received annual allocations based on the 2008 OA procedure, and therefore any deviation in Project performance below the D2 line was fully shouldered by New Mexico under the D3 allocation procedure. During the 2008 - 2017 period, Texas was also able to carry over significant amounts of water, resulting in Texas's annual allocation far exceeding its historical 43% share, and forcing more ground water pumping New Mexico, for which Brandes seeks to blame New Mexico.

Brandes Opinion 8 *– Figure 5.2 is a plot of cumulative releases from Caballo Reservoir (or from Elephant Butte before 1938) and cumulative Rio Grande flows at El Paso beginning in 1930 and extending through 2015. As shown, the cumulative curves for both the Caballo releases (red circles) and the El Paso Rio Grande flows (green squares) exhibit steeper segments reflecting higher flow conditions and also flatter segments indicating lower flow conditions. The effects of the high flows during the early 1940s and mid-1980s and the low flows of the early to mid-1950s are readily apparent in the two curves. Lower flow conditions also are indicated beginning around 2010, which is consistent with observed climatic and hydrologic conditions. Overall, the cumulative curve for the Rio Grande flows at El Paso generally shows a somewhat flatter trend after the 1950s, indicating less river water reached El Paso relative to what was released from Caballo. The early 1950s, of course, is when significant groundwater pumping for irrigation began in New Mexico. Flattening of the slope of the cumulative curve for the Rio Grande flows at El Paso beginning in the early 1950s is more likely than not indicative of the effects of lowered groundwater levels and increased losses from the Rio Grande and drainage ways that resulted from the development of significant groundwater pumping in the Rincon and Mesilla basins. (Page 19 paragraph 1).*

Response:

The historical flow of the Rio Grande at the El Paso gage is not relevant to this litigation because (a) it is not a point of compliance for the Compact, and (b) it is not a point of delivery for the Project. The Project was conceived and has been operated to provide equal delivery of water per acre of irrigated land. Until 1979, Reclamation was responsible for making water available for delivery to the users on an equal per acre basis. After the districts took over the internal distribution of water to the Project water users, Reclamation's obligation to deliver water was changed to the major canal headings with the idea that the district would perform the remainder of the water distribution that would continue equal delivery of water per acre. Since 1979, Reclamation has accounted for deliveries to EBID and EPCWID at canal headings and other points upstream and downstream the El Paso gage, but there continues to be no Project accounting at the El Paso gage.

The relative steep slopes of the reservoir releases (red circles) and El Paso flows (green squares) during the 1930s and 1940s reflects the generally above average water supply conditions that resulted in full Project supplies through that period and relatively high releases from storage. There were no annual water allocations set by Reclamation during the 1940s and 1950s and farmers ordered whatever water they thought they needed.

The general flattening of both curves after 1950 reflects the decline in average annual releases that occurred because the average water supply after 1950 was much lower than before 1950, despite the wet periods of the 1980s and 1990s. The following are comparison of the average reservoir releases before and after 1950:

Comparison of Average Annual Storage Releases
(acre-feet)

Years	All Years	Excluding Spill Years
1930-1950	829,000	781,000
1951-2017	607,000	575,000

In addition, as shown in Figure 5.1 of the Brandes Report, the Project is generally more efficient in conveying flows released from the reservoir downstream to El Paso at higher flows. The flattening and slight divergence of the cumulative reservoir release and El Paso flow curves in Figure 5.2 after 1950 are consistent with reduced river efficiency that exists at lower flows.

Brandes Opinion 9 *– Dr. Brandes presents a plot of the cumulated annual flows of the Montoya Drain from 1938 - 1995 in Figure 5.3. As shown on the graph, the historical data exhibit a drastic change of slope beginning during the early 1950s and then continuing with a flatter slope through 1995. This flattening of the slope of the historical data compared to the straight-line extension of the pre-1950 data trend (red dashed line) indicates that the flow discharging from the drain was significantly reduced – by an average of approximately 39,000 acre-feet per year from 1951 through 1995. While some of this flow reduction may be attributed to improved irrigation efficiency, it more likely than not was due to the loss of groundwater inflows to the drain that resulted from the lowering of groundwater levels caused by irrigation pumping that began in the early 1950s. (Page 21 paragraph 2).*

Response:

It appears that the Montoya Drain data plotted by Dr. Brandes in Figure 5.3 were taken directly from the USBR reports. Detailed review of these reports showed that Reclamation was inconsistent in how it aggregated and reported the drain data. Beginning in 1934 (except for 1937) the flows of the West Drain and NeMexas Drain are included in the Montoya Drain records. Prior to 1934 and in 1937, these flows are not included in the Montoya Drain records, and the recorded flows for these two drains need to be added to the Montoya Drain records during these years to create a consistent historical record.

The reported flows of the Montoya Drain were much greater during the wet period before 1950 than during comparable wet and low pumping periods after 1950. As described above, projecting conditions during the wet period of 1938-1950 forward for comparison to conditions that existed during the drier period after 1950 may exaggerate the apparent deviation in flows. As to the pumping impacts, it should be noted that most of the Montoya Drain is located in Texas and therefore most of the pumping impacts to Montoya Drain flows are likely from Texas wells.

Further, as recognized by Dr. Brandes, there likely are other factors that contributed to the reduction in drain flows other than irrigation pumping. Dr. Brandes specifically mentions improvements in irrigation efficiency as one cause. Other potential causes are listed in the response to Brandes Opinion 10 below.

Brandes Opinion 10 *– A double-mass plot of the cumulative annual Rio Grande at El Paso flow versus the cumulative annual releases from Caballo Reservoir from 1930 - 2017 is presented in Figure 5.4 of the Brandes Report. The deviation of the historical flows curve after 1950 (blue triangles) from the extension of the curve before the 1950s (dashed red line) averages 78,667 acre-feet per year, which is equivalent to a total reduction in the flow of the Rio Grande at El Paso of about 5,000,000 acre-feet for the period from 1951 through 2017, excluding the flood years of 1986-1987 and 1995. Based on this demonstration, it is more likely than not that groundwater pumping in New Mexico within the Rincon and Mesilla basins that began in the early 1950s and continues today played a major role in reducing flows in the Rio Grande at El Paso from what they were prior to the 1950s without groundwater pumping for the same annual quantities of water released from Caballo Reservoir. In essence, the extension of the 1930-1950 curve represents the “no compact violation” condition.*

In essence, the extension of the 1930-1950 cumulative flow curve beyond 1950 to 2017 on the plot in Figure 5.4 (red dashed line) can be considered to represent the cumulative flows of the Rio Grande at El Paso that would have occurred if substantial groundwater pumping had not developed in the Rincon and Mesilla basins. (Page 22 paragraph 2).

Response:

Dr. Brandes initially observes that ground water pumping in New Mexico played a major role in reducing flows in the Rio Grande at El Paso. However, he goes much further in later statements without additional evidence to conclude that extension of the 1930 - 1950 cumulative flow line represents the “no compact violation” condition and that any post-1950 deviations from the 1930 - 1950 projection were caused by pumping in the Rincon and Mesilla basins.

As previously described, Dr. Brandes used reservoir releases for Elephant Butte Reservoir prior to 1938, and this affects the 1930 - 1950 projection line. If Dr. Brandes had instead used the Rio Grande at Percha Dam flow for 1930-1938, the average deviation between the 1930-1950 projection line and the cumulative Rio Grande at El Paso flow would be less than 78,667 AF/y.

Further, it is unreasonable to attribute all deviations from the 1930 - 1950 projection line to New Mexico pumping. There are many other factors that may have contributed to the change in the slope of the double-mass curve in Figure 5.4, including the following:

- Pumping in Texas Mesilla – Well pumping in the Texas portion of the Mesilla basin including Irrigation well pumping, municipal well pumping by EPW at the Canutillo wellfield, and other non-irrigation pumping.
- Pumping in El Paso Valley and Juarez Valley – Well pumping in the El Paso Valley and the Juarez Valley that depleted deliveries of Project water and caused additional water to have to be released from Project storage to deliver water to EPCWID farms.
- Reduction in Reservoir Releases – Generally lower reservoir releases after 1950 coupled with the reduced Project delivery efficiency that exists at lower flows as shown in Figure 5.1 of the Brandes Report.
- Reduction in Diversions and FHG Deliveries – Reductions in surface water diversions and farm headgate deliveries as a result of the reduced reservoir releases that occurred after 1950.
- Increased Project Operating Efficiency – Increases in Project operating efficiency (enactment of annual water allotments, reduced waste, etc.) that occurred after the first Project water shortages in the early 1950s.
- Increased On-Farm Irrigation Efficiency – Increases in on-farm irrigation efficiency resulting from land-leveling, lateral lining, increased use of level basin irrigation, soil moisture monitoring, education, and other factors that led to reduced irrigation return flows.
- Reduced Irrigated Area – Reduction in irrigated area in New Mexico and especially in Texas that led to reduced water demands. Increasingly, the EPCWID did not take delivery of its full annual allocation.
- Changes in Crops – Changes to crops that consume more water and return less water to the stream.
- Implementation of 2008 OA – Implementation of the 2008 OA accounting starting in 2006 that reduced the overall delivery efficiency of the Project through reduced deliveries to EBID and reduced drain flow returns to the Rio Grande.

It is also important to note that the cumulative Rio Grande at El Paso flows plotted in Figure 5.4 of the Brandes Report are year-round flows, including flows during the winter period that are not considered a part of the Project water supply. Review of the Brandes analysis indicates that an average of about 16,000 AF/y of the deviation in El Paso flows from the pre-1950 line is represented by changes in flows during the non-irrigation season. Since there are no Project releases during the non-irrigation season, changes in flows during that time are not considered Project water. Further, since the flows at El Paso during the winter are reportedly comprised primarily of poor-quality drain flows, they are less usable for irrigation than Project supplies during the irrigation season.

For the reasons listed above, it is improper to conclude that pumping in New Mexico was the sole cause of reduced flows in the Rio Grande at El Paso after 1950. While the double-mass curve analysis presented as Figure 5.4 in the Brandes Report does show there was a reduction in flow relative to the releases from Project storage, it provides no information or evidence for what caused the reduction in flow.

In addition, as described above, changes in flow at the El Paso gage are irrelevant to this case, to the Compact, and to the Project operations. What is relevant is that the Project has always operated as a unit, and prior to the 2008 OA, operated to allocate and deliver equal amounts of water to each farm acre based on the D1/D2 procedure, which allowed for conjunctive use of ground water to meet irrigation demands. (Lopez, 2019) In order to understand whether pumping anywhere within the Project area has impacted the historical Project deliveries, it is necessary to develop and apply a robust simulation model of the entire Project. As described previously, the simulation model must be capable of simulating the full dynamic response of the Project operations to changes in supply. The simple double-mass curve analyses presented in the Brandes Report are not useful for determining the impact of New Mexico pumping on Texas water deliveries.

Brandes Opinion 11 *– The corresponding annual river flows in the absence of groundwater pumping after 1950 (no compact violation condition) can be estimated by calculating the incremental annual increases in the extended cumulative flow curve (red dashed line). These estimated annual flows of the Rio Grande at El Paso without the effects of groundwater pumping for the 1951-2017 period are plotted on the bar chart in Figure 5.5 along with the corresponding historical annual flows. As expected, the annual flows without the effects of groundwater pumping are higher than the actual historical annual flows which were influenced by groundwater pumping. (Page 23 paragraph 2).*

Response:

Figure 5.5 in the Brandes Report is presented as evidence for the annual effects of ground water pumping on Rio Grande at El Paso flows. The differences between the historical flows and the flows without the effects of ground water pumping in Figure 5.5 of the Brandes Report are plotted in **Figure 11-2.** The green shading in the chart indicates whether there was a full allocation of Project water in each year. The estimates of substantial impacts on El Paso flows during every non-spill year of the study period except 1988 do not make sense given how the Project operates. In full allocation years, it is reasonable to assume that the Project water users took delivery of all of the Project water they were allocated or needed. Therefore, assuming there would be more water in the river without pumping, Reclamation would reduce reservoir releases so that the same amount of water would be delivered to the Project water users in full allocation years, including EPCWID. As a result, in full allocation years without pumping, there should be little if any additional flow at El Paso compared to the historical condition, except for some additional flows during the winter resulting from the increase in drain flows that would occur without pumping.

Because the year-in and year-out effects of pumping shown in Figure 5.5 of the Brandes Report are not consistent with the expected response of the Project to changes in supply, the annual differences in the bars in Figure 5.5 are not reliable indicators of the impact of pumping in the Rincon basin and Mesilla basin on El Paso flows.

Brandes Opinion 12 *– The counterpart to the analysis of the change in the Rio Grande flows at El Paso caused by the development of groundwater pumping in the Rincon and Mesilla basins is a similar analysis of streamflow depletions. For purposes of this analysis, streamflow depletions are defined as the difference between the annual releases from Caballo Reservoir and the corresponding annual flows in the Rio Grande at El Paso. Streamflow depletions in this case are the result of diversions from the river into the main canals for irrigation in the Rincon and Mesilla basins, river channel losses due to evaporation and seepage, and evapotranspiration by vegetation along the river, offset by arroyo inflows to the Rio Grande between Caballo Reservoir and El Paso and discharges into the Rio Grande from irrigation drains and canal wasteways. Figure 5.6 presents the double-mass graph of these cumulative streamflow depletions for the 1930 through 2017 period. Here again, the distinct change in slope after groundwater pumping began in the early 1950s and the increasing deviation of the historical data after the 1950s (brown diamonds) from the projection of the pre-1950 historical data (green dashed line) are indicative of the expected effects of groundwater pumping on streamflow depletions. (Page 23 paragraph 3).*

Response:

The results shown in Figure 5.6 of the Brandes Report are skewed due to the use of Elephant Butte Reservoir releases before 1938. This affects the slope of the green line and inflates the differences between the projected 1930 - 1950 line and the cumulative depletions after 1950.

As described in Section 5, the average annual depletions between Caballo Reservoir and El Paso are about the same today as they were in the late-1930s at approximately 250,000 AF/y.

The criticisms of the double-mass curve analysis of El Paso flows described above also apply to the double-mass curve analysis of Rio Grande depletions in Figure 5.6 of the Brandes Report. The double-mass curve can show there was a change in depletions relative to reservoir releases, but does not inform as to the causes for any changes in depletions. Dr. Brandes provided no evidence to support an opinion that all increases in depletions after 1950 are due to pumping. A robust model capable of dynamic response to changes in flow is necessary to compute the portion of the changes in depletions to Rio Grande flow above El Paso caused by pumping in New Mexico and Texas.

Brandes Opinion 13 *– The various graphical illustrations presented in this section all exhibit the common theme that hydrologic conditions along the Rio Grande in the Rincon and Mesilla basins changed noticeably beginning after the 1950s. While this coincides with the onset of the severe drought of the 1950s that affected much of the southwestern United States, it also is when significant groundwater pumping began to develop and accelerate along the Rio Grande in the Rincon and Mesilla basins to provide a supplemental water supply for irrigation in New Mexico. Based on the significant changes that occurred in the observed Rio Grande flows, streamflow depletions, and drain discharges that began with the substantial increase in groundwater pumping, there is strong empirical evidence that groundwater pumping was a primary cause of these changes, which, in turn, lead to reductions in the availability of surface water supplies from the Rio Grande for Project users in Texas. (Page 24 paragraph 3).*

Response:

While I agree with Dr. Brandes that the graphical illustrations presented in Section 5 show that there were changes in drain flows, Rio Grande flows, and streamflow depletions after 1950 relative to releases from Project storage, his quantification of these changes is affected by his use of Elephant Butte Reservoir releases before 1938 in developing the 1930 - 1950 projection lines in the various figures.

In addition, for the many reasons described above, I also disagree that the empirical evidence presented by Dr. Brandes shows that the post-1950 changes are due solely to New Mexico pumping. A robust model capable of simulating the dynamic response of the Project to changes in historical conditions is necessary to assess the effects of New Mexico pumping, Texas pumping, or other operations on El Paso flows and deliveries to Project water users.

Brandes Opinion 14 *– A fundamental premise of Rio Grande Project operations is that the annual supply of water available for Project users each year is determined by the volume of water either in storage or anticipated to be in storage in Elephant Butte and Caballo Reservoirs, and changes in downstream water demands or streamflow depletions do not affect the amount of the available supply. (Page 30 paragraph 5).*

Response:

It is incorrect to state that the available Project supply is solely determined by the volume of water either in or projected to be in Project storage each year. Review of the RGJI report and the record of the deliberations of the engineer representatives of Colorado, New Mexico, and Texas indicates they were very aware of the many factors that cause variations in Project water supply. The amount of water in storage at the beginning of the season and the reservoir inflows during the irrigation season are obviously important in determining the available water supply. However, the drain flows and other return flows from irrigation downstream of the reservoirs contribute substantially to the Project supply and therefore are of significant importance to the Project operation.

The amount of water that is actually released from storage and delivered for use also depends on the demands of the Project water users. In some years, the districts request delivery of most or all of their allocation and in other years they request less. As shown in **Figure 4-4**, EBID has historically requested delivery of most or all of its allocation more often than has EPCWID.

In summary, Project releases are affected by (a) the amount of water available in storage at the beginning of the irrigation season, (b) the inflows to storage during the irrigation season, (c) the gains and losses between the Caballo outlet and the downstream delivery points, and (d) the demands of the Project water users.

The effects on Project operations resulting from variations in downstream operations is evident in comparisons of historical canal heading diversions to historical reservoir releases and historical Project supplies. **Figure 11-3** contains scatter plots of the canal heading diversions versus reservoir releases during the typical March – October irrigation season. Separate graphs are presented for the canal heading diversions of EBID, EPCWID, JID, and the total. Each plot shows a range of diversions for similar reservoir releases. This is consistent with the descriptions of Project operations in the RGJI (NRC 1938), Project histories (Reclamation, 1992), operating manuals, and other information (Reclamation, undated) that indicate reservoir releases are set to deliver the amounts ordered by the Project water users in combination with the drain flows and other gains and losses between the reservoir and the delivery points. For example, the graph of total Project diversions in the lower right of **Figure 11-3** shows that for approximately the same reservoir release, the annual diversions varied by 200,000 AF or more. Conversely, for approximately the same annual diversion, the annual reservoir releases varied by 150,000 AF to 200,000 AF.

Similar charts are presented in **Figure 11-4** showing the same irrigation season diversions plotted against the total available Project supply computed as the end of February Project storage plus the March - July reservoir inflows. There is even more scatter in the data in the graphs in **Figure 11-4** than in the graphs in **Figure 11-3**.

Another set of charts is presented in **Figure 11-5** to illustrate the year-to-year variability in Project operations. The lower left chart plots the irrigation season diversion ratio vs. the irrigation season releases and the upper left chart plots the diversion ratio vs. the annual available Project supply (end of February storage plus March-July inflows). There is substantial variability in the diversion ratio for similar annual reservoir releases and for similar annual Project supply. The diversion ratio will be higher when there are more drain flows and other return flows available to help meet diversion demands, and the diversion ratio will be lower when the return flows are lower and more reservoir water has to be released to meet demands.

Finally, the upper right chart in **Figure 11-5** shows the irrigation season reservoir releases versus the annual available Project supply. This chart shows substantial variation in annual reservoir releases for the same annual available Project supply. This variability reflects the wide range of downstream conditions that affect how much reservoir water is needed to be released to meet Project water demands.

Brandes Opinion 15 – *It is significant to note, however, that the operation of Elephant Butte and Caballo Reservoirs and the annual allocation of Project water and the associated releases from Caballo do not appear to have noticeably changed as a result of the groundwater pumping. The graph in Figure 6.4 presents a plot of annual reservoir releases from Caballo Reservoir versus the corresponding maximum combined storage in Caballo and Elephant Butte Reservoirs prior to and during the irrigation season. The storage data on this plot are limited to years when the total storage was less than 1,500,000 acre-feet because with storage amounts greater than this, annual releases have been somewhat erratic due to high river flows and releases of flood water. Data plotted on the graph are segregated into two time periods; one for 1940-1955 before the effects of groundwater pumping had fully evolved and the other for 1956-2014 after significant groundwater development had occurred. (Page 38 paragraph 4).*

Response:

The combined maximum storage in Figure 6.4 of the Brandes Report is not an accurate measure of the available annual Project water supply. Dr. Brandes computed the maximum storage separately for Elephant Butte Reservoir and Caballo Reservoir for each year based on the historical maximum end-of-month storage in each reservoir in each month from December - July. The maximum amounts for each reservoir were added together to determine the annual values plotted on the x-axis in Figure 6.4.

One problem with the Brandes methodology is that the maximum monthly storage values for each reservoir may come from different months within the December - July period, and in this instance the sum of those maximum values will exceed the maximum combined end-of-month reservoir storage for that year.

A larger problem is that the maximum monthly reservoir contents is not an accurate representation of the available supply because it does not reflect the reservoir releases before the maximum storage month, nor does it reflect the reservoir inflows after the maximum month. A better indication of the available Project supply is the end-of-February storage contents plus the sum of the reservoir inflows during March - July. These totals have appeared in prior Reclamation summaries of the Project water supply (Reclamation, 2012). This preferred indication of Project supply was used in the graphs in **Figure 11-4** and **Figure 11-5**.

Notwithstanding the inaccurate measure of Project supply plotted on the x-axis, the data plotted in Figure 6.4 of the Brandes Report do not show what Dr. Brandes claims they show. First, he states that the 1940 - 1955 data points shown as blue dots represent conditions before the effects of pumping had fully evolved. This is contrary to analyses presented in other portions of Dr. Brandes report where he describes the effects of pumping that began substantially affecting flows in 1951. Second, for similar maximum storage contents, the data in Figure 6.4 show releases from Caballo that range approximately between 100,000 AF to 200,000 AF. The reason for variations in the annual releases for similar reservoir contents is the annual variation in conditions downstream of the reservoir. This is similar to the scatter shown in the data in **Figure 11-3** through **Figure 11-5** and explained in more detail in the accompanying narrative.

Brandes Opinion 16 – *Notwithstanding the process embedded in the Operating Agreement for attempting to mitigate for the effects of groundwater pumping in New Mexico on deliveries to Texas, the fact remains that groundwater pumping along the Rio Grande in the Rincon and Mesilla basins of New Mexico is not limited and continues at significant levels, adversely affecting flows in the river and diversions for Project water users in Texas. This is evident by the data presented on the graphs in Figures 4.6, 5.4 and*

5.6 where the post-2007 data exhibit little change from conditions prior to adoption of the Agreement. (Page 38 paragraph 3).

Response:

The 2008 OA continued to allocate water to Texas and Mexico based on the D1 and D2 Curves and therefore these two entities generally receive the same allocation of water for a given amount of water in Project storage that they received under the original D1/D2 allocation procedure. To the extent that Project does not perform at the level implicit in the D1 and D2 Curves, the entire amount of the underperformance is born by a reduced allocation to New Mexico water users.

As described above, the D1 and D2 Curves implicitly grandfathered in the effects of pumping during 1951 - 1978 by New Mexico, Texas, and Mexico on Project performance and Project deliveries. To the extent that the annual flow at El Paso has declined further relative to releases from the Project storage since the 2008 OA was enacted, this may be caused in part by EPCWID taking less delivery of its allocation since the agreement was enacted. Prior to 2008 under the D1/D2 accounting in years that EPCWID had an allocation of more than 350,000 AF, the Project water deliveries to EPCWID averaged about 319,000 AF/y. Since 2008 under the 2008 OA EPCWID has taken delivery of an average of 288,000 AF/y in years with an annual allocation exceeding 350,000 AF, or about 30,000 AF/y less than before the 2008 OA was enacted.

Further, the bargain of the 2008 OA was that the percentage of surface water allocated to EPCWID would be increased, the percentage of surface water allocated to EBID would be decreased, and individual carryover accounts would be created in Elephant Butte Reservoir; and in exchange, EBID could pump additional ground water to make up for the reduction in its surface water deliveries. This forced reliance on ground water for EBID under the 2008 OA, would have reduced non-irrigation season return flows that reached the El Paso gage, and this would have contributed to further deviations in the double-mass curve lines after 2008. This impact of the 2008 OA was ignored by Dr. Brandes.

Brandes Opinion 17 *– The graph in Figure 7.2 presents an application of [the double-mass curve methodology] to the New Mexico deliveries to farms data for the 1938-2016 period. As shown, the curve represented by the historical data on this graph exhibits the same break in slope around the early 1950s as the curve for the Rio Grande flows at El Paso shown in Figure 5.4. Again, this supports the conclusion that groundwater pumping in the Rincon and Mesilla basins for irrigation of farms in New Mexico, which began to develop during the early 1950s, more likely than not impacted the deliveries of Project water to farms in New Mexico. The total reduction in farm deliveries for the 1951-2016 period is* *about 2,100,000 acre-feet, which translates to an average annual reduction of 33,547 acre-feet. (Page 41 paragraph 4).*

Response:

As for the other double-mass curves in the Brandes Report, the projection of the 1930 - 1950 line in the Figure 7.2 is skewed by the use of Elephant Butte Reservoir releases during 1930 - 1937. As described above, there are likely many other reasons that annual Project deliveries decreased relative to Project releases after 1950, and these would have also affected deliveries to New Mexico farms. To the extent that ground water pumping did affect deliveries to New Mexico farms, this obviously means that New Mexico pumping does not somehow only affect El Paso flows. In fact, because New Mexico nominally was allocated 57 percent of the Project supply (until 2008) and tended to use more of its allocation than did Texas, any changes in Project performance, regardless of the cause, would generally tend to impact deliveries to New Mexico users more than deliveries to Texas water users.

In addition to the change in slope of the New Mexico deliveries in Figure 7.2 in the early 1950s, there is another break in slope around the time that the 2008 OA went into effect. This would be consistent with the significant reduction in Project water allocations to New Mexico that resulted from the provision of the 2008 OA that causes New Mexico to bear the effect of any and all negative deviations of Project performance from the performance that is implicit in the D1 and D2 Curves.

A robust model capable of simulating the dynamic response of the Project to changes in historical conditions is necessary to assess the effects of New Mexico pumping, Texas pumping, or other operations on deliveries to New Mexico farms.

***Brandes Opinion 18** – The estimated annual values of the New Mexico farm deliveries without the reductions caused by groundwater pumping can be determined by calculating the annual incremental increases in the 1951-2016 extension of the 1938-1950 data curve (red dashed line). These values are plotted on the bar chart in Figure 7.3 along with the corresponding historical deliveries to farms in New Mexico for the 1951-2016 period. (Page 43 paragraph 1).*

Response:

Figure 7.3 in the Brandes Report compares the historical annual deliveries to New Mexico farms to the estimated annual deliveries without the effects of pumping derived from the double-mass curves presented in Figure 7.2. The estimates of substantial impacts on deliveries to New Mexico farms in all years of the study period do not make sense given how the Project operates. In full allocation years, it is reasonable to assume that the Project water users took delivery of all of the Project water they were allocated or needed. Therefore, assuming there would be more water in the river without pumping, Reclamation would reduce reservoir releases so that similar amounts of water would be delivered to the Project water users in full allocation years, including EBID. Because the year-in and year-out effects of pumping shown in Figure 7.3 of the Brandes Report are not consistent with the expected response of the Project to changes in supply, the annual differences in the bars in Figure 7.3 are not reliable indicators of the impact of pumping in the Rincon basin and Mesilla basin on deliveries to EBID farms.

Brandes Opinion 19 *– Estimates of the total annual deliveries to Texas in the El Paso Valley have been derived by subtracting from the irrigation-season Rio Grande flow at El Paso the amount of water diverted into the Acequia Madre for Mexico and adding the annual quantities of the City of El Paso's Canutillo well field pumping. These annual values are plotted on the bar chart in Figure 7.4 along with the corresponding annual deliveries to Texas farms in the Mesilla basin as developed by Montgomery. (Page 43 paragraph 2).*

Response:

The estimates of annual Texas deliveries in Figure 7.4 of the Brandes report are not reasonable estimates of deliveries to water users in Texas. The estimates of annual Texas deliveries generally represent the flow at El Paso adjusted to include Canutillo wellfield pumping and exclude Acequia Madre diversions. As such, these estimates overstate Texas deliveries because they are not reduced for the substantial conveyance losses between the El Paso gage and the Texas farm headgates and the EPW diversion points.

Brandes Opinion 20 *– The double-mass analysis approach has been applied to the historical total Project water deliveries to Texas to assess apparent changes in historical delivery patterns relative to releases from Caballo Reservoir. As shown in Figure 7.5, the curve represented by the historical data on the graph exhibits the same downward change in slope during the early 1950s as depicted on the double-mass graph for deliveries to farms in New Mexico in Figure 7.2. Again, more likely than not this is indicative of the effects of groundwater pumping that began about this same time in the Rincon and Mesilla basins for irrigation of farms in New Mexico. The deviation of the curve represented by the Texas total historical deliveries data (green squares) after 1950 from the extension of the 1938-1950 data curve out to 2016 (red dashed line) demonstrates that there was less water delivered to Texas relative to the releases from Caballo Reservoir. The total reduction in the total deliveries for the 1951-2016 period is about 2,400,000 acre-feet, which translates to an average annual reduction in deliveries of 39,689 acre-feet per year. Whether these reductions in deliveries to Texas are directly attributable to the effects of groundwater pumping in the Rincon and Mesilla basins of*

New Mexico may not be clearly established with this demonstration; however, the trend of reduced deliveries after groundwater pumping began in the late 1950s certainly is consistent with the reductions in the Rio Grande flows at El Paso. Based on these trends, one would conclude more likely than not that groundwater pumping in the Rincon and Mesilla basins played a major role in adversely affecting deliveries of Project water to Texas. (Page 45 paragraph 2).

Response:

The alleged reduction in Texas deliveries of 39,689 AF/y described in the report text does not match the 37,689 AF/y reduction shown on Figure 7.5.

The previously described issue with use of Elephant Butte Reservoir releases during 1930 - 1937 affects the projection of the 1930 - 1950 data in Figure 7.5 (dashed red line). As previously stated, a double-mass curve can illustrate a change in the relationship between two variables (in this case reservoir releases and Texas diversions); however, it does not provide information on the cause(s) of the change. Dr. Brandes admits that the curve in Figure 7.5 does not clearly establish that the reductions in Texas diversions are caused by New Mexico pumping. As described above, there are many factors other than New Mexico pumping that may have affected downstream water supplies relative to Caballo releases, and these factors would have also affected Texas diversions.

A robust model capable of simulating the dynamic response of the Project to changes in historical conditions is necessary to assess the effects of New Mexico pumping, Texas pumping, or other operations on diversions by Texas and deliveries to Texas farms.

Brandes Opinion 21 *– The deliveries of Project water to Texas that would have occurred in the absence of these apparent effects of groundwater pumping can be derived from the incremental annual increases in the projected extension of the 1938-1950 data curve from 1950 out to 2016 (red dashed line) in Figure 7.5. The resulting annual Texas deliveries without the effects of groundwater pumping are plotted on the bar chart in Figure 7.6 along with the corresponding historical Texas deliveries. As shown, the total deliveries to Texas without the effects of groundwater pumping generally are greater than the historical deliveries, thus demonstrating the adverse impacts of groundwater pumping. As discussed above, the average reduction in Texas deliveries from the projected deliveries without the effects of groundwater pumping in the Rincon and Mesilla basins is about 40,000 acre-feet per year. Since both the historical delivery values and the projected delivery values without groundwater pumping reflect the underlying calculation approach for estimating the historical deliveries of Project water in the El Paso Valley, any inherent uncertainties in this approach are embedded in both sets of total deliveries, which* *suggests that the calculated annual differences between the two sets of total delivery values are likely unaffected by these uncertainties. (Page 45 paragraph 3).*

Response:

Similar to the above criticisms of Figure 5.5 in the Brandes Report, the annual differences between the historical Texas deliveries (actually diversions as described above) and the estimated deliveries without pumping do not make sense in the context of the Project supply conditions. For example, there are significant differences between the green bars and orange bars in each year from 1979 - 1985 and yet these were full supply years under the Project, and Texas would have received the same full allocation with or without the effects of pumping. Further, during 1979 - 1985 EPCWID's Project water deliveries averaged approximately 58,000 AF/y less than its average annual allocation (see **Table 4-3**). During these full supply years that EPCWID left substantial portions of its annual allocations unordered and unused, it is unreasonable to claim that Texas deliveries were being impacted by New Mexico pumping. The annual effects of pumping on Texas deliveries allegedly shown in Figure 7.6 of the Brandes Report are not consistent with the expected response of the Project to changes in supply, and therefore the annual differences in the bars in Figure 7.6 are not reasonable or reliable indicators of the impact of New Mexico pumping on Texas deliveries or diversions.

I disagree that cancelling of errors in the method used to compute the Texas deliveries causes the results to be unaffected by the errors. Cancelling of errors does not relieve the method of its deficiency in not considering the conveyance losses in delivering water to Texas farmers. There is also the problem of the 1930 - 1950 projection line being skewed by the use of Elephant Butte Reservoir releases. Finally, the 1930 - 1950 projection line inherently assumes there is no variability in the straight-line accumulation of annual values in the dashed red line in the double-mass plot in Figure 7.5. The lack of variation in the dashed red line compared to the inherent annual variability in the green squares likely introduces significant error when deriving annual values from the differences between the projected 1930-1950 line and the accumulation of actual values in the green squares.

12.0 RESPONSE TO MONTGOMERY AND ASSOCIATES REPORT

Staffan W. Schorr and Colin P. Kikuchi, Ph. D. of Montgomery & Associates ("M&A") prepared a May 31, 2019 expert report on behalf of the State of Texas entitled, *Water Budget Estimates in Support of Groundwater Model Development: Rincon and Mesilla Basins, New Mexico, Texas, and Northern Mexico, 1938 Through 2016* ("M&A Report"). Information in the M&A Report was used for three primary purposes. First, M&A compiled much of the hydrologic and water use data for the study area into a database for use by the other Texas experts. Second, M&A prepared water budgets for the Rincon and Mesilla basins for the period from 1938 - 2016 period for the purpose of estimating certain inputs for the Texas Model, including irrigation pumping, and return flows from irrigation and non-irrigation uses. Finally, M&A prepared a water budget analysis of irrigation operations in the El Paso Valley in Texas that was used in analysis of alleged damages to Texas from water quality impacts caused by New Mexico pumping during the period from 1985 - 2016.

SWE was asked by legal counsel for New Mexico to review the water budget analyses and data compilations presented in the M&A Report to identify information or opinions that we disagreed with, and to prepare expert opinions to respond to these issues. We attempted to identify and respond to all substantive issues in which there appeared to be differences of opinion, however a lack of response to a particular issue should not be interpreted as tacit agreement with the opinions in the M&A Report.

***M&A Opinion 1** – I prepared separate water budgets for Rincon Basin and Mesilla Basin because the basins are separated by a bedrock constriction, which limits the hydrologic connection between the basins. The overall water budget for each basin comprises three types of budgets: Land-Surface Water Budget, Surface Water Budget, and Groundwater Budget. I used this approach to facilitate budget development by compartmentalizing common components. (Page 3 paragraph 2 and 3).*

Response:

The Montgomery water budget analyses provide comprehensive and detailed accounting of the inflows and outflows of (a) the Land Surface system, (b) the Surface Water system, and (c) the Groundwater system using actual data, estimated data, and water balances, and other calculation and modeling techniques. Certain of the computed water budget terms were used as inputs to the Texas Model and these were the focus of our review of the M&A analyses.

In all water budget analyses the sum of the inflows minus the sum of the outflows equals the change in storage. For the Land Surface Budget, this would be the change in soil moisture storage. For the Ground Water Budget this would be the change in ground water storage in the subsurface aquifers. In the Surface Water Budget, there are no changes in storage at the monthly time scale the budgets were prepared, and there are no reservoirs simulated (Elephant Butte Reservoir and Caballo Reservoirs are upstream of the geographical areas included in the water budget analyses).

Figure 12-1 through **Figure 12-3** summarize the computed average annual values for each of the water budget terms in the M&A Land-Surface Budget, Surface Water Budget, and Groundwater Budget, respectively. Positive values (bars to the right) represent inflows to the system and negative values (bars to the left) indicate outflows from the system. Changes in storage are shown as positive or negative as appropriate.

The bars in **Figure 12-1** through **Figure 12-3** are color-coded in relation to whether and how each of the water budget terms are used in the Texas Model.

- Blue bars – Model inputs that do not change in the reduced pumping model runs.
- Red bars – Model inputs that change in the reduced pumping model runs.
- Yellow bars – Quantities that are simulated in the model.
- Black bars – Quantities that are neither input to or simulated in the model.

For the water budget values that are inputs to the model, the abbreviations at the end of the bars indicate the whether the values are input through the MODFLOW WEL Package as cell-by-cell inputs or through the MODFLOW SFR Package as stream segment inputs.

The size of the bars gives an indication of the relative significance of the water budget terms to the three water budgets and to the modeling. The colors of the bars reflect the importance of the terms to the modeling of alternative scenarios. Model inputs that are changed between model runs (red bars) or are simulated in the model (yellow bars) are most significant. Model inputs that do not change between runs are less significant because they have little effect on the simulated differences between model runs. Obviously, the quantities that are not input or simulated in the model (black bars) are of least importance in the modeling. Note that while the on-farm consumptive use is not simulated in the model, the specified amount of consumptive use in the Land Surface Budget affects the computed pumping and irrigation returns flows (deep percolation and surface runoff) that are inputs to the Texas Model.

***M&A Opinion 2** – A farm water budget analysis was conducted to estimate monthly farm deep percolation and agricultural applied groundwater pumping in each basin (Rincon* *basin and Mesilla basin). In addition, estimates for change in agricultural soil moisture storage and agricultural surface water return flows were also determined by the farm water budget analysis. (Page 16 paragraph 1).*

Response:

The M&A Farm Budget Model was used to compute inputs to the Texas Model for applied ground water pumping for irrigation, and on-farm deep percolation and surface runoff from irrigation in the Rincon and Mesilla basins. The Farm Budget analysis was performed for the period from 1938 - 2016 using a monthly timestep. The monthly results were aggregated to annual values for input to the Texas Model which has annual stress periods.

The M&A Farm Budget Model is similar to the SWE CFB Model (and to the almost identical RiverWare farm budget algorithm) in that both models use a mass balance water budget approach to simulate the on-farm water deliveries, consumptive use, soil moisture storage, and irrigation return flows. In addition, supplemental pumping is assumed to meet unmet irrigation demands after commencement of widespread irrigation pumping in the Rincon basin and Mesilla basin. While there are similarities in the farm budget simulations, there are also some significant differences in model inputs and processes that result in material differences in the farm budget model outputs for irrigation pumping and on-farm irrigation losses due to deep percolation and surface runoff.

M&A Opinion 3 *– A soil water balance model was developed to estimate agricultural groundwater pumping and deep percolation over the time period of interest, 1938 through 2016. The model tracks soil moisture within the maximum extent of irrigated agricultural lands of the Rincon and Mesilla basins on a monthly time step. Four separate models were developed for this analysis: lands inside District boundaries in Rincon Basin, lands outside District boundaries in Rincon Basin, lands inside District boundaries in Mesilla Basin, and lands outside District boundaries in Mesilla Basin. The models follow identical governing equations and differ only in their respective data inputs. (Page 19 paragraph 1).*

Response:

The soil water balance model developed by M&A is a complex, non-linear iterative model. Inputs to the model include precipitation, applied surface water, and ground water pumping; and outputs consist of crop evapotranspiration (“ET”), deep percolation (“DP”), and soil moisture storage. The crop evapotranspiration and deep percolation are computed as functions of the soil moisture storage, and the soil moisture storage depends on the computed ET and DP. Because of these interdependencies, an iterative simulation process is performed in the model to simultaneously solve for the ET, DP, and soil moisture in each monthly stress period.

The soil water balance model simulates “virtual fields” for the Rincon basin and the Mesilla basin (including the Texas portion of the Mesilla basin) that are intended to represent aggregations of all the fields in each basin. Each virtual field is simulated as if it was a gravity-irrigated field as illustrated in Figure 2.3 of the M&A Report. Applied irrigation water (surface water and pumped ground water) is assumed to be introduced at the top of the field (left side in Figure 2.3) and assumed to flow across the virtual field to the bottom of the field (right side in Figure 2.3). Because irrigation water is present at the top of the field longer than at the bottom of the field, the soil water balance model simulates more infiltration of surface water at the top of the field than at the bottom of the field. Thus, the top of the virtual field can be adequately irrigated to bring the soil moisture to a level sufficient to avoid crop stress and meet the full ET demand of the crop, while the lower portion of the field can be insufficiently irrigated resulting in crop stress and a reduction in crop ET.

There are two time-series ET inputs to the soil water balance model that come from Land IQ. The first is the crop-weighted average theoretical ET computed as the reference ET multiplied by crop coefficients obtained from various references. The crop coefficients used by Land IQ were not locally calibrated. The second is an adjusted ET that is roughly 30% less than the theoretical ET until about 1970, with the adjustment transitioning to no adjustment by about 1990.

The parameterization of the soil moisture distribution under each virtual field is adjusted in the M&A soil water balance model during each month of the study period so that the simulated soil moisture across the virtual field is at the levels necessary for the computed aggregate ET to match the adjusted ET from Land IQ. Before 1970, when the target ET for most crops is 30% lower than the theoretical ET, the soil water balance model is calibrated to simulate substantial soil moisture stress in order for the simulated ET to match the target ET. The simulated soil moisture stress is gradually reduced during 1970 - 1990 as the adjusted ET from Land IQ transitions to the full theoretical ET. After that time, there is little or no simulated soil moisture stress and therefore the ET computed in the soil water balance model reaches the full theoretical ET across the entire virtual field.

There are five soil moisture states that represent important soil moisture thresholds in the root zone of an irrigated crop. These soil moisture thresholds are listed below in order from low to high soil moisture levels:

- <ins>Residual Moisture</ins> – Lowest soil moisture level.

- Wilting Point – Soil moisture level below which the crop is incapable of extracting water through the roots.
- Critical Moisture – Soil moisture level below which the crop will begin to experience stress and a reduction in ET.
- Field Capacity – Approximately maximum soil moisture content that can be retained in the soil against gravity. This typically occurs within a few days after a thorough irrigation or heavy precipitation event after gravity drainage of moisture stored temporarily above the field capacity level.
- Porosity – Maximum soil moisture content in which the soil is saturated and virtually all of the pore spaces between the soil particles are filled.

As described above, the soil water balance model simulates a continuous range of soil moisture across each virtual field creating sufficient stress (or no stress) so that the simulated aggregate ET matched the adjusted ET values from Land IQ. The model generally simulates less soil moisture stress through time as the adjusted ET values become closer to the theoretical ET values.

Figure 12-4 and **Figure 12-5** contain graphs that show the simulated monthly soil moisture in the Rincon and Mesilla virtual fields during the 1938 - 2016 study period. Each graph contains five dotted horizontal lines that represent the five soil moisture states referenced above. The solid black line represents the simulated maximum soil moisture level (θmax) at the top of the virtual field where infiltration would be greatest. The solid grey line represents the simulated minimum soil moisture level (θmin) at the bottom of the virtual field where infiltration would be least. The solid red line is the simulated average soil moisture across the virtual field (θavg).

The graphs for the simulated virtual fields representing the Rincon basin and Mesilla basin are generally similar. The following observations regarding the soil water balance model simulation of the Mesilla virtual field illustrated in **Figure 12-5** are also generally applicable to the simulation of the Rincon virtual field.

1. Maximum Soil Moisture – The simulated maximum soil moisture at the top of the field (black line) fluctuates from month to month, but remains well above the field capacity of the soil, and often reaches the total porosity of the soil. This result is nonsensical as the soil moisture in the root zone of a crop cannot physically remain above field capacity for more than a few days after an irrigation. The soil water balance model simulates the soil moisture at the top of the virtual field well above field capacity for the entire 1938 - 2016 simulation period.

2. Minimum Soil Moisture – The simulated minimum soil moisture at the bottom of the field (grey line) fluctuates from month to month, but remains below the wilting point through the mid-1980s. This is also nonsensical as it indicates that prior to the mid-1980s, significant portions of the fields in the Mesilla basin never had sufficient soil moisture to produce any ET. In other words, the crops were dead in those portions of the fields.
3. Average Soil Moisture – The average soil moisture fluctuates between field capacity and the critical level until around 1970. After that time, the average soil moisture begins fluctuating above field capacity for months at time through about 1985 and then generally remains continuously above field capacity through the remainder of the study period. As described above, this result in nonsensical.

The soil moisture conditions simulated in the M&A soil water balance model are illustrated in another form in the graphs presented in **Figure 12-6**. These figures show the simulated soil moisture conditions across the virtual field from top to bottom for an entire year at 10-year intervals from 1945 - 2015. There are four charts on each page and each chart shows the conditions for a three-month period – Jan-Mar, Apr-Jun, Jul-Sep, and Oct-Dec. The solid lines in each chart display the simulated soil moisture, which is highest at the top of the field and lowest at the bottom of the field. Note that the vertical axis for the soil moisture is reversed so as to intuitively mirror the infiltration of water below the ground surface. For reference, each chart includes horizontal dashed black and grey lines that depict the five key soil moisture states described above.

Also shown in each chart is the simulated crop stress coefficient (Ks) for each month across each virtual field, represented as dotted lines that are read on the right axis. The soil moisture water balance model simulates soil moisture stress when the simulated soil moisture falls below the critical level. The stress coefficient decreases linearly from 1.0 at the critical soil moisture to 0.0 at wilting point. When the stress coefficient is at 1.0, the ET simulated in the soil water balance model is at the full theoretical value, and when the stress coefficient is at 0.0 the simulated ET is zero.

The following are observations of the conditions during the principal growing season (April - September) in decadal interval charts presented in **Figure 12-6**.

- 1945 - 1965: 40% of the field is above field capacity, 60%-70% of the field is above critical soil moisture with no stress and full theoretical ET. 10%-20% of the field is in a stressed condition with reduced ET. 20% of the field is at or below wilting point, indicating the crop is dead.
- 1975: 40%-50% of the field is above field capacity, 65%-75% of the field is above critical soil moisture with no stress and full theoretical ET. 10%-20% of the field is

in a stressed condition with reduced ET. 20% of the field is at or below wilting point, indicating the crop is dead.

- 1985: 60% of the field is above field capacity, 85% of the field is above critical soil moisture with no stress and full theoretical ET. 10%-15% of the field is in a stressed condition with reduced ET. 5% or less of the field is at or below wilting point, indicating the crop is dead.
- 1995 - 2015: 70% of the field is above field capacity, 95% or more of the field is above critical soil moisture with no stress and full theoretical ET. 5% or less of the field is in a stressed condition with reduced ET. None of the field is at or below wilting point.

The results from the M&A soil water balance model are nonsensical because they depict simulated conditions that are physically impossible and contrary to the conditions that would be expected to exist in a productive and well-managed irrigation district like EBID in the Rincon and Mesilla basins. As described above, it is physically impossible for the moisture content in the crop root zone of a well-drained soil to be above field capacity for more than a few days after an irrigation. It is also wholly unreasonable for 20% of the virtual field representing all fields in the Mesilla basin to be under soil moisture stress and another 20% of the virtual field to be dead during all simulated years through about 1970. This would reflect a level of irrigation incompetence that is not consistent with (a) farmers whose livelihood depends on their work, and (b) the adequate water supply that existed between the available Project supply and the supplemental ground water available to most farmers.

M&A Opinion 4 *– Annual surface water deliveries to farms (farm deliveries) and agricultural groundwater pumping in Rincon and Mesilla basins are shown on Figures 2.9 and 2.10, respectively. Agricultural groundwater pumping in Rincon and Mesilla basins varied through time depending principally on surface water availability. Groundwater pumping generally increased during years when surface water deliveries were low, and vice versa. The largest groundwater withdrawals occurred during the early to mid-1950s, and from 2003 through 2016, when surface water deliveries to farms were small for many consecutive years. The smallest amount of groundwater pumping occurred during the period of full Project allotment from 1979 through 2002. (Page 45 paragraph 2 and 5).*

Response:

Figure 12-7 through **Figure 12-9** summarize and compare various annual values from the M&A Farm Budget Model and the SWE CFB Model. One of the key outputs from the models is the simulated pumping, as the effects of ground water pumping are a primary focus of the case. The differences in the simulated annual pumping in large part reflect the aggregation of all differences in input data and computational methods into a single result. This is because pumping to compute the unmet demand after applied surface water is one of the last steps in both the M&A Farm Budget Model and the SWE CFB Model.

The simulated annual pumping volumes from the M&A Farm Budget Model and the SWE CFB Model for the Rincon and Mesilla basins combined are shown in **Figure 12-7**. The simulated annual pumping in the SWE CFB Model exceeds the pumping in the M&A Farm Budget Model in most years until the early 1980s when the results flip and the M&A Farm Budget Model pumping exceeds the SWE CFB Model pumping in most years through the remainder of the study period.

Most of the differences in the outputs from the M&A Farm Budget Model and the SWE CFB Model, including the differences in pumping, are due to differences in the following:

- Irrigated area,
- Crop evapotranspiration,
- Farm headgate deliveries,
- On-farm seepage losses, and
- Soil moisture simulation procedure.

The M&A Farm Budget Model includes two soil water balance models for each simulated region (e.g., two models for the Mesilla basin Project lands). One model simulates irrigation and evapotranspiration for the cropped area that is being actively irrigated, and another model simulates bare soil evaporation in the non-cropped or fallowed area.

The simulated cropped area varies from month to month depending on the monthly ET for each crop. If there is no ET demand (i.e., during the early spring before the crop has been planted or during the fall and winter after the crop has been harvested) M&A assumed the crop was not irrigated (with some exceptions for simulated pre-irrigation). The land associated with a crop is in the crop model if it is being irrigated and in the non-crop model if it is not being irrigated. As a result, the simulated area in the crop model is highest in the middle of the irrigation season and lowest or zero in the winter. As the simulated irrigated area changes through the year, the simulated soil moisture is transferred between the two soil water balance models based on changes in the overlying areas. When the cropped area increases from one month to the next, a portion of the non-cropped soil moisture is moved to the irrigated model, and when the cropped area decreases, a portion of the cropped area soil moisture is moved to the non-irrigated model.

The upper right chart in **Figure 12-8** compares the sum of the maximum monthly cropped areas in each year in the Rincon and Mesilla basins in the M&A Farm Budget Model to the comparable annual irrigated areas in the SWE CFB Model. The total crop area for the Rincon and Mesilla basins is generally higher in the M&A Farm Budget Model than in the SWE CFB Model until about 1977, when the comparison flips and the area in SWE CFB Model is higher than the M&A Farm Budget Model through the end of the study period.

The upper left chart in **Figure 12-8** compares the simulated annual ET of applied water in M&A Farm Budget Model against the annual values from the SWE CFB Model. There are two lines for the M&A Farm Budget Model values shown in **Figure 12-8**. The solid line reflects the ET of applied water during the growing season for each crop and the dotted line reflects the addition of computed ET on bare ground outside of the growing season within the annual irrigated acreage for each year. This adjustment was made to make the M&A figures more comparable to the SWE values obtained from DE that also included bare ground ET outside of the growing season.

The difference between the M&A and SWE lines in **Figure 12-8** reflect differences in irrigated area, cropping pattern, unit crop ET values, and other factors. The annual ET of applied water in the M&A Farm Budget Model is generally greater than the annual values in the SWE CFB Model through 1984. From 1985 through the end of the study period, the ET of applied water is greater in the M&A Farm Budget Model during most years and this is the primary reason that the pumping in the M&A Farm Budget Model is also greater during this period.

The lower left chart in **Figure 12-8** compares the area-weighted annual unit crop ET for the Rincon and Mesilla basins for the M&A Farm Budget Model and the SWE CFB Model. The unit ET for the M&A Farm Budget Model was computed as the simulated annual ET volume (shown in the upper left chart in **Figure 12-8**) divided by the simulated maximum monthly irrigated area in that year (upper right chart in **Figure 12-8**). As for the upper left chart, there are two lines for the M&A values. The solid line is the computed weighted average ET for the crop ET and the dotted line adds the additional ET on bare ground within the annual irrigated area. The differences in the annual unit ET values reflect the combination of differences in the unit ET values for the individual crops and differences in the annual crop mix. The unit ET values in the M&A Farm Budget Model are less than in the SWE CFB Model until the mid-1980s, and more than in the SWE CFB Model thereafter.

The lower right chart in **Figure 12-8** summarizes the annual FHG delivery inputs to the M&A Farm Budget Model and the annual totals for the SWE CFB Model. The FHG deliveries are very similar between the two models through 1979, after which there are some differences. The post-1979 differences in FHG deliveries are due to differences in how the EPCWID delivery totals were disaggregated between the El Paso Valley and the Texas Mesilla areas. M&A disaggregated the EPCWID deliveries based on irrigated area, and SWE disaggregated the deliveries based on diversions. On average, the M&A farm headgate deliveries are 4% greater than the SWE farm headgate deliveries during the 1985 - 2016 period.

Another difference between the M&A Farm Budget Model and the SWE CFB Model involves an assumption regarding on-farm conveyance losses. M&A assumed a 10% on-farm conveyance loss, and so the surface water applied to the fields was specified as 90% of the FHG deliveries. The SWE CFB Model does not explicitly simulate on-farm seepage losses, but rather any such losses are incorporated in the specified MFE that is part of the irrigation simulation procedure in the SWE CFB Model. Note that the M&A FHG deliveries shown in the lower right chart in **Figure 12-8** are before the 10% on-farm conveyance loss.

The SWE CFB Model and the RiverWare Model both employ a widely used water balance process that simulates the process of delivering irrigation water to the field, limiting the amount of water made available for crop water consumption based on a specified maximum farm irrigation efficiency, and simulating storage of irrigation water in the soil moisture reservoir underlying the field for later use when the surface water supply is inadequate. The simulation algorithm in the SWE CFB Model is described in more detail in Section 6.

Figure 12-9 compares the simulated deep percolation and surface runoff from irrigation in the Rincon and Mesilla Valleys The deep percolation is less in the M&A Farm Budget Model than in the SWE CFB Model before the mid-1980s, and then becomes roughly comparable thereafter. Conversely, the surface runoff in the M&A Farm Budget Model is much greater than in the SWE CFB Model.

M&A Opinion 5 *– A non-farm water budget analysis was conducted to estimate consumptive use, runoff, and deep percolation for urban and non-urban (upland watershed) areas in the Rincon and Mesilla basins, based on measured or estimated water supply and wastewater discharges. Non-farm lands in the study area include urban areas and undeveloped areas consisting primarily of native vegetation. The non-farm water budget is subdivided into urban lands and upland areas that are not classified as farm (agricultural) or urban (i.e., watershed area minus farm and urban areas) (Figure 2.1). The urban water budget is evaluated by water source: applied water and precipitation water. The applied water budget analysis is based on measured or estimated groundwater withdrawals (pumping), measured or estimated wastewater discharges, and estimates for consumptive use and deep percolation. The precipitation water budget analysis uses monthly precipitation and estimates for consumptive use (i.e., effective urban precipitation) and runoff to estimate urban deep percolation of precipitation. Use of* *surface water deliveries for non-farm purposes is minor compared to groundwater use and considered negligible for this analysis. (Page 16 paragraph 1 and Page 52 paragraph 1).*

Response:

The M&A Non-Farm Water Budget analyses were also performed for the period from 1938 - 2016 using a monthly timestep with certain results aggregated to annual values for input to the Texas Model.

The M&A Urban Applied Water Budget was used to prepare inputs to the Texas Model for applied ground water pumping for urban and domestic uses, wastewater treatment plant discharges, and urban deep percolation from applied water. While SWE did not prepare a full urban applied water budget, data were compiled or estimated for urban and domestic pumping, WWTP discharges, and urban deep percolation for the entire LRG Area, including the Rincon and Mesilla basins. Several charts were prepared to compare the values used in New Mexico's ILRG Model to the comparable values developed by M&A for the Texas Model as shown in **Figure 12-10**.

The upper left chart in **Figure 12-10** compares the urban and domestic pumping in the Rincon basin and Mesilla basin that were input to the ILRG Model against the values used in the Texas Model. The urban and domestic pumping volumes in the Rincon and Mesilla basins are similar between the Texas Model and the ILRG Model, with slight variations throughout the study period.

The upper right chart in **Figure 12-10** compares the WWTP discharges input to the ILRG Model in the Rincon basin and Mesilla basin against the values used in the Texas Model. The annual WWTP discharges simulated in the ILRG Model average approximately 1,300 AF more than the values used in the Texas Model. The reason for the difference is that (a) the ILRG Model includes estimates of El Paso Electric WWTP discharges prior to the records that begin in 2004 while the Texas Model does not and (b) the ILRG Model uses actual records of Las Cruces WWTP discharges while the Texas Model uses estimates.

The lower left chart in **Figure 12-10** compares the estimated urban deep percolation inputs for the ILRG Model in the Rincon and Mesilla Valleys against the values input to the Texas Model. On average, the urban deep percolation in the Rincon and Mesilla basins is approximately 5,300 AF/y greater in the Texas Model than the ILRG Model, and the Texas Model shows more variability than the ILRG Model throughout the study period. Reasons for differences between the urban deep percolation estimates are generally two-fold. First, the Texas Model estimates reflect an assumption that all pumping from the Canutillo wellfield is used locally in the Texas portion of the Mesilla basin compared to the values for the ILRG Model that are based on estimates of urban deep percolation from all the EPW supplies distributed evenly across all of the EPW service area. Second, the values for the Texas Model were computed as a residual in an urban water budget calculation compared to the values for the ILRG Model that were computed based on percentages of non-irrigation water use.

The M&A Urban Precipitation Water Budget was used to estimate the urban precipitation runoff and urban deep percolation of precipitation that were input to the Texas Model. The lower right chart in **Figure 12-10** shows the annual urban precipitation runoff and deep percolation values that were input to the Texas Model. While the ILRG Model does not simulate urban precipitation runoff and deep percolation, this not a substantive deficiency for two reasons. First, the combined urban precipitation runoff and deep percolation represents only 0.1% of the total input to the Texas Model. Second, these inputs are not varied in the alternative model runs involving changes in pumping. As a result, the presence or absence of simulated urban precipitation runoff and deep percolation will have very little or no effect on the computed differences between the alternative model runs.

M&A Opinion 6 – *Tributary inflows represent the volume of water that flows into the Rio Grande from ephemeral streams as a result of stormwater runoff in the upland areas of the study area. The watersheds that contribute flow to the Rio Grande were taken from a 1996 study by the U.S. Army Corps of Engineers. The majority of tributary arroyos in Mesilla Basin do not contribute runoff discharges to the Rio Grande. Contributing watersheds in each basin are shown on Figure 3.4. Watershed runoff models require detailed streamflow data and information on physical characteristics for drainages and sub-watersheds. The lack of streamflow gages on the majority of drainages to the Rio Grande within the study area prevents the use of surface water modeling for determining tributary runoff for this water budget. Because of this limitation, we estimated runoff as a percentage of the precipitation falling on the contributing watersheds. Tributary inflow was assumed to be three percent of precipitation, based on results of a rainfall-runoff study conducted by Stone and Brown (1975) in a small semiarid watershed in the Jornada Basin in New Mexico. Annual tributary inflows in Rincon and Mesilla basins are shown on Figure 3.5. The estimated average annual tributary flows are about 5,500 AF in Rincon Basin and about 100 AF in Mesilla Basin. (Page 72 paragraph 1, 2, 4 and Page 74 paragraph 2).*

Response:

Precipitation runoff from undeveloped areas as a percentage precipitation can vary widely depending on slope, soils, vegetation cover, precipitation intensity and other factors. The estimate of 3% runoff from the PRISM precipitation data, while not unreasonable, should be considered approximate and having substantial uncertainty.

The estimated average annual tributary inflows from upland areas totaling 5,600 AF/y for the Rincon and Mesilla basins represents only 0.2% of the simulated average annual inflows to the Texas Model. Also, similar to the urban precipitation runoff and deep percolation, the tributary inflows from upland areas do not vary in the alternative runs of the Texas Model and therefore have little or no effect on the computed differences between the model runs.

M&A Opinion 7 *– Natural aquifer recharge in the Rincon and Mesilla Basins principally occurs as mountain-front recharge along the basin margins near the lateral extent of the Santa Fe Formation. Recharge occurs where runoff from precipitation in the upper portions of the watershed infiltrates into the basin alluvium deposits. Mountain-front recharge in the United States portions of the study area was evaluated using the Hearne-Dewey (1988) regression equation for mean annual recharge of a tributary basin. The Hearne-Dewey regression equation was developed, based on data for 16 basins in northern New Mexico, to estimate average annual basin water yield based on winter precipitation, basin slope, and basin area. The Hearne-Dewey (1988) regression analysis yielded mountain-front recharge rates of about 9,360 AF/year and 5,430 AF/year for the Rincon and Mesilla basins respectively. (Page 97 paragraph 3 and Page 99 paragraph 3).*

Response:

The M&A estimates of mountain front recharge are input as specified inflows around the lateral boundaries of the Texas Model. A comparison of the annual M&A mountain front recharge estimates against the annual mountain front recharge in the Rincon and Mesilla basins in the ILRG Model is provided in **Figure 12-11**.

The annual combined mountain-front recharge for the Rincon and Mesilla basins in the ILRG Model averages 15,700 AF during 1951 - 2016 compared to 14,800 AF in the Texas Model. Given that the average difference of 900 AF/y is only 0.03 % of the total inflows to the Texas Model and the mountain front recharge is not varied in alternative model runs, the differences in mountain front recharge between the Texas Model and the ILRG Model is not significant.

M&A Opinion 8 *– I was asked by counsel to develop farm water budget for two agricultural districts located in El Paso Valley, Texas to support economic analyses by Dr. David Sunding and Dr. Lydia Dorrance. The two districts are El Paso County Water Improvement District #1 (EPCWID#1) and Hudspeth County Conservation and Reclamation District 1 (HCRRD1). EPCWID#1 has lands in both Mesilla Basin and El Paso Valley; this* *farm budget considers only the portion of EPCWID#1 located in El Paso Valley. For the analysis, a farm water budget was developed for agricultural lands in EPCWID#1 and HCRRD1 with the principal goals of estimating (1) agricultural groundwater pumping for irrigation and (2) deep percolation beneath agricultural fields. Due to the lack of historic direct measurements of agricultural applied groundwater (pumping) and agricultural deep percolation, soil water balance models were used to estimate these components, along with surface runoff and soil moisture changes on agricultural lands. The soil water balance models were developed and implemented using GoldSim simulation software. Model results were used to prepare the farm water budgets for EPCWID#1 and HCRRD1. (Appendix G, Page 1, Paragraph 1).*

Response:

The monthly farm budget analyses prepared by M&A for the EPCWID (El Paso Valley) and the HCCRD (a.k.a. HCCRD1) for the period from 1985 - 2016 utilized the same soil water balance model as was used for the farm budget analyses of the Rincon and Mesilla basins. These farm budget analyses were compared to the SWE CFB Model analyses for the same areas to assess differences between the input data and results. The farm budget inputs and outputs during the 1985 - 2016 study period are compared in **Figure 12-12** through **Figure 12-14** for the El Paso Valley and **Figure 12-15** and **Figure 12-16** for the HCCRD.

El Paso Valley

Figure 12-12 compares the computed annual supplemental pumping in the M&A Farm Budget Model to the comparable values from the SWE CFB Model during the 1985 - 2016 period. The annual pumping in the M&A Farm Budget Model averages about 78,900 AF compared to an average of 14,300 AF in the SWE CFB Model, a difference of about 64,700 AF. The differences in supplemental pumping are due largely to differences in the ET of applied water between the models.

The simulated pumping in the M&A Farm Budget during the full supply years from 1985 - 2002 is unrealistically high considering the following:

- Full Project water allocations made by Reclamation (see **Table 4-3**),
- Unused EP1 allocations (see **Table 4-3**),
- High FHG deliveries per acre (see **Figure 5-12**), and
- High operational waste through this period (see **Figure 5-23**).

The upper right chart in **Figure 12-13** compares the maximum annual cropped area in the El Paso Valley in the M&A Farm Budget Model to the annual irrigated area in the SWE CFB

Model. The M&A Farm Budget Model simulates much greater irrigated area than the SWE CFB Model until the last ten years when the values are similar. On average, the M&A Farm Budget Model acres for the El Paso Valley are about 14% greater than SWE CFB Model acres.

The irrigated area figures used in the M&A Farm Budget Model were provided by Land IQ. Based on review of the Land IQ data files, it seems possible that the irrigated area data that M&A used for the El Paso Valley portion of EPCWID may also include the EPCWID irrigated area in the Texas portion of the Mesilla Valley. This would explain most of the difference in irrigated area between the models in the El Paso Valley.

The upper left chart in **Figure 12-13** compares the annual ET of applied water in the El Paso Valley. The annual ET of applied water in M&A Farm Budget Model is much larger than the SWE CFB Model values throughout the 1985 - 2016 period, averaging about 47% more. In some years, the ET of applied water in the M&A Farm Budget Model is almost double the SWE CFB Model values. The differences are due largely to differences in irrigated area, unit crop ET, and cropping pattern.

The lower left chart in **Figure 12-13** compares the area-weighted annual unit crop ET in the El Paso Valley for the M&A Farm Budget Model and the SWE CFB Model. The differences in the unit crop ET reflect the combined differences in cropping pattern and the unit irrigation requirements of the individual crops. The unit ET for the M&A Farm Budget Model was computed as the annual ET of applied water volume (shown in the upper left chart in **Figure 12-13**) divided by the maximum monthly irrigated area in that year (upper right chart in **Figure 12-13**). The unit ET values in the M&A Farm Budget Model average almost 30% greater than the SWE CFB Model values during 1985 - 2016.

The lower right chart in **Figure 12-13** compares the annual FHG delivery volumes that are simulated in the M&A Farm Budget Model of the El Paso Valley to the SWE CFB Model values. On average, the FHG deliveries in the M&A Farm Budget Model are about 11% less than the values in the SWE CFB Model. It appears that the reported 2010 FHG deliveries for the El Paso Valley may be in error. If these are corrected, the average difference will be larger than 11%.

A closer look at the differences in the annual FHG deliveries is shown in **Figure 12-14**. The small differences in FHG deliveries that are present from 1985 - 2008 are due to differences in how the records of total Eastside Canal and Westside Canal FHG deliveries were disaggregated between EBID and EPCWID. SWE disaggregated the FHG deliveries based on relative diversions and M&A disaggregated the deliveries based on relative irrigated area.

After 2008, the differences in FHG deliveries are more substantial, and except for 2010, in which the data used by M&A appear to be in error[7], the M&A FHG deliveries are much less than the SWE FHG deliveries. During this time (except for 2010), there are no FHG delivery data for the El Paso Valley or for EPCWID. SWE estimated the FHG deliveries after 2008 for the El Paso Valley based on the reported monthly El Paso Valley diversions reduced by monthly average conveyance loss percentages derived from historical records. M&A estimated the missing data by first estimating the Texas Mesilla FHG deliveries from data and estimates of EBID FHG deliveries, then extrapolating the estimated Texas Mesilla FHG deliveries to total EPCWID FHG deliveries, and finally pro-rating those values to estimates of the El Paso Valley FHG deliveries. The convoluted M&A procedure did not consider that EBID and EPCWID FHG deliveries were no longer comparable on a per acre basis after the 2008 OA went into effect. As shown in the lower chart in **Figure 12-14**, the M&A procedure results in unrealistically low estimates of El Paso Valley FHG deliveries as a percentage of El Paso Valley canal heading diversions.

HCCRD

Figure 12-15 compares the computed annual supplemental pumping in the M&A Farm Budget Model to the comparable values from the SWE CFB Model during the 1985 - 2016 period. The annual pumping in the M&A Farm Budget Model averages about 19,400 AF compared to an average of 2,100 AF in the SWE CFB Model, a difference of about 17,300 AF. The differences in supplemental pumping are due largely to differences in the ET of applied water and differences in FHG deliveries between the models.

The simulated pumping in the M&A Farm Budget Model during the full supply years from 1985 - 2002 is unrealistically high considering the following:

- High FHG deliveries per acre (see **Figure 5-13**),
- High Ft. Quitman flows (see **Figure 5-3**), and
- High operational waste through this period (see **Figure 5-23**).

The upper right chart in **Figure 12-16** compares the maximum annual cropped area in the HCCRD in the M&A Farm Budget Model to the annual irrigated area in the SWE CFB Model. The irrigated area figures are relatively comparable with the M&A Farm Budget Model acres averaging about 3% less than the SWE CFB Model acres.

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[7] As described in Section 6.4.5, Reclamation records of EPCWID FHG deliveries exceed canal heading diversions in many months and are assumed to be in error.

The upper left chart in **Figure 12-16** compares the annual ET of applied water in the HCCRD. The annual ET of applied water in M&A Farm Budget Model is larger than the SWE CFB Model values throughout the 1985 - 2016 period, averaging about 30% more. The differences are due largely to differences in unit crop ET and cropping pattern.

The lower left chart in **Figure 12-16** compares the area-weighted annual unit crop ET in the HCCRD for the M&A Farm Budget Model and the SWE CFB Model. The differences in the unit crop ET reflect the combined differences in cropping pattern and the unit irrigation requirements of the individual crops. The unit ET for the M&A Farm Budget Model was computed as the annual ET of applied water volume (shown in the upper left chart in **Figure 12-16**) divided by the maximum monthly irrigated area in that year (upper right chart in **Figure 12-16**). The unit ET values in the M&A Farm Budget Model average over 30% more than the SWE CFB Model values.

The lower right chart in **Figure 12-16** compares the annual farm headgate delivery volumes that are simulated in the M&A Farm Budget Model of the HCCRD to the SWE CFB Model values. On average, the farm headgate deliveries in the M&A Farm Budget Model are about 26% less than the values in the SWE CFB Model.

13.0 RESPONSE TO HUTCHISON REPORT

William R. Hutchison, Ph.D., P.E., P.G. prepared a May 31, 2019 expert report on behalf of the State of Texas ("Hutchison Report"). The subjects of the Hutchison Report are generally twofold. First, the report describes the development of a MODFLOW ground water model of the Rincon and Mesilla basins in New Mexico and small portions of Texas and Mexico ("Texas Model") over a study period from 1938 - 2016. Second, the report describes use of the Texas Model to simulate reduced pumping and other scenarios during all or portions of the historical study period. The Hutchison Report includes a main summary report, 17 technical memoranda detailing the development and calibration of the Texas Model, and 4 technical memoranda describing use of the model to simulate reduced pumping and other scenarios.

SWE was asked by legal counsel for New Mexico to review the input data sets for the Texas Model and the model simulations of the reduced pumping scenarios to identify information or opinions with which we disagreed, and to prepare expert opinions to respond to these issues. We attempted to identify and respond to all substantive issues in which there appeared to be differences of opinion, however a lack of response to a particular issue should not be interpreted as tacit agreement with Dr. Hutchison's opinion(s).

Hutchison Opinion 1 – *The 1938 condition can be viewed as a combination of three elements: 1) minimal groundwater pumping, 2) a specific number of irrigated acres and a specific distribution of irrigated crops, and 3) a specific amount of irrigation water that was applied (expressed in terms of acre-feet of water per irrigated acre). Simulations with the Texas Model demonstrate that increases in groundwater pumping have had a larger impact to Rio Grande at El Paso flows than increases in agricultural consumptive use. (Page 12 paragraph 1).*

Response:

New Mexico's legal counsel have advised that a 1938 condition is not appropriate for characterizing the water entitlements of the states. Moreover, it would be inappropriate to define a 1938 condition based on historical operations in a single year as Dr. Hutchison does in his analyses.

Hutchison Opinion 2 – *Simulations with the 2007 OSE Model and the Texas Model demonstrate that groundwater pumping resulted in decreased flows in the Rio Grande. Brandes (2019) developed an estimate of hypothetical Rio Grande at El Paso flows that would have occurred under a "without the effects of groundwater pumping" condition.*

Brandes (2019) concluded that the average increase in flow as compared with historic flows from 1951 to 2017 is about 79,000 AF/yr. (Page 12 paragraph 2).

Response:

As described in the response to Brandes Opinion 10 in Section 11, the analyses of historical data by Dr. Brandes unreasonably attributed all changes in Rio Grande at El Paso flow that occurred after 1950 to the effects of New Mexico pumping and did not consider other factors that may have contributed to reductions in flow at El Paso. Likewise, the modeling by Dr. Hutchison does not consider these other factors.

Hutchison Opinion 3 *– Simulations with the Texas Model demonstrate that an overall 60 percent reduction in all pumping would result in a hypothetical increase in Rio Grande at El Paso flow of about 73,000 AF/yr from 1951 to 2016. About 81 percent of the increase (59,000 AF/yr) is attributable to New Mexico pumping, and about 19 percent of the increase is attributable to Texas pumping (13,000 AF/yr). (Page 12 paragraph 2).*

Response:

The reduced pumping simulations performed by Dr. Hutchison are unreasonable and unreliable because the Texas Model does not simulate the dynamic operational responses of the Project and the LRG Area irrigation systems that would occur if pumping was reduced or turned off.

The following is a summary of the changes in inputs that are specified to occur in each of Dr. Hutchison's reduced pumping simulations:

- Irrigation pumping is reduced by a specified percentage (10% to 100%),
- Non-irrigation pumping and the corresponding urban infiltration are reduced by the same percentage, and
- On-farm deep percolation is reduced proportionately based in the reduction in total irrigation supply (SW+GW).

The following are inputs that are not changed in the reduced pumping simulations:

- Releases from Project storage,
- Canal diversions of Project water, and
- Wastewater treatment plant discharges.

The following are the simulated responses in Texas Model resulting from the foregoing changes in model inputs:

- Increased ground water levels and ground water storage,
- Increased riparian ET,
- Increased drain flows,
- Reduced canal seepage and river seepage,
- Increased Rio Grande flow from increased drain flows and reduced river seepage.

Because the reservoir releases and canal diversions are fixed at the historical amounts in the alternative runs, all increases in Rio Grande flow accumulate as increased flow at the downstream end of the model at El Paso. This simple process of the additional river flow running out the bottom of the model is not what happens during the irrigation season in the real world when the supply changes. In the real world, reservoir releases are continually adjusted in response to changing conditions downstream so as to deliver the ordered amounts of water.

The system response to the additional flow that would be in the river with a reduction in pumping would vary depending on whether it occurred in a year with a full allocation of Project water or a year with less than a full allocation. In a year with a full allocation, deliveries of Project water are limited by either the allocated amount or the water demand. In either case, it is reasonable to assume that Project water deliveries in a full allocation year would be about the same in a reduced pumping scenario as they were in the historical operation. Therefore, during a full allocation year in a reduced pumping scenario, the additional flow in the river would allow Reclamation to reduce reservoir releases and still deliver the same amounts to the Project water users. The reduction in reservoir releases would accumulate additional water in storage that would be carried over and allocated to EBID and EPCWID in subsequent years. The additional reservoir storage would also result in increased evaporation due to the greater surface area in the reservoir and would also result in increased spills when the Project storage filled to capacity.

During non-full supply years, the additional accumulated reservoir storage during prior years would lead to increased allocations and increased deliveries to Project water users.

Because the Texas Model does not include simulation of reservoir and Project operations, it has no capability to simulate the real-world responses of the Project including changes in allocations, reservoir releases, diversions, and farm headgate deliveries. As a result, the increased river flow that occurs in the reduced pumping scenarios simply runs downstream to El Paso. This causes the Texas Model to overstate the effects of pumping in the Rincon and Mesilla basins on the flow of the Rio Grande at El Paso. The lack of simulation mechanisms in the Texas Model for reasonable dynamic responses to the changes in supply that would occur under conditions that are different from historical conditions renders the results from the Texas Model simulation of alternative scenarios meaningless and not helpful in assessing the effects of reduced pumping or changed conditions on Project operations and deliveries to LRG water users.

Figure 13-1 and **Figure 13-2** were prepared to compare the simulated changes in El Paso flow from the Texas Model and the ILRG Model for the scenario in which all pumping in the Rincon and Mesilla basins is turned off. In each figure the simulated changes in flows in the ILRG Model are summarized to show the changes during March - October (blue bars) and the changes during November - February and during months that the Project storage is spilling (grey bars). The results from the Texas Model are shown as a colored line representing the annual change in El Paso flow (purple line for simulation of no pumping during 1951-2016 and orange line for simulation of no pumping during 1985-2016).

Figure 13-1 compares the simulated change in El Paso flow in the ILRG Model for the a scenario in which all pumping in the Rincon and Mesilla basins is curtailed to the Texas Model simulation of the comparable scenario The average annual change in El Paso flow in the Texas Model during 1985 - 2016 is 124,700 AF compared to 93,900 AF in the ILRG Model (of which 25,100 AF occurs during reservoir release periods and 68,800 AF occurs during the non-release season or during spills). The simulated change in flow in the Texas Model is substantially greater because most of the increased river flow in the no-pumping scenario flows downstream to El Paso. In the ILRG Model with a simulated dynamic response to the changes in river flow, the reservoir releases are reduced in full allocation years and some of the increased flow in non-full supply years is allocated to EBID and as a result, much less of the additional flow makes it to El Paso. The simulated annual changes in El Paso flow in the ILRG Model reflect the expected response of the Project operation with little increased irrigation season flow during full allocation years (e.g., during the much of the 1980s and 1990s). Conversely, in the Texas Model the simulated changes in annual El Paso flow are relatively steady as they represent increases in river flow without the re-operation of the Project.

Figure 13-2 is similar to **Figure 13-1** with the results from the ILRG Model shown for the scenario with no New Mexico pumping (i.e., the pumping in the Texas Mesilla area was left on). The simulated average annual change in El Paso flow in the ILRG Model during 1985 - 2016 of 74,400 AF is about 19,500 AF less than when all pumping in the Rincon and Mesilla basins is turned off, and only 17,600 AF of the average annual change in flow occurs during periods when reservoir releases are occurring (excluding spills).

Hutchison Opinion 4 *– One of the components of the "1938 condition" is the irrigated acreage and associated consumptive use expressed as acre-foot per acre in 1938. As documented in Technical Memorandum 3, agricultural consumptive use in New Mexico has increased since 1938 as shown in Figure 1. This technical memorandum documents the results of five scenarios where agricultural consumptive use is limited to that of 1938. The simulations were run from 1938 to 2016, but the modifications were applied only after 1950 to provide a means of comparison with other scenarios.*

The agricultural pumping, agricultural deep infiltration, and surface water diversion components of the hypothetical consumptive use scenarios were developed by summing the consumptive use of 1938 (149,005 AF/yr) and the associated canal losses and farm-level infiltration associated with irrigation. For each year, this sum was viewed as a demand and was compared with the annual historic surface water diversions for agricultural use. If the historic surface water deliveries were higher than the new demand, the excess remained in the surface water system (i.e. surface water flow diversions were reduced as compared with historic levels). If the historic surface water deliveries were less than the new demand, groundwater pumping for irrigation was set equal to the deficit. The five scenarios involve alternative urban and domestic groundwater pumping:

- *Scenario 1: limit of 10,000 AF/yr*
- *Scenario 2: limit of 20,000 AF/yr*
- *Scenario 3: limit of 30,000 AF/yr*
- *Scenario 4: limit of 40,000 AF/yr*
- *Scenario 5: limit of 50,000 AF/yr*

(Technical Memo 20 - Page 1 paragraphs 1 and 2; and page 4 paragraph 2).

Response:

Dr. Hutchison's Technical Memo 20 describes simulations under a presumption that New Mexico is entitled to consume for irrigation the same amount of water that it was consuming in 1938, which he estimates was 149,005 AF. When the historical annual surface water diversions during the simulation period were insufficient produce 149,005 AF of irrigation consumptive use, it was assumed that New Mexico water users could pump water to eliminate the deficit. Conversely, if the surface historical water supply was more than needed to produce 149,005 AF of consumptive use, then the diversions were reduced by the excess amount.

New Mexico's legal counsel have advised that a 1938 condition is not appropriate for characterizing the water entitlements of the states. Moreover, it would be inappropriate to define a 1938 condition based on historical operations in a single year.

The Alternative Consumptive Use scenarios imply that New Mexico should be limited to the irrigation consumptive use that allegedly existed in 1938 (149,005 AF), even if that means that New Mexico would have to reduce its use of Project water. However, Texas has provided no technical support for the notion that New Mexico's Project deliveries should be limited to the 1938 level.

Further, the simulations of reductions in New Mexico diversions of surface water in the Texas Model are nonsensical because there is not a corresponding reduction in simulated reservoir releases. Therefore, when the New Mexico diversions are reduced, the volume of the reduced diversion is left in the Rio Grande to run downstream to El Paso. In reality, if New Mexico's irrigation consumptive use was somehow limited under a 1938 condition, the reservoir releases would be reduced as necessary to limit the consumptive use of surface water and there would be no increase in El Paso flow during such years.

In addition, as described in the response to the reduced pumping scenarios, any change in pumping from what occurred historically would result in a dynamic response of the Project operation that would change the available surface water supply resulting in changed Project water allocations, diversions, and deliveries to Project water users. The Texas Model is not capable to simulating this dynamic response.

Because of the limitations of the Texas Model, the results of the simulations described in in Technical Memorandum 20 are of little value in assessing any alternative consumptive use scenarios based on a 1938 condition or otherwise.

It is unclear if the Alternative Consumptive Use scenarios are presented to illustrate Dr. Hutchison's analysis of how to achieve potential Compact compliance for New Mexico. It is also unclear whether Dr. Hutchison is proposing an analogous consumptive use cap for all Texas Project lands based on his 1938 condition.

Hutchison Opinion 5 *– The preferential use of surface water and the use of groundwater to meet demand deficits is the definition of conjunctive use. The simulations documented in this technical memorandum evaluated alternative hypothetical conjunctive use scenarios where historic groundwater pumping only occurred in years with less than specified amounts of surface water availability (i.e. pumping only in dry years to meet demand deficits). For purposes of these simulations, five scenarios were developed as follows:*

- *Scenario 1 assumed that groundwater pumping is zero when annual releases from Caballo are above 790,000 AF/yr (i.e. no pumping in 13 years, historic pumping in 66 years)*
- *Scenario 2 assumed that groundwater pumping is zero when annual releases from Caballo are above 700,000 AF/yr (i.e. no pumping in 30 years, historic pumping in 49 years)*
- *Scenario 3 assumed that groundwater pumping is zero when annual releases from Caballo are above 600,000 AF/yr (i.e. no pumping in 52 years, historic pumping in 27 years)*
- *Scenario 4 assumed that groundwater pumping is zero when annual releases from Caballo are above 500,000 AF/yr (i.e. no pumping in 60 years, historic pumping in 19 years)*
- *Scenario 5 assumed that groundwater pumping is zero when annual releases from Caballo are above 400,000 AF/yr (i.e. no pumping in 66 years, historic pumping in 13 years)*

(Technical Memo 21 - Page 2 paragraphs 1 and 5).

Response:

The Conjunctive Use scenarios described in Technical Memorandum 21 are similar to the 100% reduced pumping scenario described in Technical Memorandum 18 except that the pumping is only turned off in selected years rather than every year. Therefore, the same criticisms of the reduced pumping scenarios described above also apply to the Conjunctive Use scenario simulations. The lack of a mechanism in the Texas Model to simulate a dynamic response in the Texas Model to changing water supply renders the results of the Conjunctive Use scenarios as unreasonable.

It is also unclear if the Conjunctive Use scenarios are presented to illustrate Dr. Hutchison's analysis of how to achieve potential Compact compliance. It is also unclear whether Dr. Hutchison is proposing the same type of conjunctive use limits for Texas.

14.0 RESPONSE TO DORRANCE REPORT

Lydia R. Dorrance, Ph. D. prepared a May 31, 2019 expert report on behalf of the State of Texas ("Dorrance Report"). There were two primary subjects covered in the Dorrance Report. First, the report described analyses to translate simulated changes in the annual flows of the Rio Grande at El Paso computed by the Texas Model into changes in monthly surface water deliveries to EPCWID farmers in the El Paso Valley, farmers in the HCCRD, and municipal water users in the EPW service area. Second, the report described the effect that changes in the monthly surface water deliveries would have on the salinity of the mixed surface water and ground water supplies of farmers and municipal water users.

SWE was asked by legal counsel for New Mexico to review the analysis by Dorrance to translate modeled annual changes in El Paso flows into changes in deliveries of surface water to irrigation and municipal water users in the El Paso Valley to identify information or opinions with which we disagreed, and to prepare expert opinions to respond to these issues. We attempted to identify and respond to all substantive issues in which there appeared to be differences of opinion, however a lack of response to a particular issue should not be interpreted as tacit agreement with Dr. Dorrance's opinion(s).

Dorrance Opinion 1 – *Modeling results provided by Dr. Bill Hutchinson demonstrate that in an alternative scenario in which pumping in the Rincon and Mesilla Valleys is reduced every year between 1985 and 2016 by 60% relative to that which was historically recorded, surface flow at El Paso increases. I evaluated how this increase in flow would impact the salinity of water applied for agriculture in EP1 and HCCRD1 under the alternative scenario. (Page 19 paragraph 3).*

Response:

The modeling results provided by Dr. Hutchison and used by Dr. Dorrance in her analysis were from a scenario in which 60% of all pumping in the Rincon and Mesilla basins was reduced, including irrigation and municipal pumping in the Texas portion of the Mesilla basin (including the Canutillo wellfield pumping). Therefore, the analyses by Dr. Dorrance of the effects of increased El Paso flows on deliveries to Texas users do not represent the effects of New Mexico pumping because they also include the effects of Texas Mesilla pumping. This results in inflated impacts attributed to New Mexico pumping that also inappropriately inflate the subsequent damage analyses by Dr. Sunding that are based on the results from the Dorrance analysis.

In addition, because of the absence of re-operation of the Project in Dr. Hutchison's modeling of the reduced pumping scenarios, the additional annual flows from simulation of the 60% reduced pumping scenario that Dr. Dorrance used in her analysis are unreliable and unusable for estimating the impacts of New Mexico pumping on irrigation and municipal water users in Texas.

In addition to the improper attribution of effects of pumping in the Texas portion of the Mesilla basin to New Mexico ground water pumping and the lack of re-operation of the Project in the Texas modeling results, the following additional responses are presented to the analyses by Dr. Dorrance.

Dorrance Opinion 2 *– The additional Rio Grande at El Paso flow in any given month would be delivered to EP1 under the Rio Grande Project. The delivery of additional water to EP1 would also result in additional surface water being made available for HCCRD1, and the historical ratio of surface water use between EP1 and HCCRD1 would remain unchanged in the alternative scenario. This assumption is supported by the clear positive correlation between discharge at El Paso and surface water use by to both EP1 and HCCRD1, such that both districts receive more surface water in years with greater flow at El Paso (See Figure 4). (Page 19 paragraph 4).*

Response:

Because the Texas Model operates with annual stress periods, Dr. Dorrance had to disaggregate the additional annual flows at El Paso from the Texas Model into monthly values introducing further error and uncertainty in her analysis. This disaggregation was based on percentages computed as historical monthly El Paso flows divided by the annual El Paso flow in each year. This presumes that the additional Rio Grande flow at El Paso that may result from a reduction in pumping in the Rincon and Mesilla basins would accrue in the same monthly proportions as the historical flows. However, Dr. Dorrance did not present any evidence to support this assumption.

It is possible that the additional flows with a reduction in upstream pumping would arrive with significantly different monthly timing. For example, the additional flow might allow the districts to begin reservoir releases earlier in the year, or to save water in storage for an additional release of water later in the irrigation season. In a full supply year, there may be no additional flow in any months because no additional deliveries would be appropriate in such a year. This is an example of why a model capable of simulating the dynamic response of the system to changes in supply is needed.

Further, the analysis by Dr. Dorrance presumes that nearly all of the simulated additional flow at El Paso in the reduced pumping scenario would be available for use by EPW, EPCWID, and HCCRD. This is contrary to the historical records that show on average only 64% of the monthly flow, after delivery of water to Mexico at the Acequia Madre, was delivered for use by EPW, EPCWID, and HCCRD during the March - October period in non-spill years.

Historical records of the monthly and annual flows of the Rio Grande at El Paso (less deliveries to Mexico) are shown in the black line in **Figure 14-1**. The monthly and annual deliveries to EPW, EPCWID, and HCCRD are shown in the stacked bars in **Figure 14-1**. The reason that an average of only 64% of the adjusted flow at El Paso was delivered to the Texas water users is because of the conveyance losses and other inefficiencies in the EPCWID and HCCRD delivery systems. Note that the 2010 historical farm delivery amounts in the Dorrance analysis are suspect as the sum of the deliveries significantly exceeds the total flow at the El Paso gage.

Figure 14-2 contains similar graphs showing the monthly and annual increased El Paso flows simulated in the Texas Model as a result of a 60% reduction in the Rincon-Mesilla pumping from 1985 - 2016 (black line) and the portions of that flow that Dr. Dorrance computed to be available for delivery to EPW, EPCWID, and HCCRD (stacked bars). The graphs show that Dr. Dorrance made available almost all of the additional flow at El Paso for delivery to the Texas water users. On average, 97% of the increased El Paso flow was determined by Dr. Dorrance to be available for delivery to Texas water users during the March - October period compared to the historical average of 64% of the El Paso flows that were actually delivered to Texas water users. Note that Dr. Dorrance also did not make any of the simulated increases in El Paso flow available for delivery to Mexico.

Finally, **Figure 14-3** compares the simulated increased monthly and annual El Paso flows (black line) and the amount of the increased flow that Dr. Dorrance estimated would actually be delivered for use by EPW, EPCWID, and HCCRD (stacked bars). The amount of the increased El Paso flow available to EPW in **Figure 14-3** that would have been delivered for use by EPW was limited so that the sum of the historical delivery plus the increased delivery did not exceed the historical maximum monthly EPW deliveries. The amounts of the increased El Paso flow delivered to EPCWID and HCCRD were limited to the simulated historical pumping by each district. In other words, it was assumed that each district would use the same amount of water that they did historically (surface water plus estimated pumping) and the additional surface water deliveries would only replace the portion of their supply that was historically pumped. As indicated in **Figure 14-3**, during many years most or all of the increased El Paso flow is assumed by Dr. Dorrance to be delivered for use during many or all months of the irrigation season. The full amount of the increased flow at El Paso (100%) was assumed delivered to the Texas water users in 37% of the March - October study period months. The full amount of the additional El Paso flow is assumed by Dr. Dorrance to be delivered to Texas users when there is sufficient historical unmet demand (i.e., historical pumping that can be replaced by surface water deliveries). In months that the simulated increased El Paso flow is greater than the total historical unmet demand, the excess El Paso flow goes undelivered in the Dorrance analysis, apparently as an increase in operational waste.

It is unreasonable for Dr. Dorrance to assume that most or all of the increase in El Paso flow that would occur by reducing pumping in the Rincon and Mesilla basins could be delivered for use by Texas water users undiminished by conveyance loss (i.e., as indicated in **Figure 14-3** when the stacked bars reach or nearly reach the black line). As a result, Dr. Dorrance's analysis overstates the effect that a reduction in pumping in the Rincon and Mesilla basins would have on increasing the supply of surface water to Texas users that they could use to replace what they historically pumped. Because the increase in deliveries to Texas water users from a reduction in Rincon-Mesilla pumping is overstated, so too are the damages from that pumping on Texas water users computed by Dr. Sunding.

Dorrance Opinion 3 *– In a given month and year, applied agricultural water in EP1 and HCCRD1 consists of a combination of surface water and groundwater (and can consist of exclusively surface water or groundwater) and groundwater is pumped to compensate for the shortfall between surface water agricultural application and total agricultural water application. In other words, groundwater is only pumped when there is not enough surface water delivered. (Page 19 paragraph 5).*

Response:

Figure 14-4 compares the annual changes in El Paso flow that Dr. Dorrance obtained from the Texas Model simulation of a 60% reduction in pumping in the Rincon and Mesilla basins during 1985 - 2016 to the simulated annual changes in El Paso flow from the ILRG Model simulation of the No New Mexico Pumping scenario. The average annual changes in El Paso flow during 1985 - 2016 are similar, with the Texas Model average being approximately 4% less than the ILRG Model average. While changes in flow are similar, the amounts of pumping turned off to produce the changes in flow were substantially greater in the ILRG Model than in the Texas Model. Because of the re-operation of the Project in the ILRG Model, a significant portion of the increased river flow in the no-pumping run was allocated to and used by EBID water users. The simulated change in flow at El Paso in the ILRG Model reflects increased allocations and deliveries to EPCWID and JID, increased winter flows and increased spills. Conversely when pumping is turned off in the Texas Model, most of the increase in river flow runs downstream to El Paso because there is no re-operation. Therefore, turning off a smaller amount of pumping in the Texas Model can produce a similar increased in average flows at El Paso as turning off a larger amount of pumping in the ILRG Model.

Figure 14-5 through **Figure 14-7** compare the increased deliveries to Texas users (EPCWID for irrigation, EPW, and HCCRD) computed by Dr. Dorrance from the Texas Model simulated increased El Paso flows against the comparable changes in Texas deliveries from the ILRG Model simulation of the No New Mexico Pumping scenario. In each figure, the annual changes from the Texas analyses during 1985 - 2016 are shown as an orange line and the annual results from the ILRG Model are shown as blue bars.

Figure 14-5 compares the estimates by Dr. Dorrance of changes in deliveries to EPCWID irrigation users in the El Paso Valley to the simulated changes in deliveries from the ILRG Model. The average annual change in deliveries from the ILRG Model (4,100 AF) is much less than the Dorrance estimate (28,000 AF). The reasons for the differences are primarily three-fold. First, as described previously, Dr. Dorrance makes virtually all of the simulated increase in El Paso flow available for delivery to the Texas users without conveyance losses. Second, contrary to the ILRG Model, the M&A farm budget analysis shows substantial unmet demand in all years during the historical period and so the additional flow in the reduced pumping scenario is used to meet the unmet demand. Third, much of the simulated increase in flows in the ILRG Model occurs during the non-release season and during spills, and so these supplies are not usable to meet unmet irrigation demands that may exist.

Figure 14-6 compares the changes in simulated deliveries to EPW between the Dorrance analysis and the ILRG Model. The Dorrance analysis shows much greater changes in EPW deliveries because she assumed EPW would receive certain percentages of the simulated additional El Paso flow. Conversely, the ILRG Model delivers additional flow to EPW only in years when there is an increase in the EPCWID Project water allocation. Because there were full allocations during 1985 - 2002, there are no simulated increases in allocations in these years and therefore no simulated increases in deliveries to EPW.

Figure 14-7 compares the changes in simulated deliveries to HCCRD between the Dorrance analysis and the ILRG Model. The Dorrance analysis shows much greater changes in HCCRD deliveries because she assumed HCCRD would receive certain percentages of the simulated additional El Paso flow to replace the M&A estimates of historical pumping. Conversely, the ILRG Model delivers additional flow to HCCRD only when there is unmet demand which is rare during most years during the 1985 - 2016 period.

Dorrance Opinion 4 *– The ratio of surface water supplied to the City of El Paso and the El Paso Valley irrigation districts (EP1 and HCCRD1) for a given month would be the same in the alternative scenario as was historically observed. This ratio can therefore be used to allocate excess surface water in the alternative scenario between the City of El Paso and the El Paso Valley irrigation districts. However, if, based on this partitioning, the City of El*

Paso's surface water delivery would exceed its maximum recorded delivery for a given month (as described below), the surplus would be allocated to the El Paso Valley irrigation districts. (Page 20 paragraph 2).

Response:

It is unreasonable to assume that the historical proportions between monthly El Paso flows and monthly EPCWID deliveries, EPW deliveries, and HCCRD deliveries would be preserved as to any increased El Paso flows. For example, HCCRD receives as its supply waste and drain flows leaving the EPCWID service area. The flows to the HCCRD can be significantly variable in response to the amount of water leaving the EPCWD service area. It is unreasonable to assume that a large historical spike in the historical supply reaching the HCCRD would be proportionally increased by any additional flow that the EPCWID would have available. It is more likely that the EPCWID would not waste more water, but rather would take delivery of that water at times it could be more beneficially used.

In addition, it is our understanding that EPW has been selling water to HCCRD since at least 2001 (Lopez, 2019). The historical records of deliveries to HCCRD likely reflect these deliveries, and therefore the proportioning method used by Dr. Dorrance would improperly allocate a proportion of the increased El Paso flow to HCCRD because of these sales.

In summary, the methodology applied by Dr. Dorrance over-allocates and improperly distributes the increased annual El Paso flows from the Texas Model (that have already been shown to be unreliable) among EPW, EPCWID, and HCCRD1. Therefore, the results from the Dorrance analysis are unreliable and unsuited for use in the analyses of economic damages that were conducted by Dr. Sunding.

In order to reasonably estimate the timing and amount of increased surface water deliveries to the Texas water users that would occur in a reduced pumping scenario, it is necessary to simulate this scenario using a robust model like the ILRG Model that is capable of simulating the dynamic response of the Project and the LRG irrigation systems to changes in flow. It is essential that such modeling include simulation of the El Paso Valley downstream of El Paso rather than using simple historical proportions.

15.0 RESPONSE TO SUNDING REPORT

David L. Sunding, Ph.D. prepared a May 31, 2019 expert report on behalf of the State of Texas ("Sunding Report") that describes his analysis of economic damages to Texas resulting from excessive pumping in New Mexico during the years 1985 - 2016. Damages were computed to agricultural water users, customers of the EPW, and to the broader West Texas regional economy.

SWE was asked by legal counsel for New Mexico to review Dr. Sunding's description of El Paso municipal water use and his characterization of the effects of excessive New Mexico pumping on Texas water users to identify information or opinions with which we disagreed, and to prepare expert opinions to respond to these issues. We attempted to identify and respond to all substantive issues in which there appeared to be differences of opinion, however a lack of response to a particular issue should not be interpreted as tacit agreement with Dr. Sunding's opinion(s).

Sunding Opinion 1 *– Because of the seasonal nature of surface water deliveries, the configuration of El Paso's conveyance system differs between the summer irrigation season and the rest of the year. Figure 7 shows the typical distribution of water supply in El Paso during summer and winter, respectively. The map on the left side of Figure 7 shows how the city delivers water when surface water is available. The southern parts of the city are delivered surface water from the Jonathan Rogers Water Treatment Plant as shown in grey, and the central parts of the city are delivered surface water from the Robertson/Umbenhauer Surface water treatment plant as shown in Orange. The northwestern parts of the city are delivered shallow groundwater from the Upper Valley Water Treatment Plant supplied by the Canutillo Wellfield. However, the righthand panel shows the distribution pattern that is typical in winter, and also during periods of summer when surface water is unavailable. (Page 24 paragraph 2)*

Response:

The map in Figure 7 of the Sunding Report gives the impression that there are distinct areas where Project water is delivered when it is available. In reality, the delivery of water to various portions of the City varies continuously depending on the relative amounts of water available from the City's sources and fluctuations in water demand. In addition, there are not bright lines between where surface water is delivered and ground water is delivered. According to John Balliew (EPW president and CEO), different water sources can mix in the distribution system and a blend of surface water and ground water is delivered to many areas when surface water is available (Balliew, 2019 p. 21).

Sunding Opinion 2 *– Figure 8 shows the average production of water in El Paso for each month of the year. Water use in El Paso is highest during summer, when high temperatures cause demand for irrigation and cooling to peak. During summer EPWU can cover this peak demand with surface-water from the Rio Grande during years that it receives its full allocation of project water. During winter, demand is significantly lower, less than half of peak summer demand. The city has to rely entirely on groundwater during the winter when there are no surface water deliveries. However, because the peak in summer demand often outstrips available supply from the Rio Grande, groundwater demand also peaks during the summer. As a result, any shortfalls in Rio Grande supply during summer require additional capital investments in groundwater capacity to make up the difference. (Page 25 paragraph 1)*

Response:

Project water supplies can be very low during extended drought periods with or without the effects of New Mexico pumping. EPW's drought planning is based on a conservative assumption that no project water would be available to meet the peak summer demand (Balliew, 2019; pp. 210-211, 276). This condition could exist with or without pumping impacts on Project supplies. In very dry years with low Project water allocations, the typical operational practice is to aggregate the Project releases into two or three short releases during the irrigation season to minimize river conveyance losses. During such years, the reservoir gates can be shut for weeks at a time with no Project water deliveries. During these periods of no Project water deliveries, which can occur during times of peak summer demand, the EPW would have to meet its water demands solely from ground water pumping. Therefore, the City's ground water infrastructure would be necessary without or with the effects of New Mexico pumping.

Sunding Opinion 3 *– To evaluate the economic impacts on Texas from New Mexico's excessive groundwater pumping, I compare the historical deliveries of Rio Grande water above El Paso to a hypothetical scenario that assumes New Mexico significantly reduced groundwater pumping. The hypothetical water supply scenario was provided to me by Dr. Bill Hutchison and it assumes a 60 percent reduction in New Mexico groundwater pumping between 1938 and 2016. Figure 9 shows the historical and hypothetical Rio Grande flows at the border and is taken directly from Dr. Hutchison's calibrated model. The difference between water supply scenarios is most pronounced during dry years. Dr. Hutchison's model shows that under this hypothetical scenario, between 1985 and 2016, an additional 71,000 acre-feet of water would flow across the Texas-New Mexico border on average each year. (Page 27 paragraph 2)*

Response:

The historical and simulated annual Rio Grande at El Paso flows are from Dr. Hutchison's simulation of 60% reduction of all pumping in the Rincon and Mesilla basins, including irrigation pumping in the Texas portion of the Mesilla basin, and the municipal pumping from the Canutillo wellfield. As a result, Dr. Sunding's analyses of Texas damages in the El Paso Valley inappropriately includes damages from pumping by Texas farmers in the Mesilla basin and by City of El Paso pumping from the Canutillo wellfield.

Note that the 71,000 AF/y of average additional El Paso flow is an annual figure comprised of flows in both the irrigation season and non-irrigation season. The simulated increased flows at El Paso from the Texas Model and the disaggregation of these flows by Dr. Dorrance to increased deliveries to EPW, EPCWID, and HCCRD are unreliable and overstated for the reasons described in Sections 13 and 14 above.

Sunding Opinion 4 *– Excessive groundwater pumping in New Mexico caused EPCWID and HCCRD to receive reduced deliveries from the Rio Grande; consequently, they must deliver less surface water to their agricultural customers. In her expert report, Dr. Dorrance estimates that every additional 100 acre-feet of water delivered to the Texas-New Mexico border results in EPCWID and HCCRD delivering 58 and 20 additional acre-feet respectively to each of their districts. Dr. Dorrance's numbers indicate that had New Mexico reduced its excessive groundwater pumping, EPCWID and HCCRD would have delivered an average of around 45,000 and 14,000 additional acre-feet of water, respectively, every year between 1985 and 2016. (Page 30 paragraph 1 and 2)*

Response:

As described in Section 14, the portion of Hutchison's modeled increase in flow at El Paso that would be delivered to EPCWID, HCCRD, and EPW is overstated because Dr. Dorrance assumed that virtually all of the increased El Paso flow would be available for delivery to Texas water users without loss. This compares to the historical deliveries that averaged 62% of the flow at El Paso using the historical flow data presented in the Dorrance report.

Dr. Sunding misstates the results of the Dorrance analysis when he asserts the analysis showed that deliveries to EPCWID would increase by 45,000 AF/y and deliveries to HCCRD would increase by 14,000 AF/y in every year between 1985 – 2016. These are average annual increases in deliveries from the analysis by Dr. Dorrance. Further, as described previously, the Dorrance results are unreliable because they are based on results from Dr. Hutchison's Texas Model that lack the capability to re-operate the Project and LRG irrigation systems in response to changes in water supply.

Sunding Opinion 5 *– EPWU conjunctively uses groundwater and surface water to meet its demands. There is seasonality in EPWU's water supply portfolio. The share of customers supplied by surface and groundwater changes throughout the year, as previously shown in Figure 8, and also between wet and dry years. During the irrigation season, EPWU delivers the available surface water supply to its customers, and then pumps groundwater to meet remaining demand. (Page 45 paragraph 2)*

Response:

The chart in Figure 8 of the Sunding Report shows the monthly average EPW production of surface water and ground water. **Figure 15-1** shows the same information for each month of each year of the period from 1985 - 2016. As shown in this closer look of EPW production, monthly surface water deliveries vary significantly from month to month and year to year. During the full supply years of the 1980s, EPW's peak monthly Hueco pumping approached 10,000 AF per month. During the recent dry years, there was only one month with Hueco pumping in excess of 10,000 AF. Based on these comparisons there seems to be little connection between the peak monthly Hueco pumping and EPW's use of Project water.

The characterization that EWPU delivers surface water supply to customers and then pumps ground water to meet remaining demand may be true for portions of the EPW operations. However, based on EPW's current infrastructure, certain areas of the city are supplied only by ground water and many areas receive a blend of ground water and surface water when surface water is available (Balliew, 2019 p 21).

Sunding Opinion 6 *– Since the shallow wells in the Upper Valley in the Mesilla Aquifer are hydraulically connected to flow in the Rio Grande, my estimates assume that all additional groundwater comes out of wells in the Lower Valley wells, connected to the Hueco aquifer. (Page 47 paragraph 2)*

Response:

EPW operates its water supply sources to meet demands that vary throughout its service area. Because of the interconnected distribution system, many areas of the City receive a blend of water from different sources depending on the available supply, particularly the available surface water supply. As to the Canutillo wellfield, pumping from this source is generally used in the northwest portion of the City, but is also delivered into the downtown area when surface water supplies are limited. (Balliew, 1999 p. 189)

Sunding Opinion 7 *– In 2007, El Paso Water in partnership with the Fort Bliss military base, opened a state of the art desalination plant, which uses reverse osmosis to remove salts* *from brackish groundwater. The plant uses five reverse osmosis skids, which give it a maximum capacity of 27.5 MGD. The construction of the Kay Bailey Hutchison desalination plant cost $91 million, which I have omitted from my analysis because the plant was partially built for strategic military purposes. However, the economic case for continued operation of the plant is not, and instead is a result of unreliable supply of the Rio Grande water during peak summer months. In my discussions with EPWU's President and CEO John Balliew, he stated that the decision to operate Kay Bailey Hutchison was marginal, and that if EPWU had received a more reliable supply of water, then the plant would have been removed from active use and put into a condition of long-term preservation. (Page 48 paragraph 2)*

Response:

The Kay Bailey Hutchison Desalination Plant ("KBH Plant") was built for a variety of reasons, not solely because of low surface water supply in drought years. Importantly, the KBH Plant prevents brackish water intrusion into freshwater portions of the Hueco Bolson. John Balliew testified that it would be necessary to operate the KBH Plant even if EPW had more surface water because of the function of the KBH Plant to manage the brackish water intrusion problem (Balliew, 2019 p. 277).

Deliveries of surface water from the Project to EPW will never be reliable with or without New Mexico pumping due to the unreliable nature of snowmelt and rainfall runoff upstream of Elephant Butte Reservoir. Further, the records of EPW water production indicate that the KBH Plant operates in years of high and low deliveries of Project water to EPW. Since 2008 (the first full year of operation of the plant), the plant delivered an average of about 4,200 AF/y in the 5 years with surface water deliveries greater than 50,000 AF/y and an average of 5,900 AF/y in the 4 years of surface water deliveries less than 50,000 AF/y. While this shows some increased use of the plant in years of low surface water deliveries, it also shows that it would be unreasonable to attribute the continued use of the plant solely due to the effects of New Mexico pumping.

Sunding Opinion 8– *Prior to 2003, El Paso had many groundwater wells in the lower valley which had fallen into disuse, either because they required maintenance and rehabilitation in excess of their costs or because they produced water with levels of arsenic and salt above Safe Drinking Water Act standards. As a result of increasingly unreliable Rio Grande deliveries during months of peak summer demand, the city decided to rehabilitate many of these wells, even going so far as to begin a program of installing reverse osmosis wellheads at 11 previously productive wells which had suffered brackish water intrusion. (Page 50 paragraph 1).*

Response:

The reduction in Project water deliveries that commenced in 2003 was due in large part to a severe multi-year drought that affected the Lower Rio Grande Basin. As shown in **Figure 5-1**, the inflows to Elephant Butte Reservoir at the San Marcial Gage have been below average during most years since 2003. Further EPW's drought planning assumes that there will be no surface water available to meet peak summer demands. As a result, it is unreasonable to attribute the cost to rehabilitate wells when the drought commenced to the effects of New Mexico pumping. The EPW wells would have needed to be rehabilitated with or without the effects of New Mexico pumping.

Sunding Opinion 9 *– As discussed in Section III.E, the Franklin Mountains, lying between the northwest parts of El Paso and the rest of the city, present a major geographical barrier to water distribution in the area. To bridge this divide the city undertook a series of investments to improve conveyance of water between groundwater wells in the Mesilla Aquifer and downtown El Paso, which is typically served in summer by surface water. The Paisano Water Line brings water from the Upper Valley Water Treatment Plant along Paisano Drive to be distributed in Downtown and East El Paso. The old Paisano line had reliability issues, which led El Paso Water to decide to replace it in 2013. During droughts, when there was peak demand and no surface water available to supply downtown El Paso, the line was a bottleneck for transmitting water from the Upper Valley WTP to downtown El Paso. Consequently, El Paso Water decided to replace the line with a 48" pipe rather than the 36" pipe that previously existed. The incremental cost of installing the larger pipe was $1.54 million in 2016 dollars. There was an additional bottleneck in distributing water that supplied the Upper Valley Treatment Plant from the Canutillo wells. Building a water transmission line to break this bottleneck and supply additional water to the city during drought periods cost the city $14.56 million in 2016 dollars. El Paso Water also drilled two wells supplying Upper Valley Water Treatment Plant in 2011, near the peak of a major drought. Wells 208 and 312 were drilled and installed at a cost of $1.77 million in 2016 dollars. (Page 51 paragraph 3-5).*

Response:

The deposition testimony of John Balliew directly contradicts the Dr. Sunding opinion about why the capacity of the Paisano Water Line was increased. Balliew testified that the capacity of the original 36-inch pipeline was sufficient to deliver water from the Canutillo wellfield south and into the downtown El Paso area. The reason that the pipeline capacity was enlarged was to be able to deliver additional surface water from the Robertson/Umbenhauer WTP to areas further north that are currently supplied by the Canutillo wellfield. (Balliew, 2019 p. 320-321).

Sunding Opinion 10 *– Surface water that EPWU delivers to its customers is less salty than groundwater. According to data provided by EPWU, the average salinity of its delivered surface water is 675 mg/L TDS and the average salinity of its delivered groundwater is 862 mg/L TDS. This difference of 187 mg/L TDS in salinity over a prolonged period of time imposes a cost on customers. Based on data from Dr. Dorrance, under the hypothetical scenario, the share of surface water delivered to customers would increase by 7.6 percent. As seen in Figure 7, these additional surface water deliveries would be localized to specific parts of the city. Based on these observations, I assume that 7.6 percent of EPWU's customers would experience a reduction in salinity in the hypothetical scenario from 862 to 675 mg/L TDS. This share of the customer base corresponds to 13,890 residential accounts, 1,453 commercial and municipal accounts and 11 industrial accounts. (Page 53 paragraph 2)*

Response:

Dr. Sunding appears to assume that an average 7.6% increase in EPW's surface water supply without New Mexico pumping would result in 7.6% of EPW customers experiencing a reduction in salinity because their supplies would be converted from ground water to surface water. Assuming EPW did receive an increase in surface water without New Mexico pumping it seems unlikely that particular customers would see their supply switch from ground water to surface water. Instead, any increases in surface water would affect the blend of surface water and ground water that many customers receive.

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FIGURES

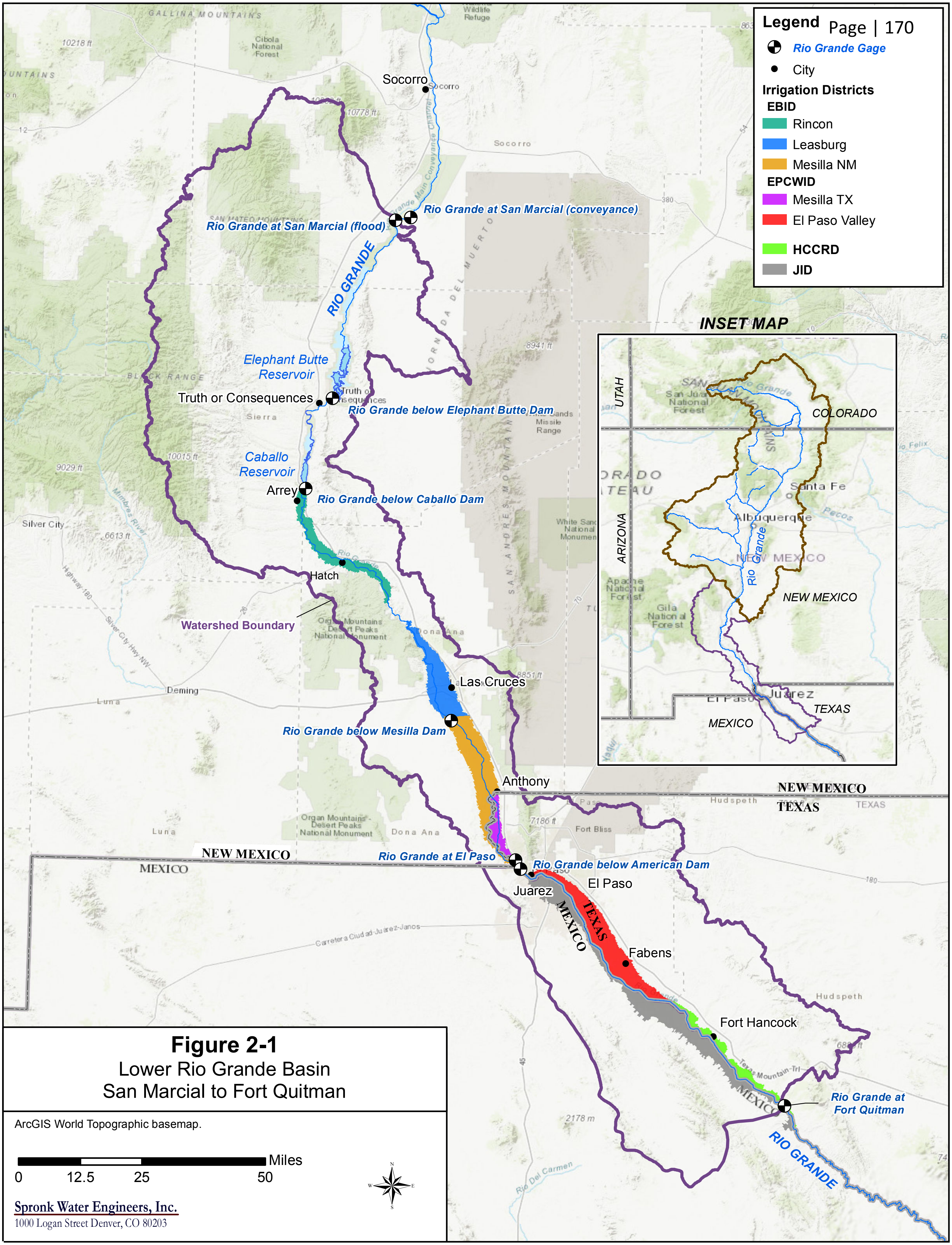

Figure 2-1

Lower Rio Grande Basin
San Marcial to Fort Quitman

ArcGIS World Topographic basemap.

Spronk Water Engineers, Inc.
1000 Logan Street Denver, CO 80203

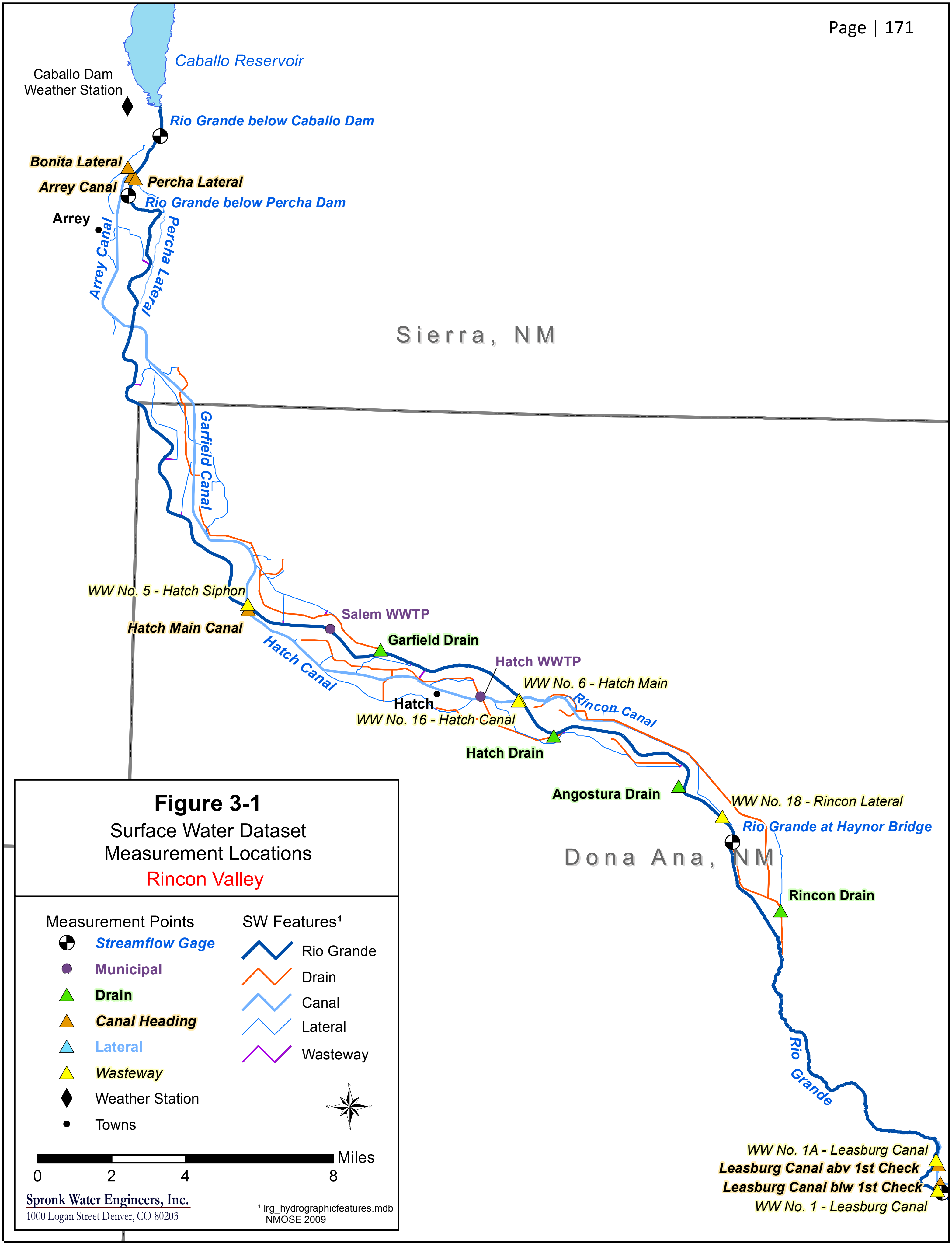

Figure 3-1

Surface Water Dataset
Measurement Locations
Rincon Valley

¹ lrg_hydrographicfeatures.mdb
NMOSE 2009

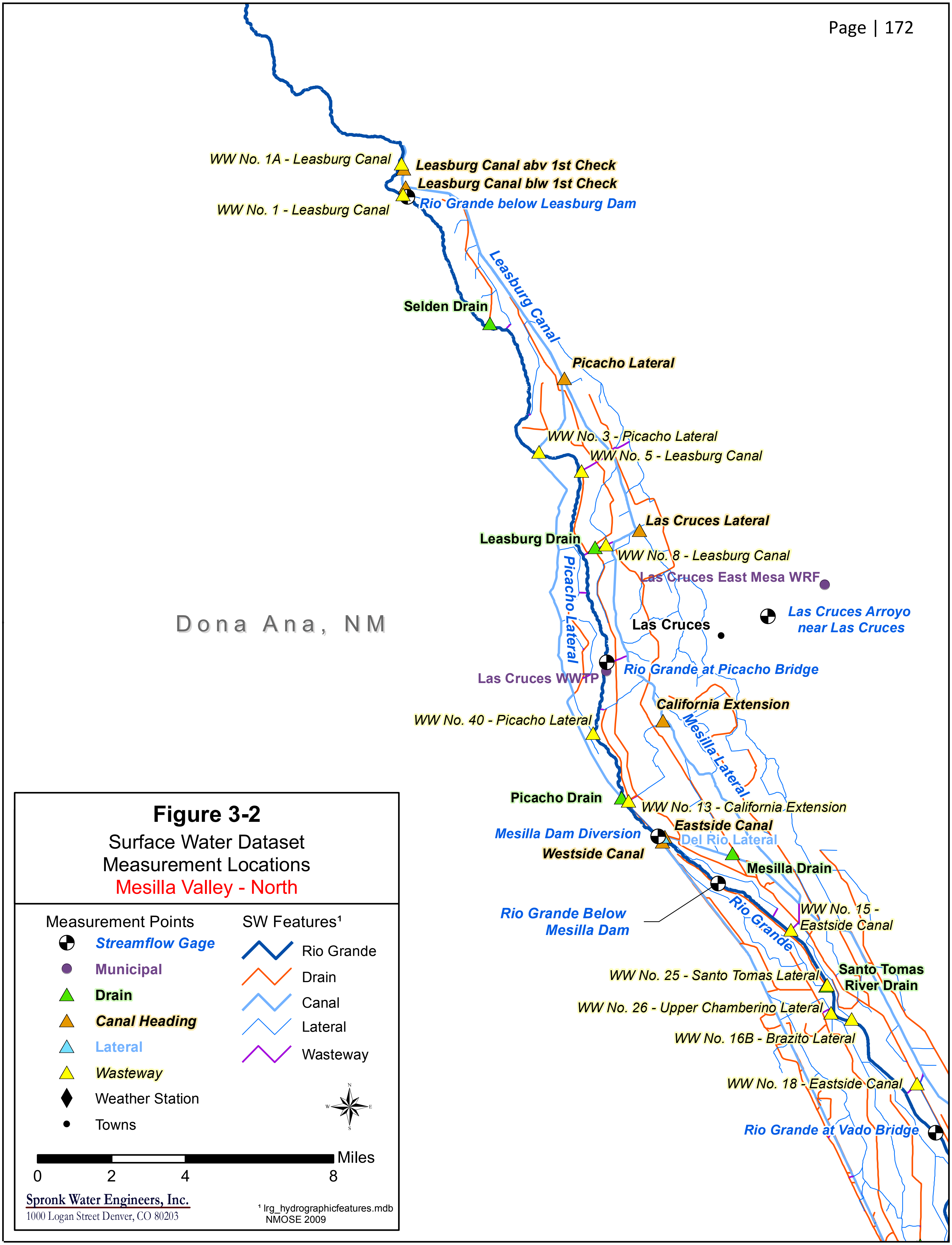

Figure 3-2

Surface Water Dataset

Measurement Locations

Mesilla Valley - North

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1000 Logan Street Denver, CO 80203

[1] lrg_hydrographicfeatures.mdb
NMOSE 2009

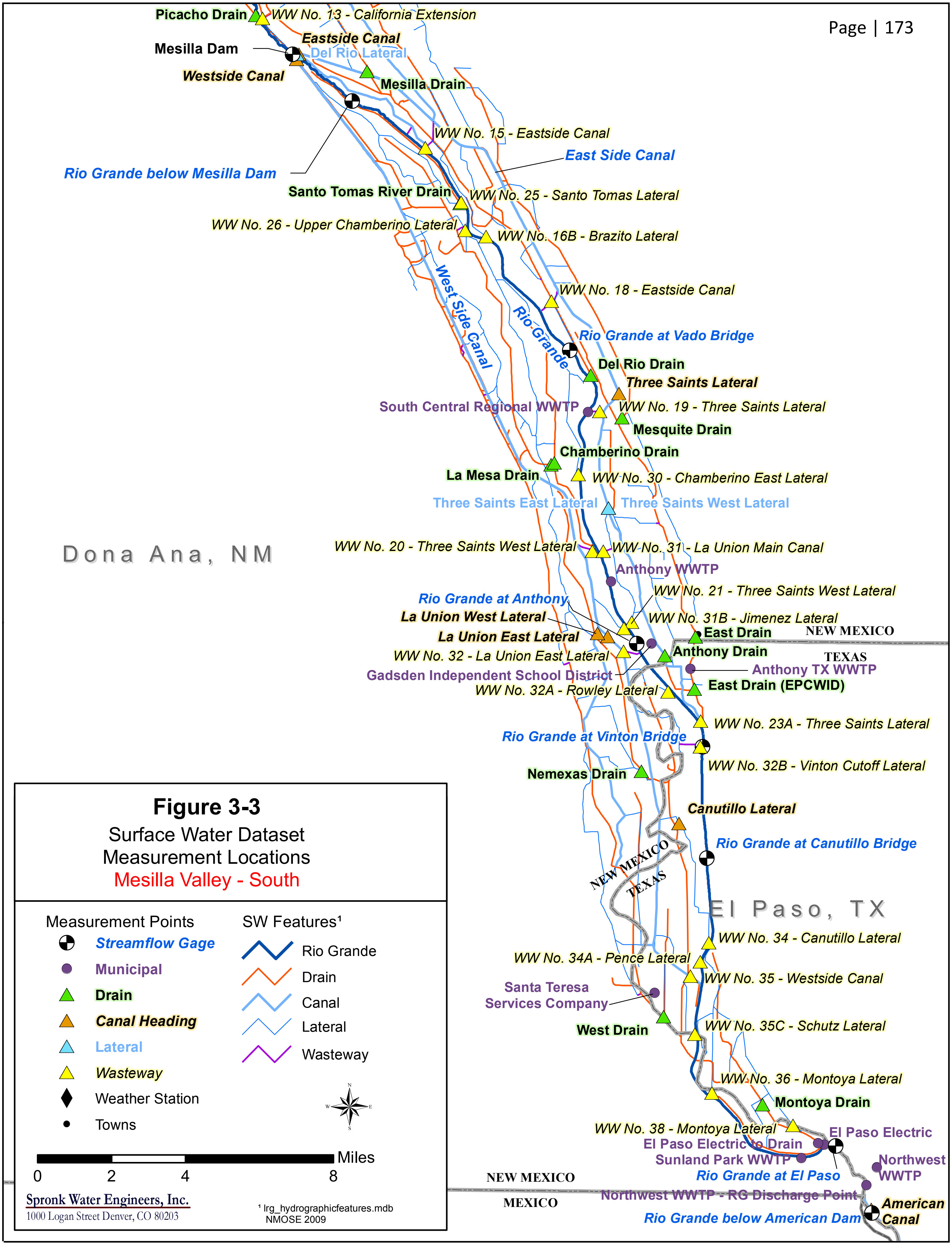

Figure 3-3
Surface Water Dataset
Measurement Locations
Mesilla Valley - South

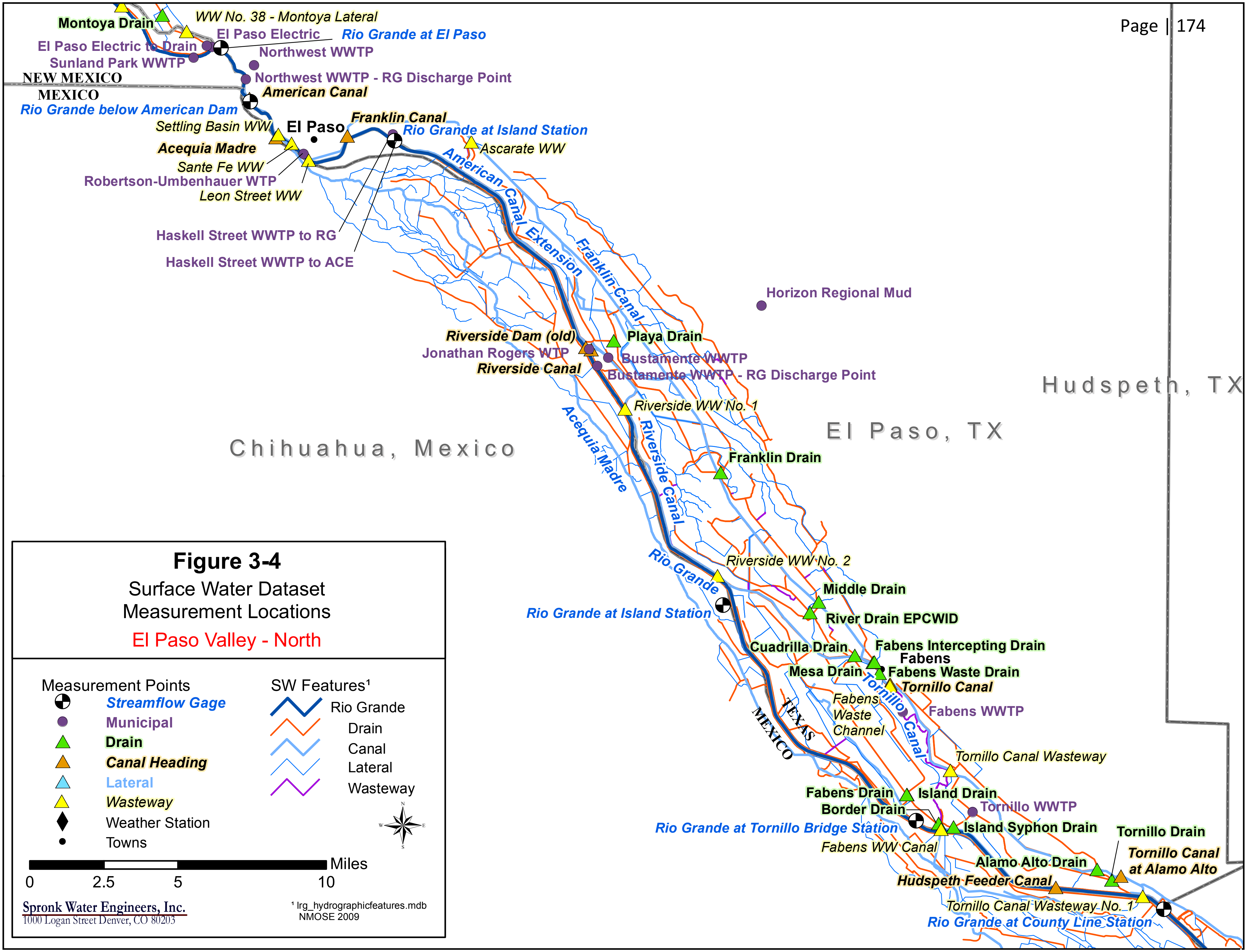

Figure 3-4
Surface Water Dataset
Measurement Locations
El Paso Valley - North

¹ lrg_hydrographicfeatures.mdb
NMOSE 2009

Spronk Water Engineers, Inc.
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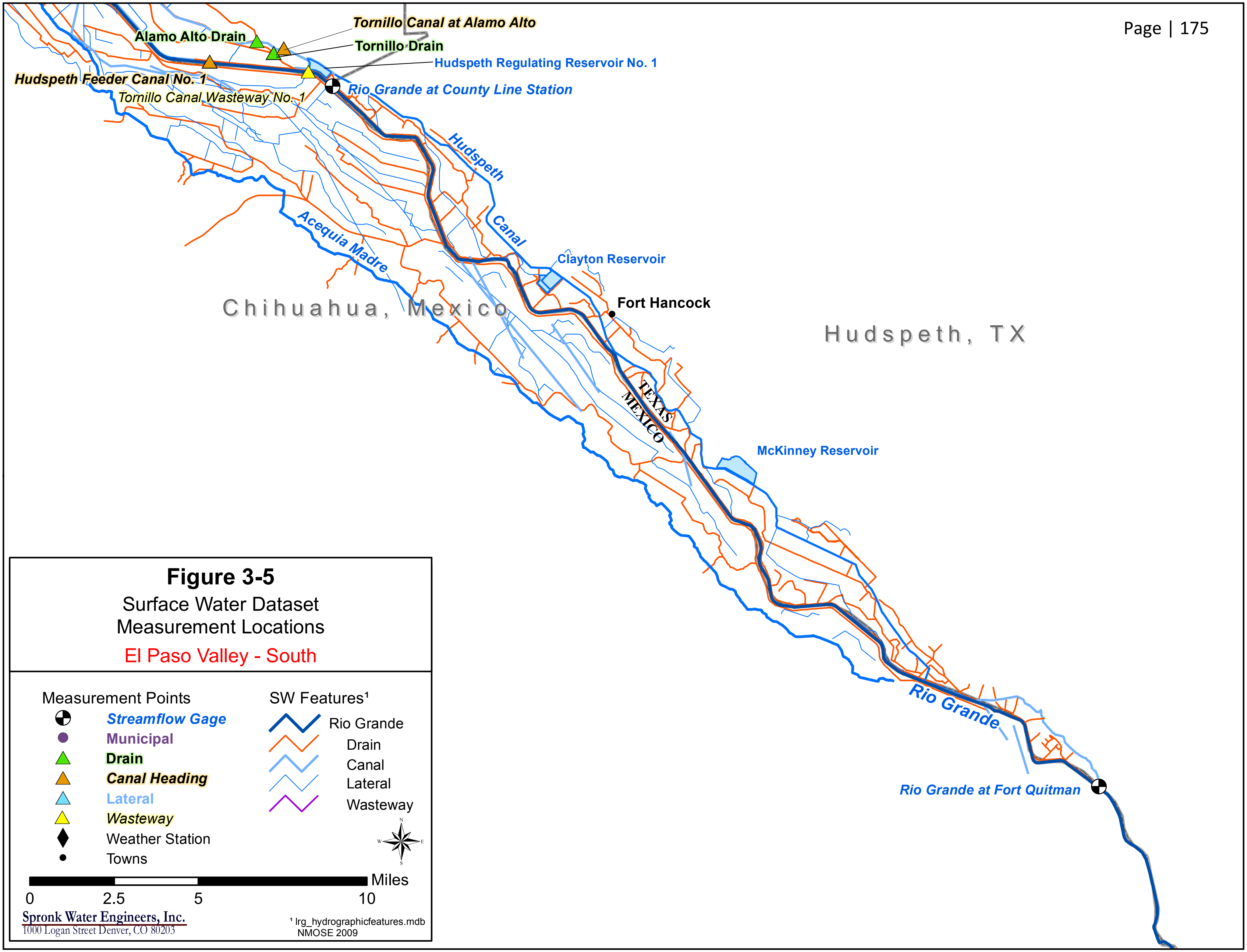

Figure 3-5

Surface Water Dataset
Measurement Locations
El Paso Valley - South

Spronk Water Engineers, Inc.
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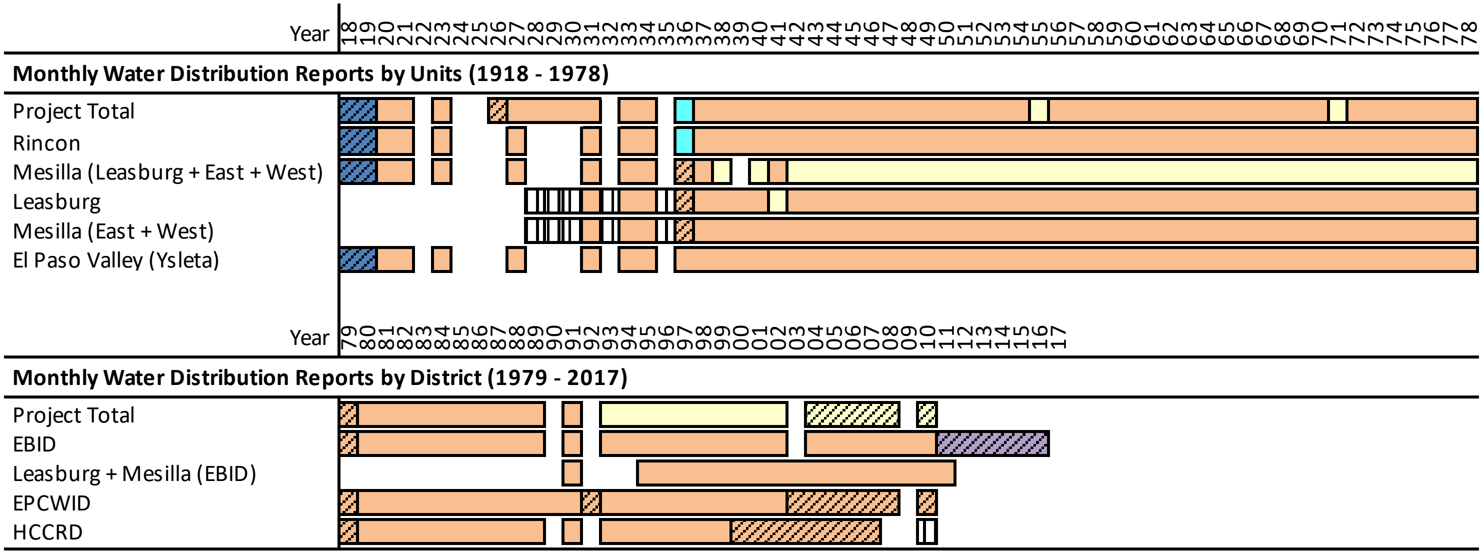
¹ lrg_hydrographicfeatures.mdb
NMOSE 2009

Figure 4-1

Water Distribution Report Data (1918 - 2017)



Key:

🟧 Water Distribution Report is available and monthly data for year are compiled.

🟪 Annual farm delivery data only.

🟦 Annual acreage and river headgate diversion data only.

■ Water Distribution Report is available but values are illegible.

🟨 Water Distribution Report is not available but values are estimated using reports for other units.

▨ Hashed where only annual data are available or only part of the records are available (e.g., only river headgate diversions are available).

▥ Acreage data only.

Notes: There may be some missing months within certain years.
Project totals include total for Rincon, Leasburg, Mesilla, and El Paso Valley (pre-1979), and EBID plus EPCWID (post-1979).
Pre-1979, Mesilla (East + West) includes lands in New Mexico and Texas under the Eastside and Westside canal systems.
Mesilla (East + West) includes lands in New Mexico and Texas under the Eastside and Westside canal systems.

Source: LRG.Doc.SW109: Water Distribution Reports.

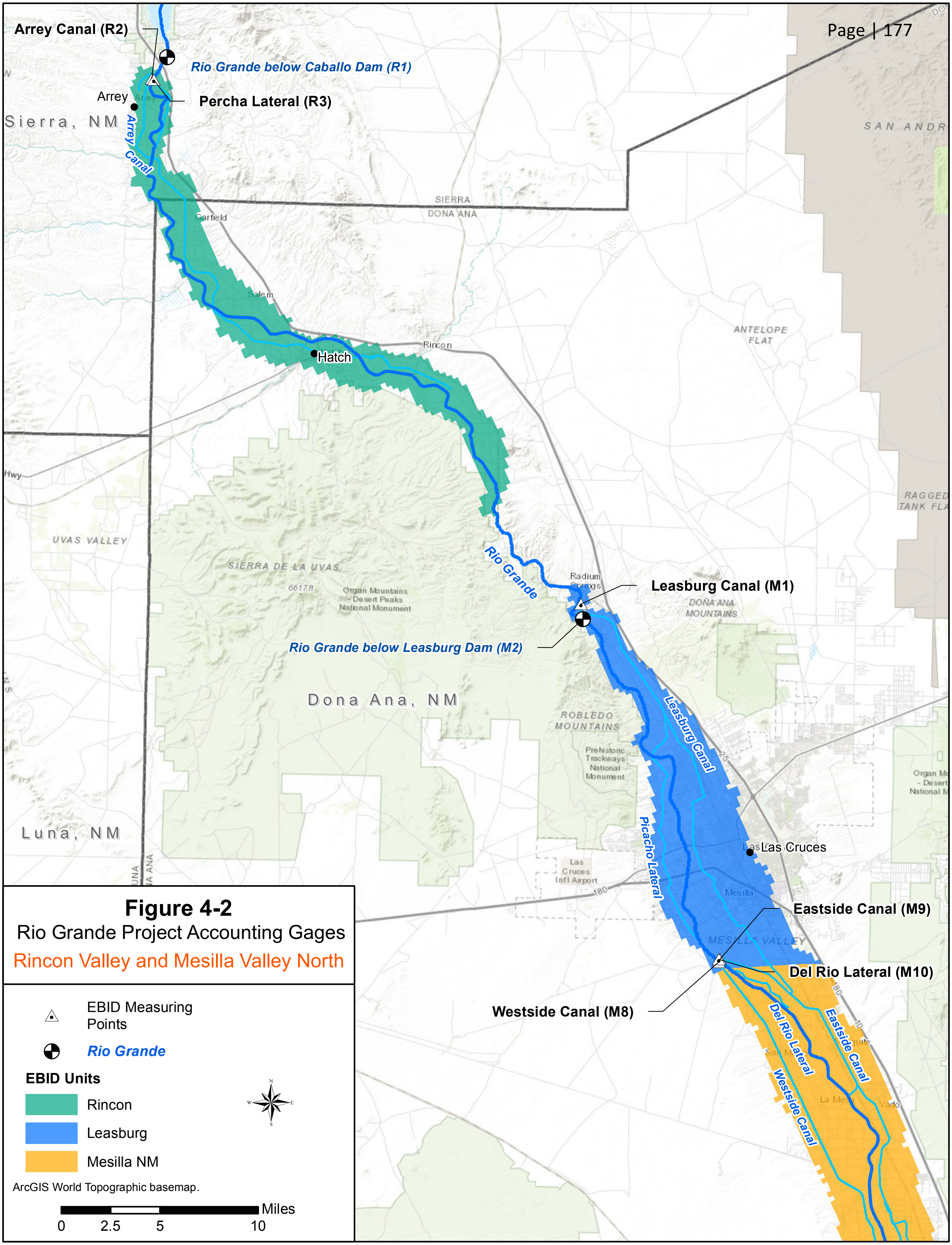


Figure 4-2

Rio Grande Project Accounting Gages

Rincon Valley and Mesilla Valley North

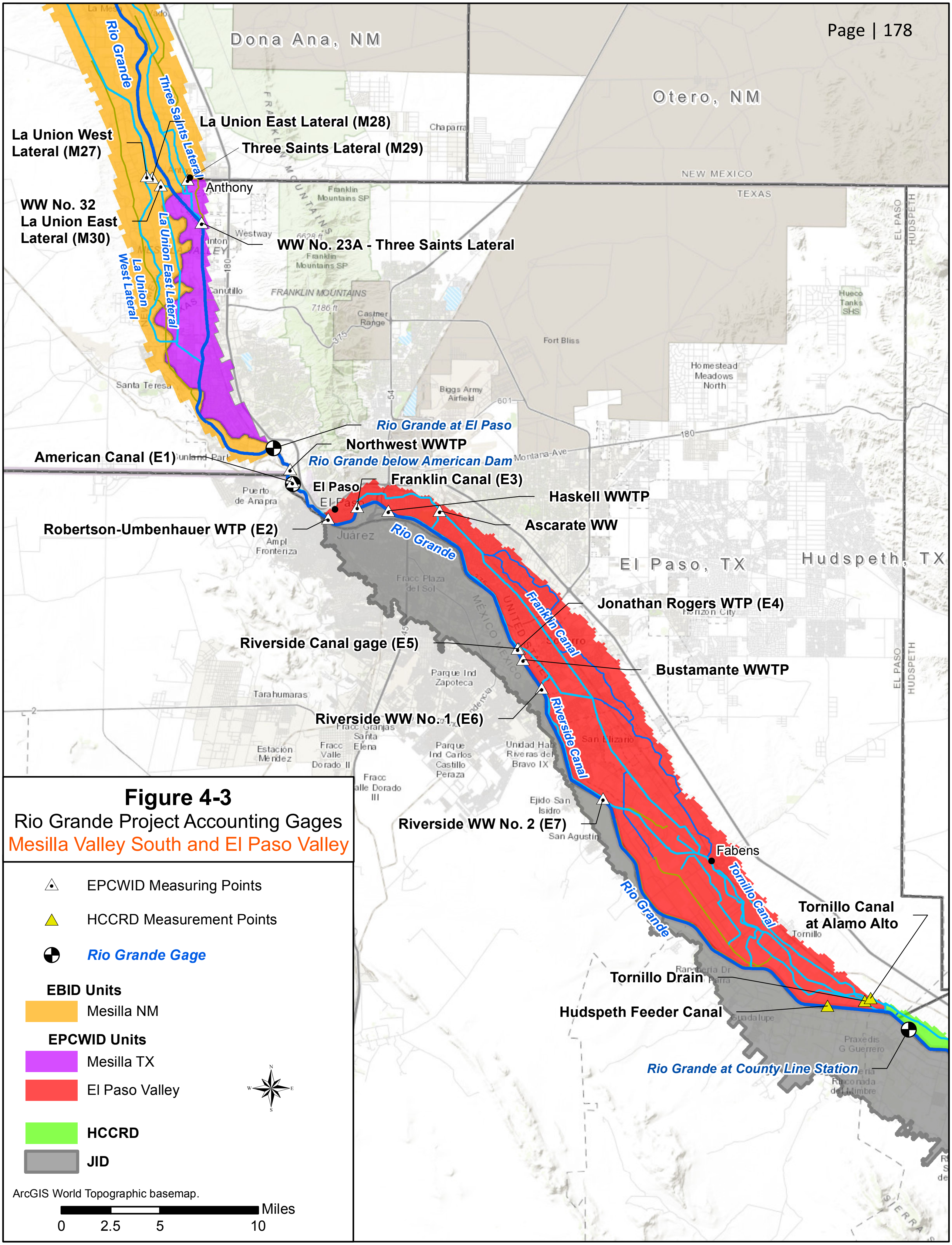


Figure 4-3

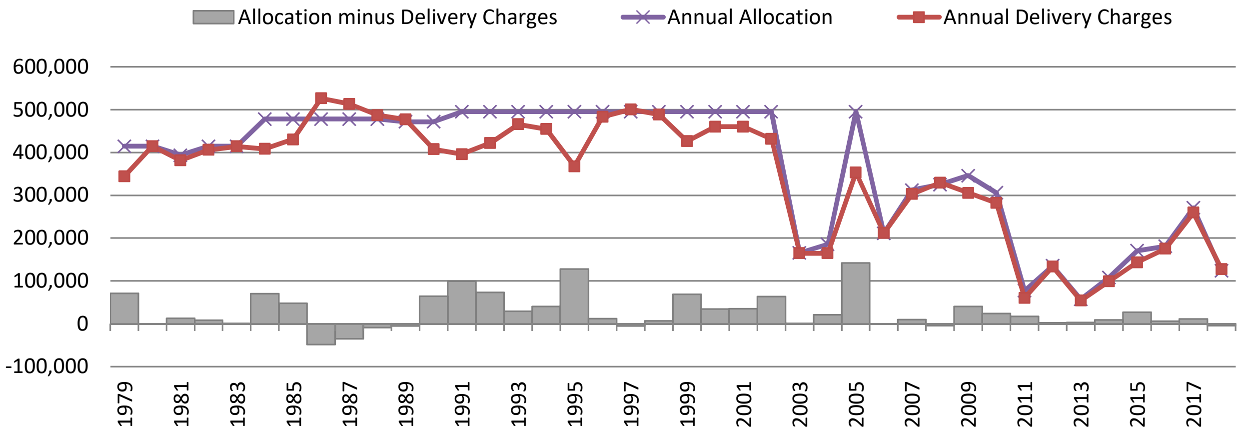
Rio Grande Project Accounting Gages

Mesilla Valley South and El Paso Valley

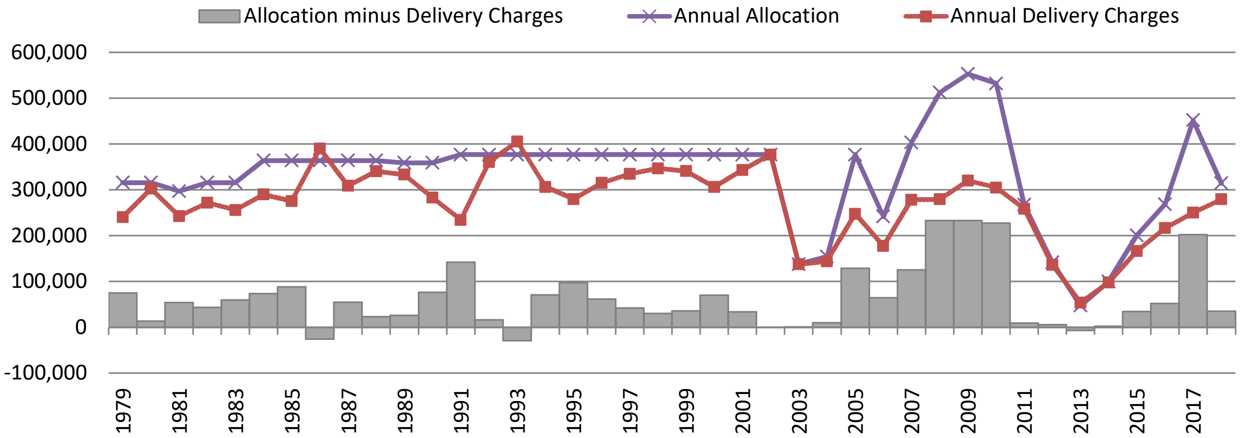
Figure 4-4

Annual Allocation and Delivery Charges
Rio Grande Project Accounting
1979-2018
(acre-feet)

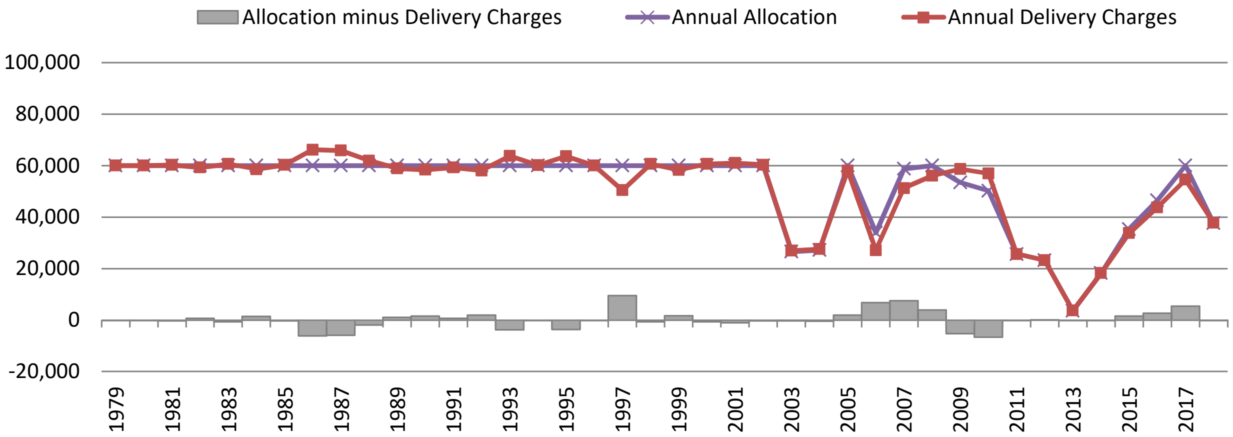
EBID



EPCWID



JID

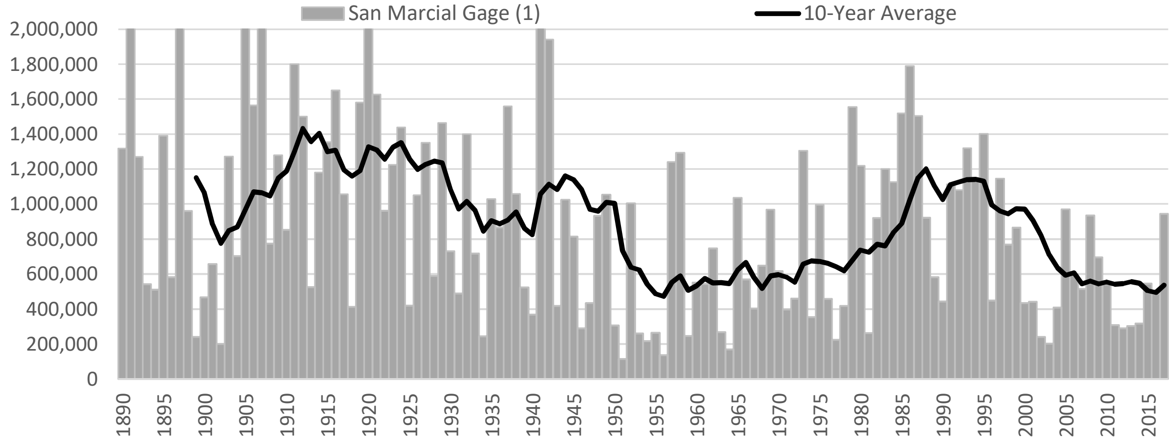


***Note Different Scales**

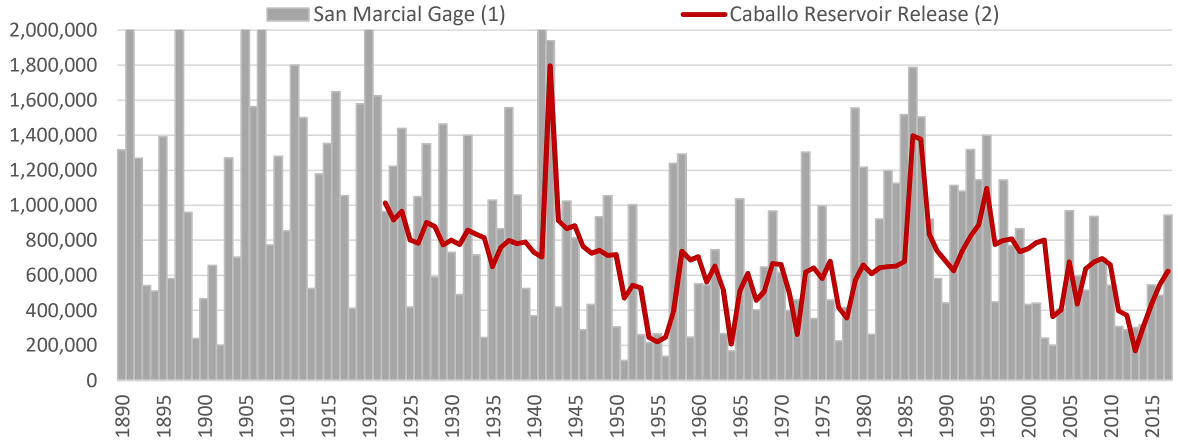
Figure 5-1

Annual Rio Grande Flows
1890 - 2017
(acre-feet)

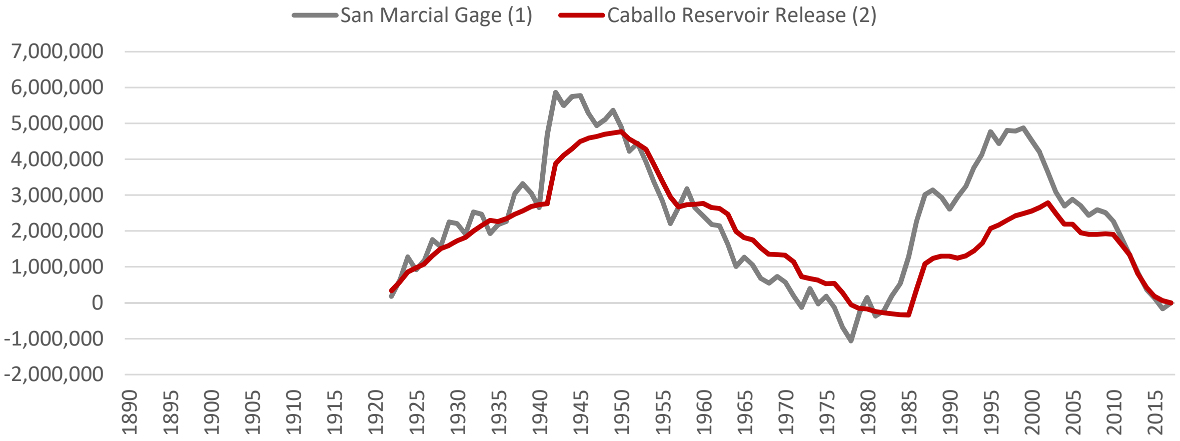
San Marcial Gage



San Marcial Gage and Caballo Reservoir Release



Cumulative Departure from Average



Notes:

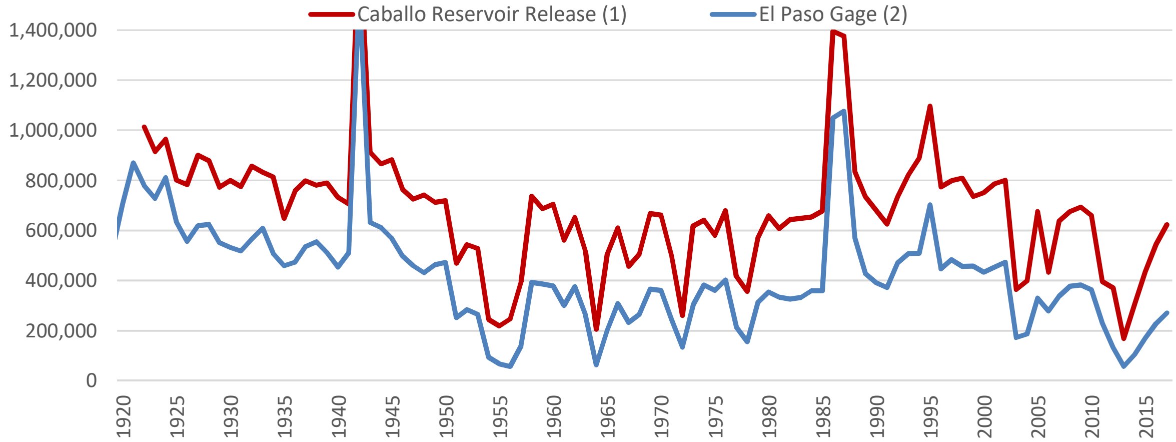
(1) San Marcial gage data from 1938 RGJI (1890-1924) and LRG SWDataSet (1925-2017).

(2) Rio Grande above Percha Dam gage used for Caballo Reservoir Release before 1938. Data from LRG SWDataSet.

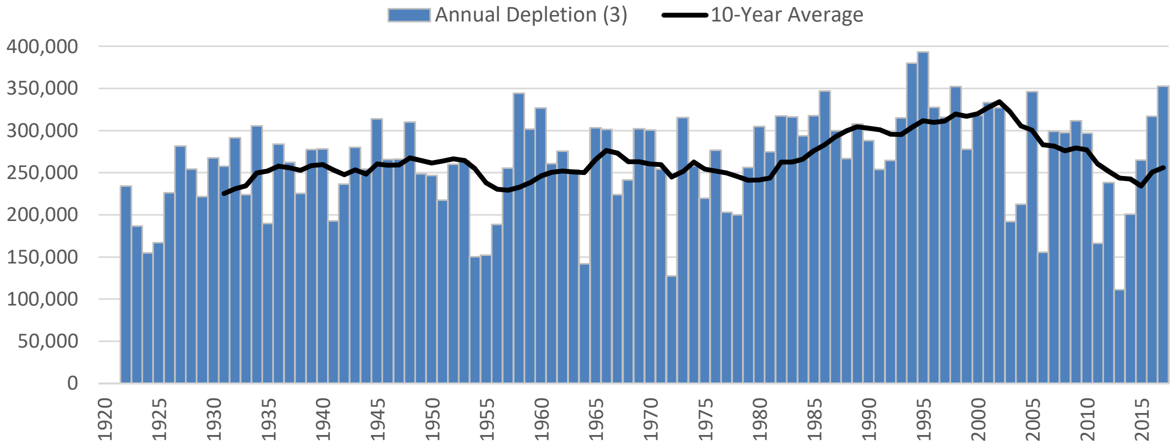
Figure 5-2

Annual Rio Grande Flows
1920 - 2017
(acre-feet)

Caballo Reservoir Release and El Paso Gage



River Depletion: Caballo Reservoir Release minus El Paso Gage



Notes:

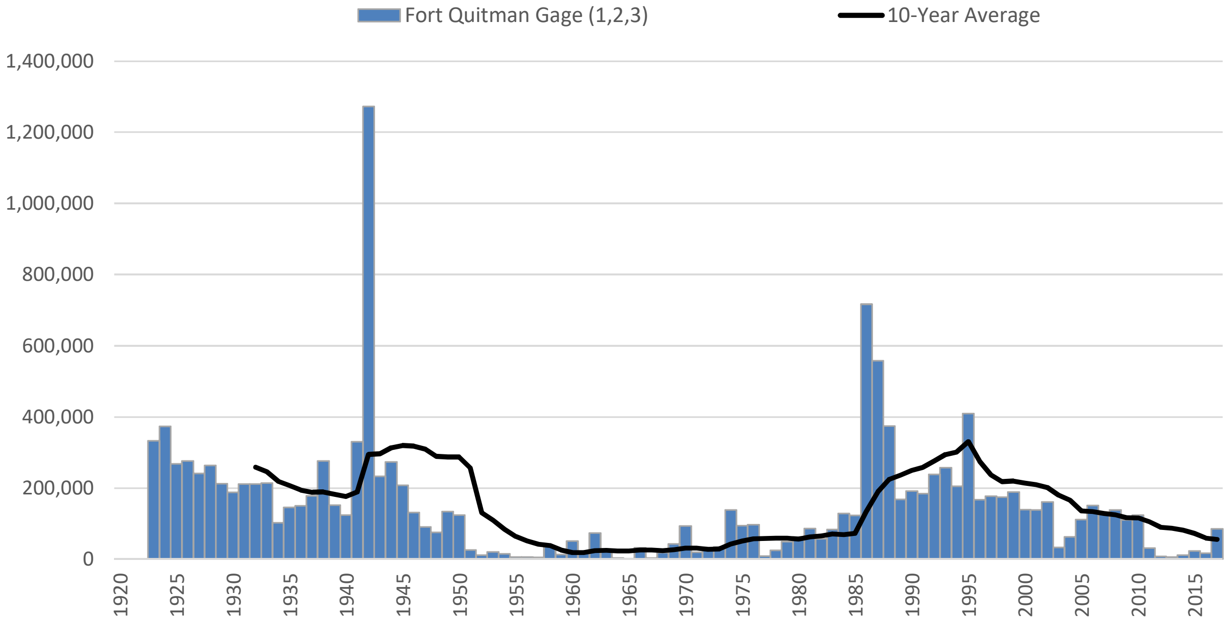
(1) Rio Grande above Percha Dam gage used for Caballo Reservoir Release before 1938. Data from LRG SWDataSet.

(2) El Paso gage data from LRG SWDataSet.

(3) Annual Depletion computed as Caballo Reservoir Release minus El Paso gage.

Figure 5-3

Annual Rio Grande Flows
1920 - 2017
(acre-feet)
Fort Quitman Gage



Notes:

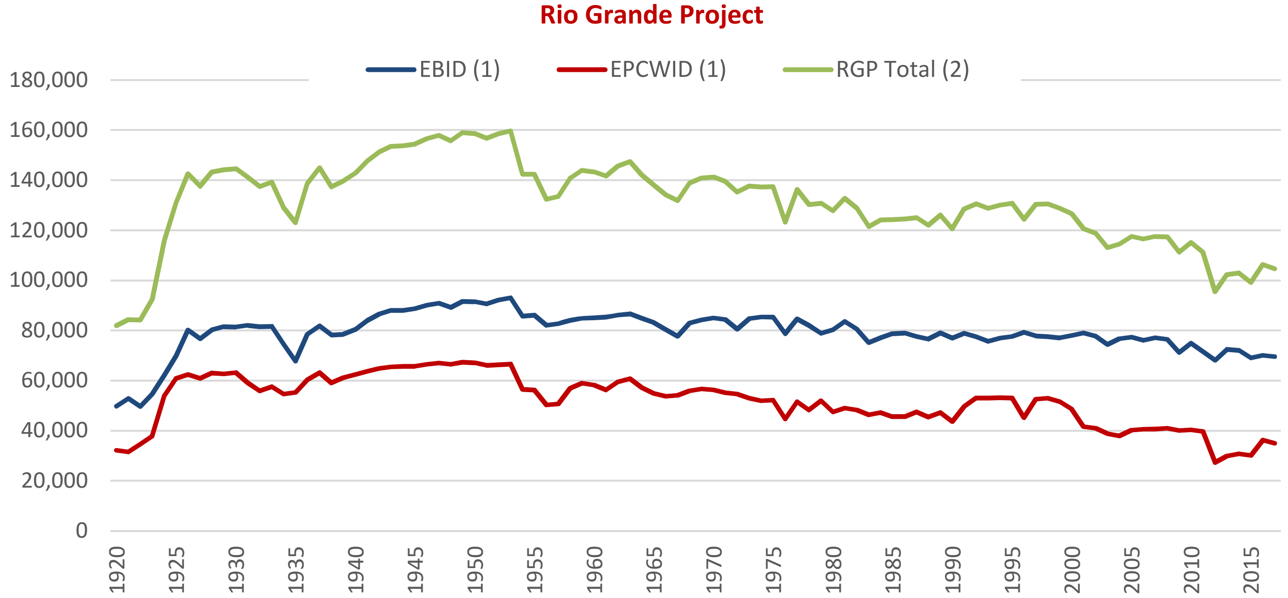
(1) Flows in 1987 are not complete (flood flows went around gage due to broken levees).

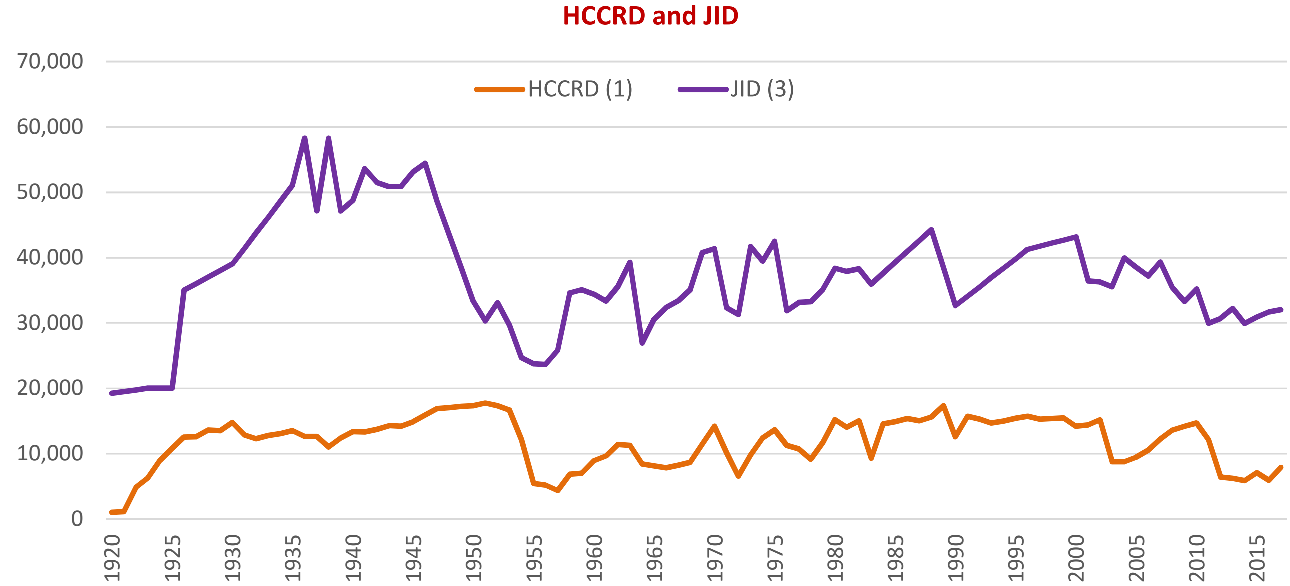
(2) Missing data from August 2016 - April 2017.

(3) Data from LRG SWDataSet. Gage data begins in 1923.

Figure 5-4

Annual Irrigated Area
1920 - 2017
(acres)





Notes:

(1) Data from 1938 Rio Grande Joint Investigation (1920-1935) and DE (1936-2017).

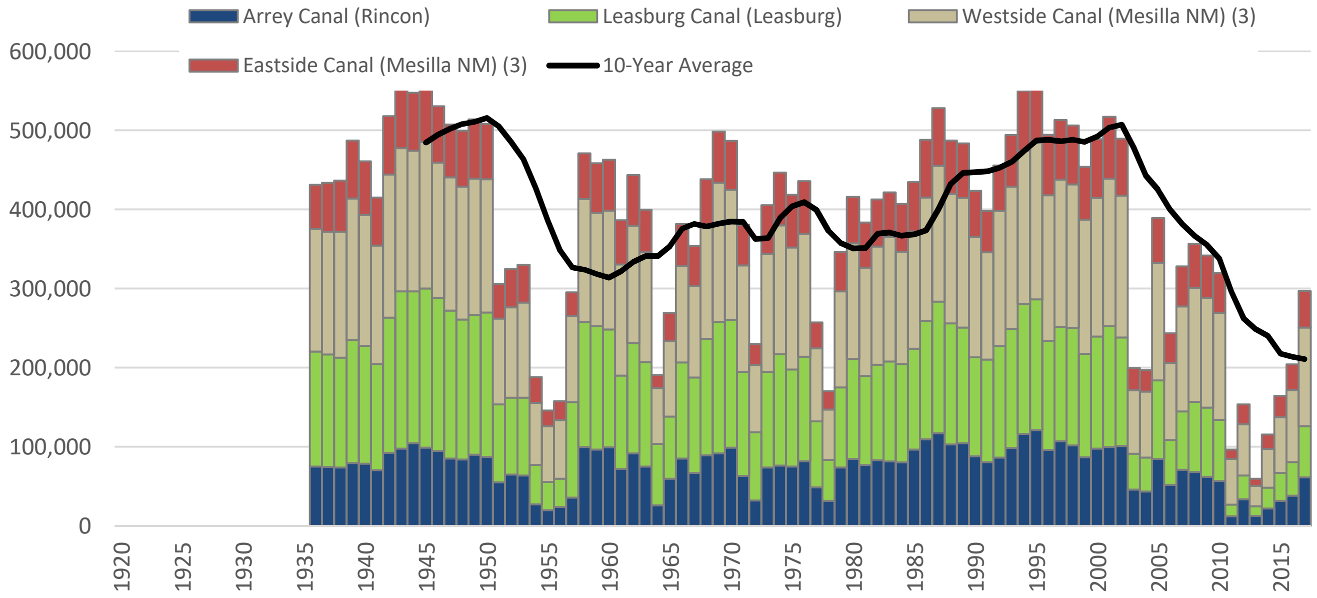
(2) RGP Total calculated as sum of EBID and EPCWID acres.

(3) Data from MMA (1920-1949) and DE (1950-2017).

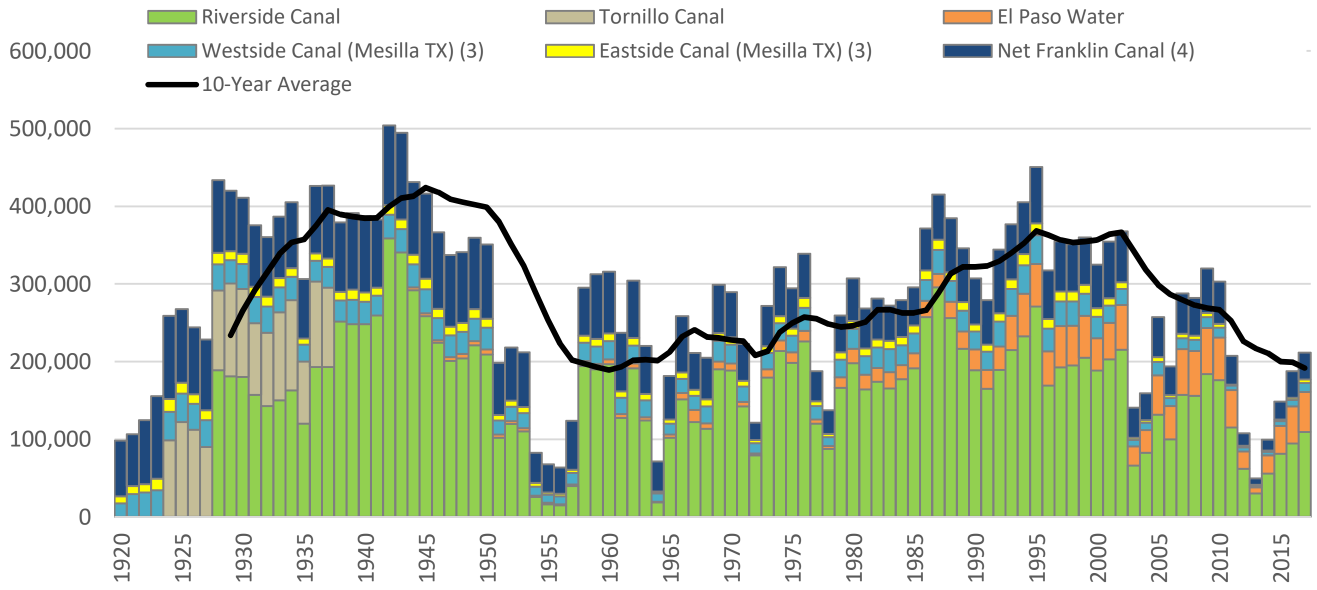
Figure 5-5

Annual Canal Heading Diversions
Irrigation Season (Mar-Oct)
1920 - 2017
(acre-feet)

EBID (1,2)



EPCWID (1)

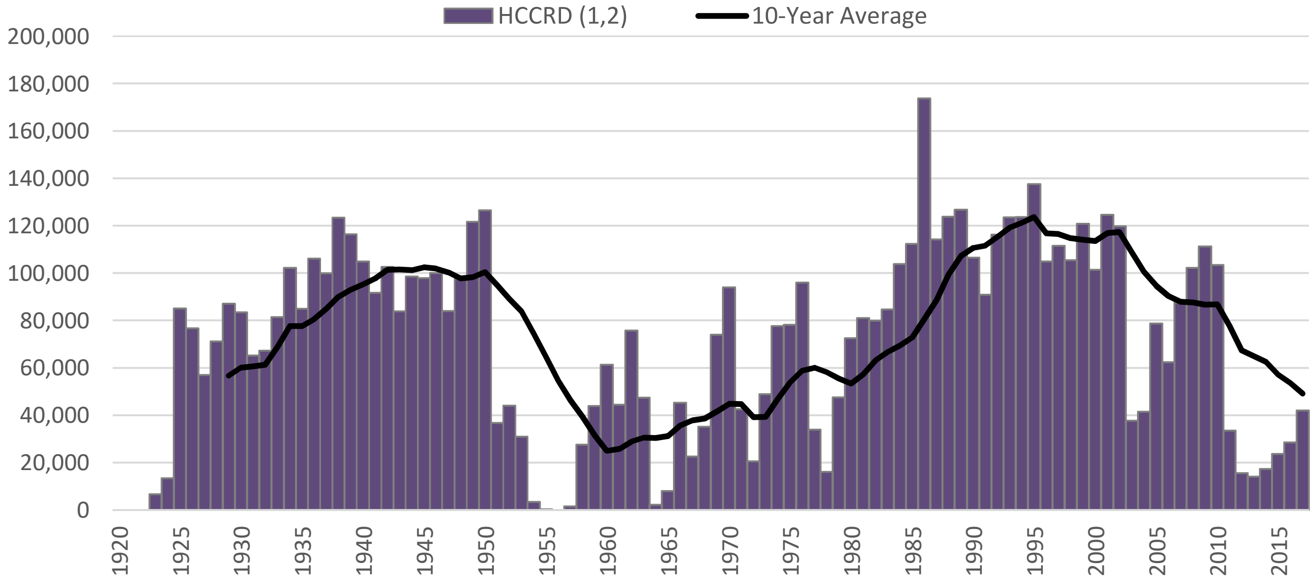


Notes:
(1) Data from LRG SWDataSet.
(2) EBID diversion data prior to 1936 are incomplete.
(3) Eastside and Westside Canal diversions split into EBID and EPCWID proportionally based on irrigated area.
(4) Net Franklin Canal computed as Franklin Canal - Ascarate Wasteway.

Figure 5-6

Annual Canal Heading Diversions
Irrigation Season (Mar-Oct)
1920 - 2017
(acre-feet)

HCCRD



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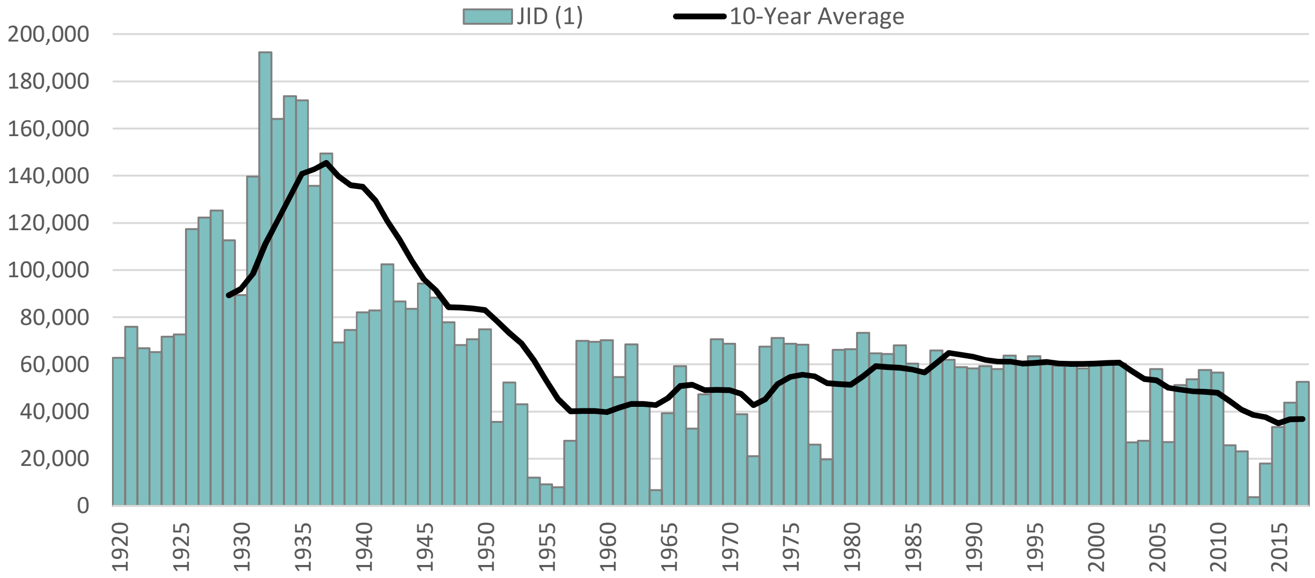


Notes:

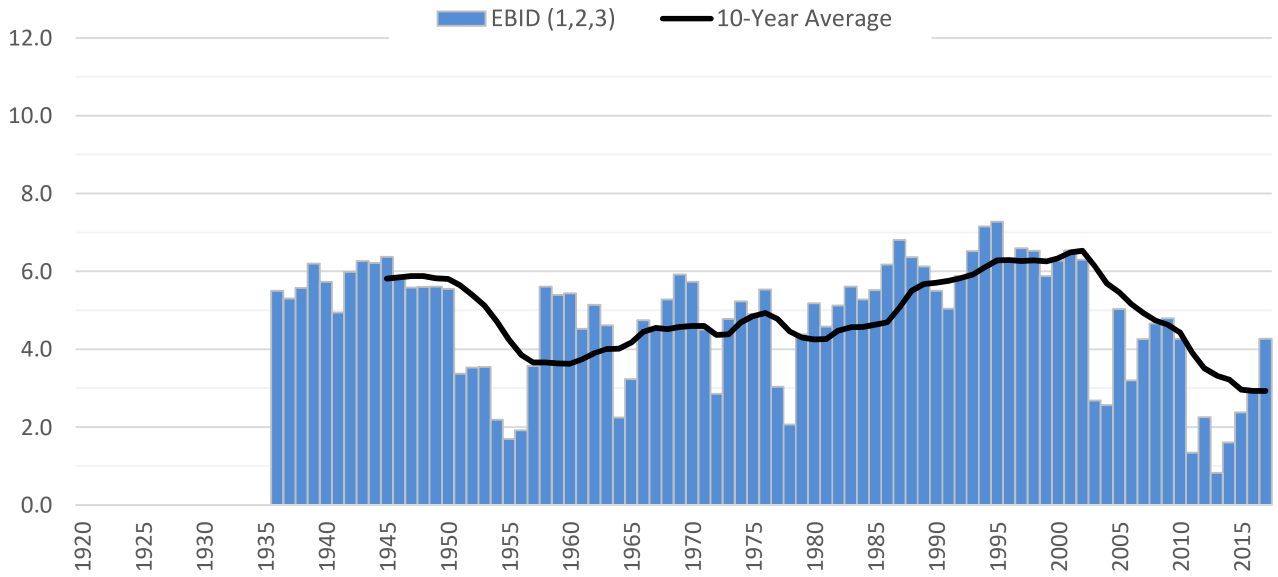
(1) Data from LRG SWDataSet.

(2) HCCRD data begins in 1923.

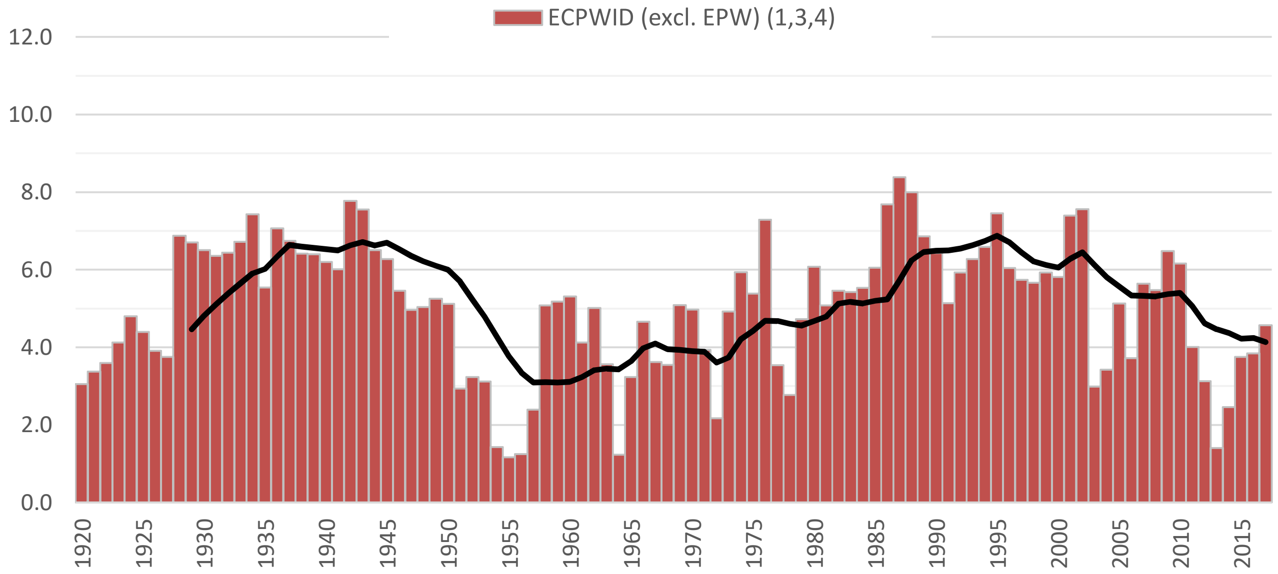
Figure 5-7

Annual UNIT Canal Heading Diversions for Irrigation (Actual Acres)
Irrigation Season (Mar-Oct)
1920 - 2017
(acre-feet/acre)

EBID



EPCWID



Notes:

(1) Data from LRG SWDataSet and Rio Grande Project Canal and Farm Budget.

(2) EBID diversion data prior to 1935 are incomplete.

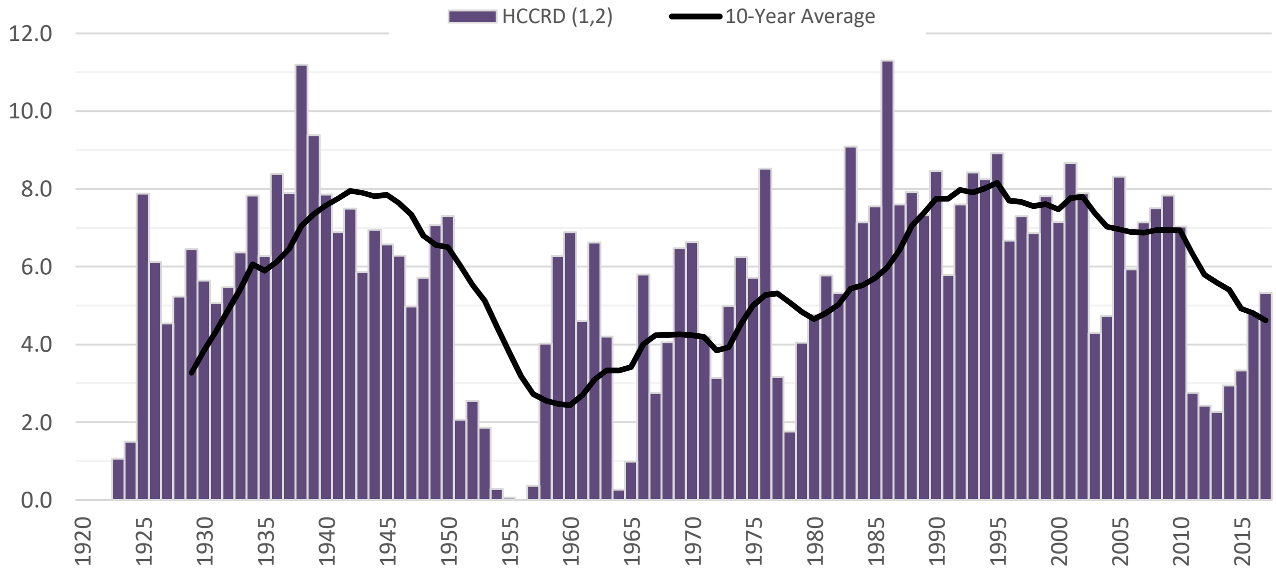
(3) Eastside and Westside Canal diversions split into EBID and EPCWID proportionally based on irrigated area.

(4) EPCWID figures do not include Project water deliveries to EPW.

Figure 5-8

Annual UNIT Canal Heading Diversions for Irrigation (Actual Acres)
Irrigation Season (Mar-Oct)
1920 - 2017
(acre-feet/acre)

HCCRD



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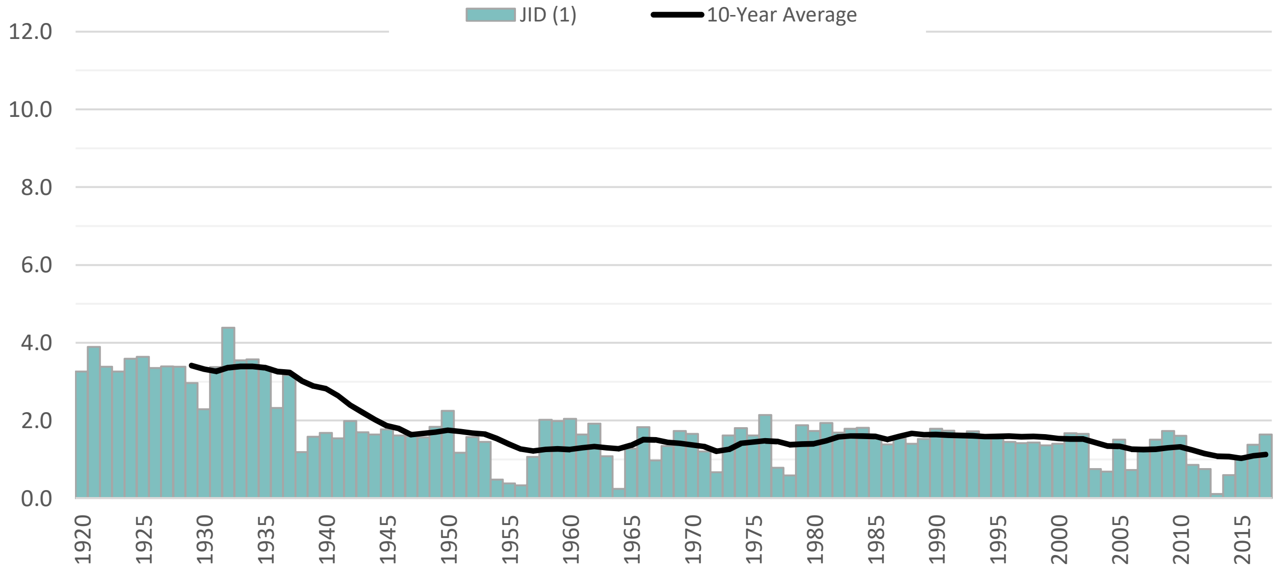


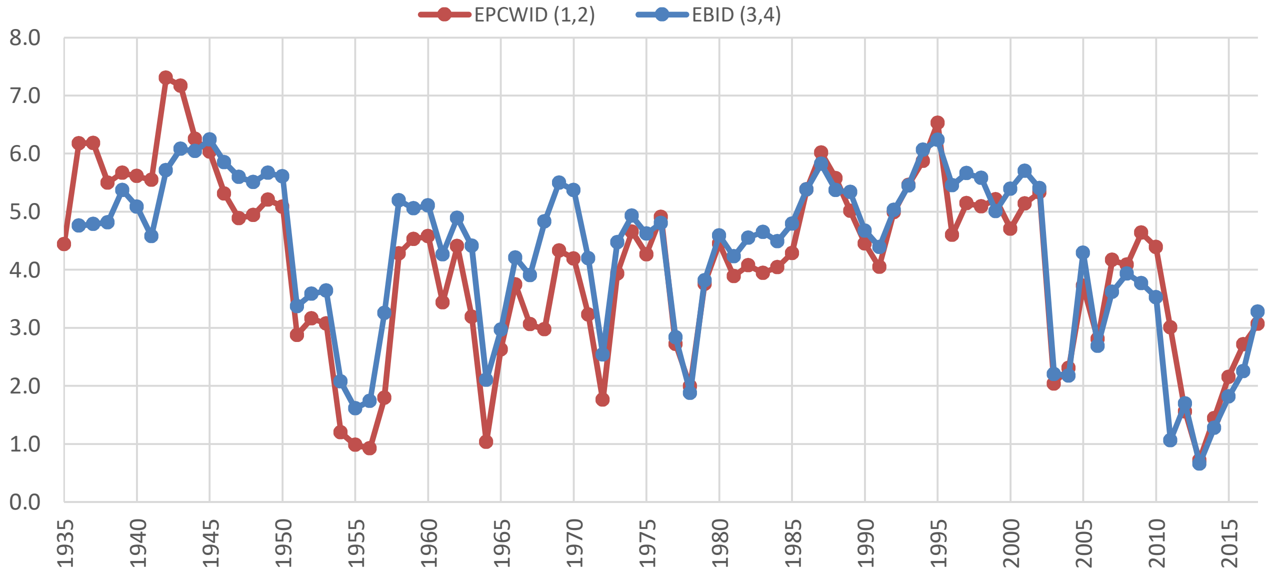
Notes:

(1) Data from LRG SWDataSet and Rio Grande Project Canal and Farm Budget.

(2) HCCRD data begins in 1923.

Figure 5-9

Annual UNIT Canal Heading Diversions for Irrigation (Authorized Acres)
Irrigation Season (Mar-Oct)
1935 - 2017
(acre-feet/acre)



<u>Notes:</u>

(1) EPCWID includes Project water deliveries to EPW.

(2) EPCWID authorized acres: 69,010 acres.

(3) EBID authorized acres: 90,640 acres.

(4) EBID data incomplete in 1935.

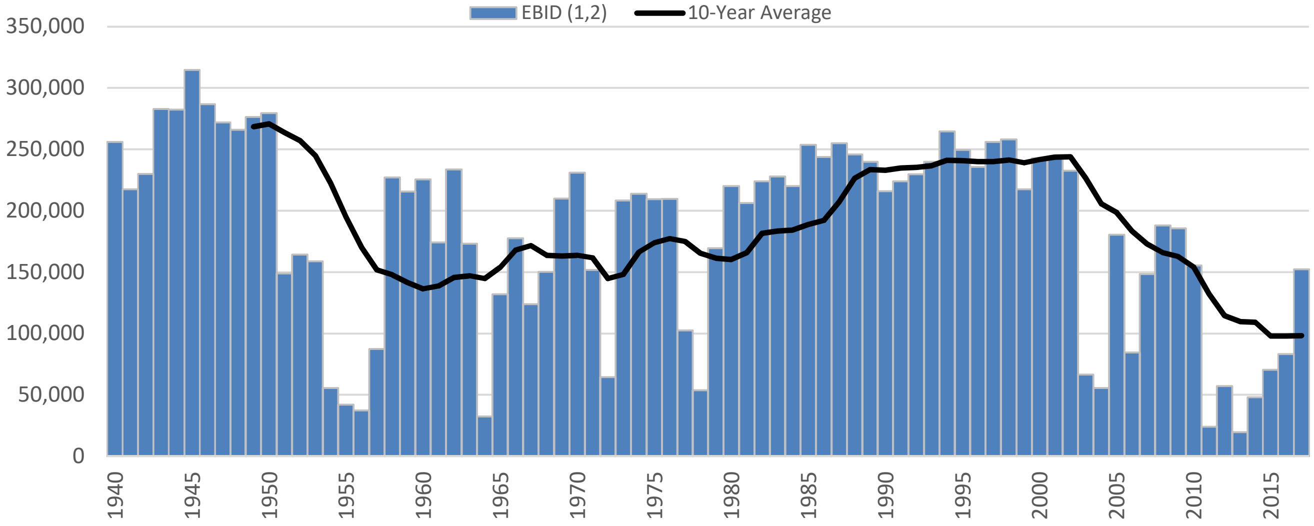
(5) Eastside and Westside Canal diversions split into EBID and EPCWID proportionally based on irrigated area.

(6) RHG data from LRG SWDataSet.

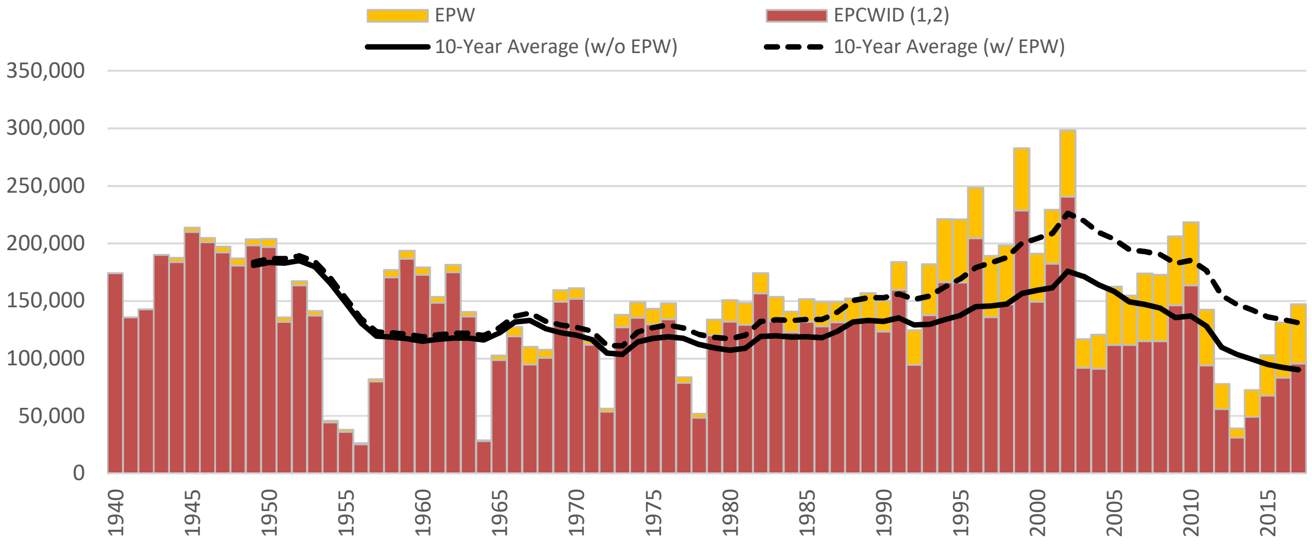
Figure 5-10

Annual Farm Headgate Deliveries
Irrigation Season (Mar-Oct)
1940 - 2017
(acre-feet)

EBID



EPCWID



Notes:

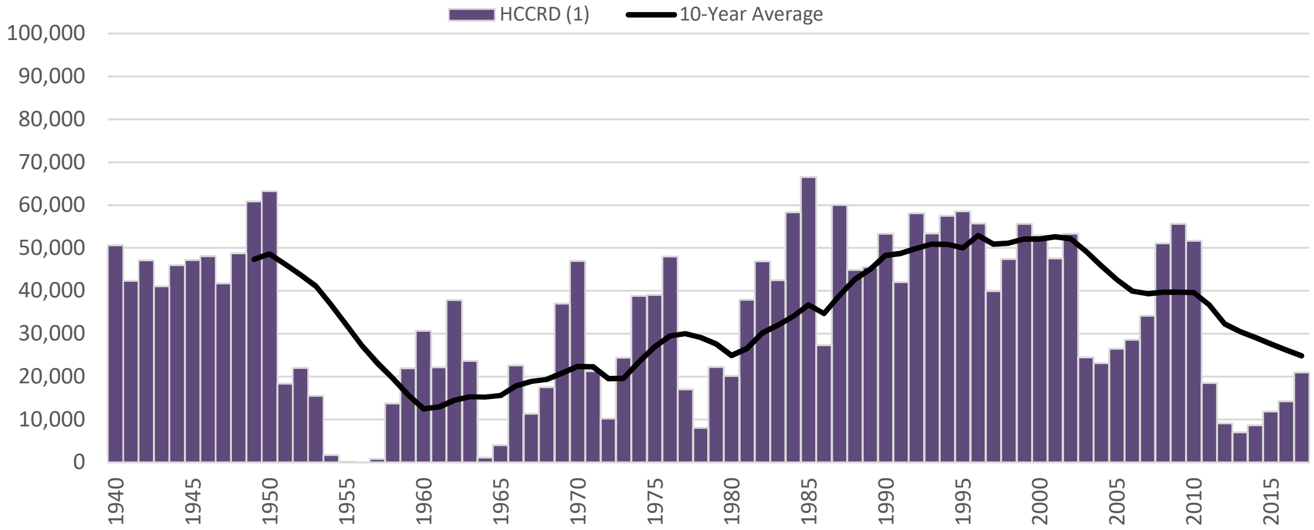
(1) Farm deliveries from records except when missing. For years with no records, farm deliveries were estimated as total diversions minus conveyance loss. Loss estimated using monthly average loss % derived from records.

(2) Pre-1979, farm deliveries split between Mesilla NM and Mesilla TX proportionally by acreage.

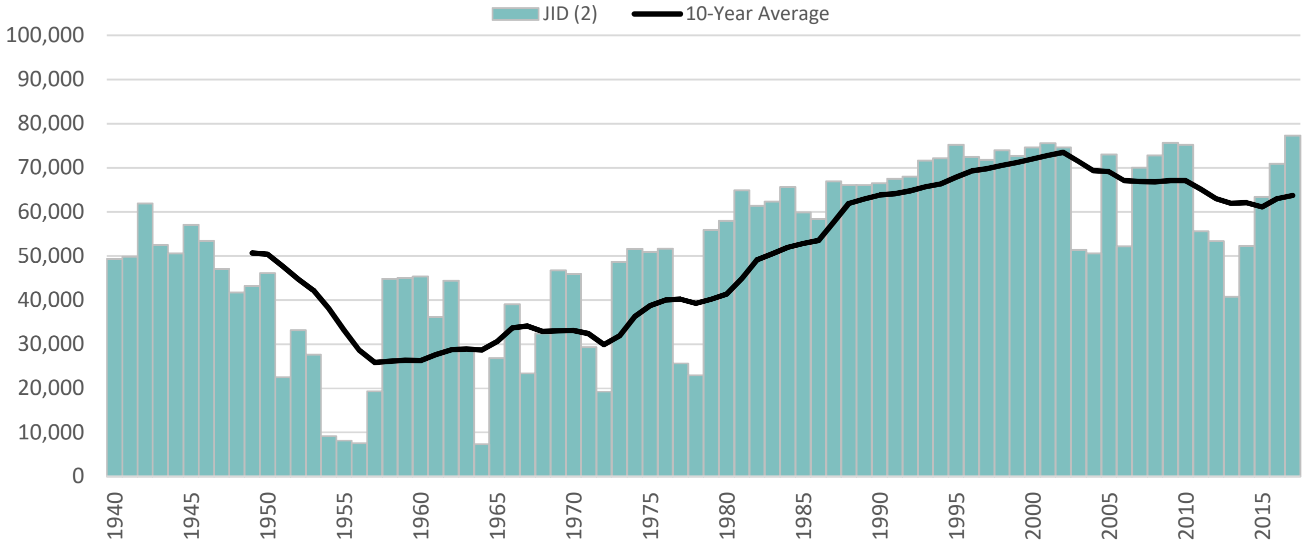
Figure 5-11

Annual Farm Headgate Deliveries
Irrigation Season (Mar-Oct)
1940 - 2017
(acre-feet)

HCCRD



JID



Notes:

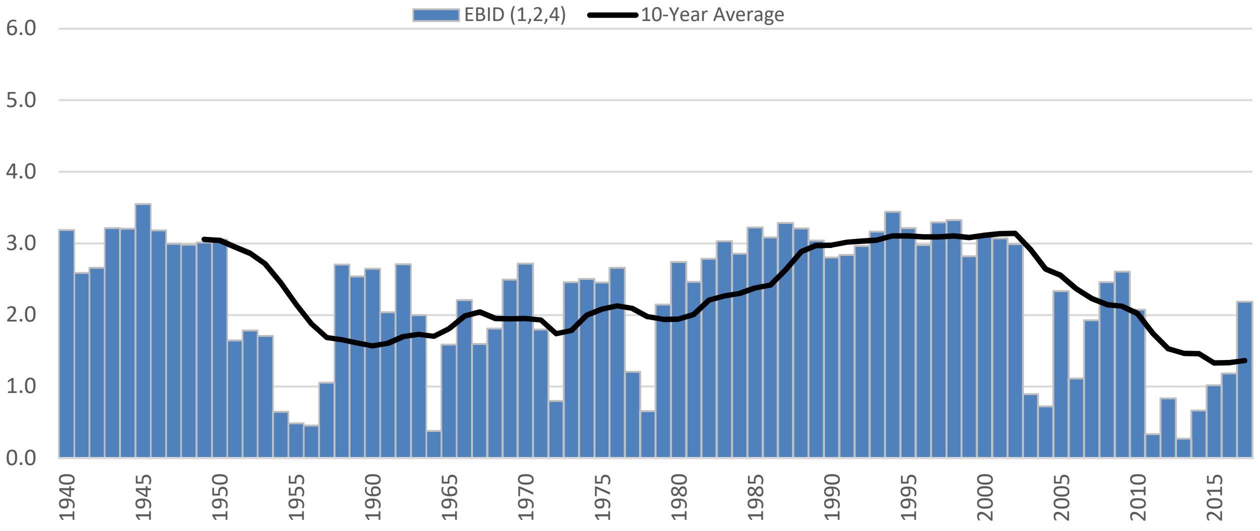
(1) Farm deliveries for HCCRD from records except when missing. For years with no records, farm deliveries were estimated as total diversions minus conveyance loss. Loss estimated using monthly average loss % derived from records.

(2) JID farm deliveries were estimated as total diversions minus canal loss.

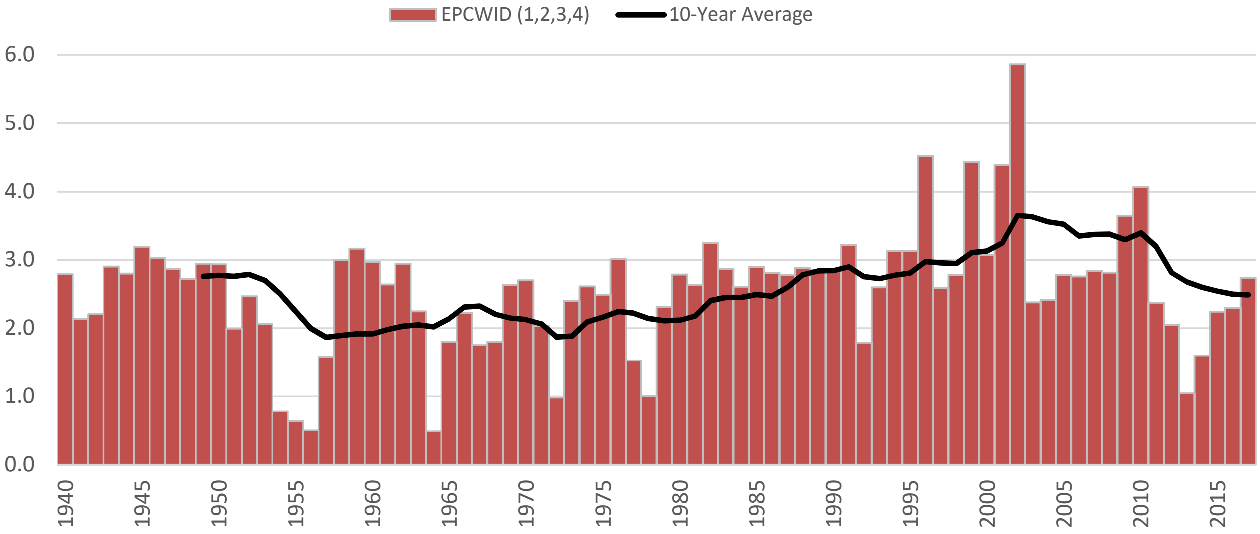
Figure 5-12

Annual UNIT Farm Headgate Deliveries (Actual Acres)
Irrigation Season (Mar-Oct)
1940 - 2017
(acre-feet)

EBID



EPCWID



Notes:

(1) Farm deliveries from records except when missing. For years with no records, farm deliveries were estimated as total diversions minus conveyance loss. Loss estimated using monthly average loss % derived from records.

(2) Pre-1979, farm deliveries split between Mesilla NM and Mesilla TX proportionally by acreage.

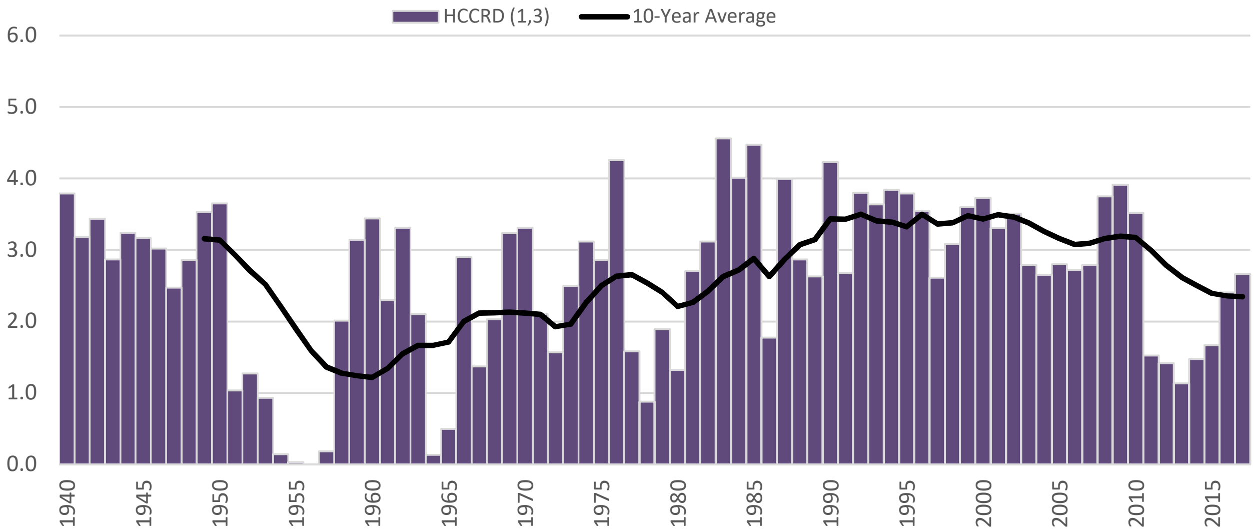
(3) EPCWID FHG deliveries do not include deliveries to EPW.

(4) Acreage data from Rio Grande Project Canal and Farm Budget.

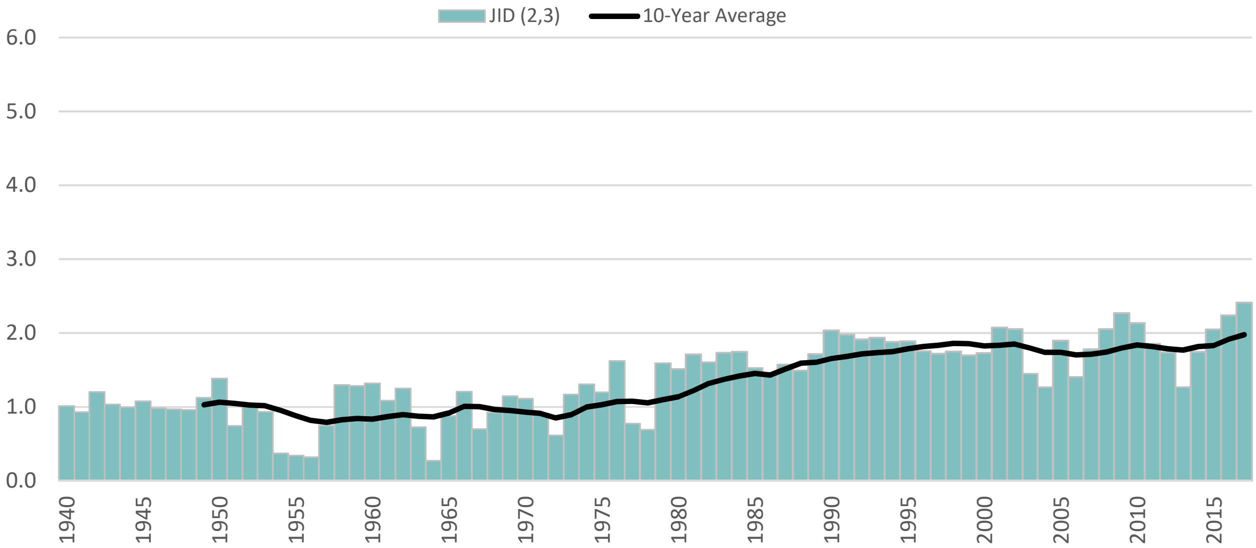
Figure 5-13

Annual UNIT Farm Headgate Deliveries (Actual Acres)
Irrigation Season (Mar-Oct)
1940 - 2017
(acre-feet)

HCCRD



JID



Notes:

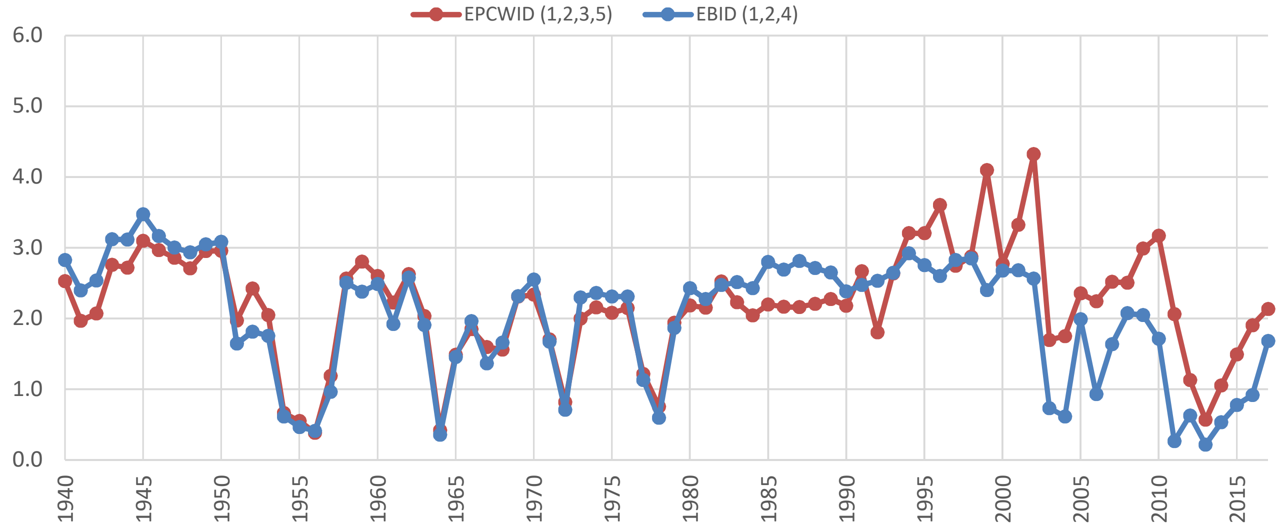
(1) Farm deliveries for HCCRD from records except when missing. For years with no records, farm deliveries were estimated as total diversions minus conveyance loss. Loss estimated using monthly average loss % derived from records.

(2) JID farm deliveries were estimated as total diversions minus canal loss.

(3) Acreage data from Rio Grande Project Canal and Farm Budget.

Figure 5-14

Annual UNIT Farm Headgate Deliveries (Authorized Acres)
Irrigation Season (Mar-Oct)
1940 - 2017
(acre-feet/acre)



<u>Notes:</u>

(1) Farm deliveries from records except when missing. For years with no records, farm deliveries were estimated as total diversions minus conveyance loss. Loss estimated using monthly average loss % derived from records.

(2) Pre-1979, farm deliveries split between Mesilla NM and Mesilla TX proportionally by acreage.

(3) EPCWID include Project water deliveries to EPW.

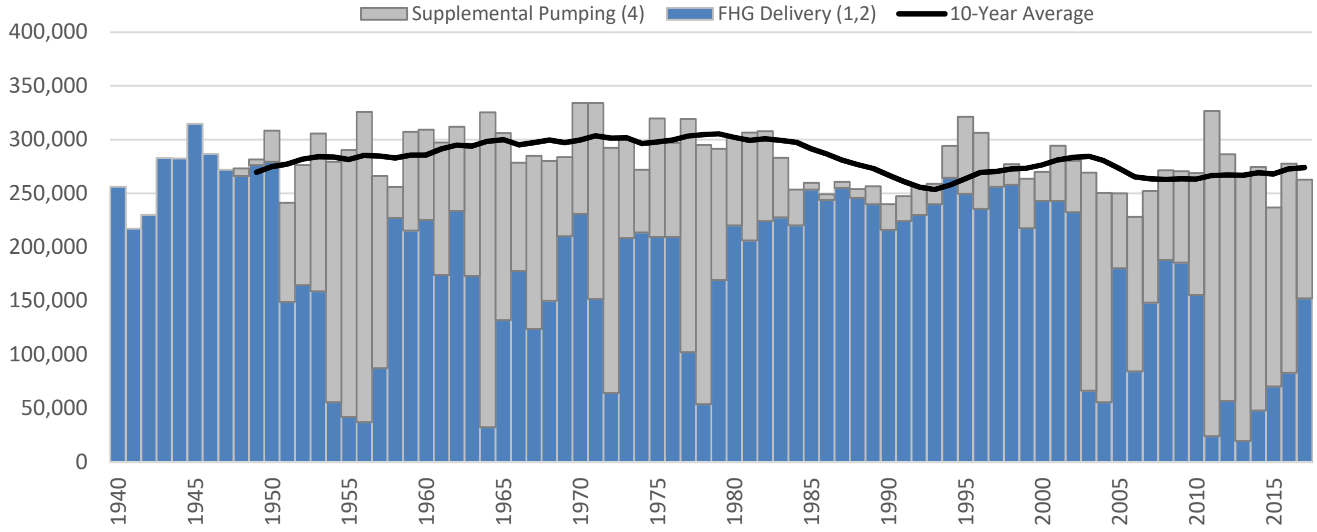
(4) EBID authorized acres: 90,640 acres.

(5) EPCWID authorized acres: 69,010 acres.

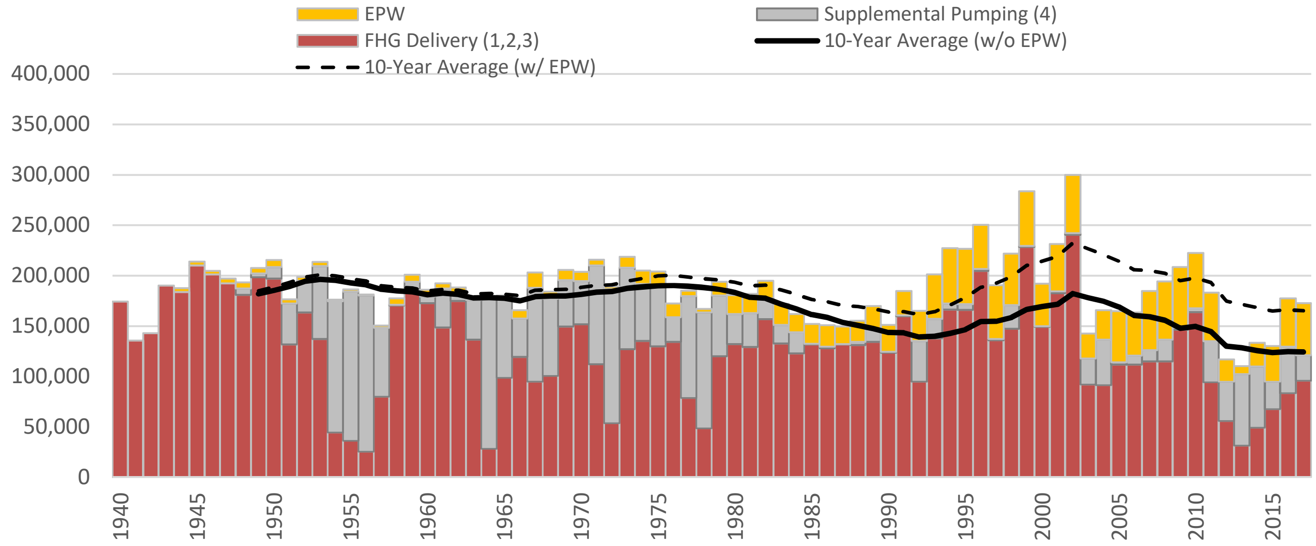
Figure 5-15

Annual Total Applied Water (SW + GW)
Irrigation Season (Mar-Oct)
1940 - 2017
(acre-feet)

EBID



EPCWID



Notes:

(1) Farm deliveries from records except when missing. For years with no records, farm deliveries were estimated as total diversions minus conveyance loss. Loss estimated using monthly average loss % derived from records.

(2) Pre-1979, farm deliveries split between Mesilla NM and Mesilla TX proportionally by acreage.

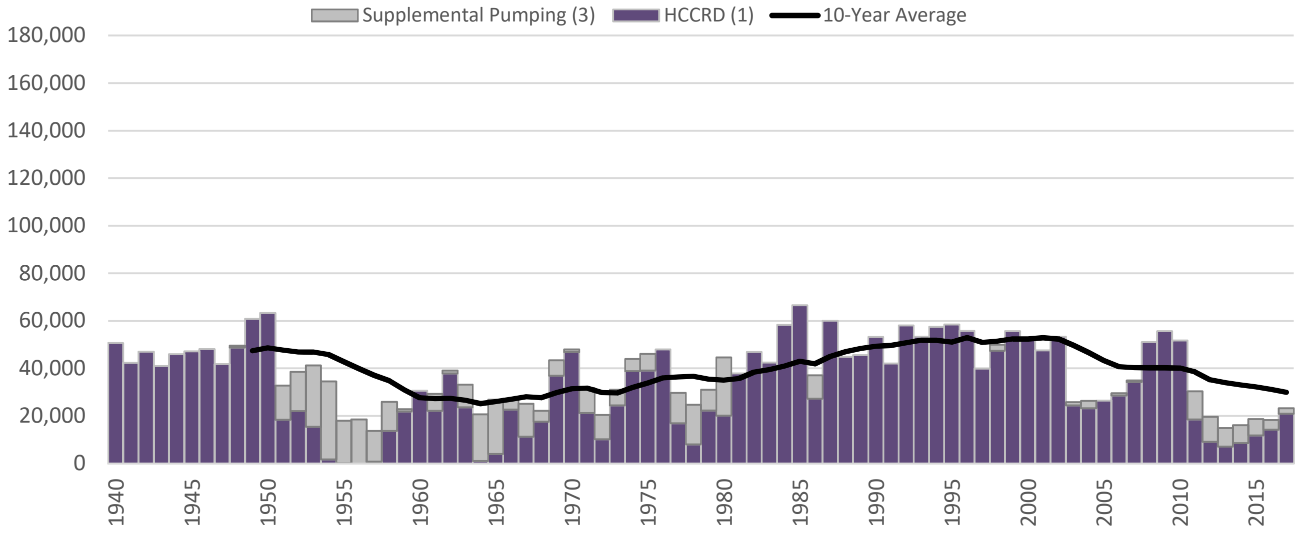
(3) EPCWID FHG deliveries do not include deliveries to EPW.

(4) Supplemental pumping computed based on unmet demand from SWE Canal and Farm Budget analysis.

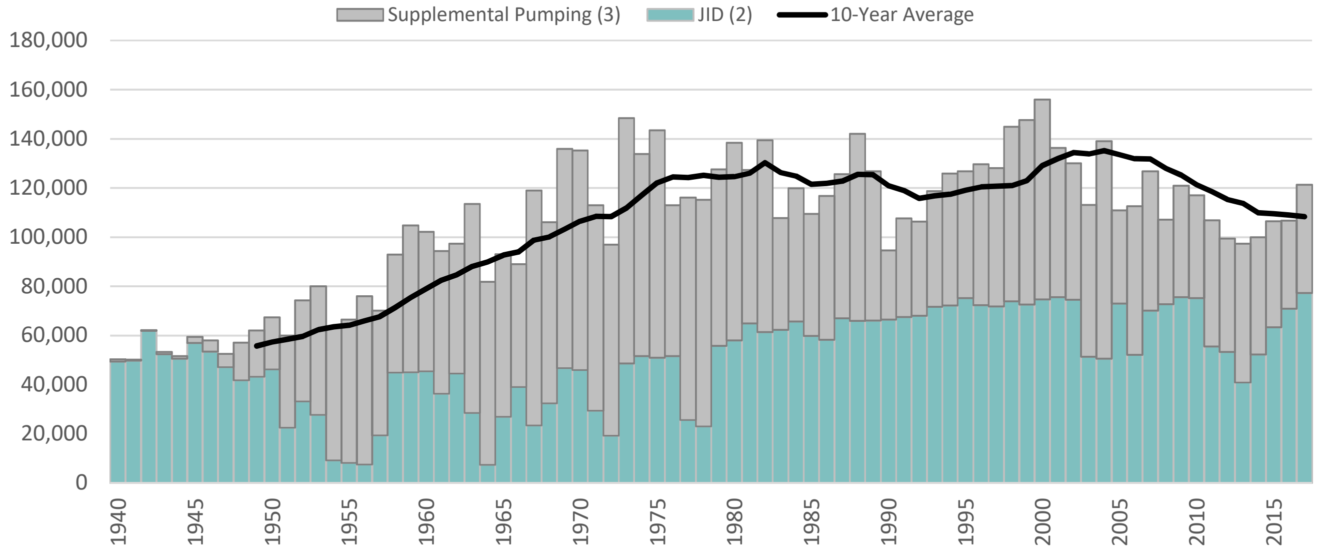
Figure 5-16

Annual Total Applied Water (SW + GW)
Irrigation Season (Mar-Oct)
1940 - 2017
(acre-feet)

HCCRD



JID



Notes:

(1) Farm deliveries for HCCRD from records except when missing. For years with no records, farm deliveries were estimated as total diversions minus conveyance loss. Loss estimated using monthly average loss % derived from records.

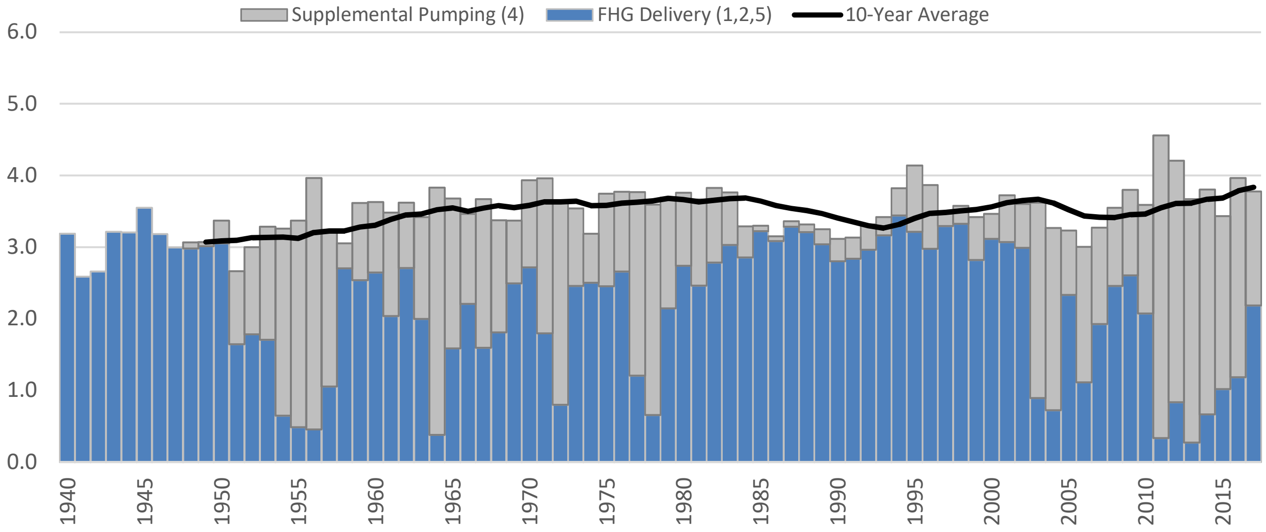
(2) JID farm deliveries were estimated as total diversions minus canal loss.

(3) Supplemental pumping computed based on unmet demand from SWE Canal and Farm Budget analysis.

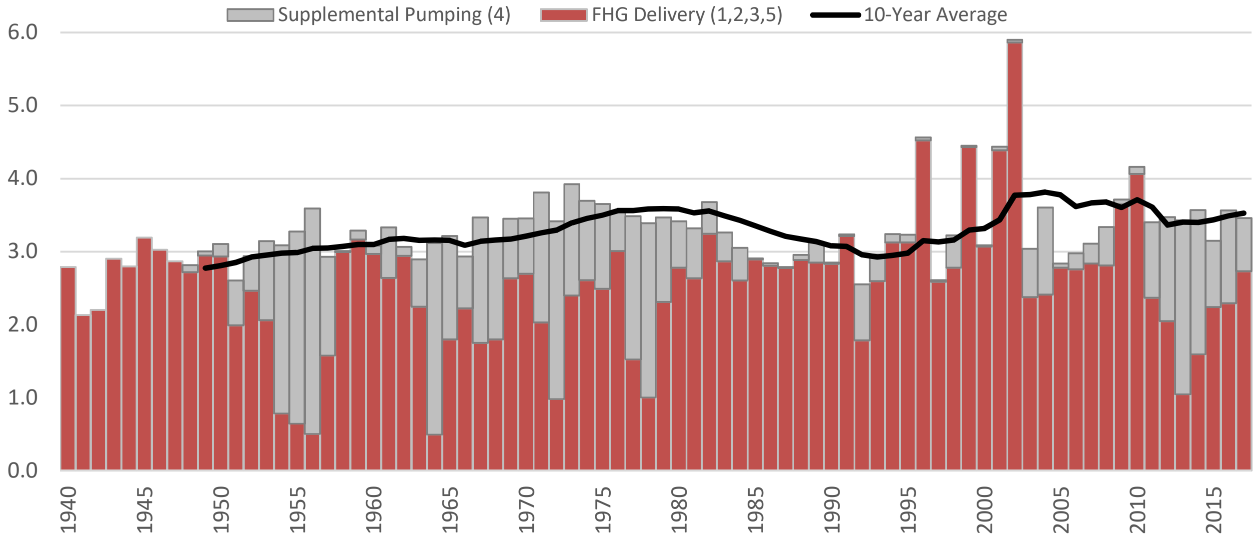
Figure 5-17

Annual UNIT Total Applied Water (SW + GW) (Actual Acres)
Irrigation Season (Mar-Oct)
1940 - 2017
(acre-feet)

EBID



EPCWID



Notes:

(1) Farm deliveries from records except when missing. For years with no records, farm deliveries were estimated as total diversions minus conveyance loss. Loss estimated using monthly average loss % derived from records.

(2) Pre-1979, farm deliveries split between Mesilla NM and Mesilla TX proportionally by acreage.

(3) EPCWID FHG deliveries do not include deliveries to EPW.

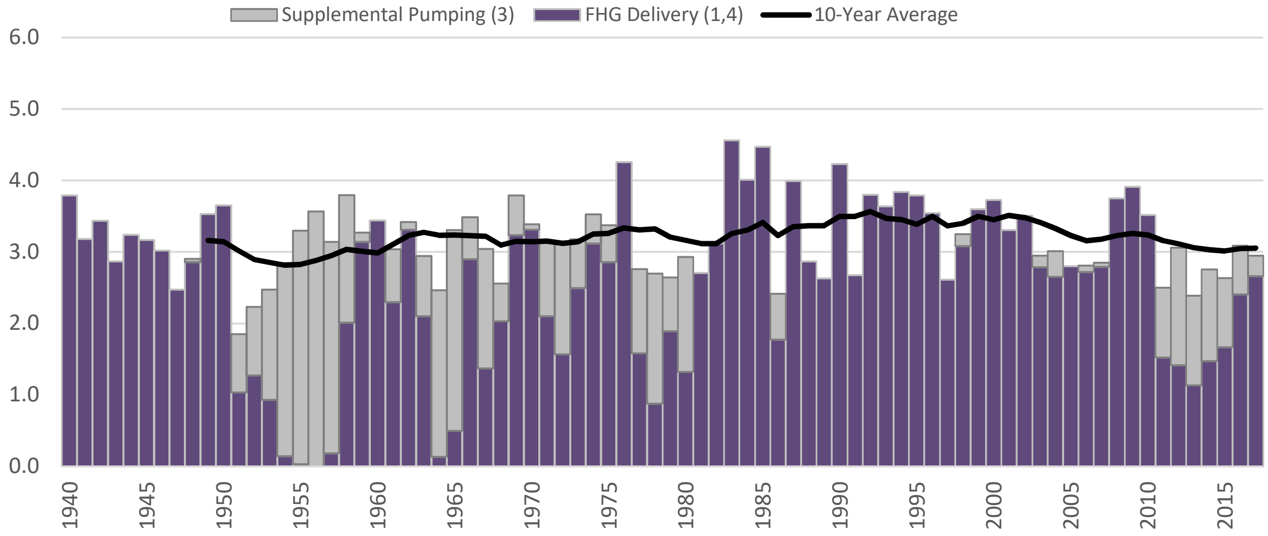
(4) Supplemental pumping computed based on unmet demand from SWE Canal and Farm Budget analysis.

(5) Acreage data from Rio Grande Project Canal and Farm Budget.

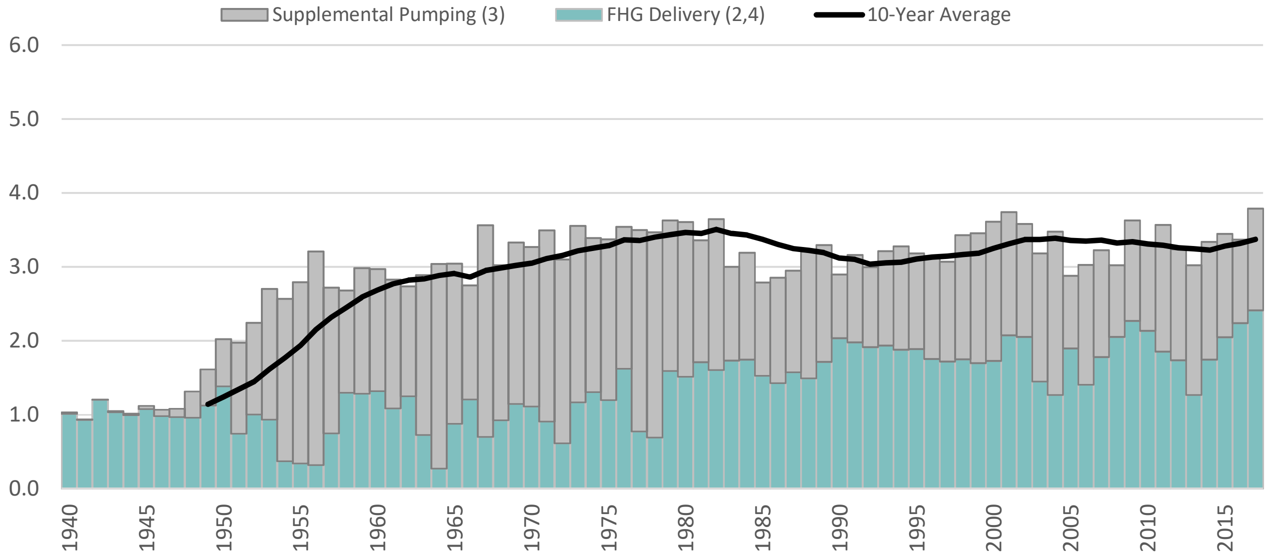
Figure 5-18

Annual UNIT Total Applied Water (SW + GW) (Actual Acres)
Irrigation Season (Mar-Oct)
1940 - 2017
(acre-feet)

HCCRD



JID



Notes:

(1) Farm deliveries for HCCRD from records except when missing. For years with no records, farm deliveries were estimated as total diversions minus conveyance loss. Loss estimated using monthly average loss % derived from records.

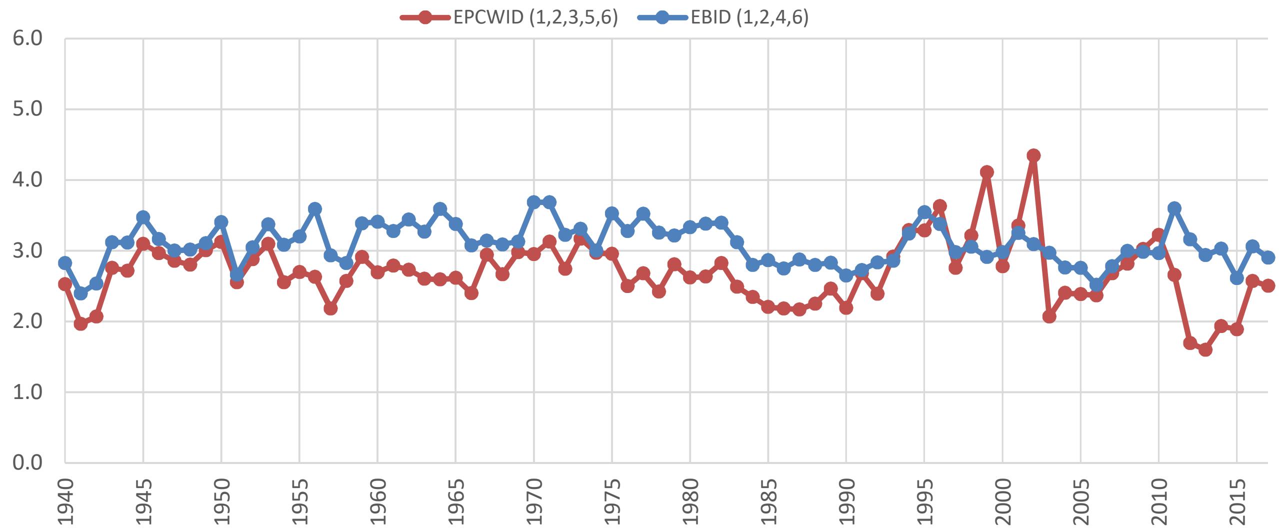
(2) JID farm deliveries were estimated as total diversions minus canal loss.

(3) Supplemental pumping computed based on unmet demand from SWE Canal and Farm Budget analysis.

(4) Acreage data from Rio Grande Project Canal and Farm Budget.

Figure 5-19

Annual UNIT Total Applied Water (SW + GW) (Authorized Acres)
Irrigation Season (Mar-Oct)
1940 - 2017
(acre-feet/acre)



<u>Notes:</u>

(1) Farm deliveries from records except when missing. For years with no records, farm deliveries were estimated as total diversions minus conveyance loss. Loss estimated using monthly average loss % derived from records.

(2) Pre-1979, farm deliveries split between Mesilla NM and Mesilla TX proportionally by acreage.

(3) EPCWID include Project water deliveries to EPW.

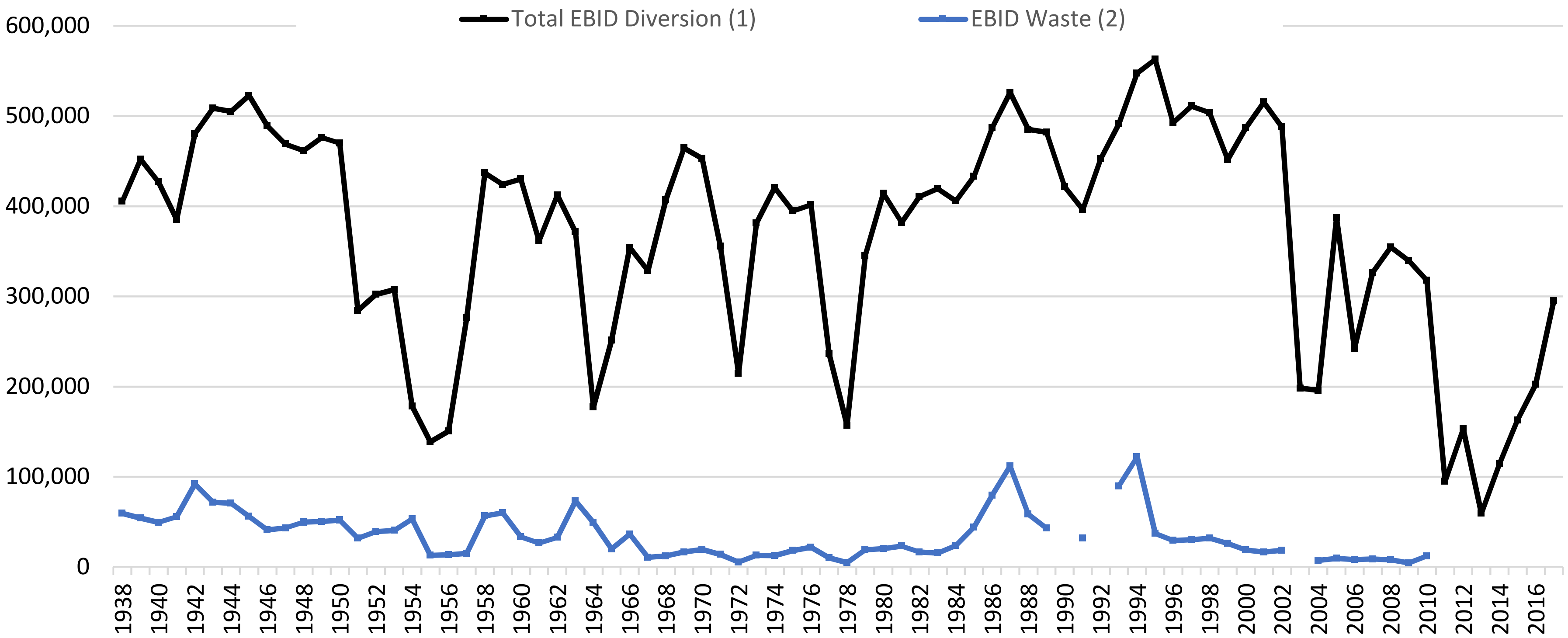
(4) EBID authorized acres: 90,640 acres.

(5) EPCWID authorized acres: 69,010 acres.

(6) Supplemental pumping computed based on unmet demand from SWE Canal and Farm Budget analysis.

Figure 5-20

Annual EBID Diversions and Waste
Irrigation Season
1938 - 2017
(acre-feet)



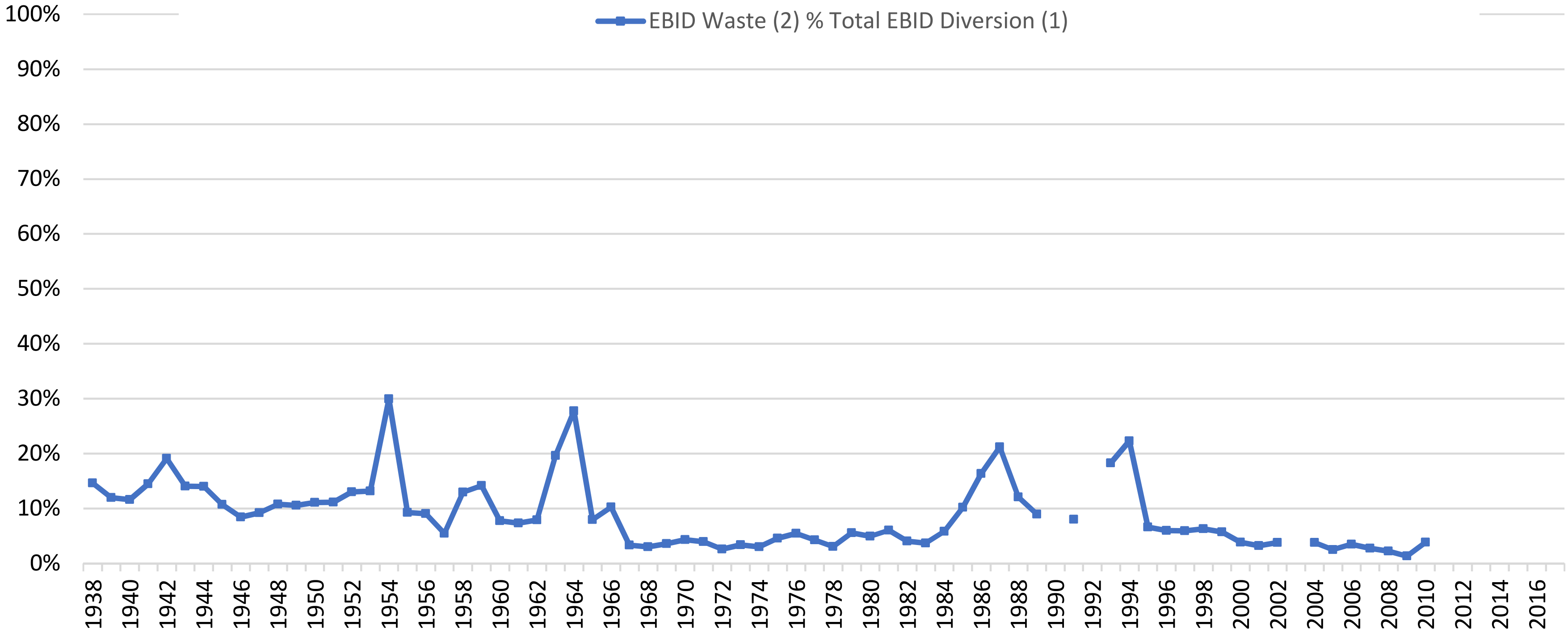
Notes:

(1) Total EBID diversions computed as the sum of diversions for Rincon, Leasburg, and NM portion of the Mesilla diversions. NM portion of the Mesilla diversions are proportional to NM irrigated acres in the Mesilla.

(2) Reported operational waste from Water Distribution Reports (missing for 1990 and 1992). Pre- 1979, waste was computed as the sum of Rincon waste, Leasburg waste, and NM portion of Total Mesilla Waste (NM portion of the total waste is proportionally to the NM irrigated acres in the Mesilla).

Figure 5-21

Annual EBID Waste (% Diversions)
Irrigation Season
1938 - 2017
(% EBID Diversions)



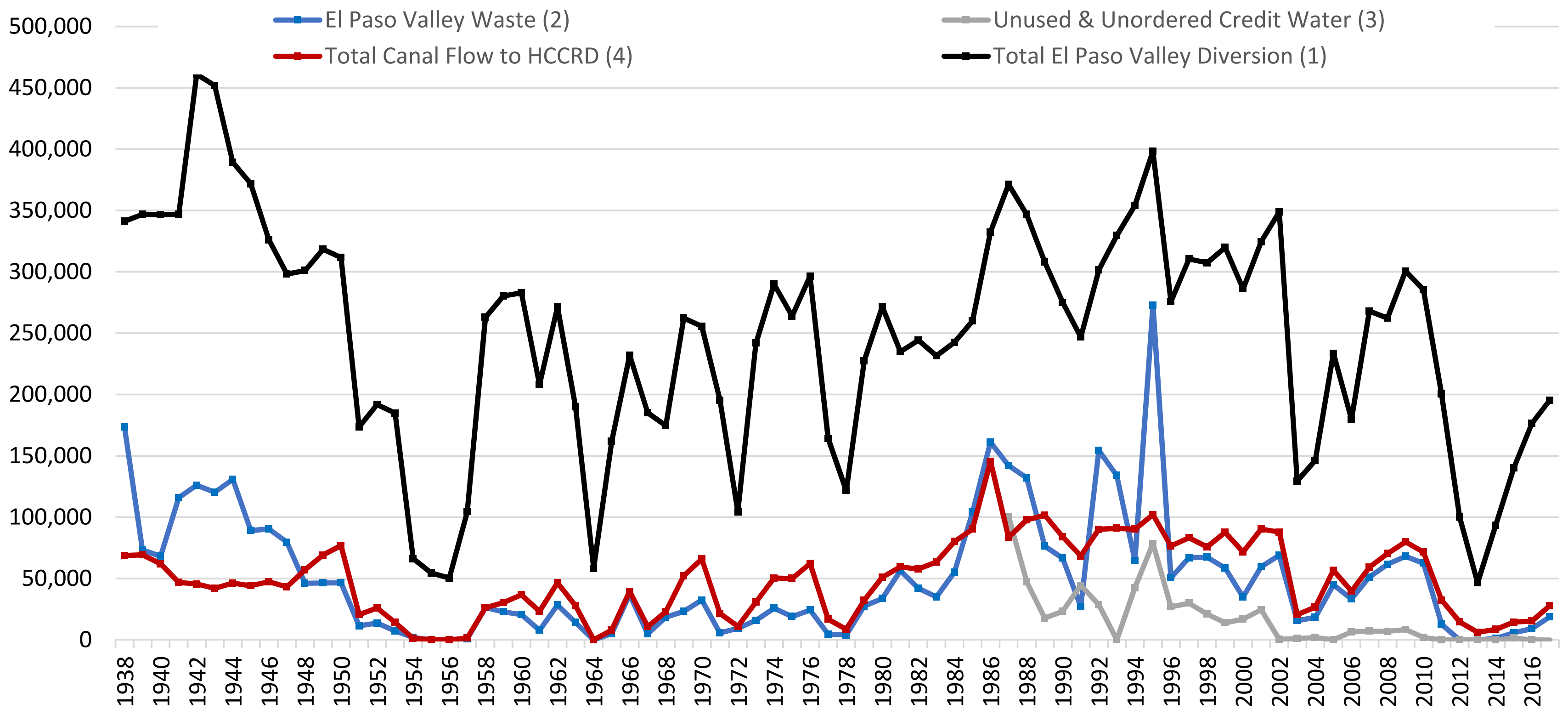
Notes:

(1) Total EBID diversions computed as the sum of diversions for Rincon, Leasburg, and NM portion of the Mesilla diversions. NM portion of the Mesilla diversions are proportional to NM irrigated acres in the Mesilla.

(2) Reported operational waste from Water Distribution Reports (missing for 1990 and 1992). Pre- 1979, waste was computed as the sum of Rincon waste, Leasburg waste, and NM portion of Total Mesilla Waste (NM portion of the total waste is proportionally to the NM irrigated acres in the Mesilla).

Figure 5-22

Annual El Paso Valley Diversions and Waste
Irrigation Season (March - October)
1938 - 2017
(acre-feet)



Notes:

(1) Total El Paso Valley diversions computed as Franklin Canal diversions minus Ascarate Wasteway (pre-ACE completion/2000) flows plus Riverside Canal gaged flows plus City of El Paso Diversions.

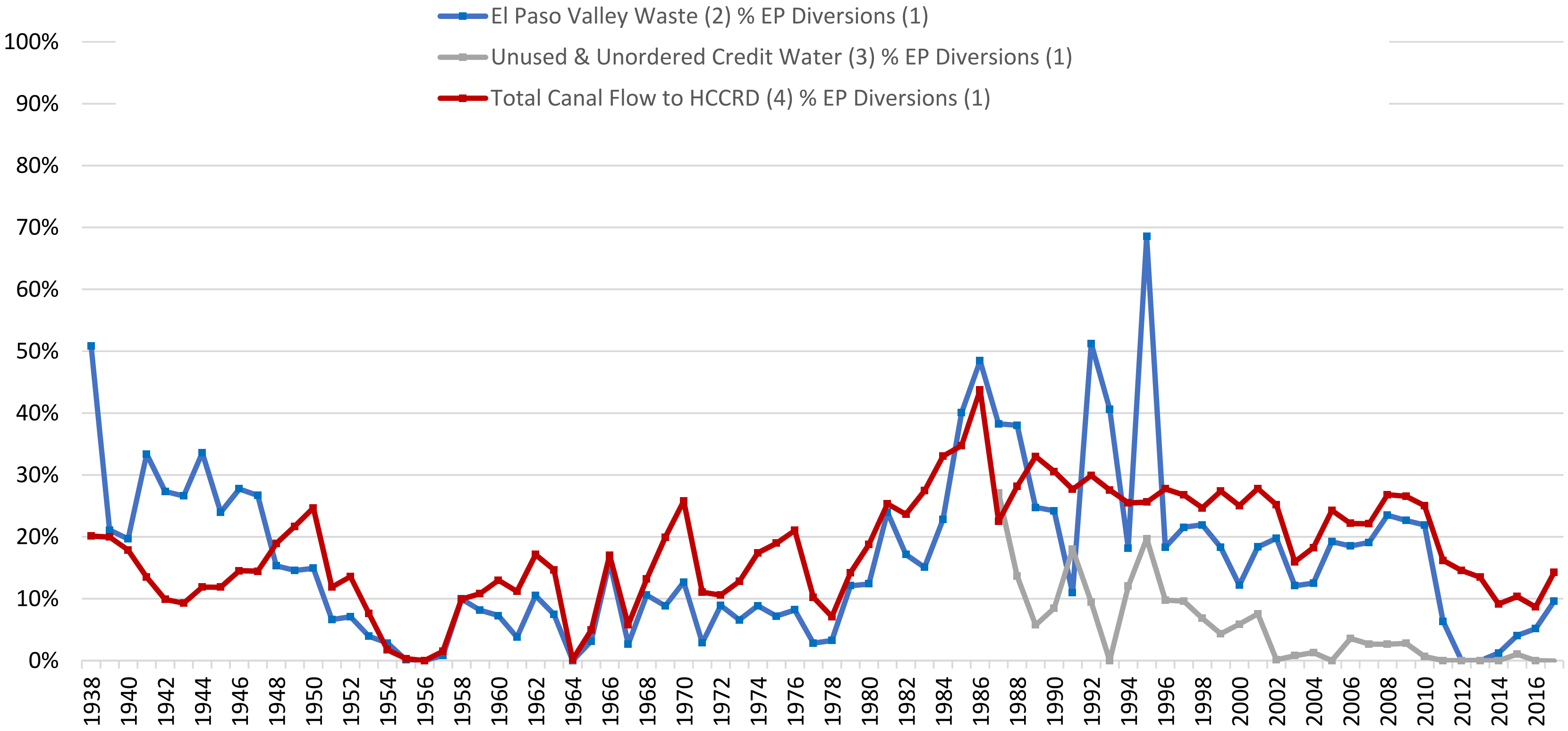
(2) Reported operational waste from Water Distribution Reports. Calculation varies per WDR notes and generally includes Riverside wasteway flows to river plus a portion of the flows to Hudspeth. Values estimated after 2002 based on regression with Hudspeth supply.

(3) Credit water to EPCWID from Accounting Reports for unused and unordered Project water.

(4) Hudspeth (Tornillo End) flows from 1938 - 4/1947 and sum of Hudspeth Feeder Canal and Tornillo Canal at AA from 5/1947 - 2017 (does not include Tornillo Drain flow).

Figure 5-23

Annual El Paso Valley Waste (% Diversions)
Irrigation Season
1938 - 2017
(% El Paso Valley Diversions)



Notes:

(1) Total El Paso Valley diversions computed as Franklin Canal diversions minus Ascarate Wasteway (pre-ACE completion/2000) flows plus Riverside Canal gaged flows plus City of El Paso Diversions.

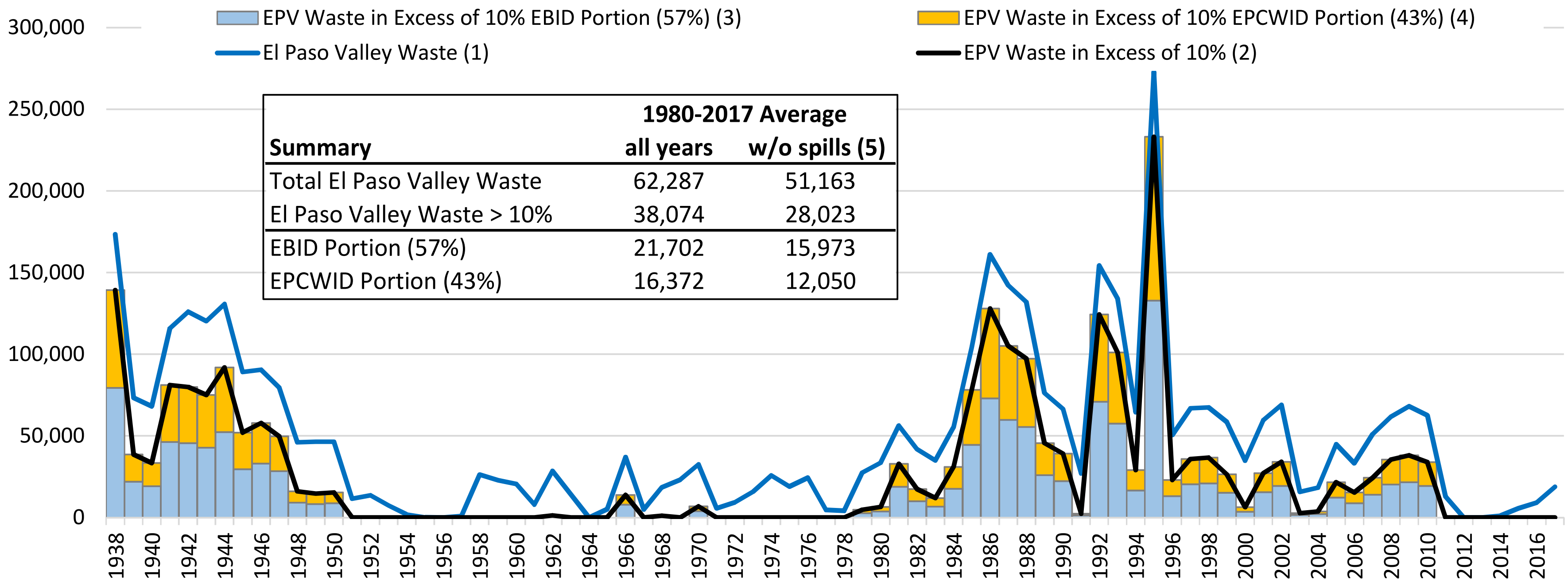
(2) Reported operational waste from Water Distribution Reports. Calculation varies per WDR notes and generally includes Riverside wasteway flows to river plus a portion of the flows to Hudspeth. Values estimated after 2002 based on regression with Hudspeth supply.

(3) Credit water to EPCWID from Accounting Reports for unused and unordered Project water.

(4) Hudspeth (Tornillo End) flows from 1938 - 4/1947 and sum of Hudspeth Feeder Canal and Tornillo Canal at AA from 5/1947 - 2017 (does not include Tornillo Drain flow).

Figure 5-24

Excess El Paso Valley Waste
Irrigation Season (March - October)
1938 - 2017
(acre-feet)



	1980-2017 Average	
Summary	**all years**	**w/o spills (5)**
Total El Paso Valley Waste	62,287	51,163
El Paso Valley Waste > 10%	38,074	28,023
EBID Portion (57%)	21,702	15,973
EPCWID Portion (43%)	16,372	12,050

Notes:

(1) Waste from WDR reports (1938 - 2002). Waste estimated from 2003 - 2017 using 1938 - 2002 regression with total flow to Hudspeth.

(2) Tabulated waste in excess of 10 percent of total river headgate diversions. Total river headgate diversions for EPCWID computed as Franklin Canal gaged flows minus Ascarate Wasteway (pre-ACE completion/2000) flows plus Riverside Canal gaged flows plus EPW Diversions of Project Water.

(3) EPV Waste in Excess of 10% (2) multiplied by 57 percent.

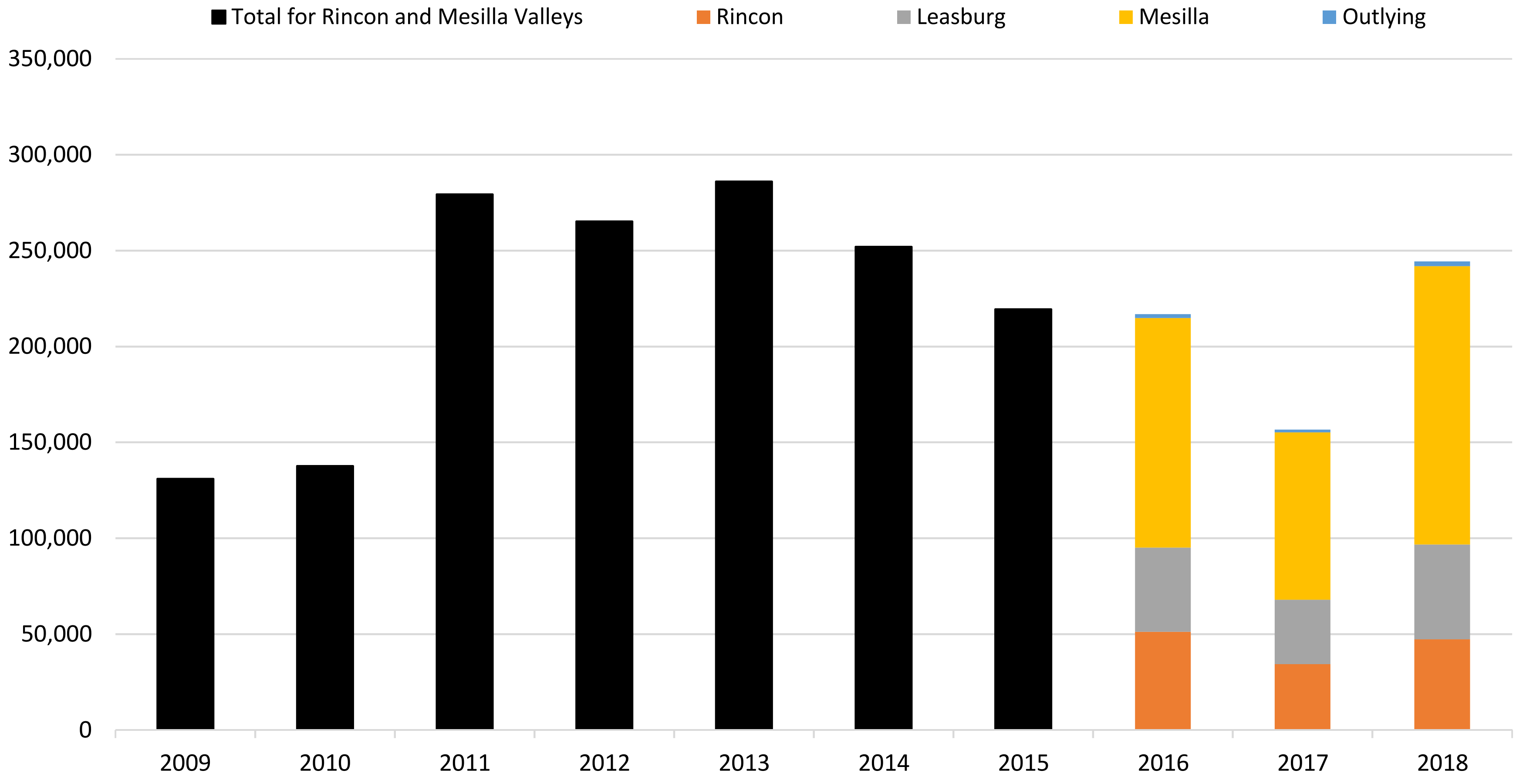
(4) EPV Waste in Excess of 10% (2) multiplied by 43 percent.

(5) Spill years were 1986, 1987, and 1995.

Figure 5-25

Irrigation Pumping in EBID Vicinity

2009 - 2018 (acre-feet)

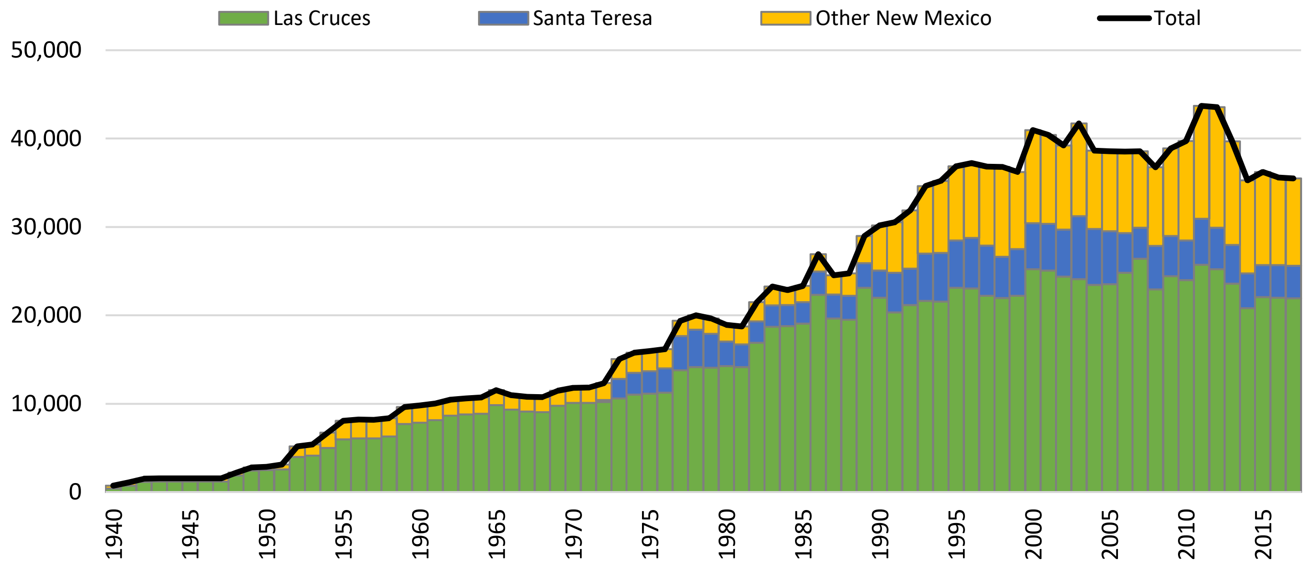


Note:
Metered irrigation pumping data provided by NMOSE (Ryan Serrano and Peggy Barroll).

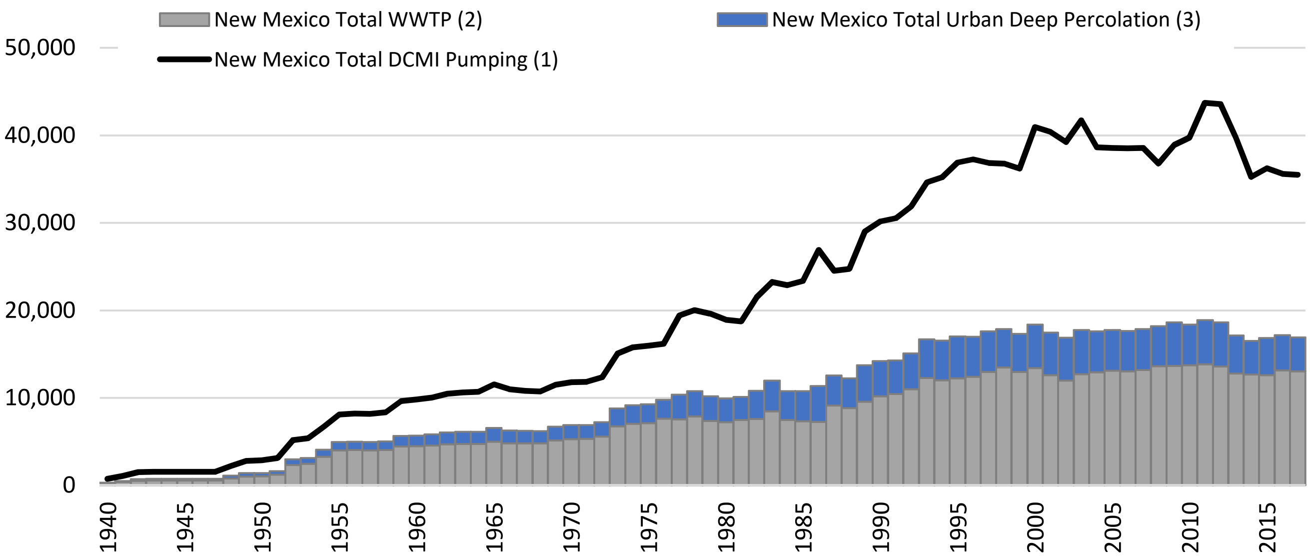
Figure 5-26

Annual Non-Irrigation Pumping and Return Flows
New Mexico
1940 - 2017
(acre-feet)

Annual Non-Irrigation Pumping



Annual Non-Irrigation Pumping and Return Flows



Notes:

(1) All DCMI pumping in the Rincon-Mesilla basin excluding EPW Canutillo and Juarez Conejos Medanos wells.

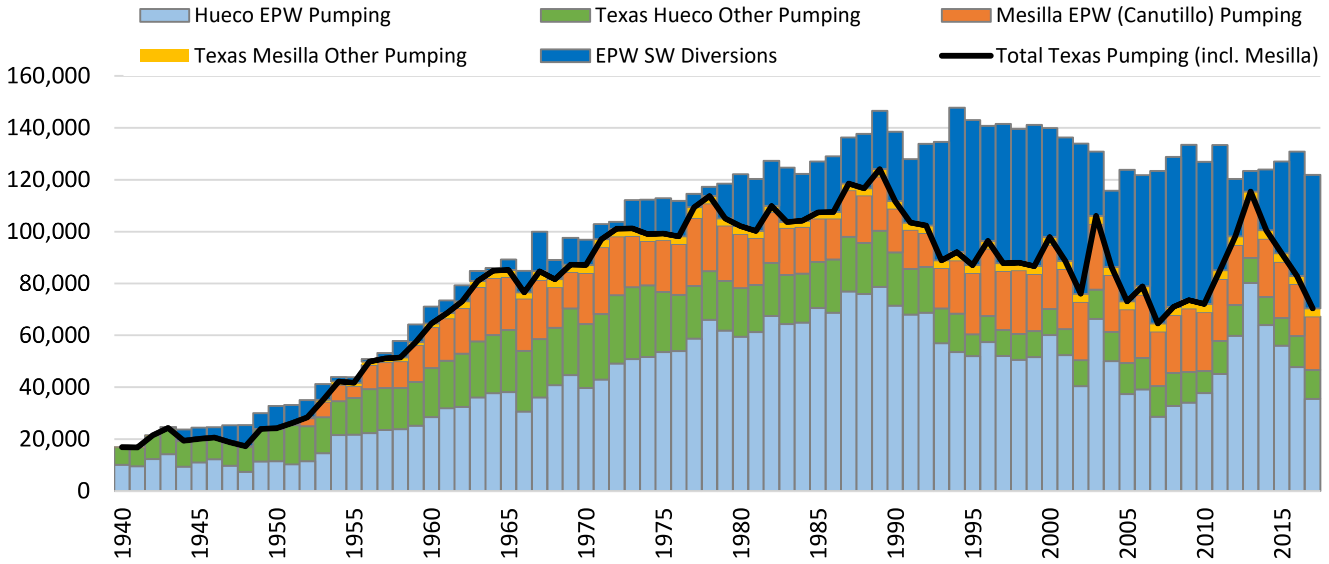
(2) All WWTP discharges compiled for input into the Integrated LRG Model (includes Total Las Cruces, Total Sunland Park/ Santa Teresa, El Paso Electric, South Central Regional, Anthony, Hatch, Salem, and Gadsden Independent School District).

(3) Rincon-Mesilla urban deep percolation computed for Las Cruces, Santa Teresa, Anthony, Mesquite, Berino, Garfield, and Radium Springs urban areas.

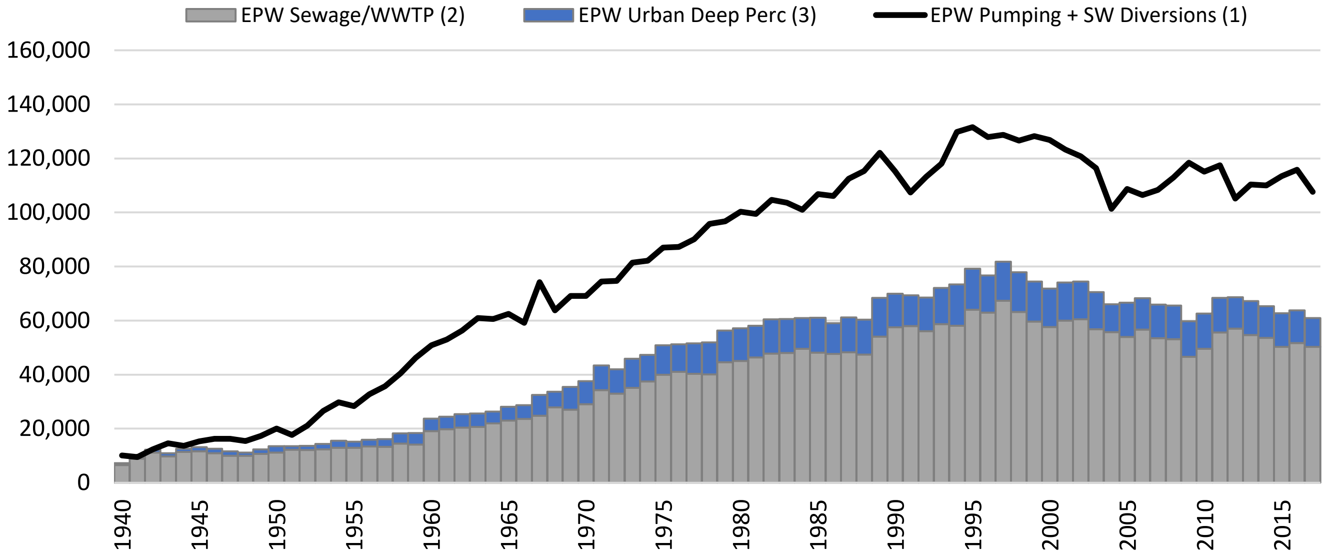
Figure 5-27

Annual Non-Irrigation Water Use and Return Flows
Texas
1918 - 2017
(acre-feet)

Annual Non-Irrigation Water Use



Annual EPW Water Use and Return Flows



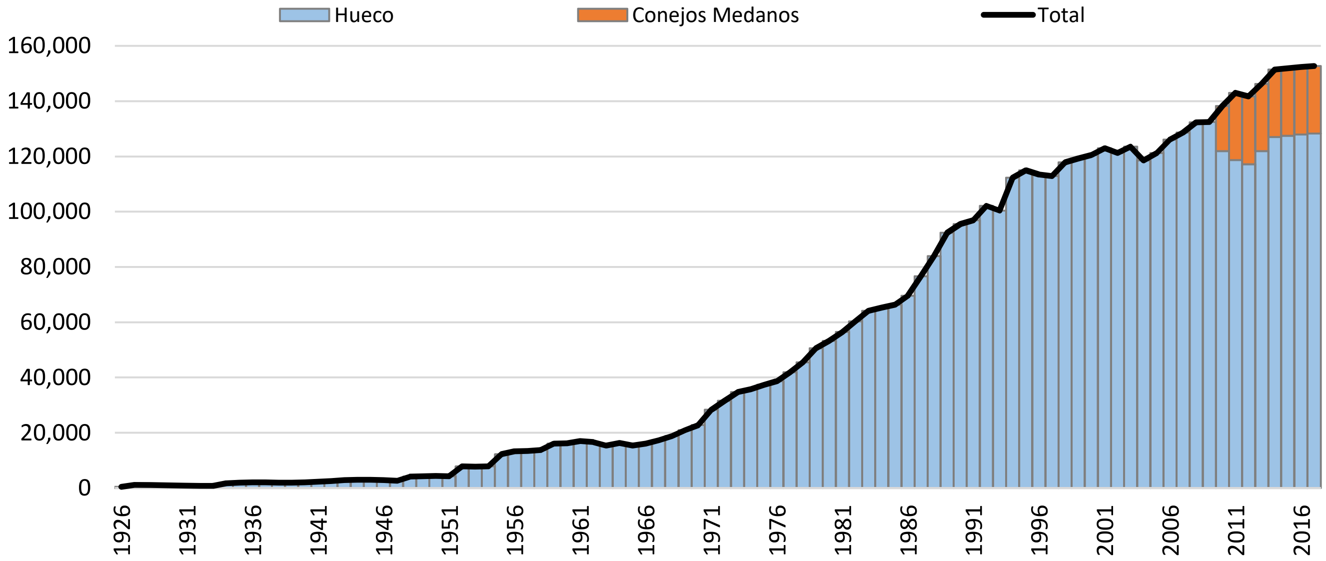
Notes:

(1) Total EPW pumping from the Hueco and Canutillo wells plus surface water (Project) diversions.
(2) Total WWTP discharge from Northwest, Haskell, Socorro, and Bustamante WWTPs.
(3) Urban deep percolation for all of the City of El Paso including areas in the Mesilla basin.

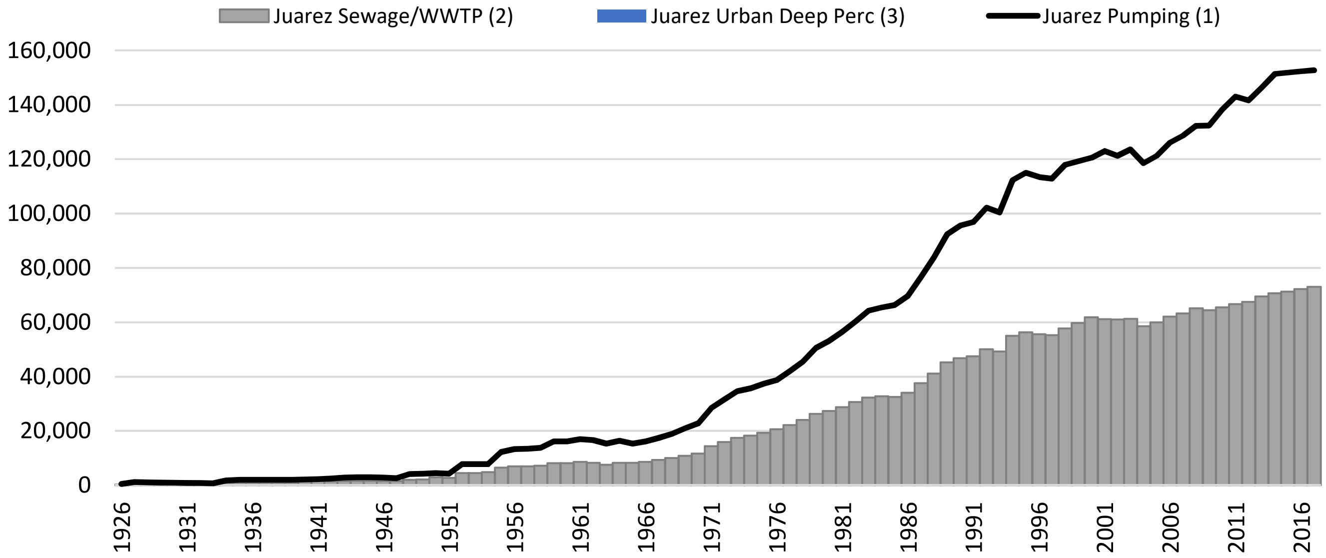
Figure 5-28

Annual Non-Irrigation Pumping and Return Flows
Mexico (Cuidad Juarez in Mesilla and Hueco Valleys)
1926 - 2017
(acre-feet)

Annual Non-Irrigation Pumping



Annual Non-Irrigation Pumping and Return Flows



(1) Total Juarez pumping from the Hueco and Conejos Medanos wells.
(2) Cuidad Juarez sewage/WWTP from IBWC for 1950 - 1984 and estimated as 49% of pumping for 1985-2017.
(3) No urban deep percolation computed for Cuidad Juarez.

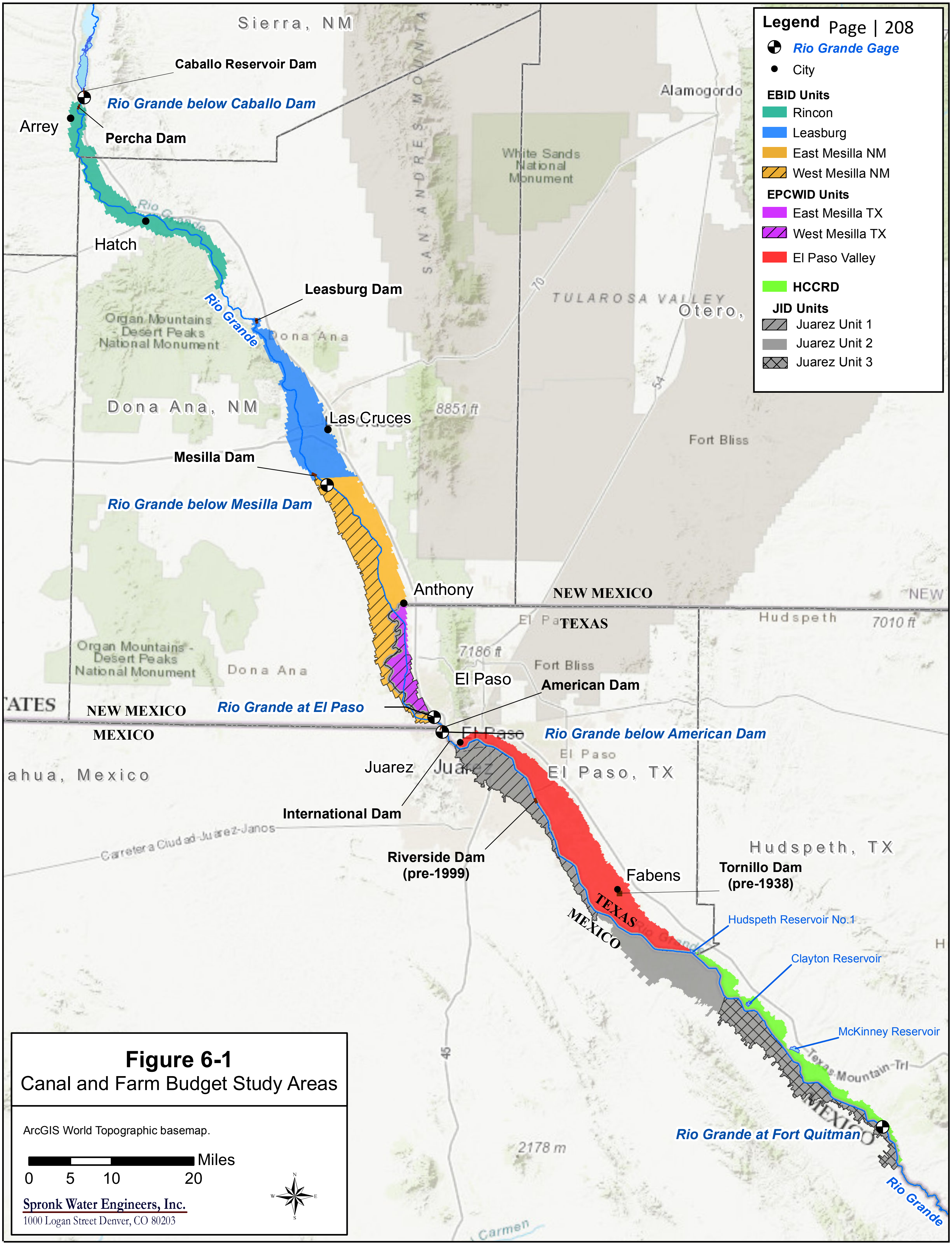


Figure 6-1
Canal and Farm Budget Study Areas

ArcGIS World Topographic basemap.

Spronk Water Engineers, Inc.
1000 Logan Street Denver, CO 80203

Figure 6-2
Canal and Farm Budget Flow Chart

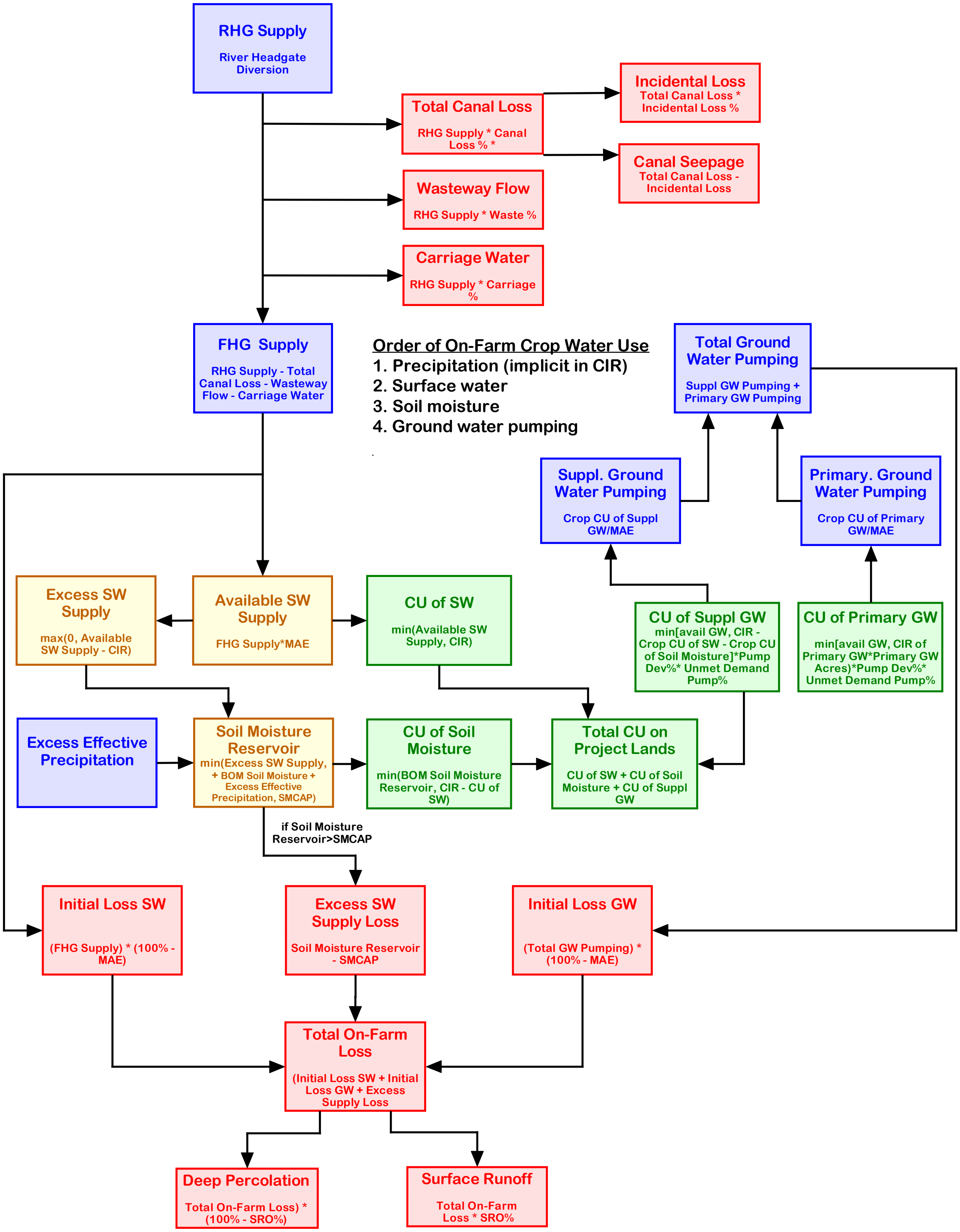


Figure 6-3

**Simplified Schematic of
El Paso Valley Diversion Works**

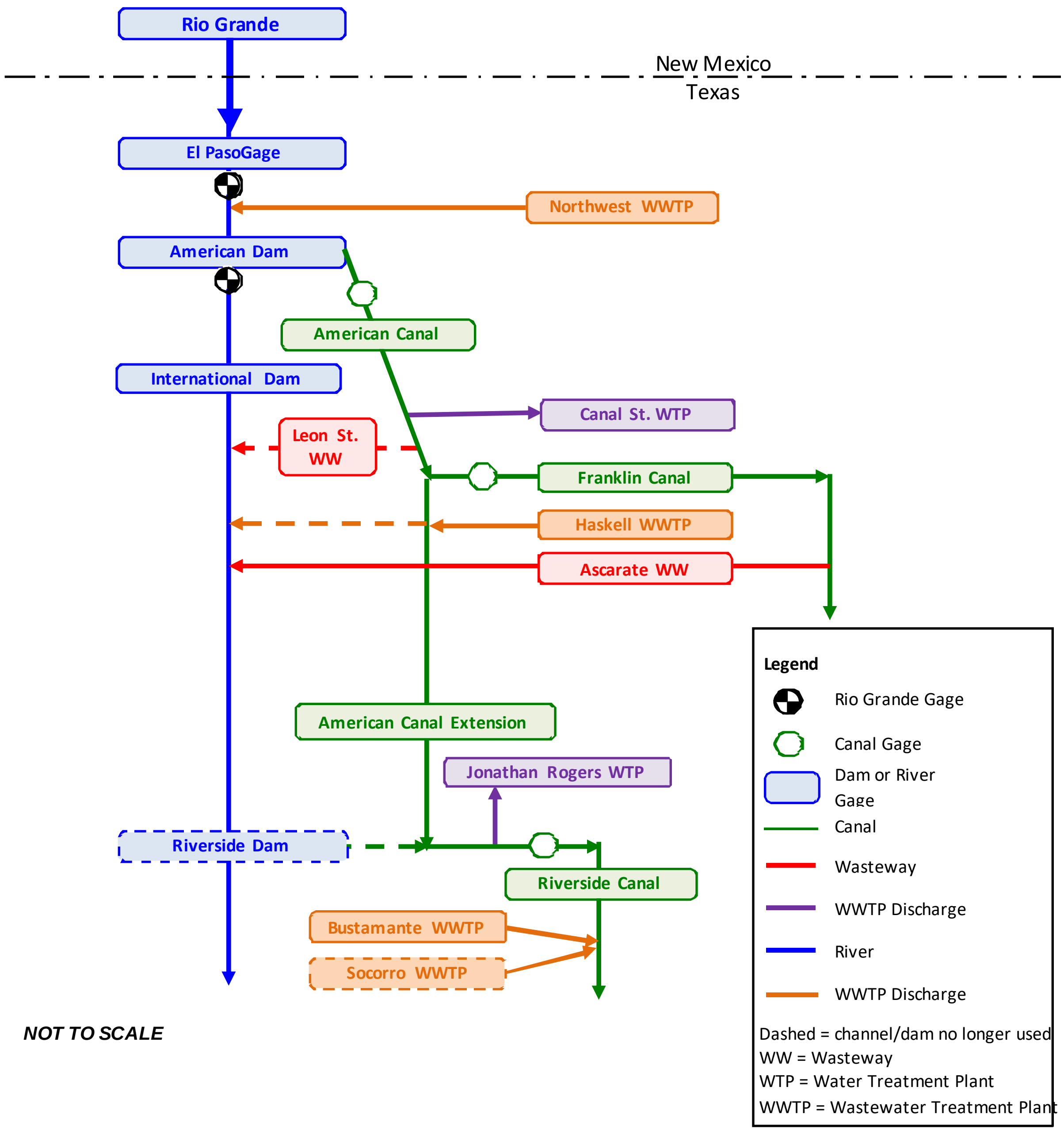
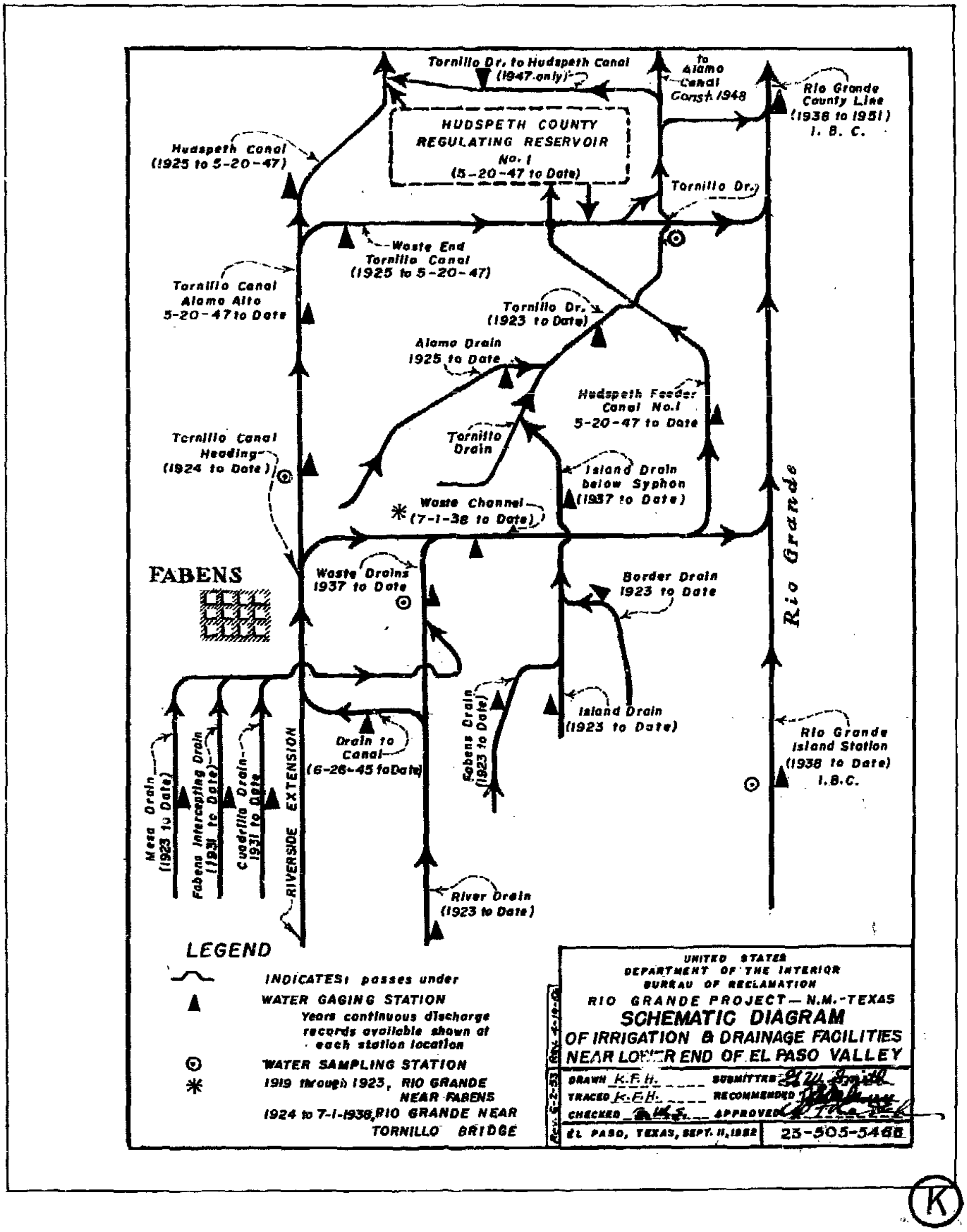


Figure 6-4

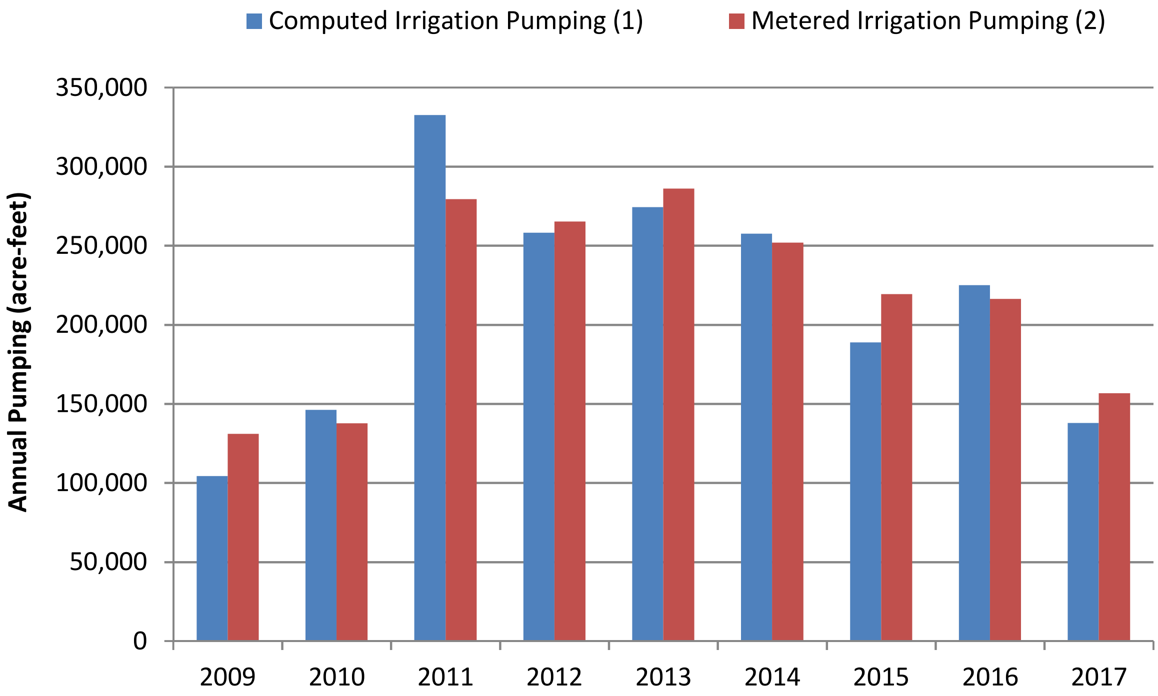
Schematic – Hudspeth Diversion Works



November 25, 1974

Figure 6-5

Comparison of Computed and Reported Annual EBID Irrigation Pumping
Canal and Farm Budget Model
2009-2017
(acre-feet)



2009 - 2017 Averages (AF)	
Computed:	213,840
Reported:	215,965

Notes:

(1) Sum of computed supplemental and primary ground water pumping for irrigation.

(2) Metered pumping from NM Water Master Reports and NMOSE data.

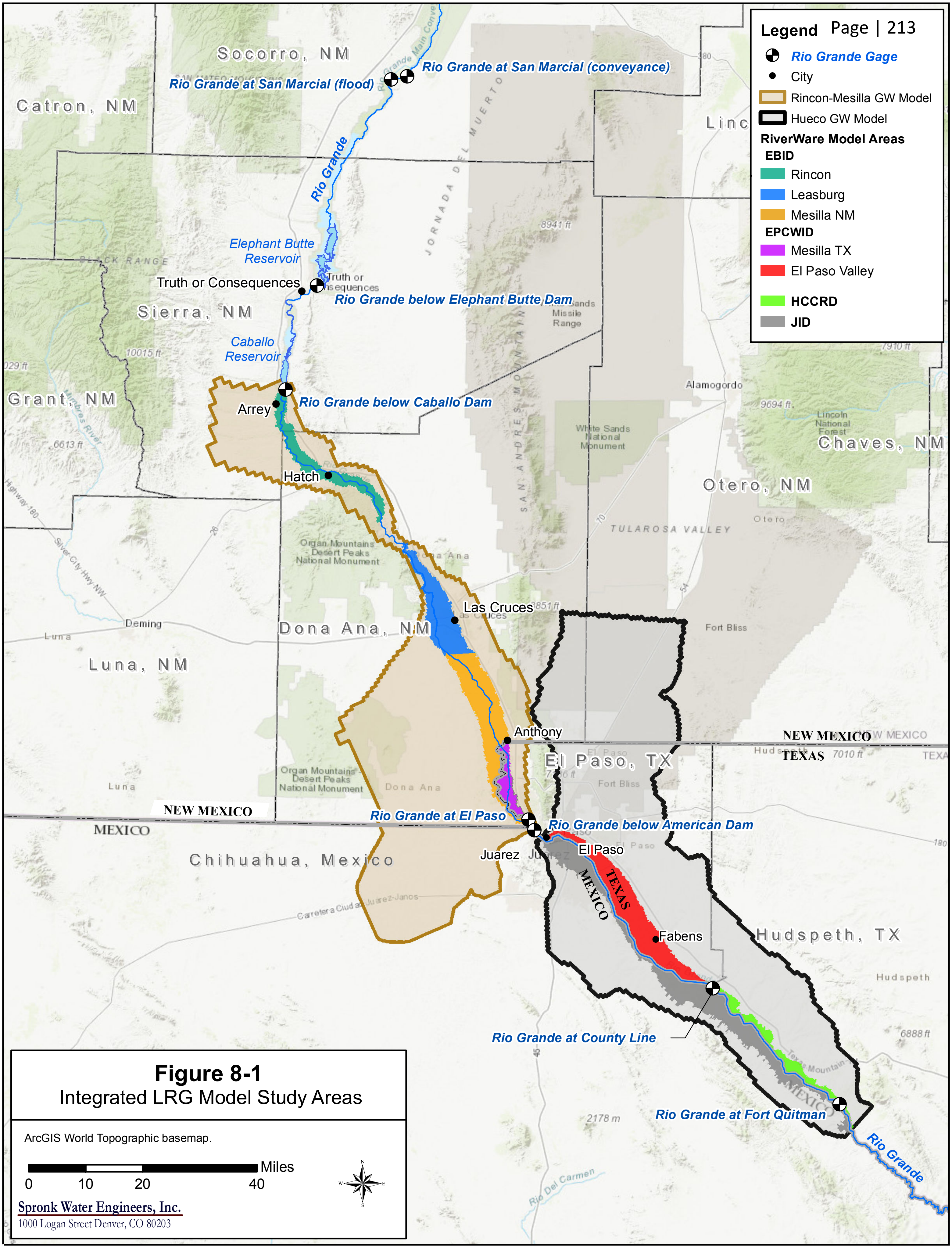


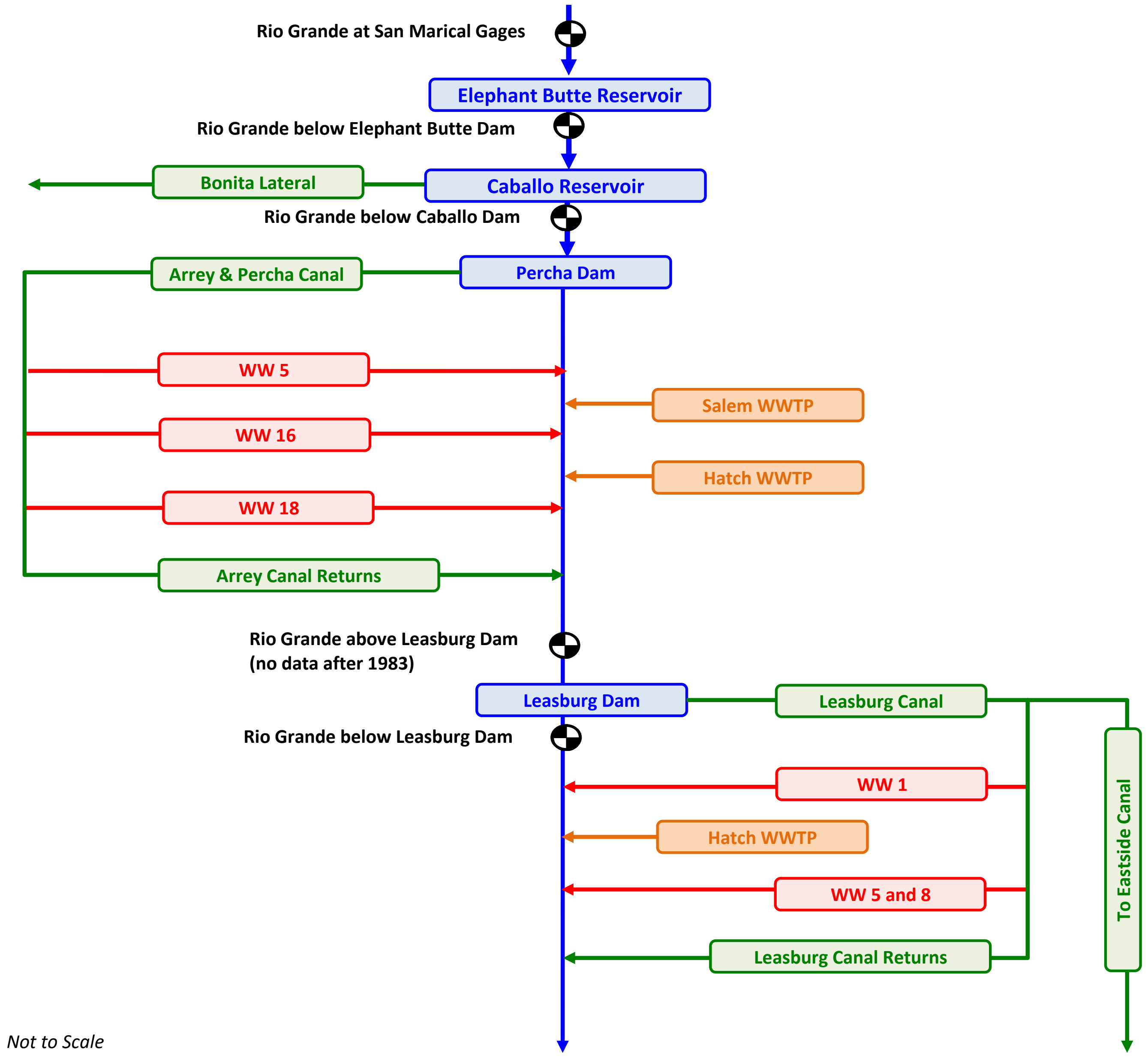
Figure 8-1

Integrated LRG Model Study Areas

ArcGIS World Topographic basemap.

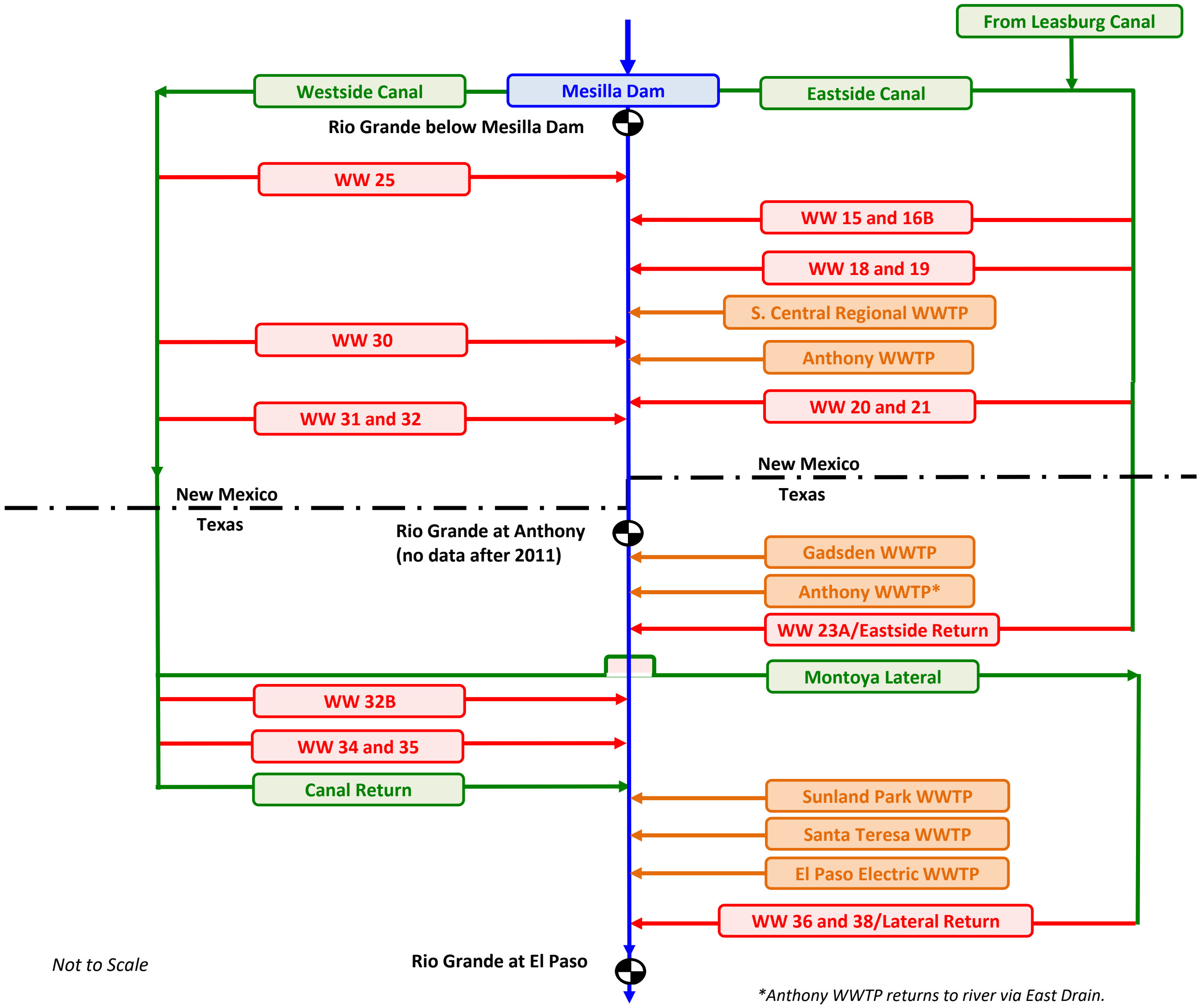
Spronk Water Engineers, Inc.
1000 Logan Street Denver, CO 80203

Figure 8-2
Simplified RiverWare Model Flow Diagram
Integrated LRG Model
San Marcial Gages to Mesilla Dam



Not to Scale

Figure 8-2
Simplified RiverWare Model Flow Diagram
Integrated LRG Model
Mesilla Dam to El Paso Gage



*Anthony WWTP returns to river via East Drain.

Figure 8-2
Simplified RiverWare Model Flow Diagram
Integrated LRG Model
El Paso Gage to County Line Gage

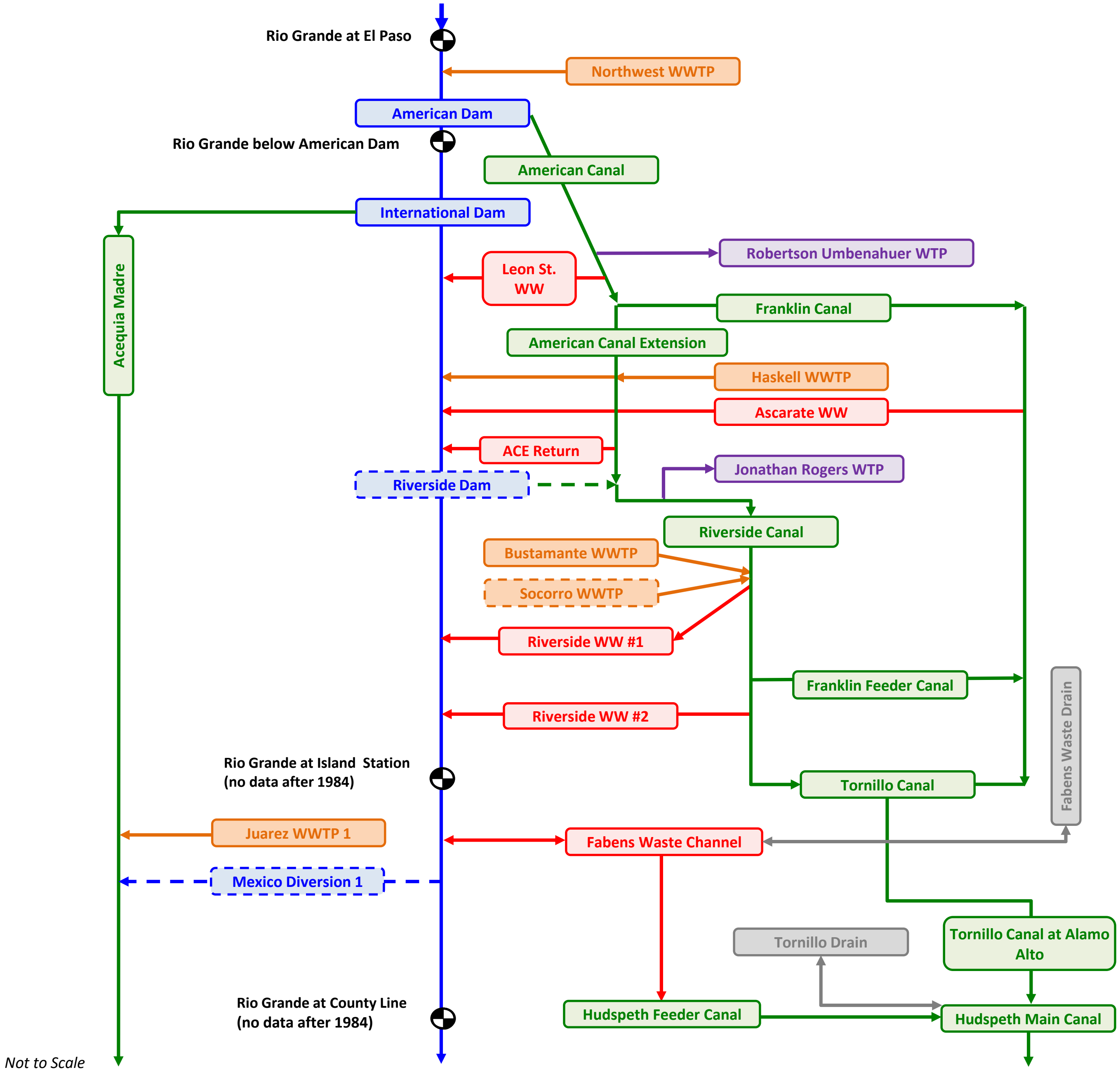


Figure 8-2
Simplified RiverWare Model Flow Diagram
Integrated LRG Model
County Line Gage to Fort Quitman Gage

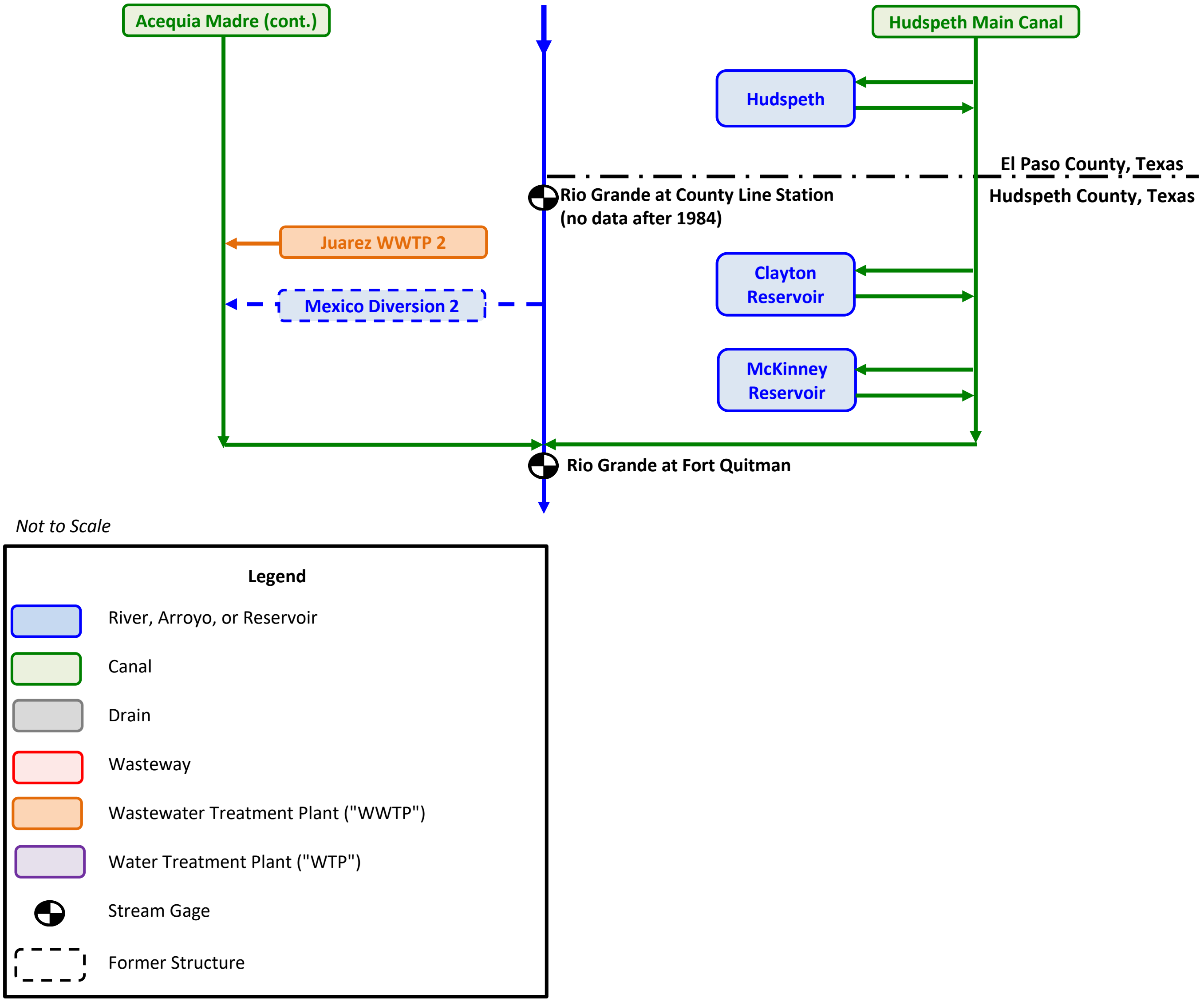


Figure 8-3

System Budget Schematic
RiverWare Model

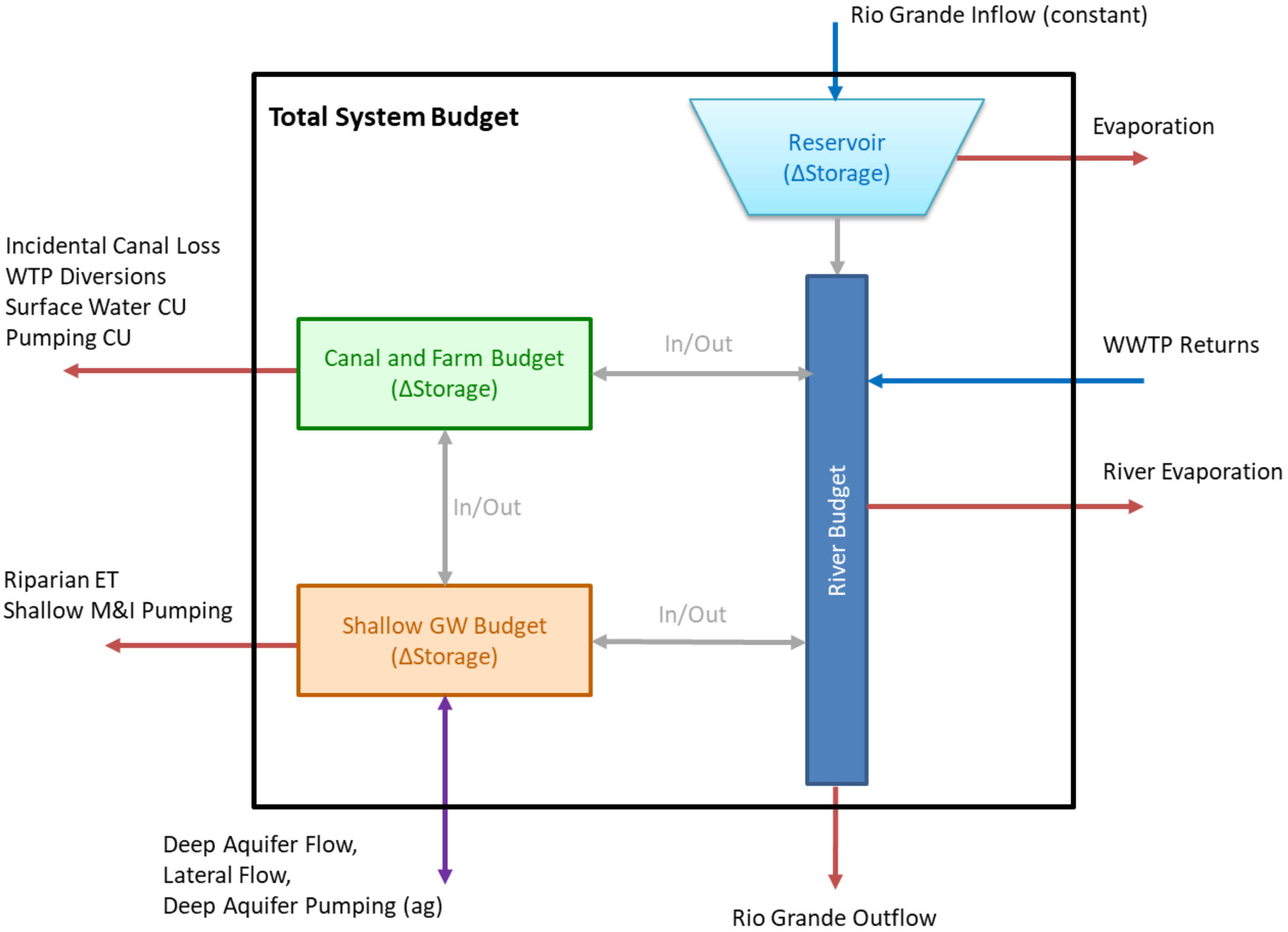


Figure 8-4

Reservoir Budget Schematic
RiverWare Model

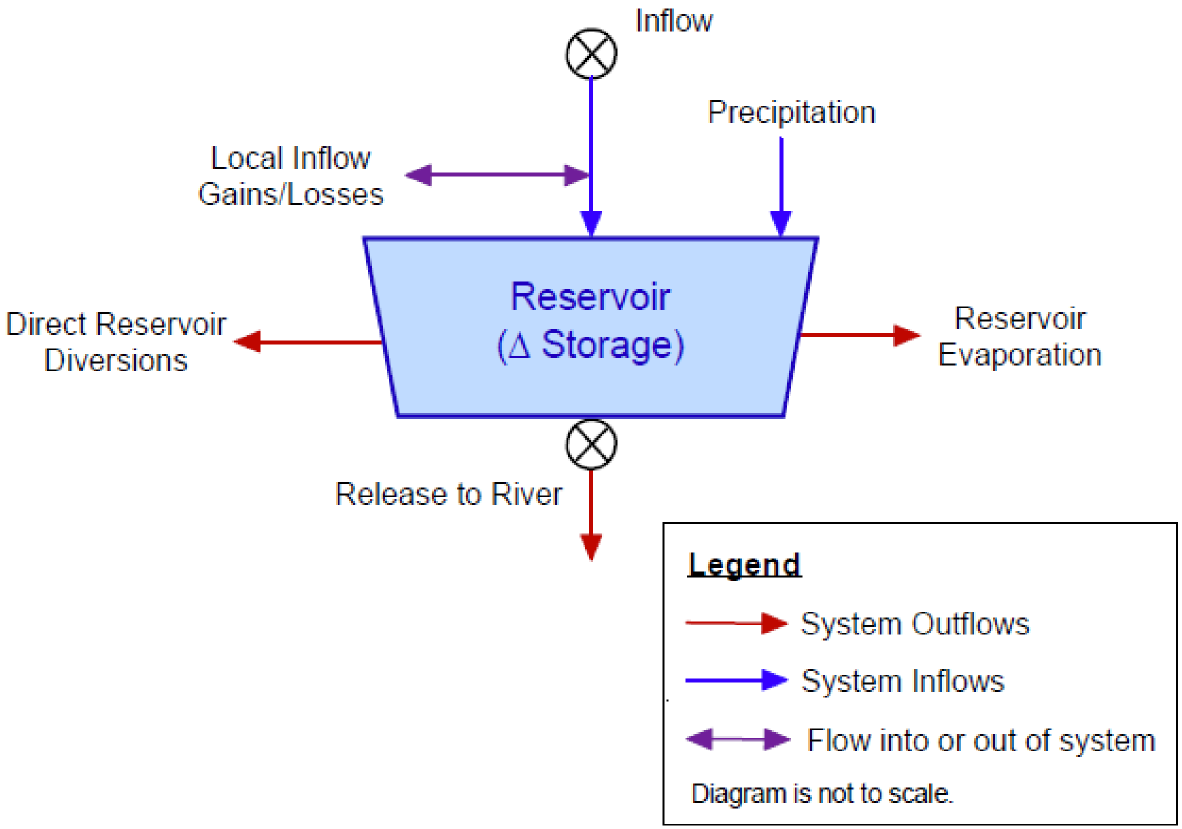


Figure 8-5

River Budget Schematic
RiverWare Model

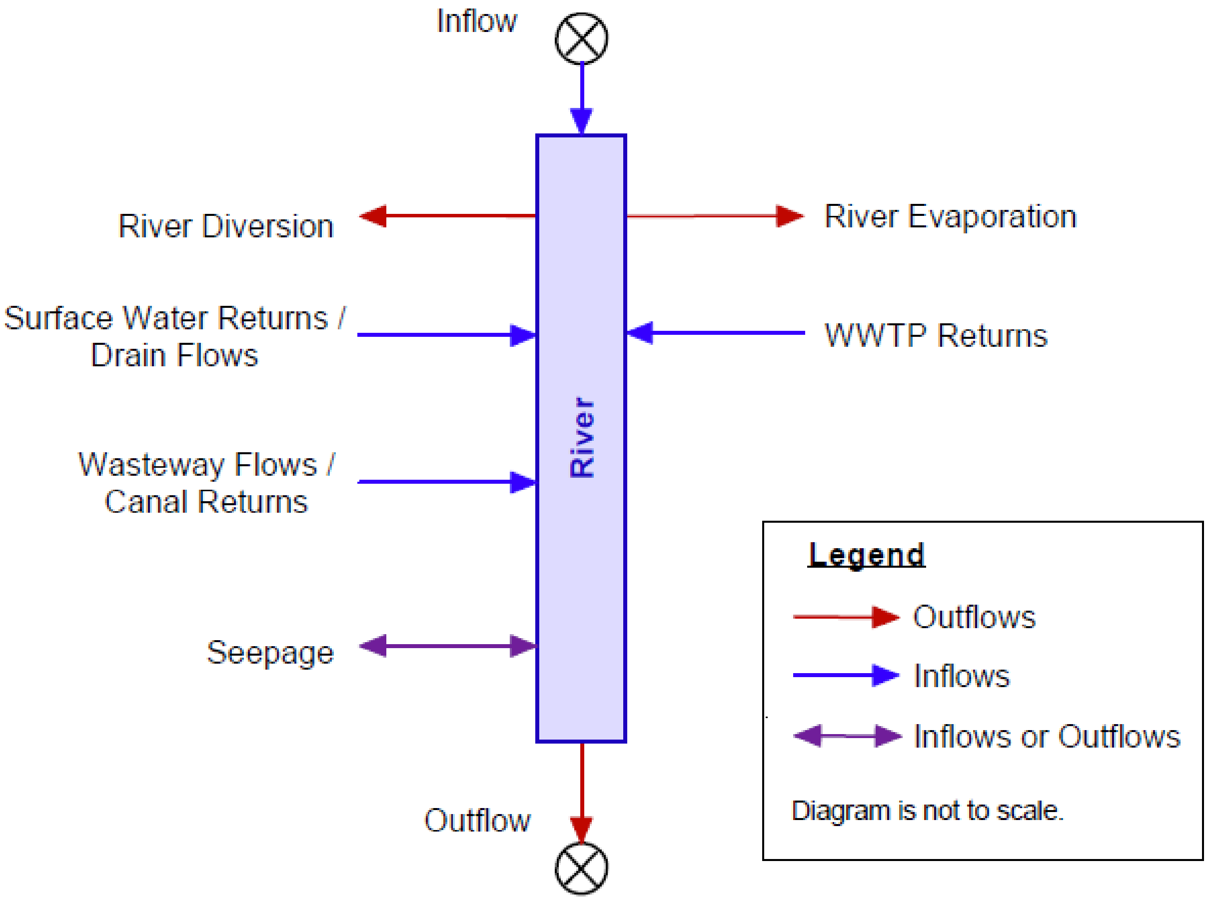


Figure 8-6

Canal and Farm Budget Schematic RiverWare Model

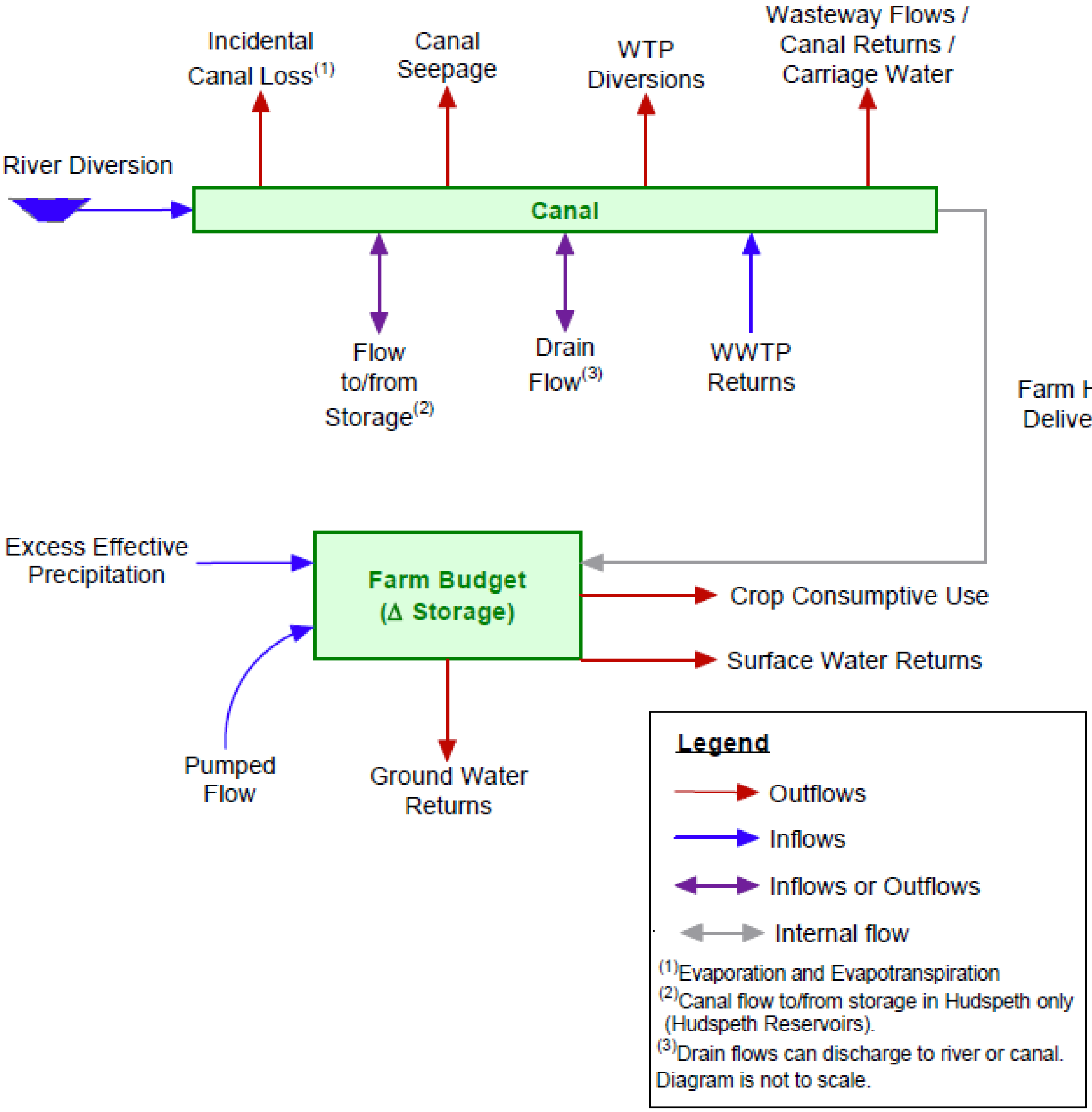


Figure 8-7

Ground Water Budget Schematic
RiverWare Model

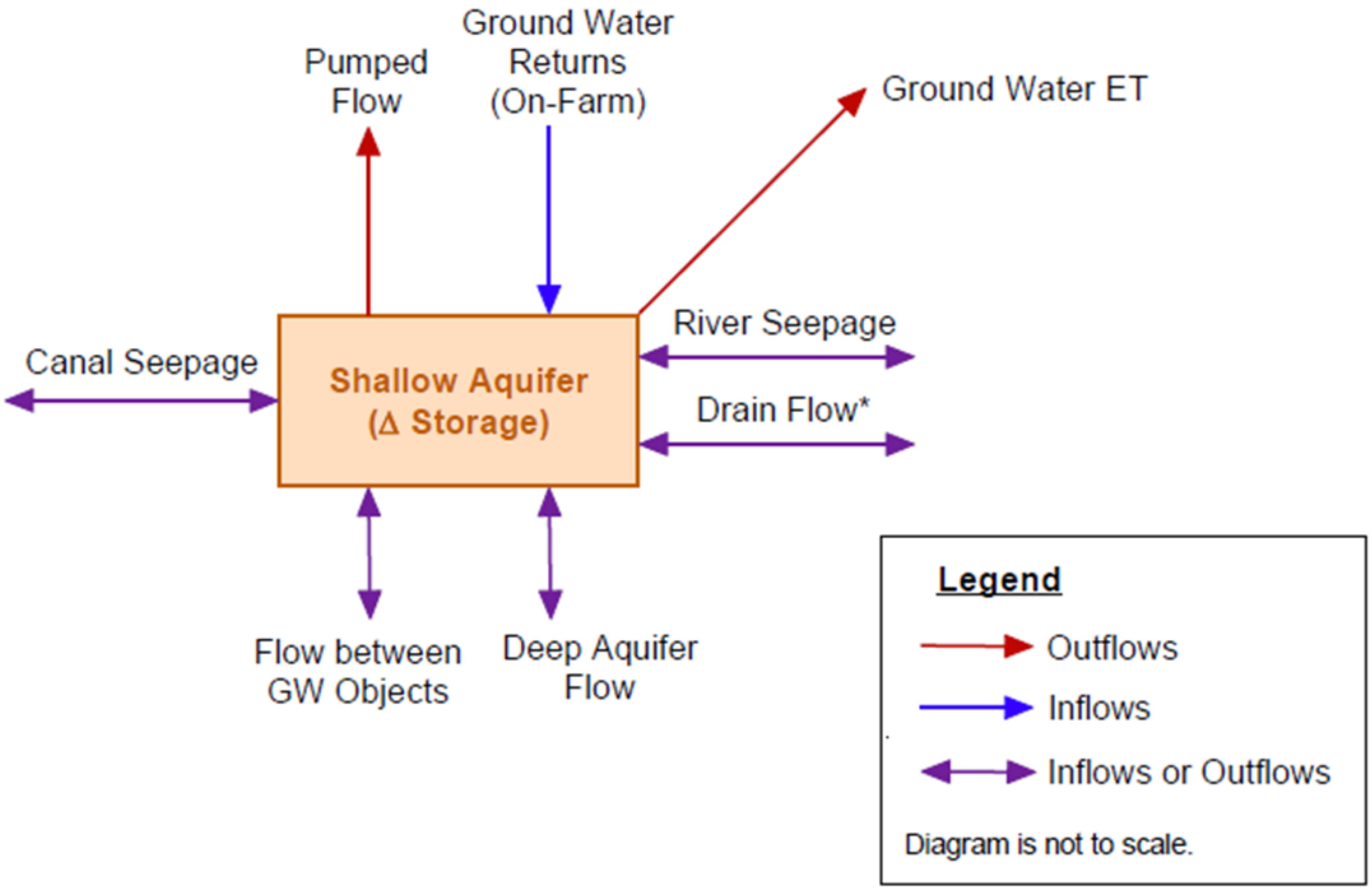


Figure 8-8

Ground Water Model Budget Schematic
Rincon-Mesilla and Hueco Ground Water Models

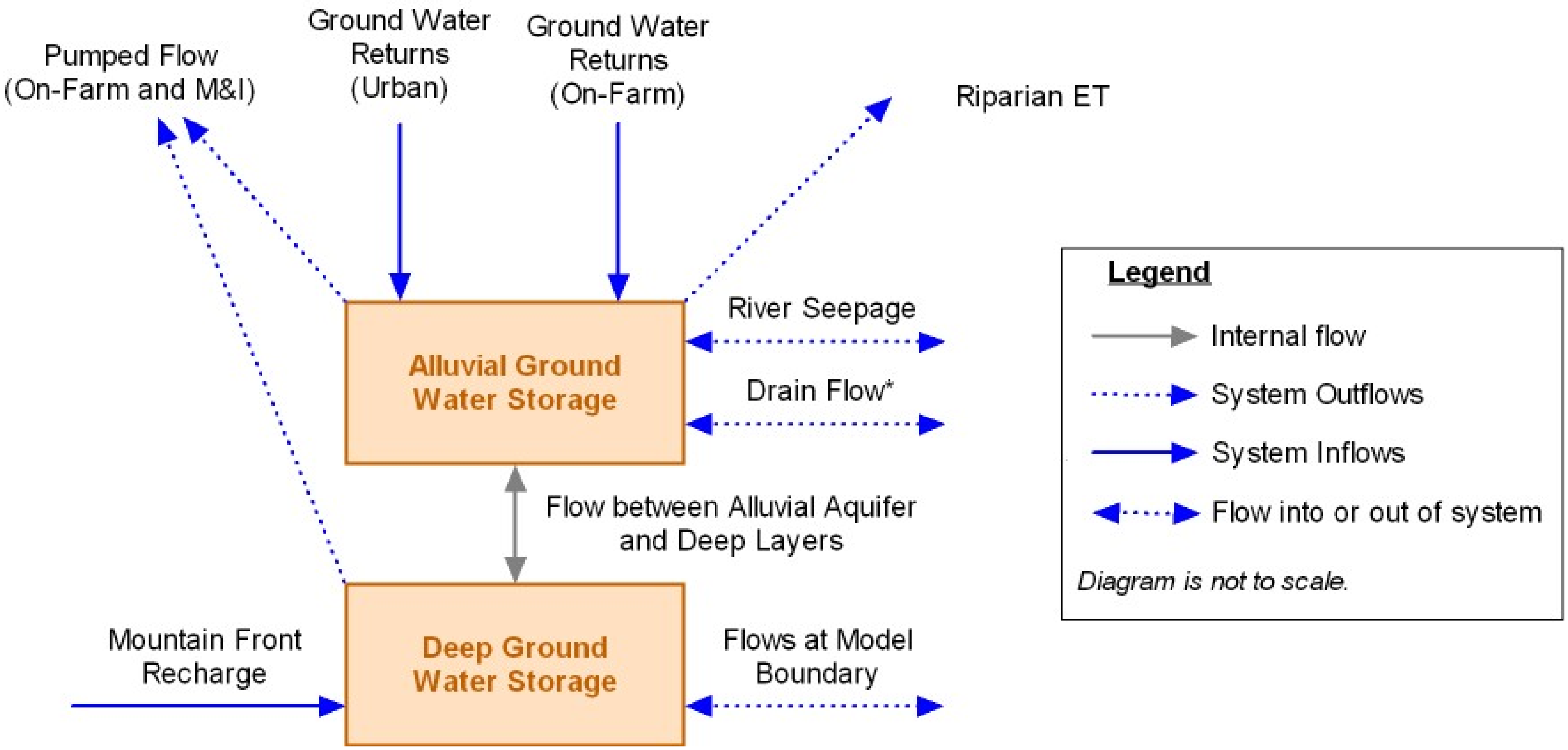
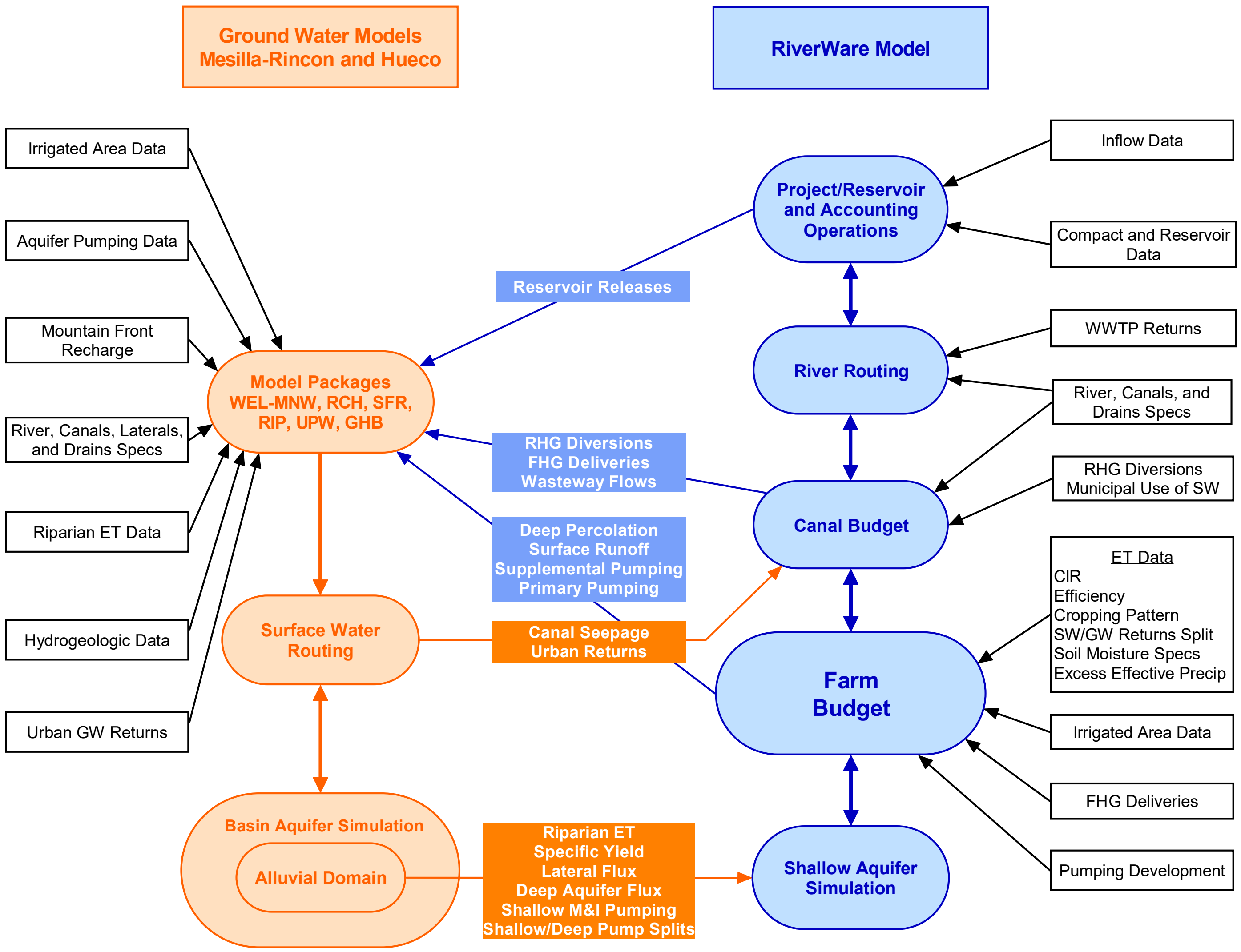


Figure 8-9

Modeling Overview
Integrated LRG Model



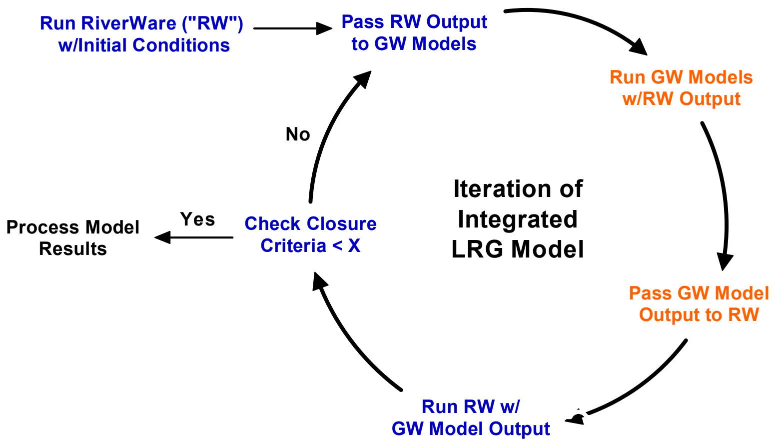


Figure 8-10

Simulation Processes and Calibration Targets
RiverWare Model

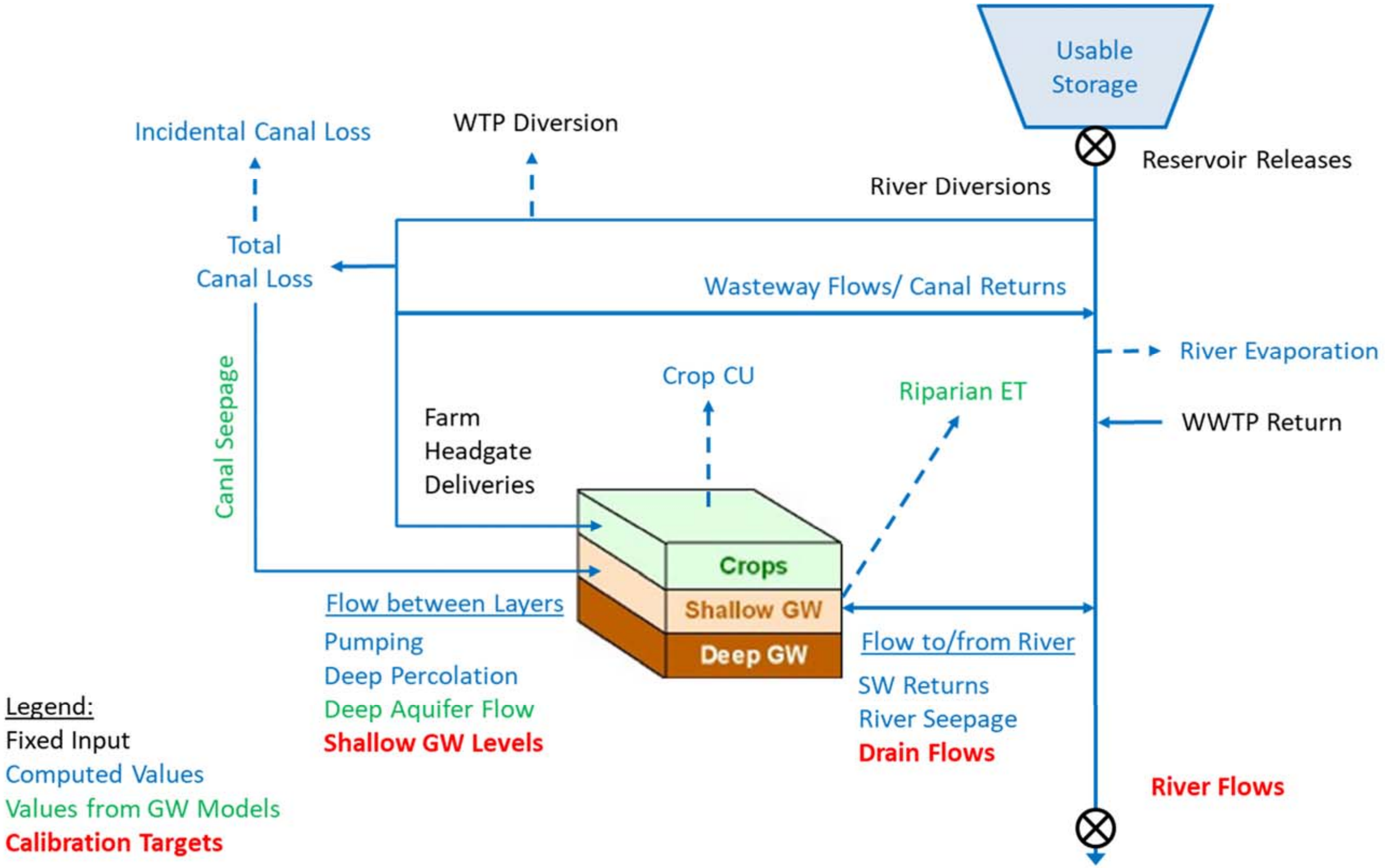
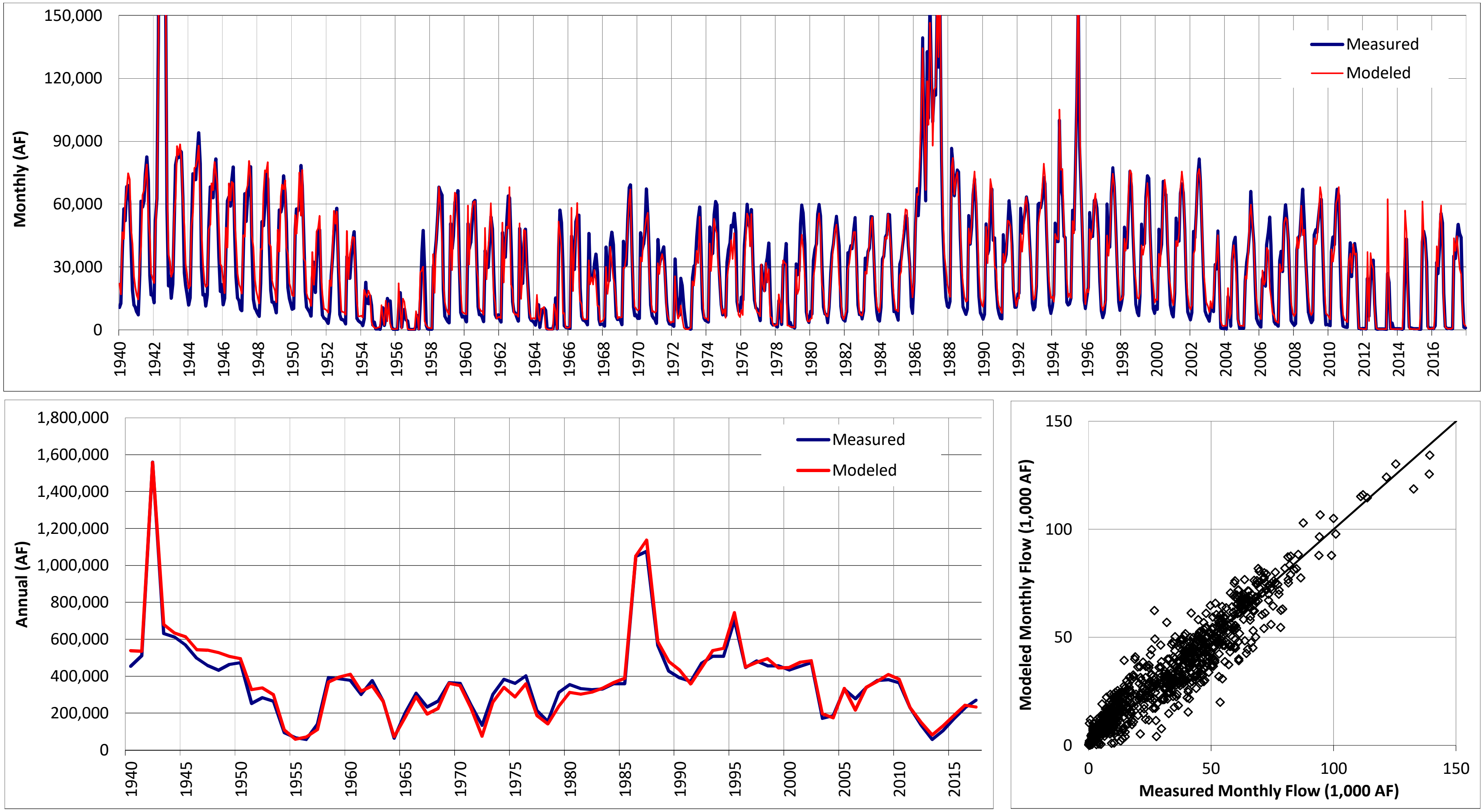


Figure 8-11

RiverWare Model Historical Calibration Results
Rio Grande at El Paso
1940 - 2017



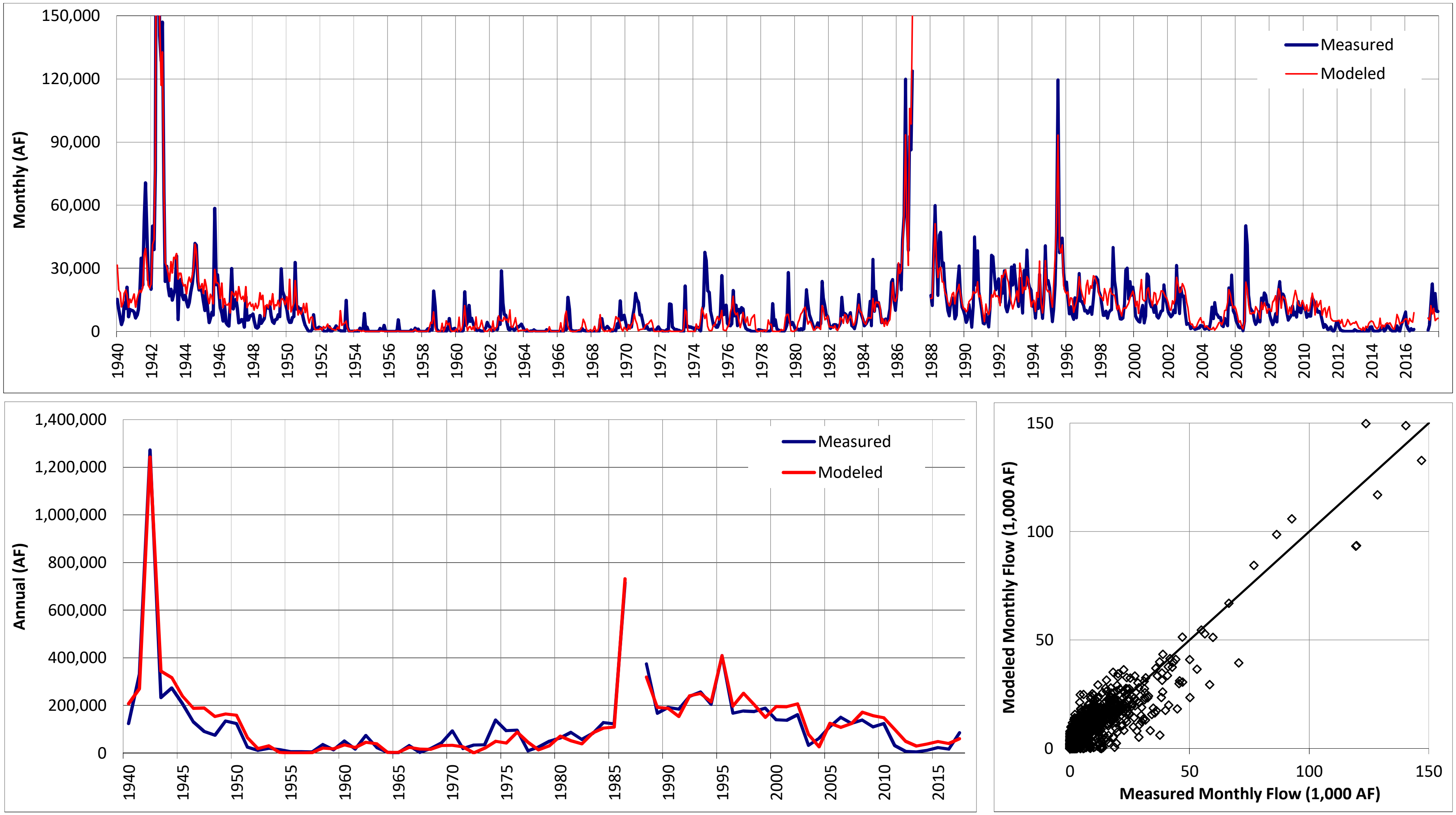
Mean Measured (af/y)	**374,297**	
Mean Modeled (af/y)	**380,374**	2%

Figure 8-12

RiverWare Model Historical Calibration Results

Rio Grande at Fort Quitman

1940 - 2017



Mean Measured (af/y)	124,143	
Mean Modeled (af/y)	132,363	7%

Note:

Data for 1987 and 8/2016-4/2017 is not included.

Figure 8-13

Simulation Processes and Tuning Targets
RiverWare Model

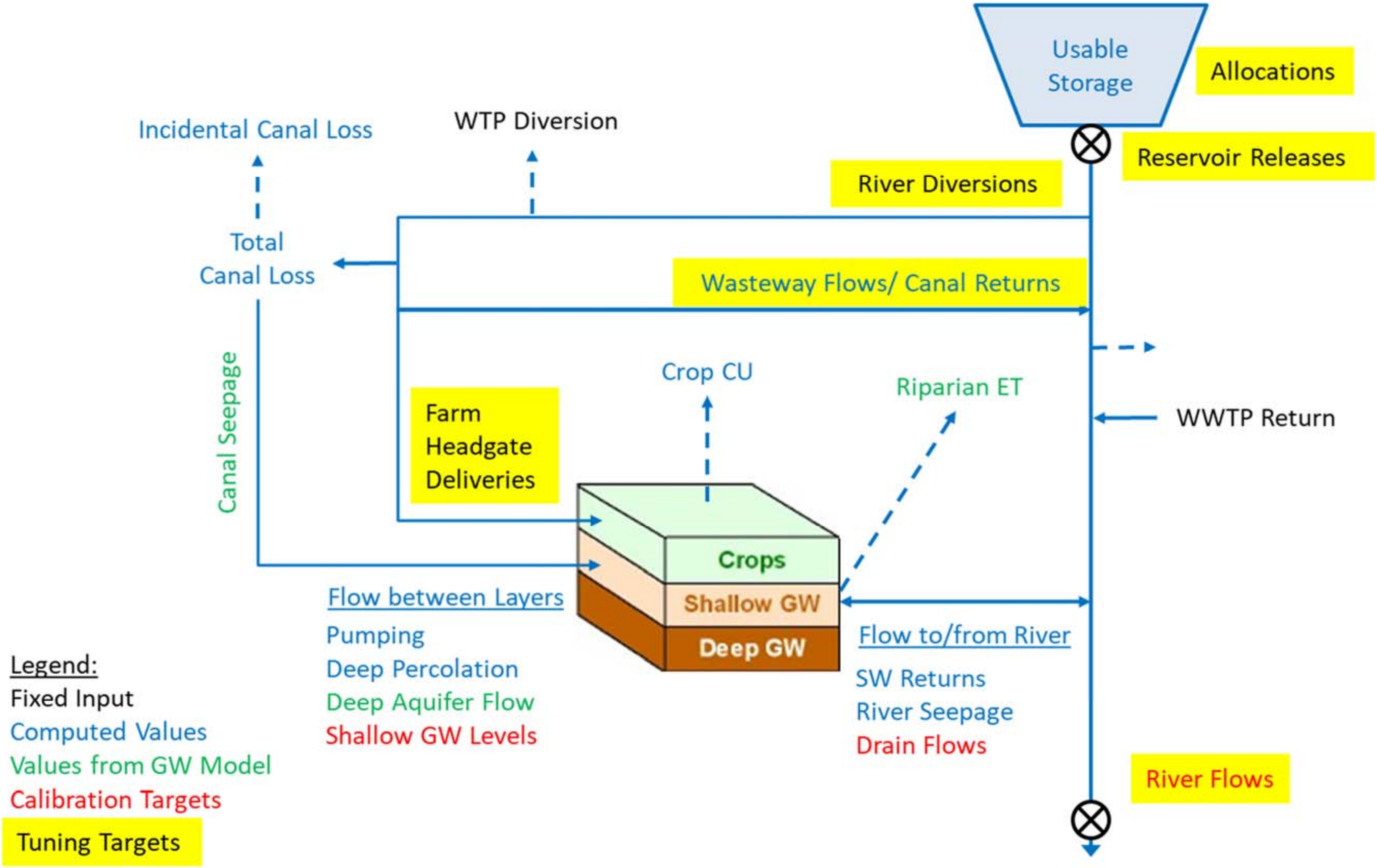
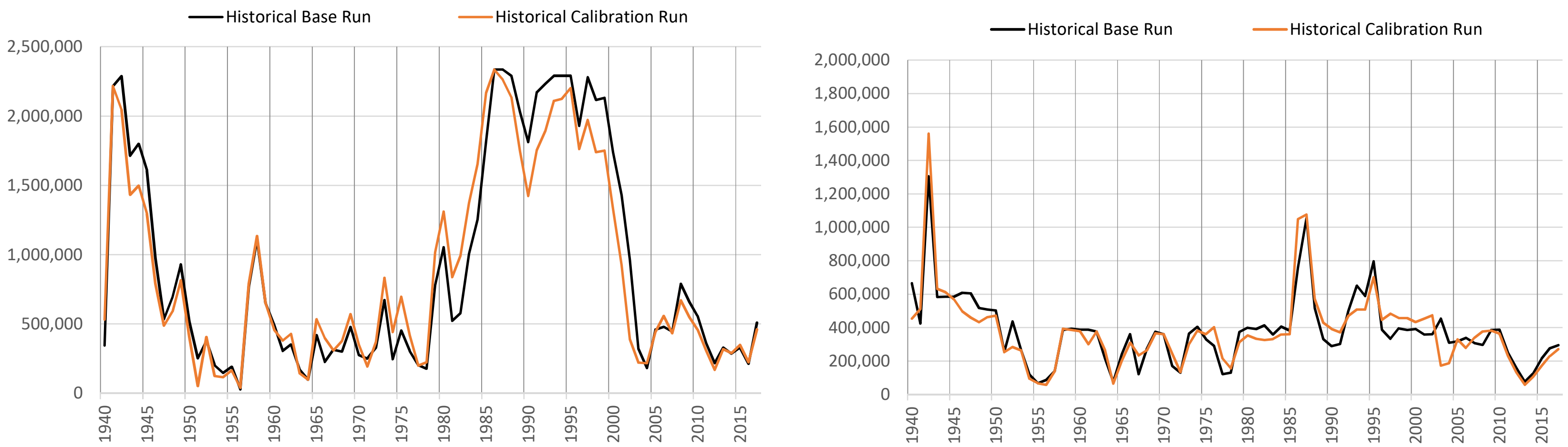


Figure 8-14

Historical Base Run v. Historical Calibration Run
Integrated LRG Model
Annual Project Storage and Rio Grande Flows
1940 - 2017 (acre-feet)

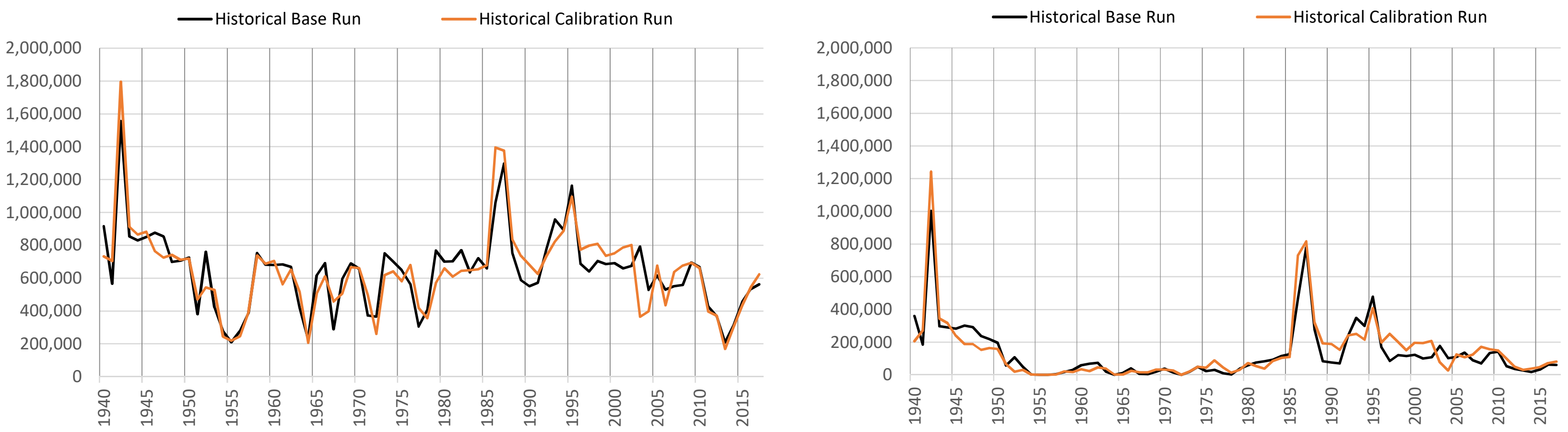
Total Year-End Project Reservoir Storage

Rio Grande at El Paso



Rio Grande Below Caballo

Rio Grande at Fort Quitman

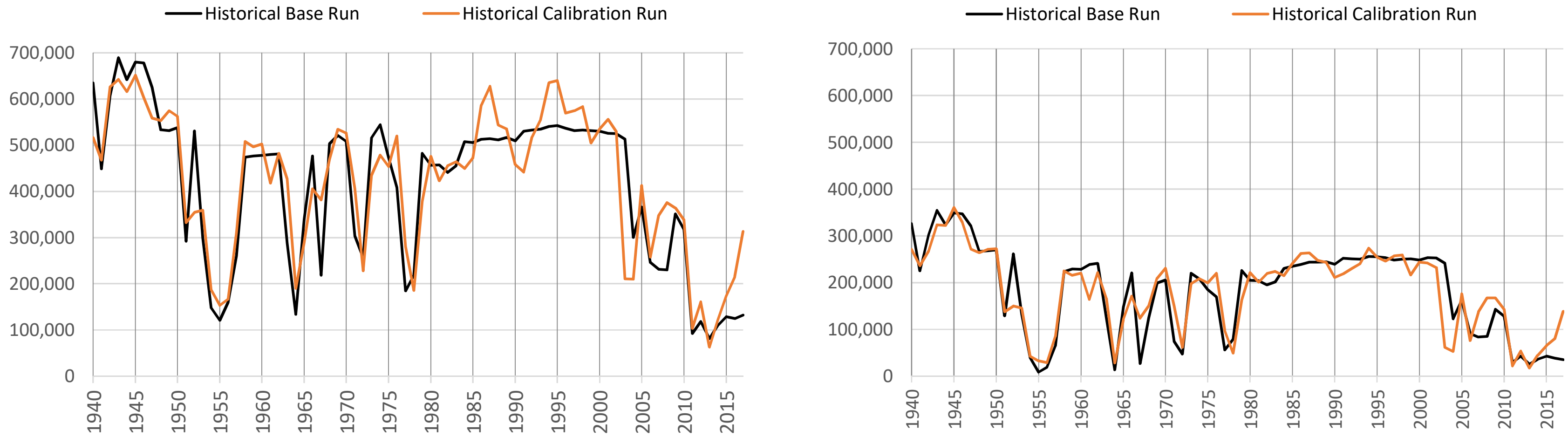


Model Version: Run 1 Summary - Operational - All Pumping On v. Run 0 Summary - Historical Calibration - All Pumping On

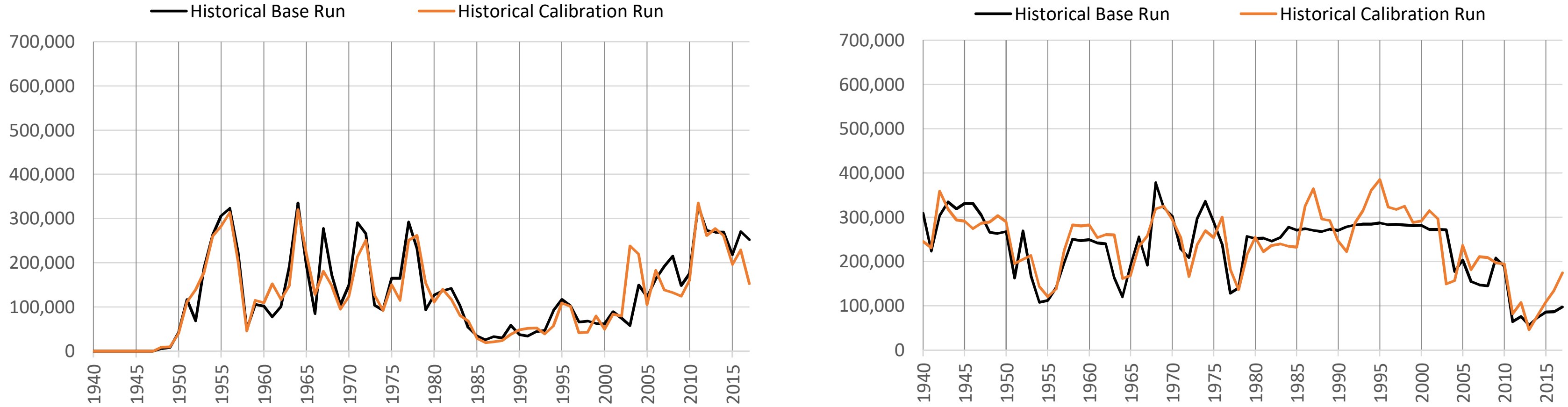
Figure 8-15

Historical Base Run v. Historical Calibration Run
Integrated LRG Model
Annual Irrigation Operations
1940 - 2017 (acre-feet)

EBID Total


River Headgate Diversions

Farm Headgate Deliveries


Pumping

RHG Diversions - FHG Deliveries

Model Version: Run 1 Summary - Operational - All Pumping On v. Run 0 Summary - Historical Calibration - All Pumping On

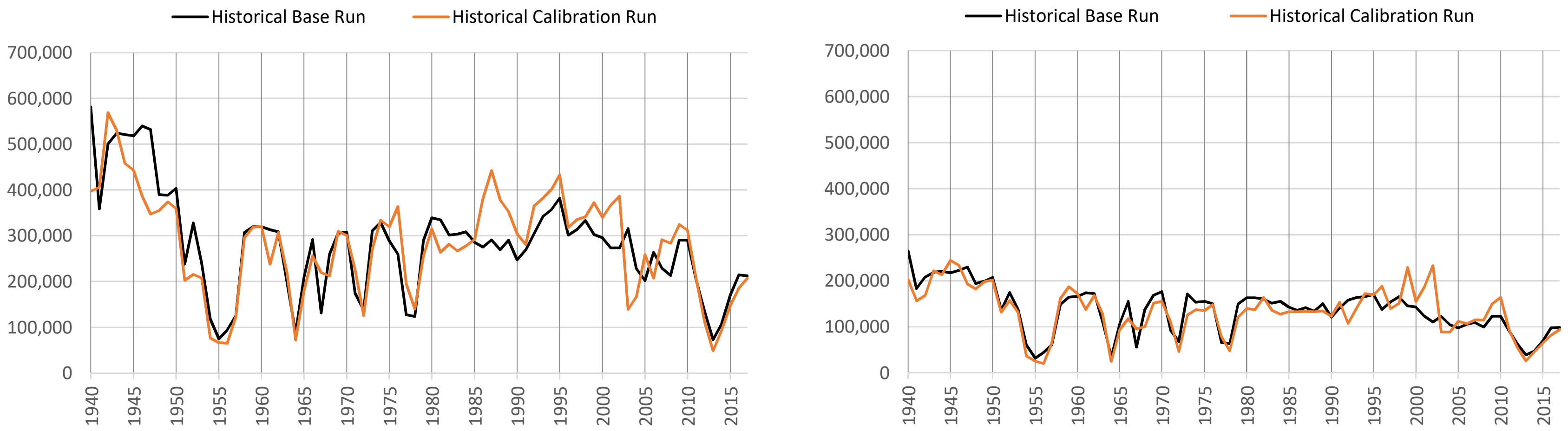
10/27/2019

Figure 8-16

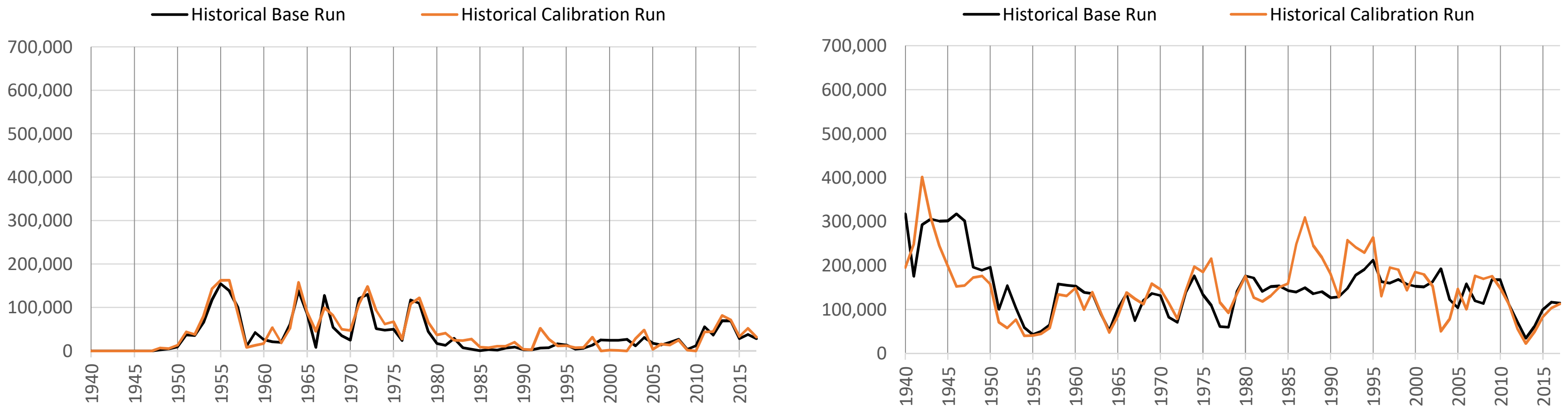
Historical Base Run v. Historical Calibration Run
Integrated LRG Model
Annual Irrigation Operations
1940 - 2017 (acre-feet)

EPCWID Total

River Headgate Diversions **Farm Headgate Deliveries**



Pumping **RHG Diversions - FHG Deliveries**



Model Version: Run 1 Summary - Operational - All Pumping On v. Run 0 Summary - Historical Calibration - All Pumping On

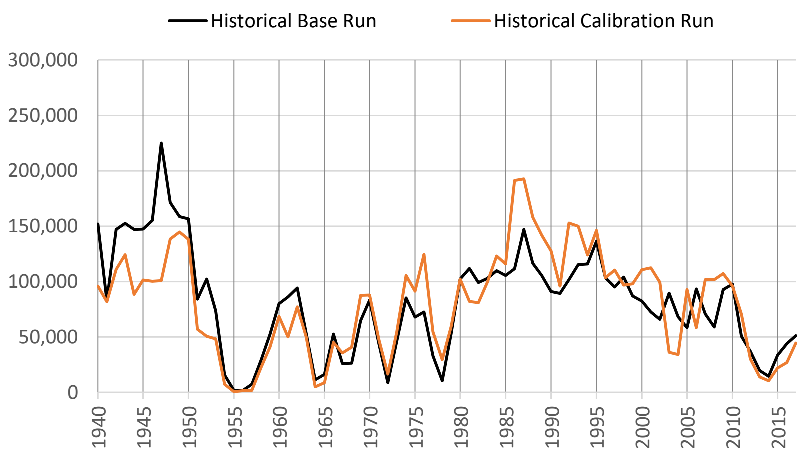
10/27/2019

Figure 8-17

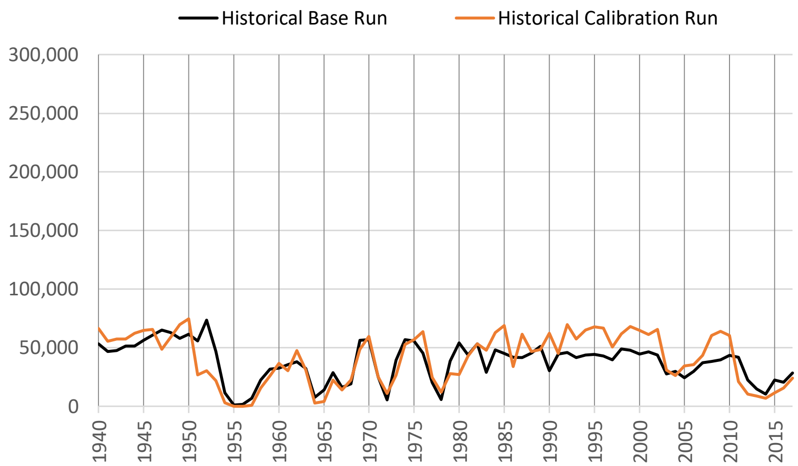
Historical Base Run v. Historical Calibration Run
Integrated LRG Model
Annual Irrigation Operations
1940 - 2017 (acre-feet)

HCCRD Total

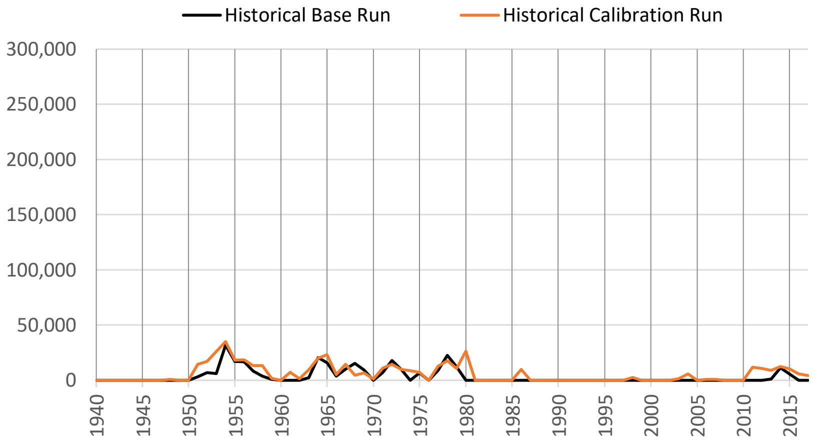
River Headgate Diversions



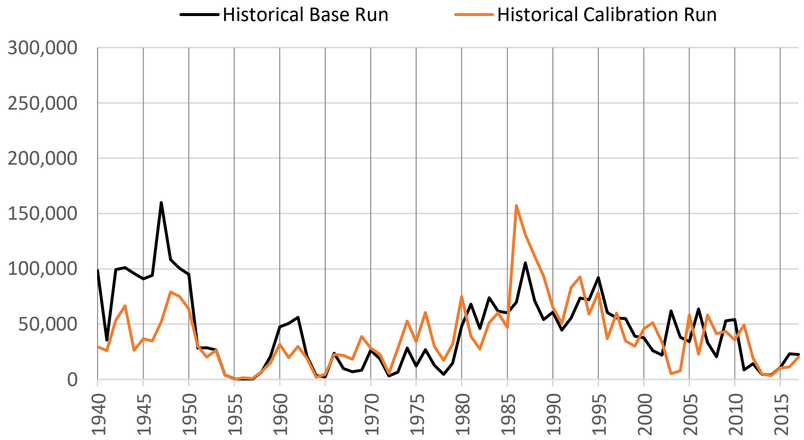
Farm Headgate Deliveries



Pumping



RHG Diversions - FHG Deliveries



Model Version: Run 1 Summary - Operational - All Pumping On v. Run 0 Summary - Historical Calibration - All Pumping On

Revised 7/15/2020

Figure 8-18

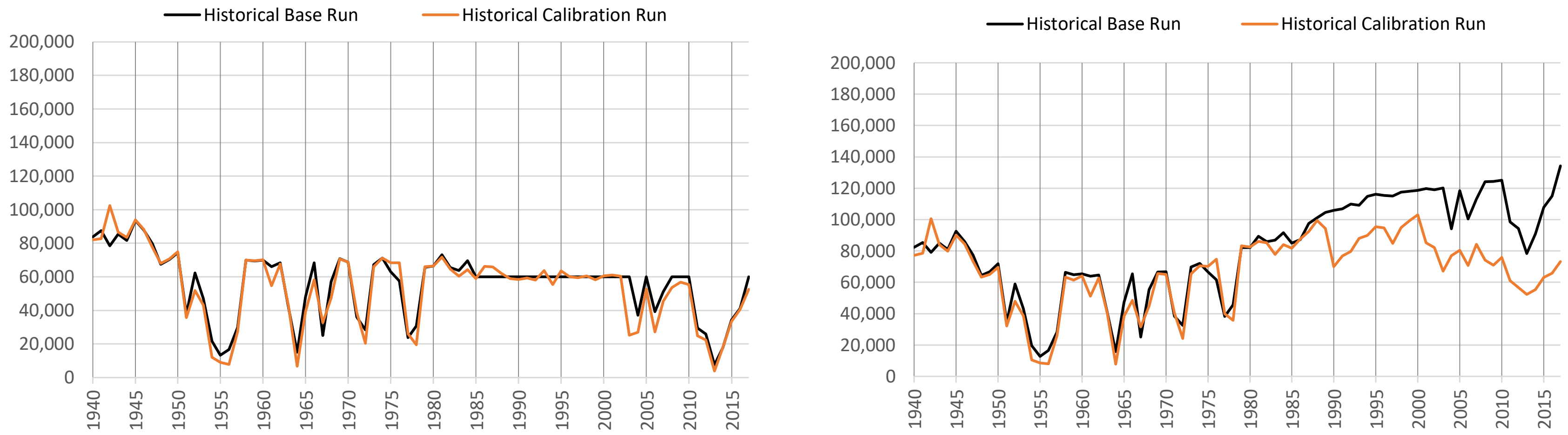
Historical Base Run v. Historical Calibration Run

Integrated LRG Model

Annual Irrigation Operations

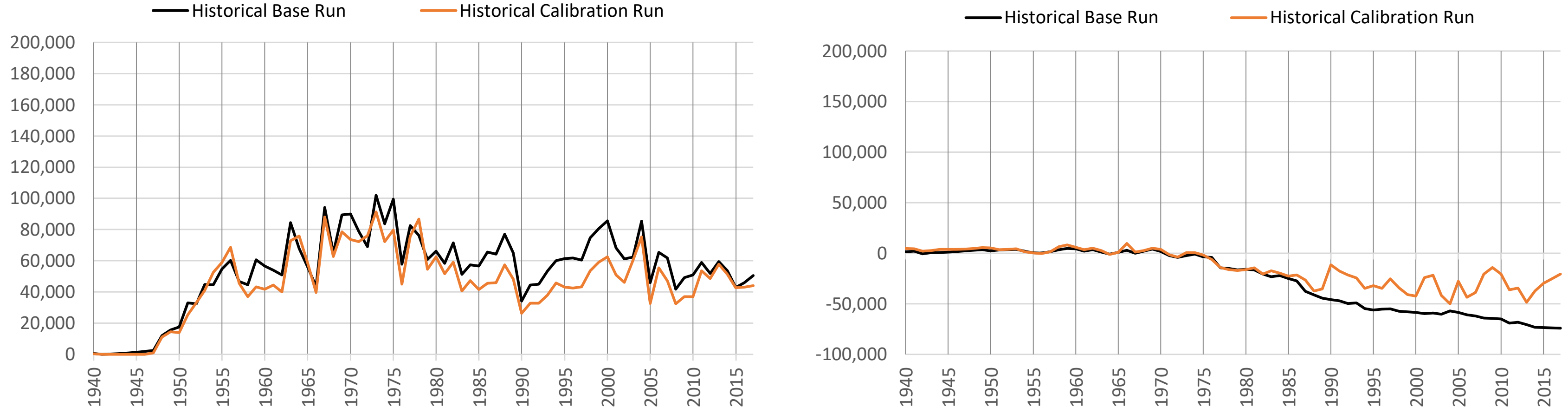
1940 - 2017 (acre-feet)

JID Total



River Headgate Diversions

Farm Headgate Deliveries



Pumping

RHG Diversions - FHG Deliveries

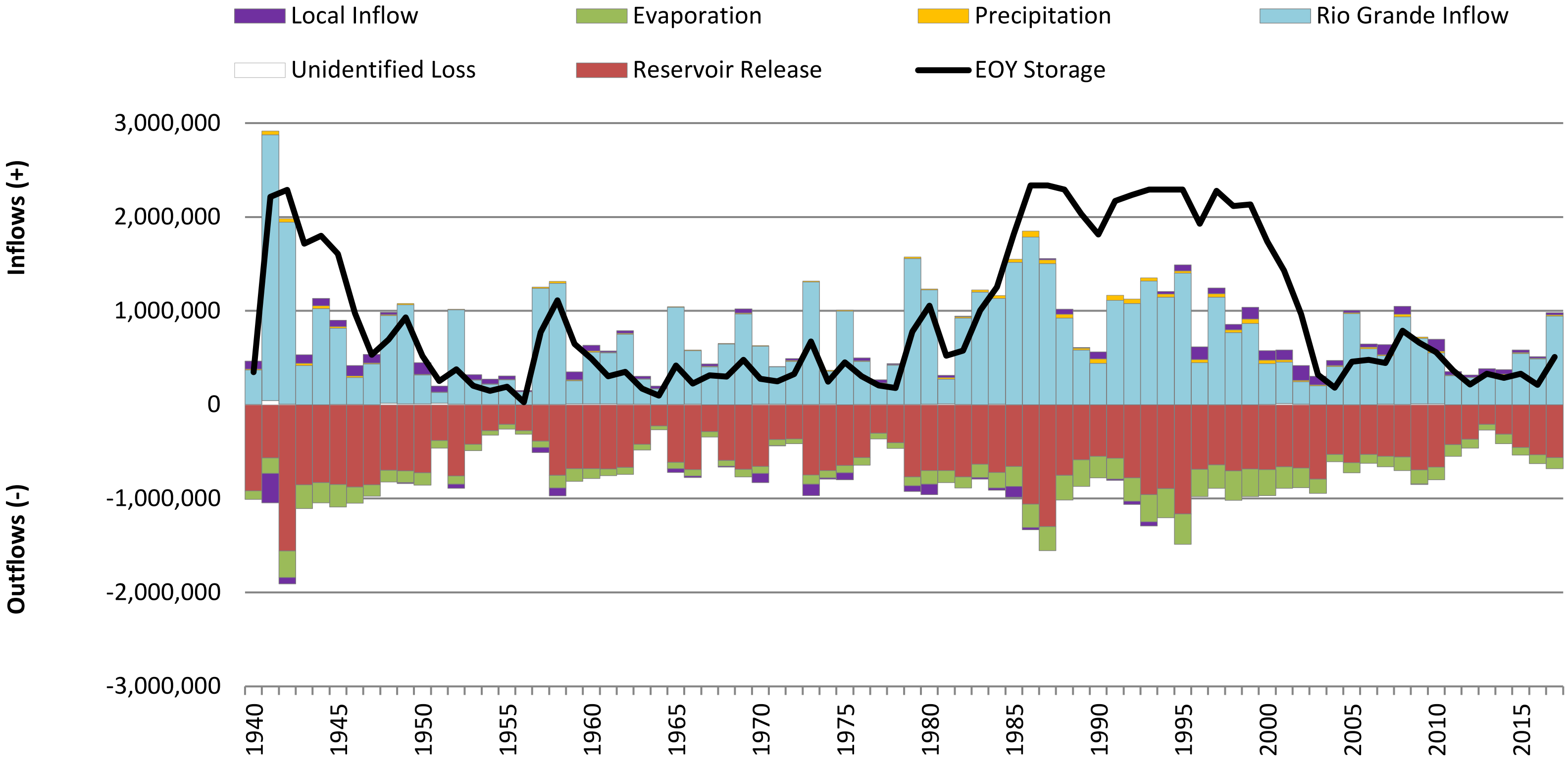
Model Version: Run 1 Summary - Operational - All Pumping On v. Run 0 Summary - Historical Calibration - All Pumping On

Revised 7/15/2020

Figure 9-1

Annual Reservoir Budget Summary
Historical Base Run
Integrated LRG Model
1940 - 2017 (acre-feet)

Elephant Butte and Caballo Reservoirs (Project Total)

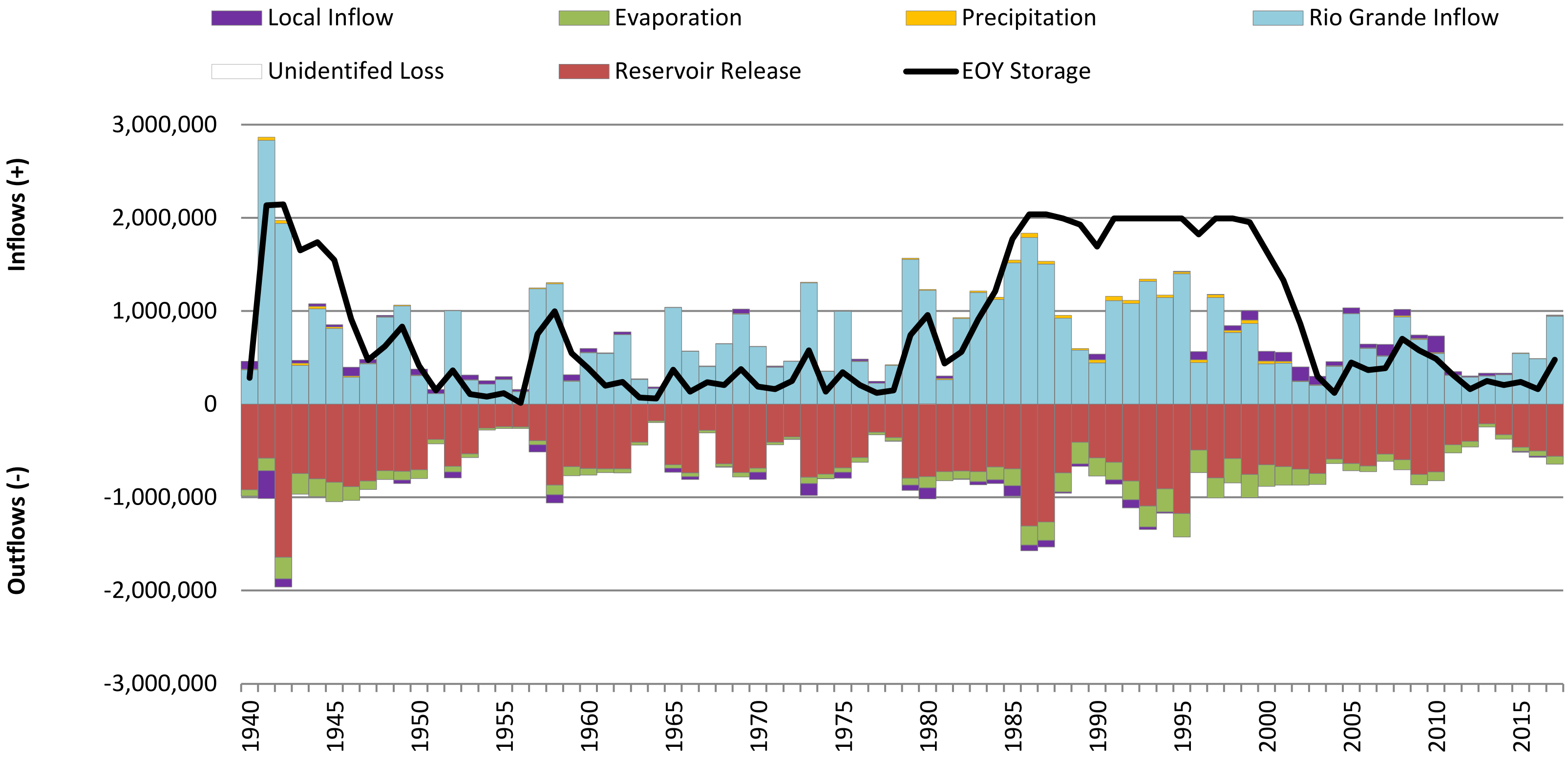


Model Version: LRG Model v106 Operational Run - Base Run (All Pumping On).

Figure 9-1

Annual Reservoir Budget Summary
Historical Base Run
Integrated LRG Model
1940 - 2017 (acre-feet)

Elephant Butte Reservoir

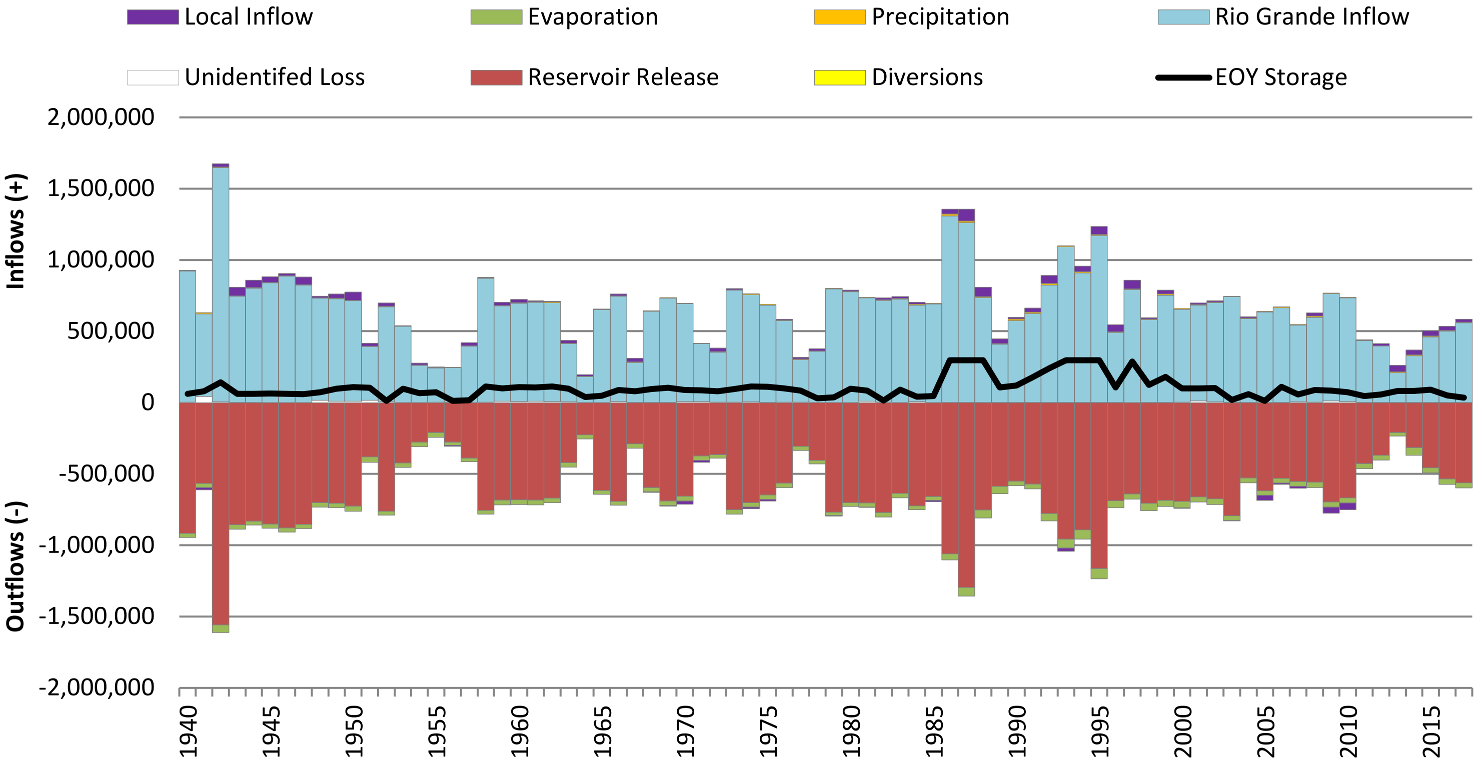


Model Version: LRG Model v106 Operational Run - Base Run (All Pumping On).

Figure 9-1

Annual Reservoir Budget Summary
Historical Base Run
Integrated LRG Model
1940 - 2017 (acre-feet)

Caballo Reservoir

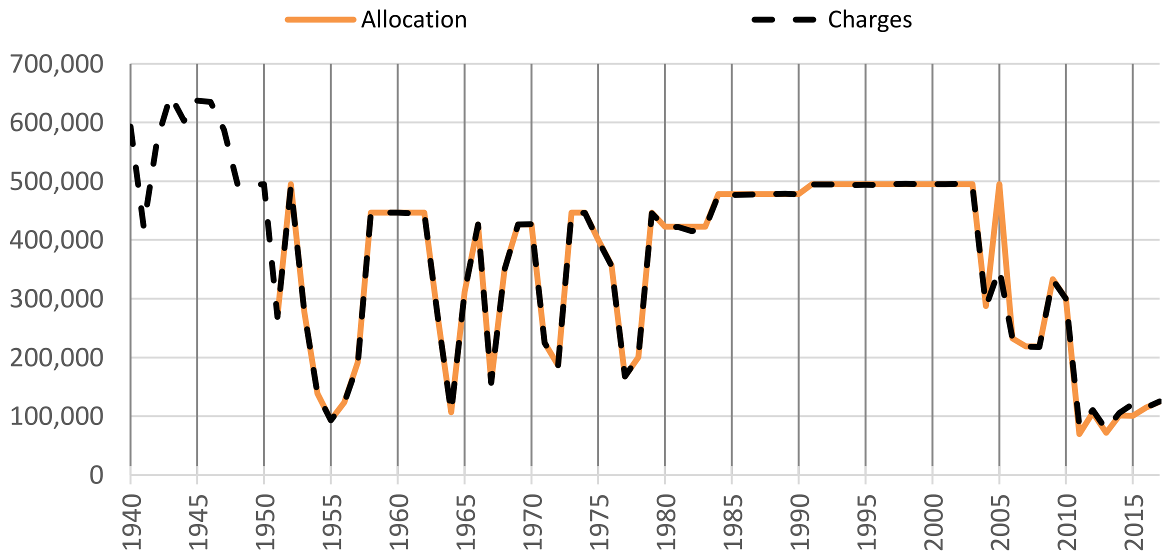


Model Version: LRG Model v106 Operational Run - Base Run (All Pumping On).

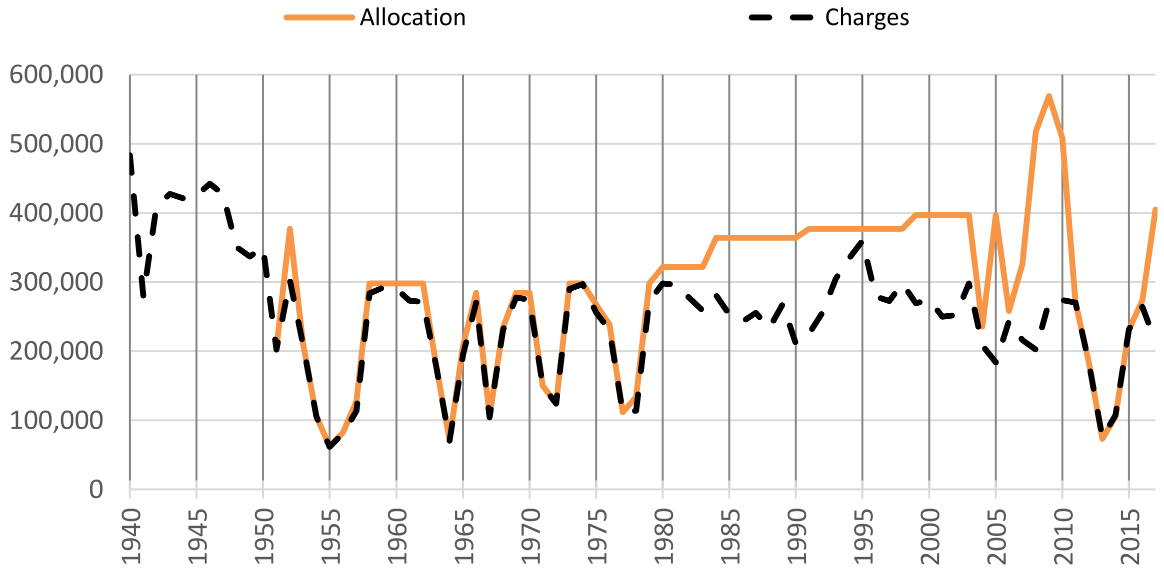
Figure 9-2

Annual Project Allocations and Charges
Historical Base Run
Integrated LRG Model
1940 - 2017 (acre-feet)

EBID



EPCWID



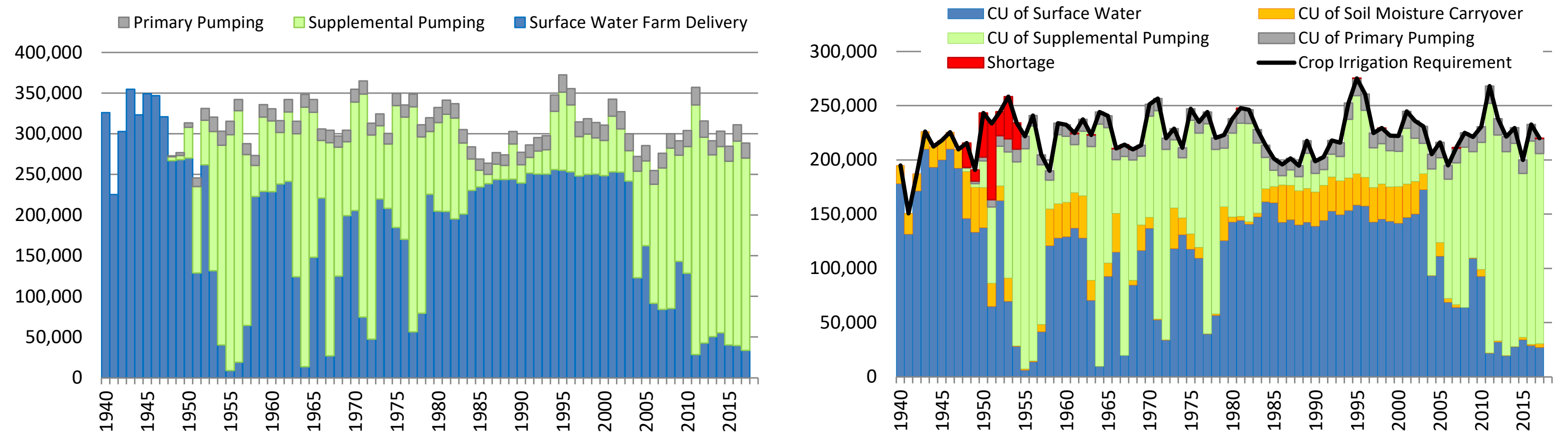
Model Version: LRG Model v106 Operational Run - Base Run (All Pumping On).

Note:

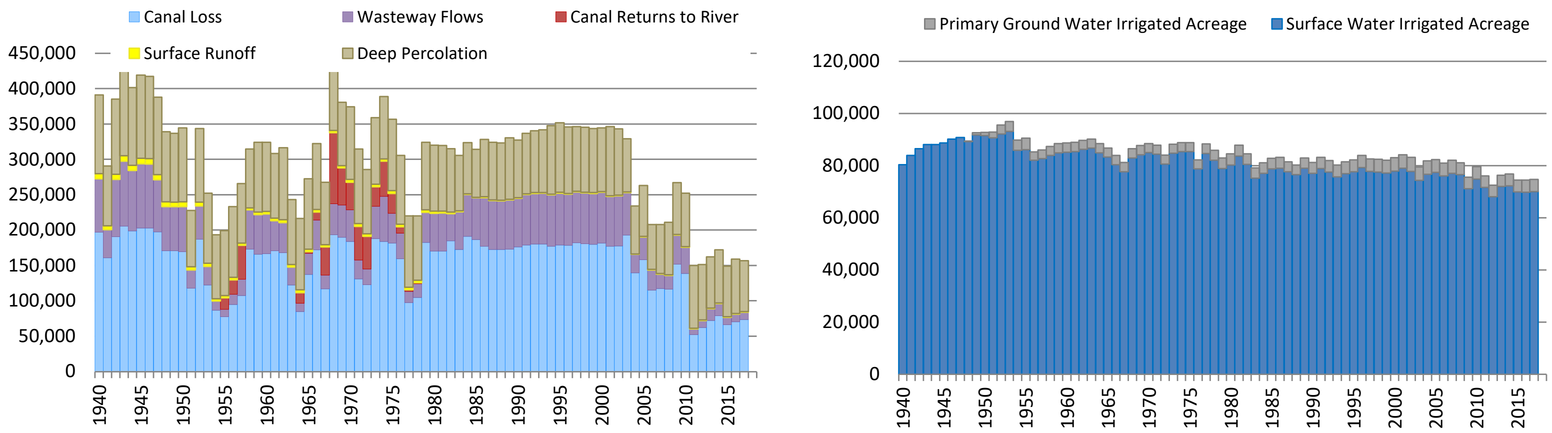
Allocation includes carryover after 2007.

Figure 9-3

Annual Canal and Farm Budget Summary
Historical Base Run
Integrated LRG Model
1940-2017
EBID Total


Annual Farm Deliveries (acre-feet)

Annual Consumptive Use (acre-feet)


Annual Losses (acre-feet)

Annual Irrigated Acres

*Note: Different Scales

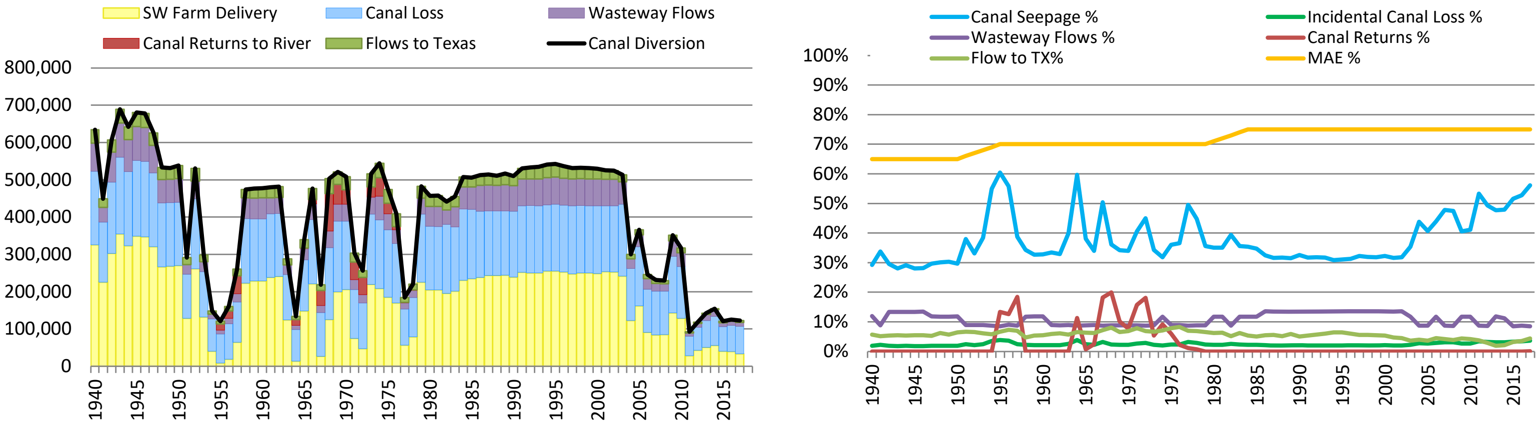
Model Version: LRG Model v106 Operational Run - Base Run (All Pumping On).

Figure 9-3

Annual Canal and Farm Budget Summary
Historical Base Run
Integrated LRG Model
1940-2017
EBID Total

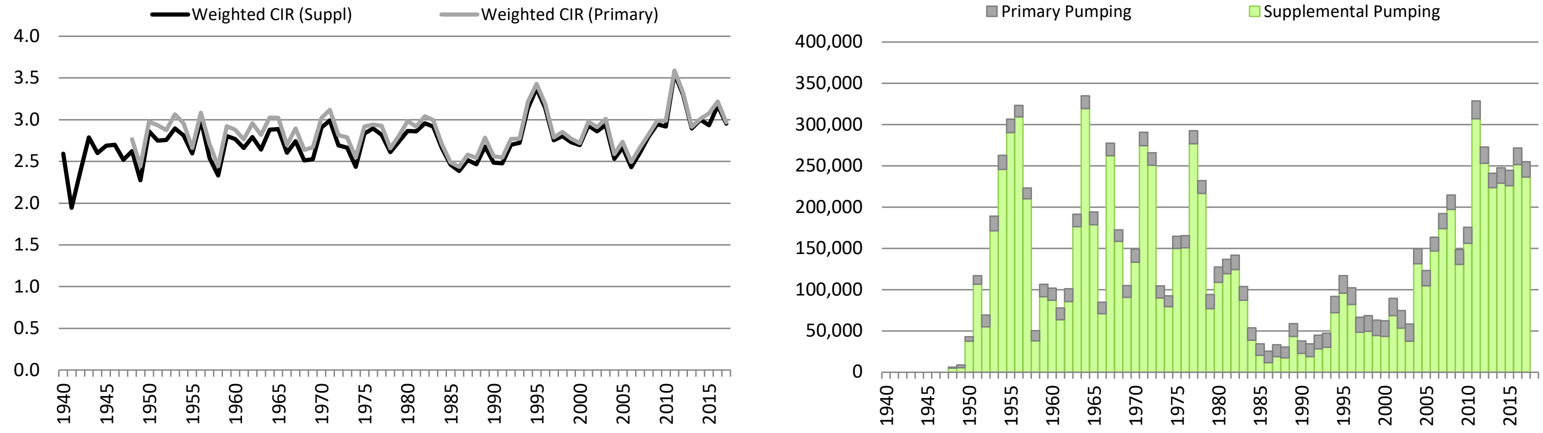
Annual Canal Diversions and Farm Deliveries (acre-feet)

Maximum Application Efficiency and Loss Percentages



Annual Weighted Crop Irrigation Requirement (feet)

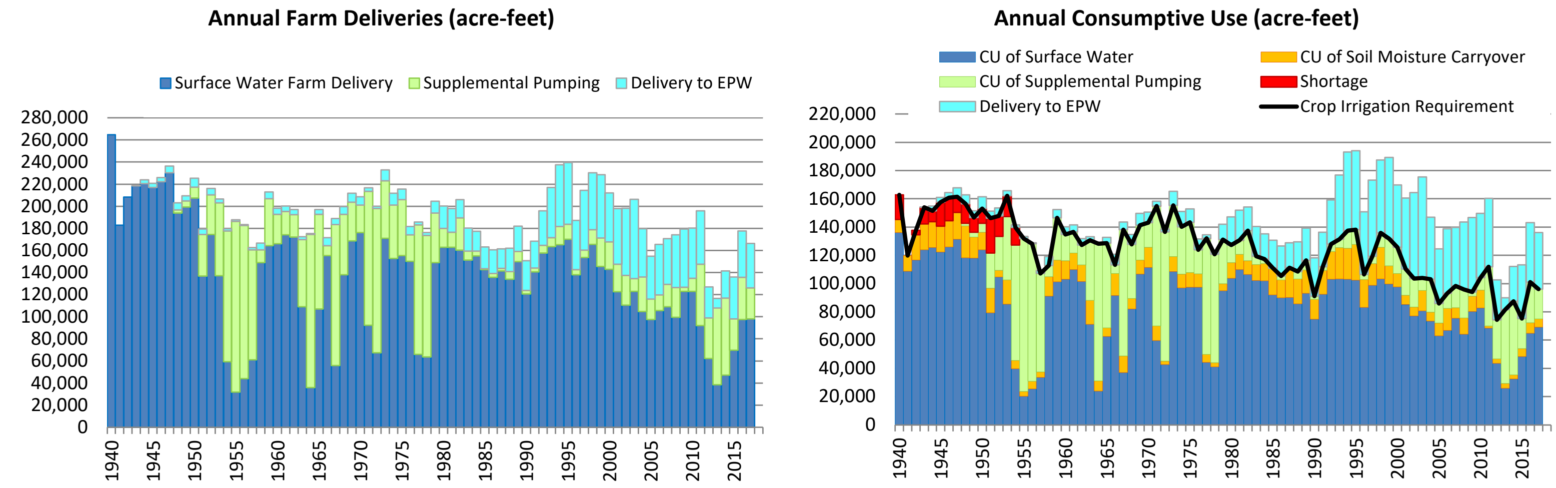
Annual Pumping (acre-feet)

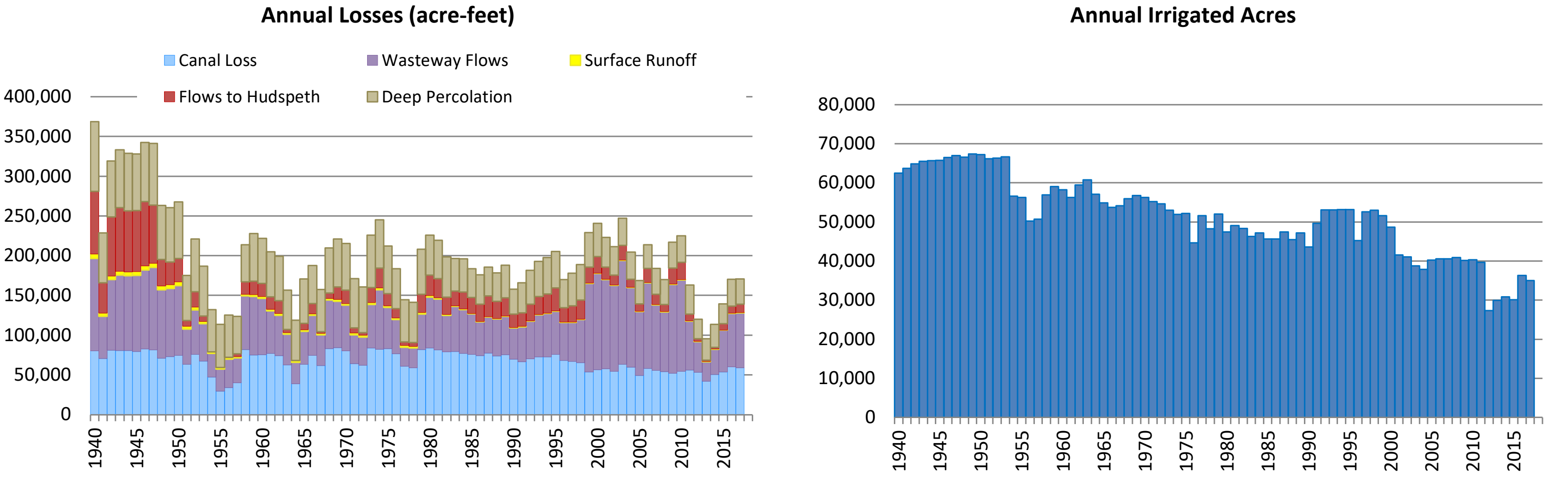


Model Version: LRG Model v106 Operational Run - Base Run (All Pumping On).

Figure 9-4

Annual Canal and Farm Budget Summary
Historical Base Run
Integrated LRG Model
1940-2017
EPCWID Total





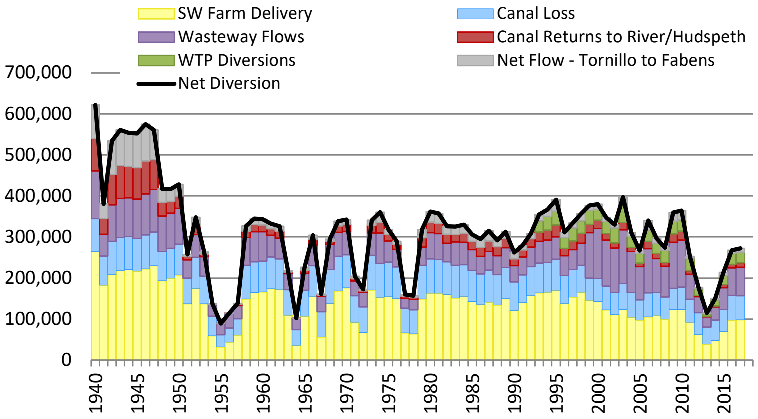
***Note: Different Scales**

Model Version: LRG Model v106 Operational Run - Base Run (All Pumping On).

Figure 9-4

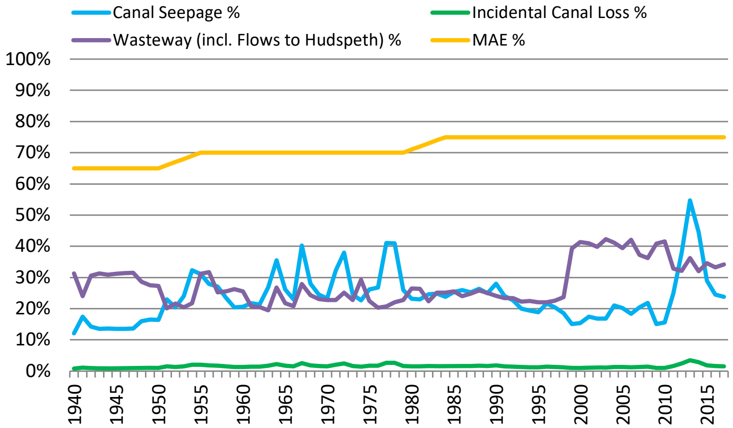
Annual Canal and Farm Budget Summary
Historical Base Run
Integrated LRG Model
1940-2017
EPCWID Total

Annual Canal Diversions and Farm Deliveries (acre-feet)

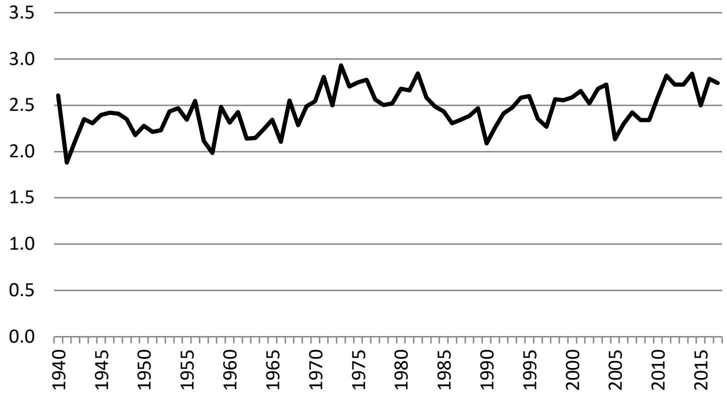


*Includes Canal Diversions, Drain Returns to Canals ,and WWTP Returns to Canals.

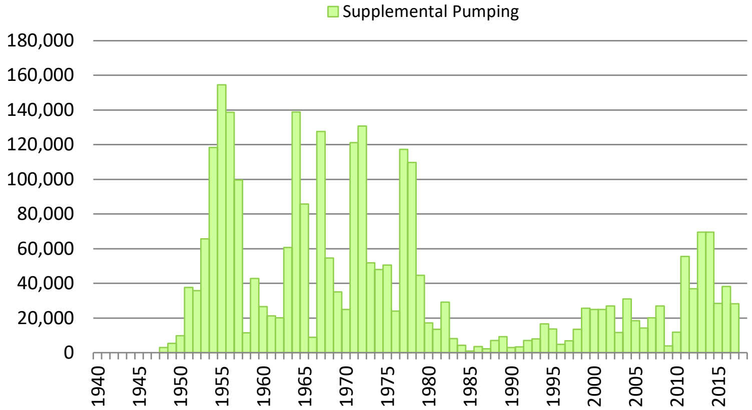
Maximum Application Efficiency and Loss Percentages



Annual Weighted Crop Irrigation Requirement (feet)



Annual Pumping (acre-feet)

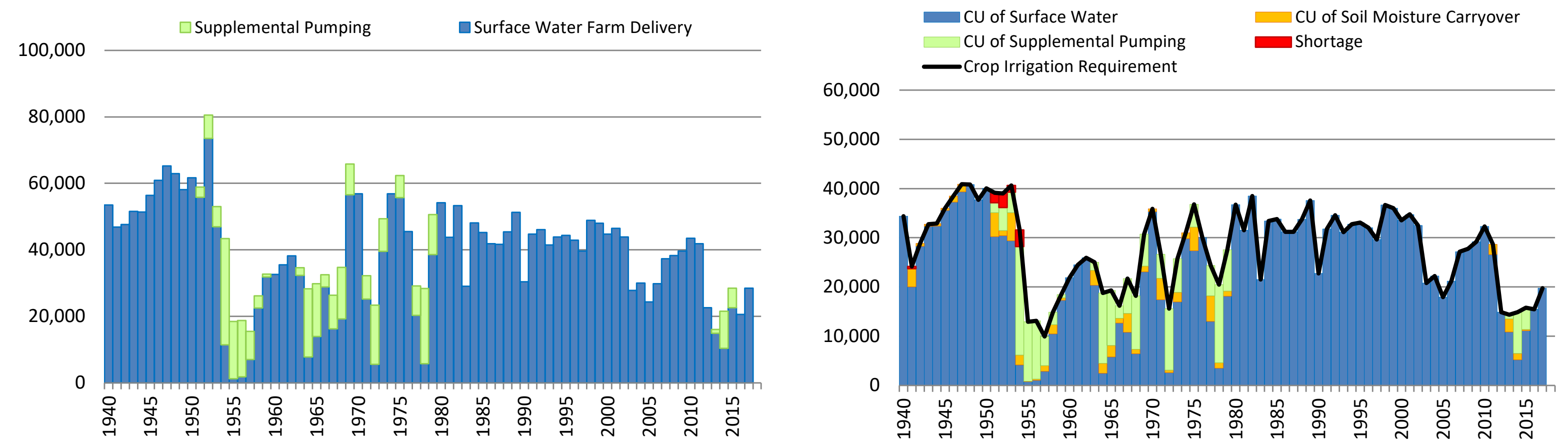


Model Version: LRG Model v106 Operational Run - Base Run (All Pumping On).

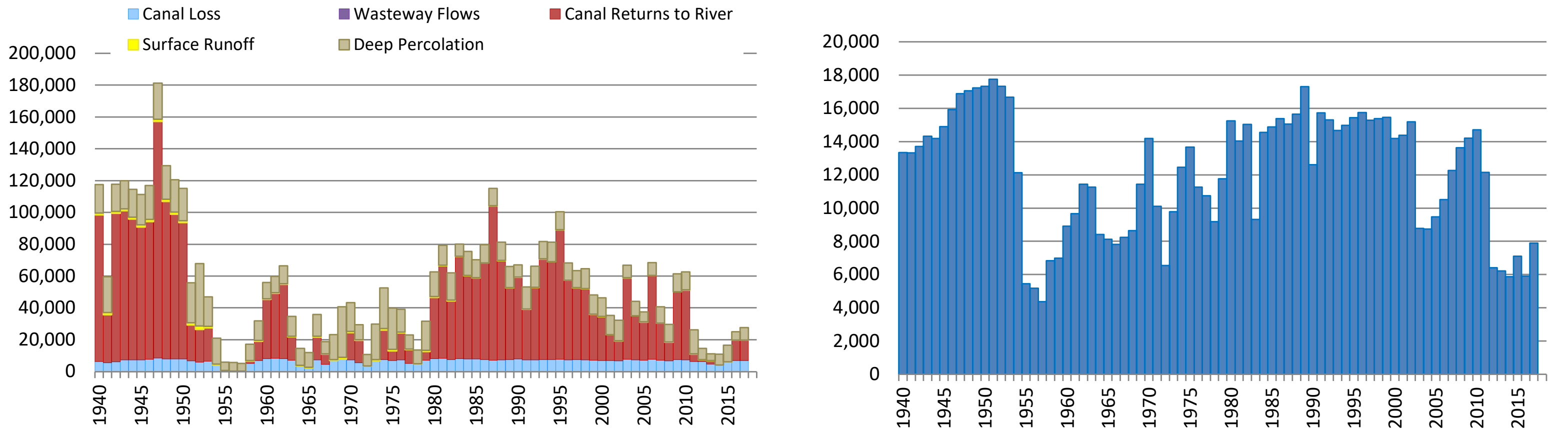
Figure 9-5

Annual Canal and Farm Budget Summary
Historical Base Run
Integrated LRG Model
1940-2017
HCCRD

Annual Farm Deliveries (acre-feet) Annual Consumptive Use (acre-feet)



Annual Losses (acre-feet) Annual Irrigated Acres



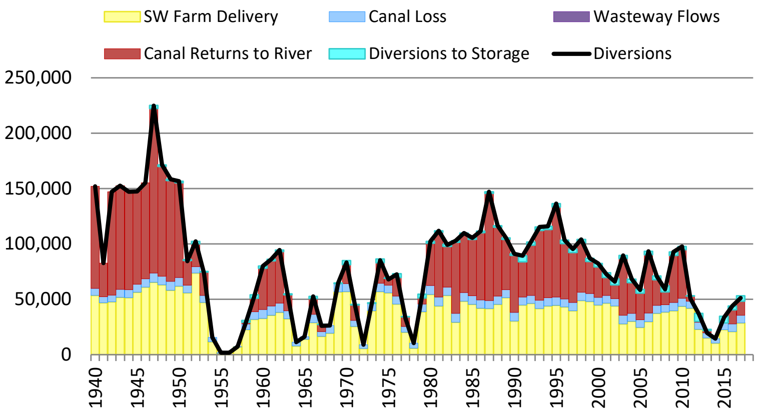
***Note: Different Scales**

Model Version: LRG Model v106 Operational Run - Base Run (All Pumping On).

Figure 9-5

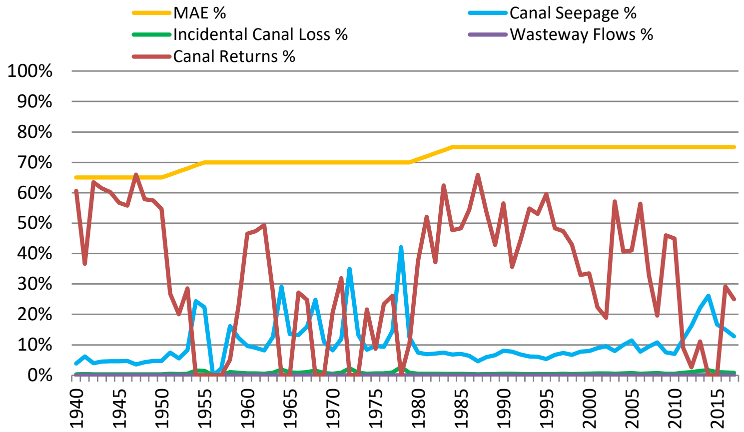
Annual Canal and Farm Budget Summary
Historical Base Run
Integrated LRG Model
1940-2017
HCCRD

Annual Canal Diversions and Farm Deliveries (acre-feet)

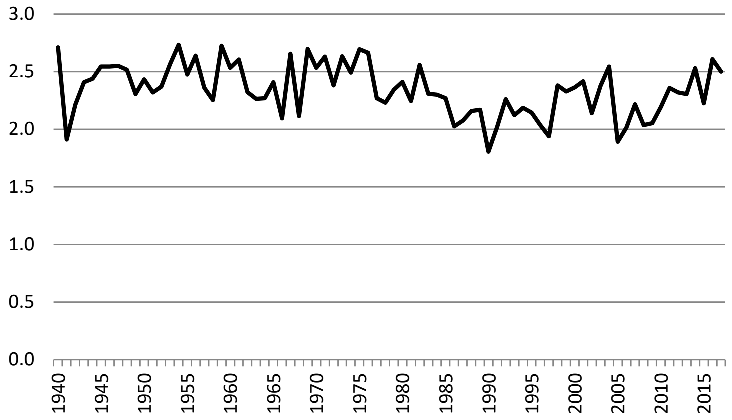


*Includes Canal Diversions, Drain Returns to Canals, and Diversions from Storage.

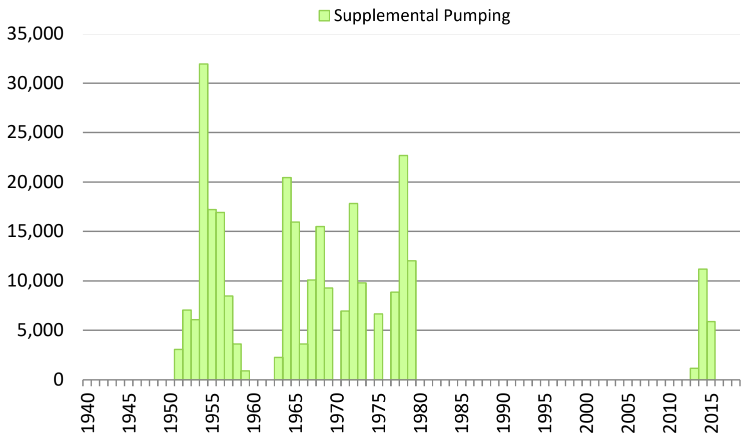
Maximum Application Efficiency and Loss Percentages



Annual Weighted Crop Irrigation Requirement (feet)



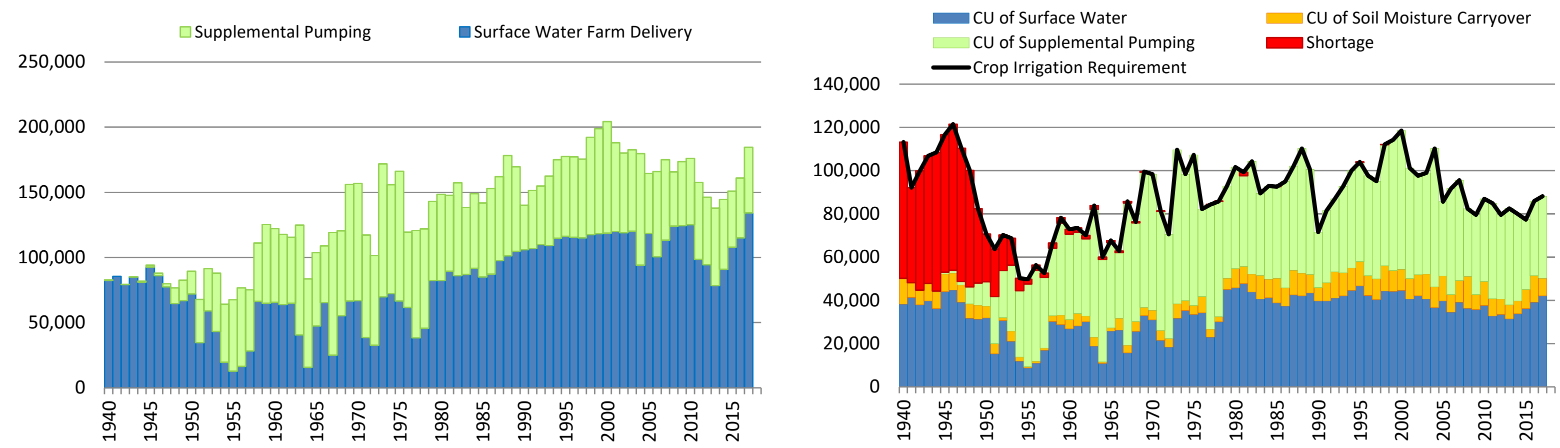
Annual Pumping (acre-feet)



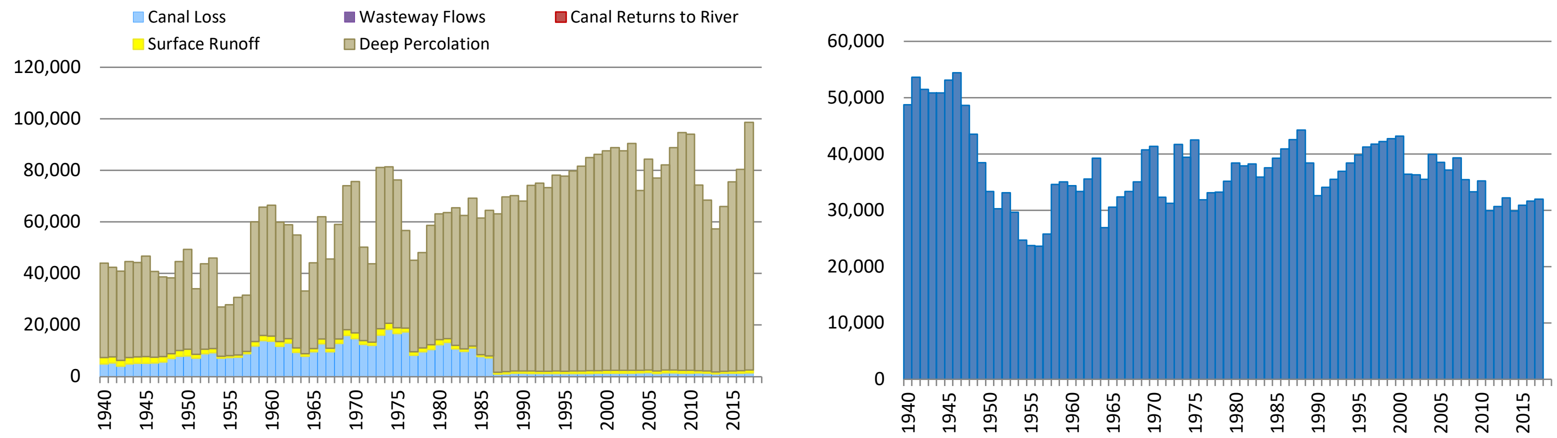
Model Version: LRG Model v106 Operational Run - Base Run (All Pumping On).

Figure 9-6

Annual Canal and Farm Budget Summary
Historical Base Run
Integrated LRG Model
1940-2017
Juarez Total


Annual Farm Deliveries (acre-feet)

Annual Consumptive Use (acre-feet)


Annual Losses (acre-feet)

Annual Irrigated Acres

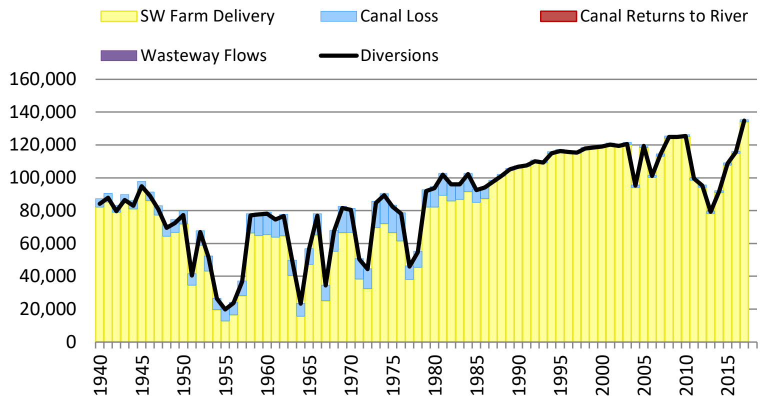
***Note: Different Scales**

Model Version: LRG Model v106 Operational Run - Base Run (All Pumping On).

Figure 9-6

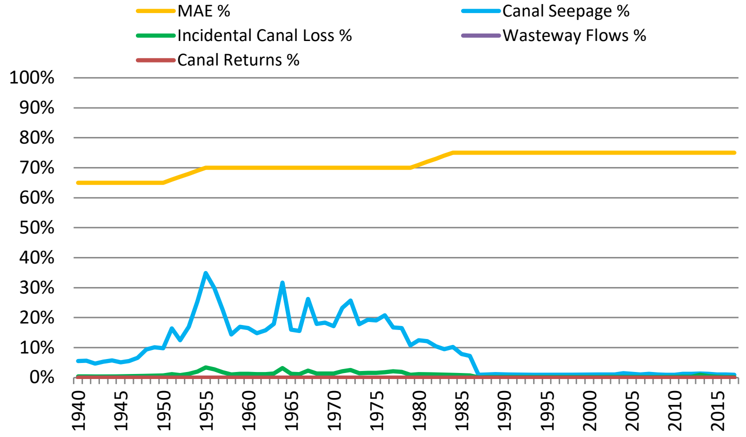
Annual Canal and Farm Budget Summary
Historical Base Run
Integrated LRG Model
1940-2017
Juarez Total

Annual Canal Diversions and Farm Deliveries (acre-feet)

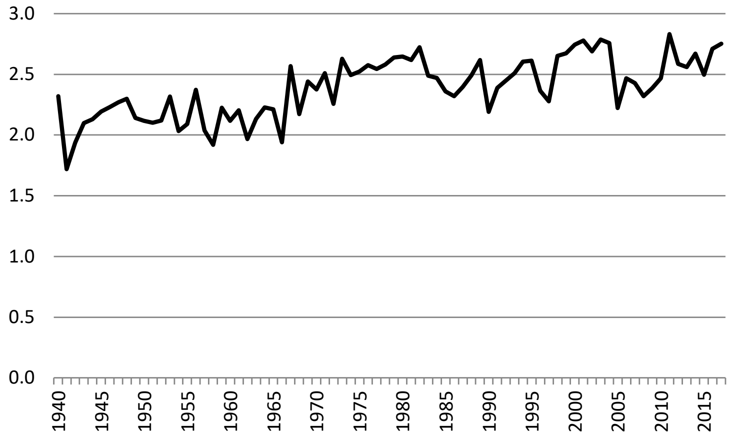


*Includes Canal Diversions, Drain Returns to Canals ,and WWTP Returns to Canals.

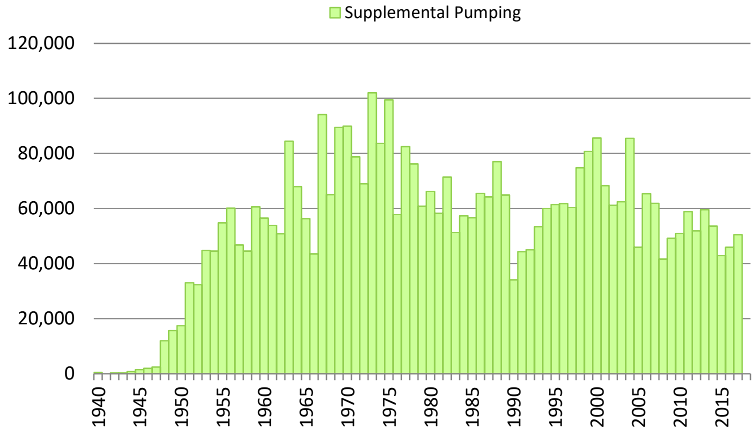
Maximum Application Efficiency and Loss Percentages



Annual Weighted Crop Irrigation Requirement (feet)



Annual Pumping (acre-feet)

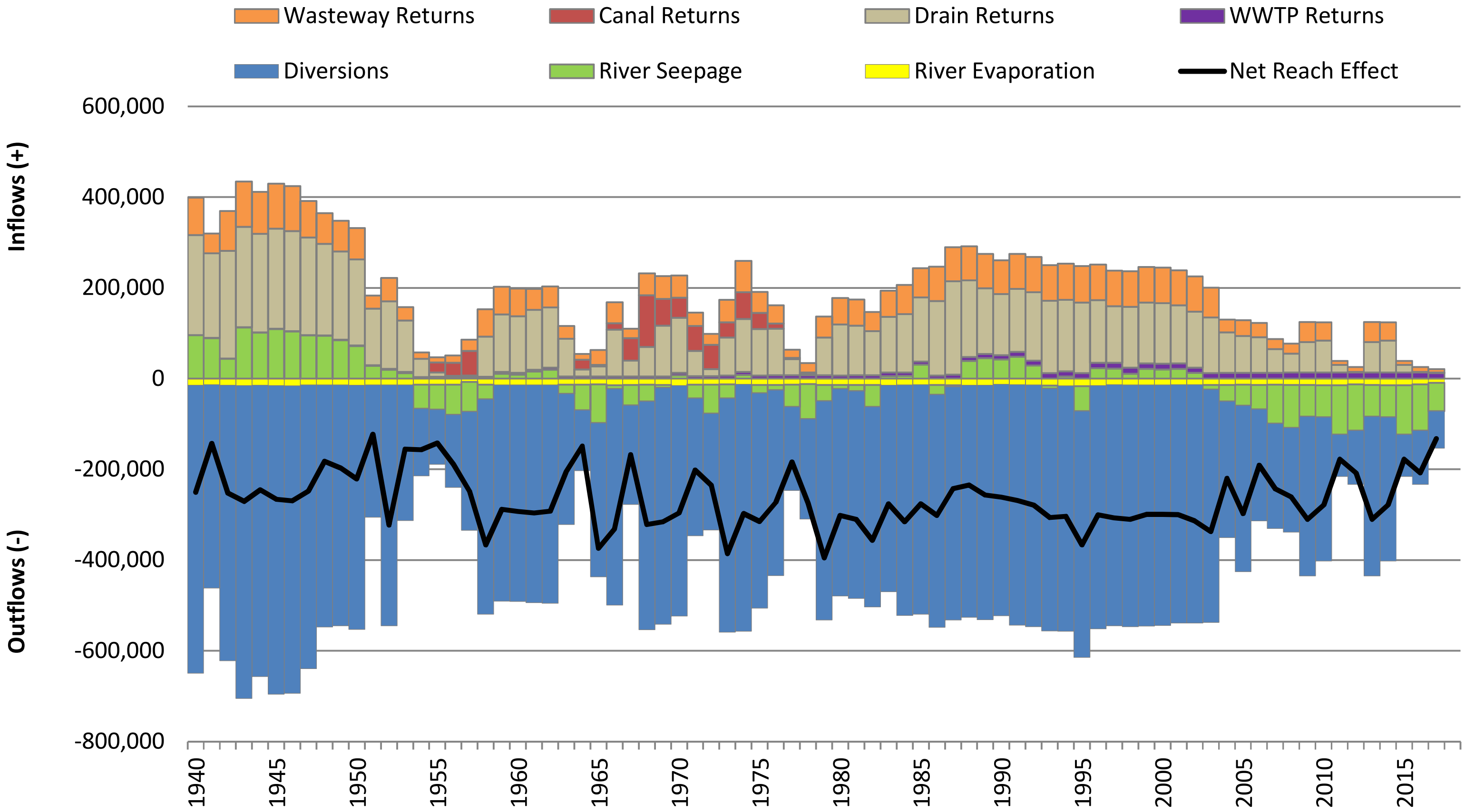


Model Version: LRG Model v106 Operational Run - Base Run (All Pumping On).

Figure 9-7

Annual River Budget Summary
Historical Base Run
Integrated LRG Model
1940 - 2017 (acre-feet)

Total Rincon-Mesilla (Below Caballo to El Paso)

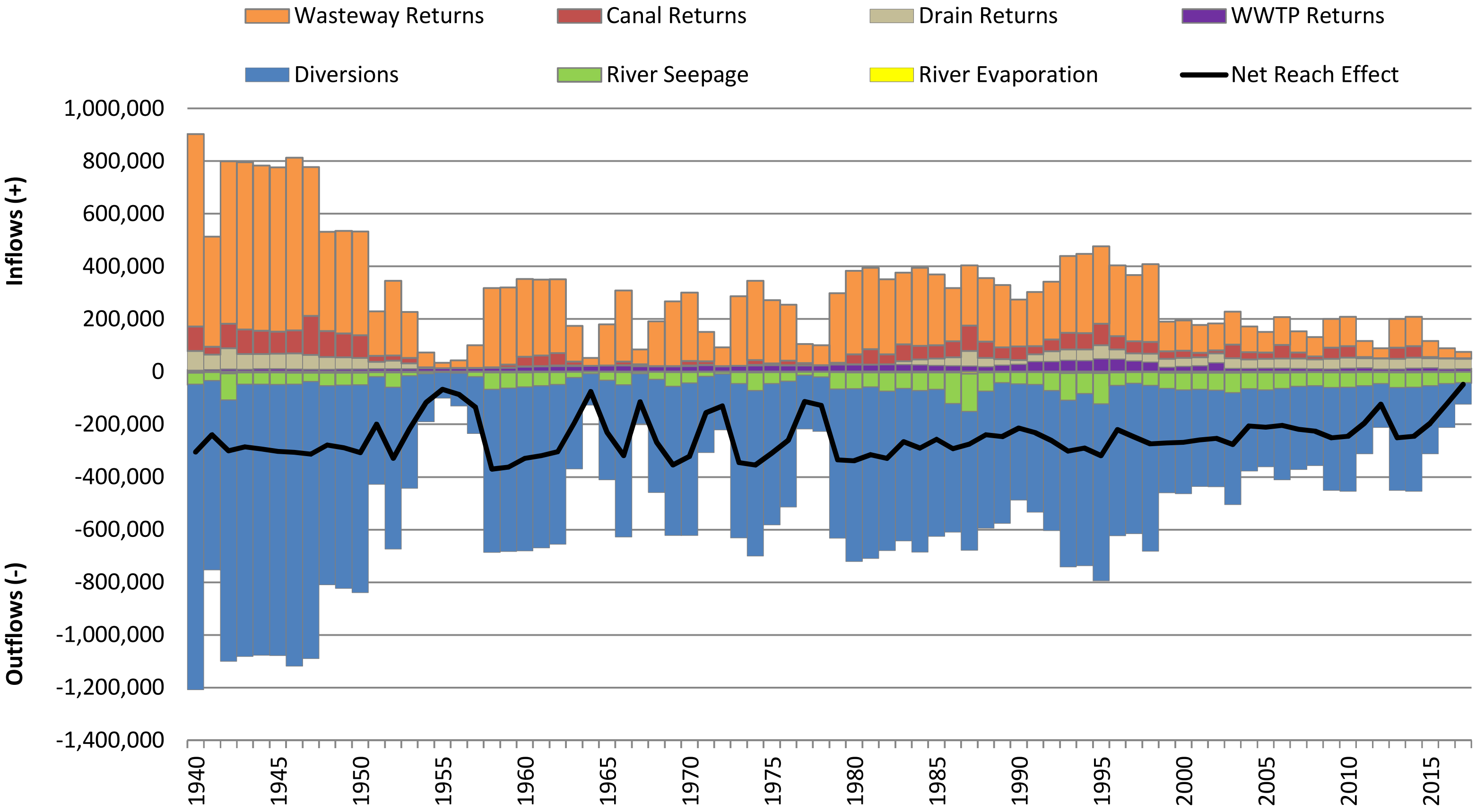


Notes:
Net Reach Effect is the change in streamflow through the stream reach, equal to total inflows minus total outflows.
River inflows and outflows not shown on graph.
Model Version: LRG Model v106 Operational Run - Base Run (All Pumping On).

Figure 9-8

Annual River Budget Summary
Historical Base Run
Integrated LRG Model
1940 - 2017 (acre-feet)

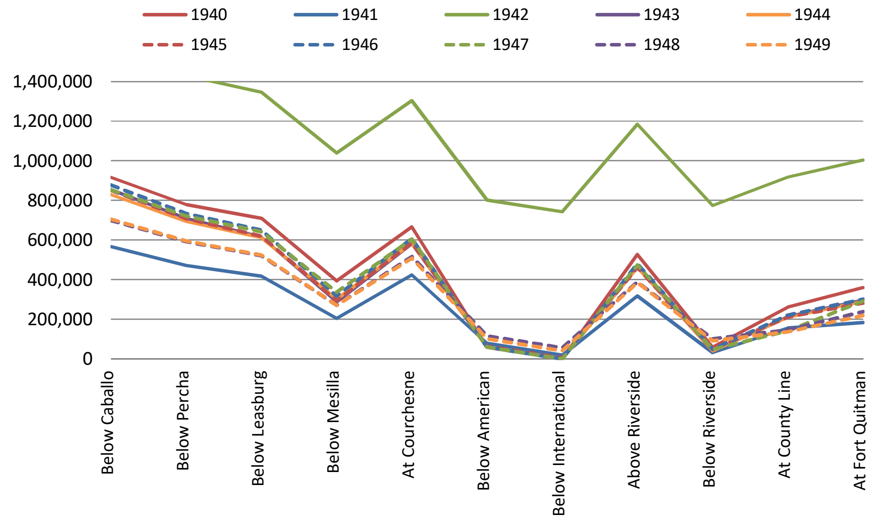
Total El Paso Valley (El Paso to Fort Quitman)

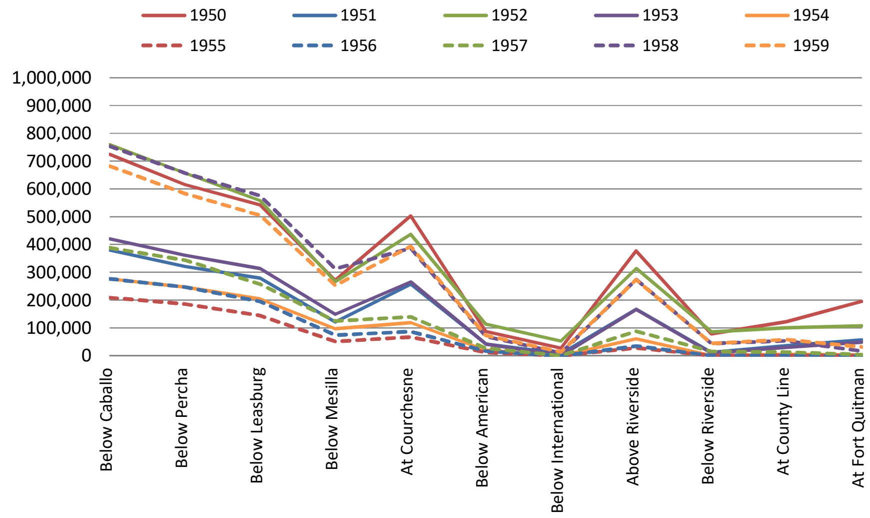


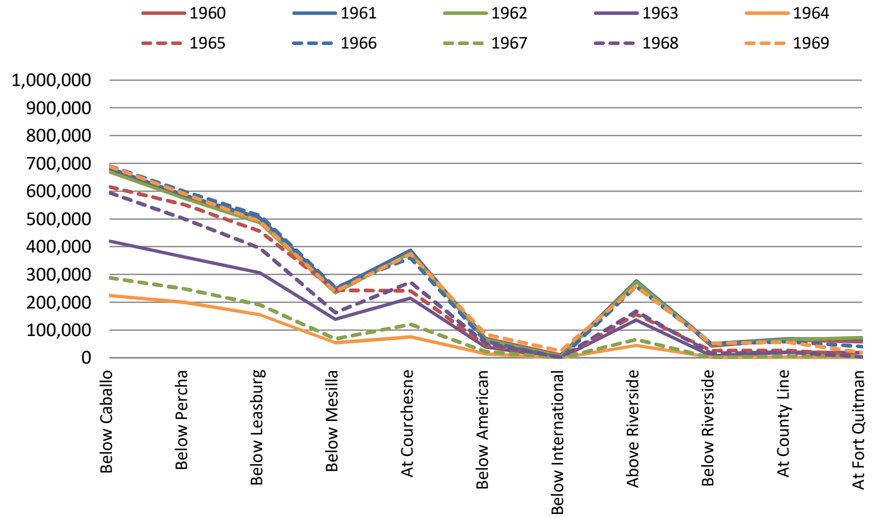
Notes:
Net Reach Effect is the change in streamflow through the stream reach, equal to total inflows minus total outflows.
River inflows and outflows not shown on graph.
Model Version: LRG Model v106 Operational Run - Base Run (All Pumping On).

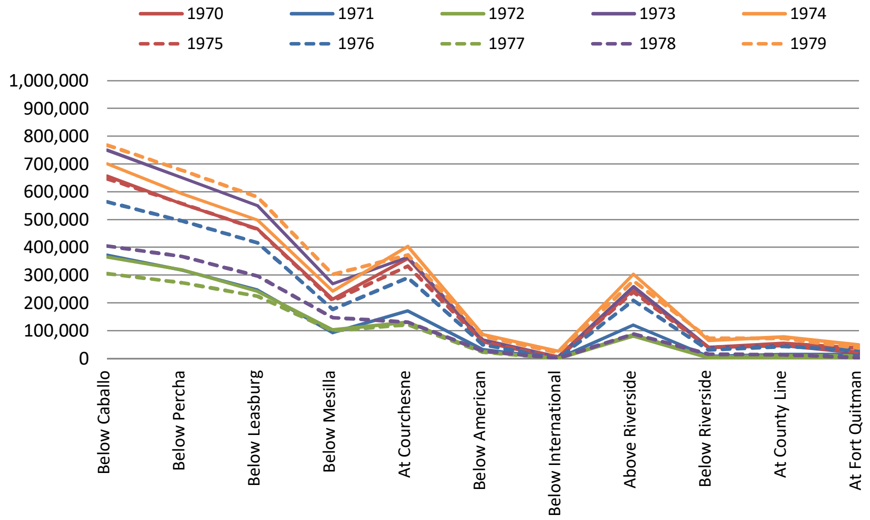
Figure 9-9

Annual Rio Grande Point Flows
Historical Base Run
Integrated LRG Model
1940-2017 (acre-feet)







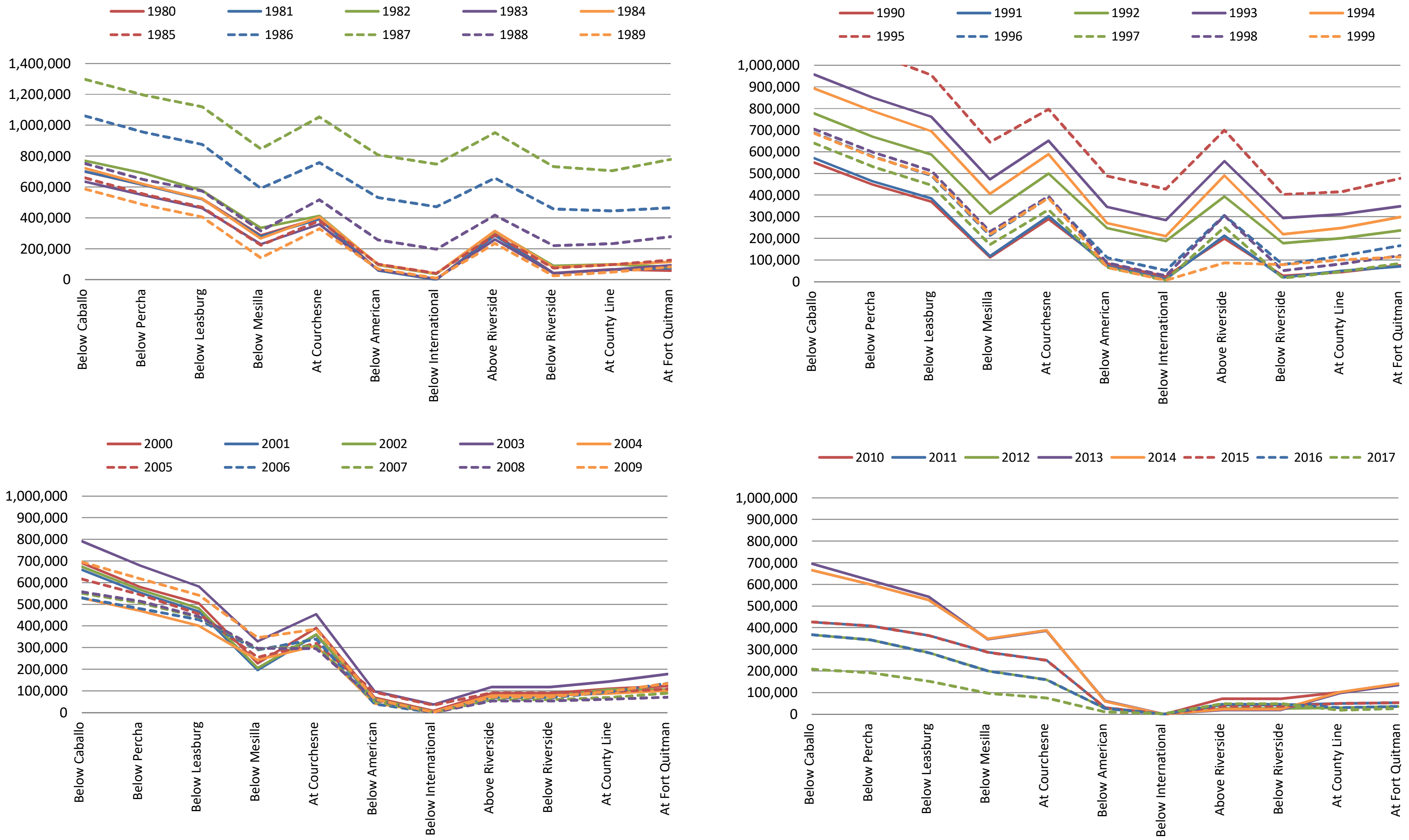


***Note Different Scales**

Model Version: LRG Model v106 Operational Run - Base Run (All Pumping On).

Figure 9-9

Annual Rio Grande Point Flows
Historical Base Run
Integrated LRG Model
1940-2017 (acre-feet)



***Note Different Scales**

Model Version: LRG Model v106 Operational Run - Base Run (All Pumping On).

Figure 9-10
Monthly Average Rio Grande Flows
Integrated LRG Model - Historical Base Run
1940 - 2017 (cfs)

Flow Legend (CFS)

⬜	0	10
🟩	10	100
▨	100	200
🟦	200	500
■	500	Max

	Month	Below Caballo	Below Percha Dam	Below Leasburg Dam	Below Mesilla Dam	At Courchesne	Below American Dam	Below Intern'l Dam	Below Riverside Dam	At County Line	At Fort Quitman
1940	Jan	0	113	113	172	344	0	0	0	227	470
	Feb	0	74	74	107	251	0	0	0	199	328
	Mar	2145	1819	1583	679	826	139	0	1	243	321
	Apr	2797	2524	1941	942	1354	210	0	138	445	535
	May	1911	1717	1379	685	1206	203	0	51	360	561
	Jun	1773	1658	1343	777	1264	210	0	79	403	547
	Jul	2254	2117	1739	997	1453	203	0	235	546	555
	Aug	2128	1962	1535	712	1274	24	0	216	542	566
	Sep	1228	1270	1075	730	1250	0	0	231	564	648
	Oct	856	861	641	285	751	0	0	19	308	483
	Nov	0	174	174	252	620	0	0	0	255	498
	Dec	0	115	115	163	396	0	0	0	230	441
1941	Jan	0	83	83	119	298	0	0	0	214	439
	Feb	0	64	64	91	241	0	0	0	185	364
	Mar	1058	912	672	307	428	157	0	6	154	206
	Apr	2021	1746	1313	579	808	142	0	33	197	197
	May	1126	1004	714	185	643	121	0	34	171	171
	Jun	1510	1395	1074	447	831	180	0	35	191	138
	Jul	1372	1281	996	453	892	203	0	39	201	119
	Aug	1786	1645	1311	647	1039	183	0	46	241	156
	Sep	58	202	180	258	715	251	251	270	394	322
	Oct	399	398	247	0	363	66	66	80	237	272
	Nov	0	132	132	179	443	0	0	0	199	246
	Dec	0	92	92	127	312	0	0	0	196	425
1942	Jan	0	68	68	95	246	0	0	0	168	357
	Feb	0	54	54	74	206	0	0	0	153	320
	Mar	1499	1256	954	357	510	165	0	9	148	183
	Apr	3334	3023	2499	1537	1782	1047	837	865	963	839
	May	9470	9147	8788	7825	7912	7121	6918	6918	6811	6420
	Jun	6287	6139	5815	5130	5618	4707	4497	4580	4620	4791
	Jul	1778	1701	1269	518	1340	201	0	146	535	962
	Aug	1141	1115	792	290	970	0	0	39	420	622
	Sep	1374	1362	1115	676	1174	0	0	193	549	639
	Oct	787	797	552	218	737	0	0	18	307	515
	Nov	0	173	173	260	630	0	0	0	263	501
	Dec	0	115	115	165	402	0	0	0	230	415
1943	Jan	0	83	83	121	304	0	0	0	222	449
	Feb	0	63	63	91	242	0	0	0	189	360
	Mar	1587	1351	1017	473	614	180	0	11	184	208
	Apr	2550	2263	1668	683	1044	210	0	51	266	319
	May	1748	1549	1156	414	989	203	0	48	247	317
	Jun	1619	1481	1131	498	1040	210	0	45	269	372
	Jul	2493	2299	1835	916	1406	186	0	192	491	439
	Aug	2137	1978	1471	584	1250	0	0	198	510	482
	Sep	1193	1161	909	439	1038	0	0	79	416	586
	Oct	736	734	484	97	652	0	0	14	263	445
	Nov	0	184	184	273	637	0	0	0	243	486
	Dec	0	122	122	173	410	0	0	0	226	469
1944	Jan	0	87	87	126	307	0	0	0	204	440
	Feb	0	65	65	95	245	0	0	0	176	352
	Mar	1393	1196	920	438	579	177	0	10	169	192
	Apr	2564	2269	1696	702	1039	210	0	51	257	299
	May	1502	1308	973	354	904	203	0	45	225	288
	Jun	1898	1730	1340	571	1072	210	0	50	271	341
	Jul	1972	1842	1451	682	1205	189	0	54	346	405
	Aug	1930	1814	1432	692	1250	0	0	225	528	518
	Sep	1403	1380	1133	665	1214	0	0	218	530	628
	Oct	1016	972	691	216	747	0	0	20	283	494
	Nov	0	186	186	280	669	0	0	0	248	473
	Dec	0	121	121	173	414	0	0	0	213	376

Figure 9-10
Monthly Average Rio Grande Flows
Integrated LRG Model - Historical Base Run
1940 - 2017 (cfs)

Flow Legend (CFS)

⬜	0	10
🟩	10	100
🟩	100	200
🟦	200	500
🟦	500	Max

	Month	Below Caballo	Below Percha Dam	Below Leasburg Dam	Below Mesilla Dam	At Courchesne	Below American Dam	Below Intern'l Dam	Below Riverside Dam	At County Line	At Fort Quitman
1945	Jan	0	86	86	123	306	0	0	0	213	438
	Feb	0	65	65	93	242	0	0	0	182	359
	Mar	1556	1316	961	314	501	162	0	10	161	183
	Apr	2563	2279	1693	706	1078	210	0	53	255	279
	May	1662	1468	1114	433	987	203	0	49	225	288
	Jun	2080	1890	1470	629	1162	210	0	52	277	372
	Jul	1979	1847	1489	787	1319	203	0	114	414	423
	Aug	2082	1926	1497	653	1251	1	0	202	497	439
	Sep	1636	1577	1276	688	1250	0	0	213	513	537
	Oct	488	530	300	0	599	81	81	94	305	486
	Nov	0	174	174	259	591	0	0	0	233	407
	Dec	0	117	117	165	389	0	0	0	225	473
1946	Jan	0	83	83	121	296	0	0	0	199	407
	Feb	0	64	64	92	240	0	0	0	177	359
	Mar	1400	1202	937	433	575	171	0	10	167	190
	Apr	2537	2241	1699	702	1043	210	0	52	253	268
	May	1847	1641	1284	529	1066	203	0	54	253	333
	Jun	2101	1910	1514	696	1220	210	0	55	332	427
	Jul	2517	2333	1835	899	1445	195	0	207	506	455
	Aug	1974	1825	1416	582	1250	0	0	198	508	493
	Sep	1219	1227	1023	631	1183	0	0	194	511	622
	Oct	864	830	570	126	668	0	0	17	273	481
	Nov	0	186	186	278	649	0	0	0	251	512
	Dec	0	122	122	173	410	0	0	0	228	460
1947	Jan	0	87	87	125	308	0	0	0	208	436
	Feb	0	65	65	94	246	0	0	0	184	360
	Mar	1222	1046	801	356	492	138	0	8	167	193
	Apr	2401	2100	1614	709	1000	210	0	47	256	239
	May	1470	1345	1056	513	984	203	0	50	121	254
	Jun	1705	1575	1247	608	1031	210	0	47	132	313
	Jul	2450	2254	1839	994	1439	203	0	181	288	406
	Aug	1837	1739	1388	719	1275	25	0	220	328	536
	Sep	1746	1656	1347	729	1250	0	0	215	337	555
	Oct	1240	1151	813	219	800	0	0	19	145	507
	Nov	0	203	203	314	733	0	0	0	100	592
	Dec	0	131	131	187	446	0	0	0	80	452
1948	Jan	0	92	92	133	326	76	76	158	189	415
	Feb	0	68	68	99	258	0	0	0	68	398
	Mar	1028	908	720	385	512	128	0	107	157	221
	Apr	1773	1530	1187	485	747	210	0	39	111	163
	May	1205	1142	939	550	922	203	0	129	197	258
	Jun	2499	2238	1613	653	1029	210	0	84	174	276
	Jul	2214	2013	1577	812	1339	203	0	115	234	311
	Aug	2341	2158	1577	692	1284	34	0	176	304	431
	Sep	457	553	444	217	821	0	0	0	118	289
	Oct	4	176	171	151	559	383	383	348	353	391
	Nov	0	111	111	162	412	287	287	307	305	415
	Dec	0	81	81	120	305	180	180	208	215	366
1949	Jan	0	64	64	96	257	7	7	87	119	291
	Feb	0	52	52	76	220	0	0	0	57	252
	Mar	1817	1565	1286	707	796	117	0	185	248	292
	Apr	1910	1635	1209	327	721	195	0	49	114	202
	May	1048	1012	801	431	857	170	0	125	184	256
	Jun	2438	2187	1579	676	1048	210	0	85	174	275
	Jul	2049	1869	1449	746	1266	203	0	108	219	329
	Aug	2305	2133	1658	821	1344	94	0	178	304	419
	Sep	49	247	220	215	776	0	0	0	108	317
	Oct	0	147	147	119	470	287	287	255	269	315
	Nov	0	95	95	139	355	230	230	254	255	350
	Dec	0	70	70	105	273	148	148	188	195	335

Figure 9-10
Monthly Average Rio Grande Flows
Integrated LRG Model - Historical Base Run
1940 - 2017 (cfs)

Flow Legend (CFS)

⬜	0	10
🟩	10	100
🟦	100	200
🟦	200	500
🟦	500	Max

	Month	Below Caballo	Below Percha Dam	Below Leasburg Dam	Below Mesilla Dam	At Courchesne	Below American Dam	Below Intern'l Dam	Below Riverside Dam	At County Line	At Fort Quitman
1950	Jan	0	55	55	82	229	0	0	63	95	263
	Feb	0	45	45	64	196	0	0	0	51	197
	Mar	2300	1971	1627	905	976	131	0	230	303	324
	Apr	2107	1837	1318	349	791	202	0	56	124	219
	May	1441	1333	1070	527	983	189	0	144	210	267
	Jun	2571	2337	1712	763	1209	210	0	101	202	334
	Jul	2170	1986	1539	684	1273	203	0	110	220	425
	Aug	1336	1343	1158	745	1259	54	0	157	271	342
	Sep	9	194	183	159	614	92	92	56	117	193
	Oct	0	107	107	25	305	145	145	108	135	191
	Nov	0	63	63	94	255	130	130	153	160	240
	Dec	0	49	49	74	212	87	87	117	128	240
1951	Jan	0	42	42	61	187	0	0	22	55	196
	Feb	0	37	37	51	167	0	0	0	39	172
	Mar	1496	1264	1028	458	533	116	0	0	52	125
	Apr	1892	1577	1097	174	510	181	0	0	48	72
	May	949	877	645	217	632	171	0	35	79	110
	Jun	1111	1073	888	472	780	67	0	0	69	120
	Jul	506	562	496	348	656	23	0	68	114	61
	Aug	319	343	289	149	363	23	0	0	38	30
	Sep	7	55	47	26	166	48	48	0	18	21
	Oct	0	22	22	20	89	73	73	75	59	15
	Nov	0	14	14	19	78	0	0	0	10	13
	Dec	0	16	16	20	89	0	0	0	11	22
1952	Jan	0	19	19	21	93	0	0	0	12	32
	Feb	0	21	21	20	92	0	0	0	13	44
	Mar	1336	1127	916	400	427	113	0	0	26	52
	Apr	557	510	414	118	314	40	0	0	24	38
	May	632	575	485	219	336	46	0	0	22	26
	Jun	1659	1442	1176	524	613	126	0	0	33	15
	Jul	3273	2926	2301	1248	1453	203	0	328	357	212
	Aug	2865	2610	1985	1015	1453	203	0	194	249	192
	Sep	1945	1746	1389	483	1059	210	0	0	79	229
	Oct	229	330	241	0	582	408	361	326	307	307
	Nov	0	140	140	198	468	343	343	357	333	364
	Dec	0	94	94	132	301	176	176	198	194	266
1953	Jan	0	69	69	97	233	0	0	63	86	216
	Feb	0	54	54	75	193	0	0	0	37	166
	Mar	1488	1263	1011	441	521	79	0	0	51	101
	Apr	1777	1475	999	110	456	130	0	0	42	69
	May	1017	930	692	241	629	156	0	29	66	72
	Jun	662	750	728	593	852	177	0	0	63	100
	Jul	628	634	560	367	568	57	0	63	95	40
	Aug	1255	1122	939	491	579	89	0	0	35	25
	Sep	65	92	71	17	175	0	0	0	13	14
	Oct	32	35	35	0	68	15	15	4	6	6
	Nov	0	8	8	11	53	0	0	0	4	2
	Dec	0	7	7	10	57	0	0	0	5	0
1954	Jan	0	9	9	10	67	0	0	0	7	1
	Feb	0	13	13	11	69	0	0	0	8	8
	Mar	1013	850	696	301	312	79	0	0	18	15
	Apr	761	668	566	238	328	72	0	0	13	12
	May	573	508	441	221	272	37	0	0	11	5
	Jun	530	465	395	178	218	37	0	0	9	2
	Jul	1049	912	774	415	406	74	0	1	13	1
	Aug	475	417	358	187	200	25	0	0	7	1
	Sep	107	89	81	36	51	0	0	0	1	1
	Oct	28	25	22	0	14	1	1	13	4	0
	Nov	0	5	5	5	15	0	0	0	0	0
	Dec	0	5	5	3	15	0	0	0	0	0

Figure 9-10
Monthly Average Rio Grande Flows
Integrated LRG Model - Historical Base Run
1940 - 2017 (cfs)

Flow Legend (CFS)

☐	0	10
🟩	10	100
🟦	100	200
🟦	200	500
🟦	500	Max

	Month	Below Caballo	Below Percha Dam	Below Leasburg Dam	Below Mesilla Dam	At Courchesne	Below American Dam	Below Intern'l Dam	Below Riverside Dam	At County Line	At Fort Quitman
1955	Jan	0	5	5	4	19	0	0	0	0	0
	Feb	0	6	6	5	23	0	0	0	0	0
	Mar	194	157	133	48	54	16	0	0	0	0
	Apr	505	411	334	67	161	47	0	0	0	0
	May	691	575	487	218	210	39	0	0	6	0
	Jun	424	351	293	89	126	23	0	0	2	0
	Jul	682	569	470	193	235	45	0	0	6	0
	Aug	576	476	378	110	195	38	0	0	4	1
	Sep	252	204	176	65	59	0	0	0	0	1
	Oct	118	93	86	36	18	0	0	10	2	0
	Nov	0	3	3	3	4	0	0	0	0	0
	Dec	0	2	2	3	3	0	0	0	0	0
1956	Jan	0	2	2	3	3	0	0	0	0	0
	Feb	0	3	3	3	3	0	0	0	0	0
	Mar	777	649	549	270	212	62	0	0	5	0
	Apr	677	559	457	68	218	56	0	0	5	0
	May	861	740	640	323	266	40	0	0	8	0
	Jun	639	536	440	109	208	47	0	0	5	0
	Jul	774	656	545	205	285	46	0	0	9	1
	Aug	554	464	386	161	183	24	0	0	5	1
	Sep	227	183	162	64	53	0	0	0	1	1
	Oct	43	27	18	0	4	0	0	6	0	0
	Nov	0	2	2	3	3	0	0	0	0	0
	Dec	0	2	2	3	3	0	0	0	0	0
1957	Jan	0	2	2	3	3	0	0	0	0	0
	Feb	0	2	2	3	3	0	0	0	0	0
	Mar	0	4	4	4	4	4	4	20	6	0
	Apr	0	4	4	3	4	4	4	18	3	0
	May	0	2	2	3	4	4	4	19	5	0
	Jun	0	2	2	3	4	4	4	21	4	0
	Jul	1289	1077	729	347	504	132	0	0	9	1
	Aug	3103	2662	2037	1103	1108	203	0	169	170	64
	Sep	1390	1184	900	337	478	88	0	0	11	0
	Oct	575	529	457	171	139	0	0	0	4	0
	Nov	0	52	52	46	25	0	0	0	0	0
	Dec	0	32	32	22	10	0	0	0	0	0
1958	Jan	0	28	28	18	8	0	0	0	0	0
	Feb	0	26	26	16	7	0	0	0	0	0
	Mar	2056	1797	1537	967	855	91	0	197	225	109
	Apr	2499	2178	1739	778	758	174	0	54	79	13
	May	1766	1646	1409	876	938	203	0	132	146	44
	Jun	2717	2456	1831	817	995	210	0	79	107	23
	Jul	2672	2453	1905	918	1212	203	0	101	154	80
	Aug	706	785	698	494	826	107	0	15	59	4
	Sep	9	151	142	120	347	58	58	17	19	0
	Oct	0	89	89	47	186	98	98	75	53	4
	Nov	0	49	49	55	126	1	1	34	23	0
	Dec	0	38	38	41	106	0	0	23	14	0
1959	Jan	0	34	34	34	99	0	0	0	2	0
	Feb	0	31	31	29	89	0	0	0	4	0
	Mar	2302	1991	1667	943	928	109	0	218	249	126
	Apr	2350	2048	1570	554	788	177	0	57	78	9
	May	1572	1451	1210	662	985	203	0	143	171	64
	Jun	2562	2316	1691	712	1044	210	0	85	132	81
	Jul	2285	2083	1655	813	1249	203	0	106	175	209
	Aug	173	319	270	202	667	86	0	0	47	17
	Sep	6	129	123	118	367	142	142	41	47	1
	Oct	0	44	44	41	117	81	81	75	53	5
	Nov	0	20	20	31	76	0	0	0	3	1
	Dec	0	17	17	23	77	0	0	0	4	0

Figure 9-10
Monthly Average Rio Grande Flows
Integrated LRG Model - Historical Base Run
1940 - 2017 (cfs)

Flow Legend (CFS)

	0	10
░	10	100
▒	100	200
▓	200	500
█	500	Max

	Month	Below Caballo	Below Percha Dam	Below Leasburg Dam	Below Mesilla Dam	At Courchesne	Below American Dam	Below Intern'l Dam	Below Riverside Dam	At County Line	At Fort Quitman
1960	Jan	0	19	19	23	82	0	0	0	5	0
	Feb	0	21	21	21	80	0	0	0	9	9
	Mar	2354	2039	1731	1034	990	120	0	233	276	195
	Apr	2462	2141	1647	632	831	210	0	61	99	42
	May	1588	1456	1202	635	956	203	0	139	176	123
	Jun	2600	2350	1725	755	1088	210	0	89	150	176
	Jul	1972	1778	1388	571	1045	203	0	88	152	205
	Aug	247	381	324	231	672	43	0	0	67	51
	Sep	5	119	113	108	339	97	97	15	42	24
	Oct	0	45	45	36	119	74	74	68	59	45
	Nov	0	22	22	38	90	0	0	0	11	38
	Dec	0	19	19	30	89	0	0	14	19	47
1961	Jan	0	21	21	28	94	0	0	0	13	42
	Feb	0	22	22	26	87	0	0	0	12	50
	Mar	1552	1318	1085	504	508	105	0	0	31	29
	Apr	2198	1848	1352	368	555	200	0	0	22	1
	May	1344	1194	928	363	663	196	0	34	50	18
	Jun	1974	1764	1352	583	855	210	0	0	43	55
	Jul	2806	2553	2055	1152	1452	202	0	455	471	365
	Aug	1358	1350	1162	749	1173	76	0	236	270	276
	Sep	16	185	168	152	525	22	22	0	53	64
	Oct	0	88	88	34	206	44	44	22	45	62
	Nov	0	39	39	60	132	7	7	50	59	82
	Dec	0	33	33	49	123	0	0	50	55	79
1962	Jan	0	30	30	42	115	0	0	0	18	53
	Feb	0	28	28	35	102	0	0	0	17	63
	Mar	1539	1311	1072	500	514	125	0	0	33	37
	Apr	2107	1767	1281	326	544	210	0	0	20	13
	May	945	865	666	258	581	122	0	31	48	16
	Jun	2267	1985	1507	622	851	210	0	0	42	48
	Jul	2878	2627	2002	1028	1388	203	0	452	465	354
	Aug	1280	1298	1151	815	1240	119	0	145	195	221
	Sep	10	156	144	116	468	1	1	0	49	134
	Oct	0	71	71	19	177	82	82	84	89	100
	Nov	0	32	32	55	127	2	2	47	57	88
	Dec	0	22	22	38	105	0	0	24	35	79
1963	Jan	0	23	23	34	104	0	0	0	18	82
	Feb	0	23	23	30	95	0	0	0	16	76
	Mar	1399	1170	928	359	401	130	0	0	26	38
	Apr	2011	1667	1199	273	471	210	0	0	20	11
	May	1161	1038	790	298	593	153	0	27	49	24
	Jun	992	980	834	465	704	94	0	0	43	49
	Jul	680	705	637	446	631	28	0	88	111	33
	Aug	579	545	487	317	348	26	0	0	28	1
	Sep	97	100	94	58	100	0	0	0	7	0
	Oct	17	20	20	0	36	7	7	17	9	0
	Nov	0	6	6	8	32	0	0	0	2	0
	Dec	0	5	5	8	32	0	0	0	3	0
1964	Jan	0	7	7	8	35	0	0	0	4	0
	Feb	0	9	9	9	40	0	0	0	4	0
	Mar	480	396	329	133	137	45	0	0	7	0
	Apr	535	438	349	60	190	52	0	0	9	0
	May	659	564	484	232	203	35	0	0	8	1
	Jun	377	315	262	73	130	26	0	0	2	2
	Jul	692	575	470	168	249	52	0	0	7	1
	Aug	601	492	396	130	188	37	0	0	5	1
	Sep	244	196	168	57	54	0	0	3	1	1
	Oct	103	79	71	24	13	0	0	26	10	0
	Nov	0	2	2	3	3	0	0	0	0	0
	Dec	0	1	1	3	3	0	0	0	0	0

Figure 9-10
Monthly Average Rio Grande Flows
Integrated LRG Model - Historical Base Run
1940 - 2017 (cfs)

Flow Legend (CFS)

⬜	0	10
🟩	10	100
🟦	100	200
🟦	200	500
🟦	500	Max

	Month	Below Caballo	Below Percha Dam	Below Leasburg Dam	Below Mesilla Dam	At Courchesne	Below American Dam	Below Intern'l Dam	Below Riverside Dam	At County Line	At Fort Quitman
1965	Jan	0	2	2	4	3	0	0	0	0	0
	Feb	0	2	2	4	3	0	0	0	0	0
	Mar	0	3	3	4	4	4	4	32	13	0
	Apr	234	179	146	24	65	21	0	10	1	0
	May	755	626	536	266	205	51	0	0	5	0
	Jun	1346	1138	944	449	380	101	0	0	7	1
	Jul	3345	2899	2313	1202	1107	203	0	192	193	84
	Aug	3426	3032	2480	1391	1294	203	0	187	204	92
	Sep	948	947	878	558	659	173	0	0	22	0
	Oct	40	122	115	25	150	0	0	0	5	0
	Nov	0	39	39	45	67	0	0	0	1	0
	Dec	0	20	20	21	36	0	0	0	0	0
1966	Jan	0	21	21	20	35	0	0	0	0	0
	Feb	0	21	21	20	34	0	0	0	0	0
	Mar	1555	1328	1073	531	523	93	0	0	16	0
	Apr	2124	1779	1262	261	480	167	0	0	0	0
	May	1428	1288	1030	402	652	193	0	30	32	0
	Jun	2028	1768	1265	394	637	202	0	0	14	0
	Jul	2866	2620	2094	1166	1397	203	0	446	450	273
	Aug	1139	1235	1151	938	1258	130	0	277	296	235
	Sep	186	325	320	284	534	0	0	0	43	27
	Oct	56	121	121	37	157	0	0	0	23	34
	Nov	0	39	39	55	113	0	0	35	40	48
	Dec	0	29	29	39	95	0	0	25	31	48
1967	Jan	0	27	27	33	89	0	0	0	15	46
	Feb	0	26	26	28	80	0	0	0	14	51
	Mar	1296	1088	824	399	412	121	0	0	21	13
	Apr	658	592	424	63	331	77	0	0	17	1
	May	533	471	344	73	271	39	0	0	15	1
	Jun	379	337	247	32	155	21	0	0	10	0
	Jul	478	417	339	142	186	27	0	0	7	0
	Aug	902	757	568	246	332	80	0	0	8	1
	Sep	352	295	233	65	90	0	0	0	1	1
	Oct	135	108	93	30	27	0	0	13	4	0
	Nov	0	5	5	5	8	0	0	0	0	0
	Dec	0	4	4	5	8	0	0	0	0	0
1968	Jan	0	7	7	6	7	0	0	0	0	0
	Feb	0	11	11	8	8	0	0	0	0	0
	Mar	1733	1512	1248	636	685	124	0	0	25	0
	Apr	2069	1756	1211	354	602	210	0	0	4	1
	May	959	884	562	51	557	116	0	23	24	1
	Jun	1061	975	682	202	441	69	0	0	10	1
	Jul	1656	1482	1124	620	695	152	0	166	147	51
	Aug	2110	1889	1365	723	903	160	0	77	92	21
	Sep	140	233	122	0	319	6	6	0	19	1
	Oct	50	102	83	0	117	22	22	0	5	0
	Nov	0	36	36	42	81	0	0	0	3	0
	Dec	0	31	31	34	69	0	0	0	5	0
1969	Jan	0	29	29	29	65	0	0	0	6	0
	Feb	0	27	27	24	62	0	0	0	7	0
	Mar	1648	1423	1111	587	619	144	0	0	29	0
	Apr	1893	1596	1090	270	606	210	0	0	17	1
	May	972	897	640	194	565	76	0	35	49	1
	Jun	1438	1299	988	487	639	161	0	0	28	1
	Jul	3294	2964	2339	1307	1387	203	0	309	323	174
	Aug	2044	1839	1452	682	1093	193	0	75	100	25
	Sep	34	207	161	90	538	193	193	141	122	41
	Oct	4	120	115	86	265	153	153	138	118	39
	Nov	0	69	69	94	178	53	53	91	81	19
	Dec	0	50	50	68	141	16	16	68	64	13

Figure 9-10
Monthly Average Rio Grande Flows
Integrated LRG Model - Historical Base Run
1940 - 2017 (cfs)

Flow Legend (CFS)

⬜	0	10
🟩	10	100
▨	100	200
🟦	200	500
■	500	Max

	Month	Below Caballo	Below Percha Dam	Below Leasburg Dam	Below Mesilla Dam	At Courchesne	Below American Dam	Below Intern'l Dam	Below Riverside Dam	At County Line	At Fort Quitman
1970	Jan	0	43	43	56	130	0	0	0	17	4
	Feb	0	36	36	45	112	0	0	0	16	45
	Mar	1425	1219	951	447	501	135	0	0	29	19
	Apr	2110	1803	1229	284	576	210	0	0	20	1
	May	1473	1297	972	324	710	203	0	32	53	1
	Jun	1586	1449	1089	448	808	168	0	0	39	8
	Jul	2346	2168	1760	1009	1308	156	0	396	408	246
	Aug	1640	1544	1227	697	1055	116	0	176	199	112
	Sep	129	223	177	70	395	0	0	0	38	15
	Oct	94	129	126	41	135	0	0	0	20	50
	Nov	0	28	28	46	104	0	0	14	24	56
	Dec	0	24	24	36	96	0	0	23	29	65
1971	Jan	0	24	24	31	92	0	0	0	15	67
	Feb	0	24	24	28	84	0	0	0	14	63
	Mar	1785	1520	1217	590	613	118	0	0	37	58
	Apr	1565	1339	966	234	603	200	0	0	26	29
	May	705	641	409	49	446	64	0	13	35	19
	Jun	1059	937	674	254	427	82	0	0	22	1
	Jul	666	615	457	205	353	39	0	64	63	8
	Aug	267	263	219	111	157	27	0	0	7	1
	Sep	73	60	51	13	36	0	0	13	5	1
	Oct	26	22	18	1	7	0	0	29	12	0
	Nov	0	5	5	6	4	0	0	0	0	0
	Dec	0	3	3	5	3	0	0	0	0	0
1972	Jan	0	3	3	5	3	0	0	0	0	0
	Feb	0	3	3	5	4	0	0	0	0	0
	Mar	1692	1420	1085	568	569	133	0	0	16	0
	Apr	1429	1214	882	300	489	138	0	0	0	0
	May	1210	1042	801	340	456	72	0	3	15	1
	Jun	448	421	311	77	208	19	0	0	6	0
	Jul	446	414	338	159	190	21	0	0	0	1
	Aug	503	421	335	138	163	32	0	0	3	0
	Sep	206	168	146	63	46	0	0	0	1	0
	Oct	73	58	53	22	10	0	0	20	7	0
	Nov	0	4	4	5	4	0	0	0	0	0
	Dec	0	4	4	5	4	0	0	0	0	0
1973	Jan	0	6	6	6	5	0	0	0	0	0
	Feb	0	9	9	7	6	0	0	0	0	0
	Mar	1775	1532	1304	718	644	143	0	0	23	0
	Apr	2523	2154	1616	588	651	210	0	0	10	1
	May	1550	1404	1099	489	727	140	0	53	59	5
	Jun	1572	1475	1175	579	765	152	0	0	23	1
	Jul	3016	2739	2114	1109	1302	203	0	426	416	246
	Aug	1836	1712	1407	774	1112	140	0	148	168	69
	Sep	40	206	164	60	507	99	99	30	39	1
	Oct	27	96	84	8	131	0	0	0	10	0
	Nov	0	36	36	46	86	0	0	0	5	0
	Dec	0	26	26	31	63	0	0	0	4	0
1974	Jan	0	25	25	27	64	0	0	0	6	0
	Feb	0	25	25	24	64	0	0	0	8	0
	Mar	2589	2267	1924	1160	1135	165	0	265	313	176
	Apr	2546	2242	1673	727	992	210	0	80	126	74
	May	2083	1911	1588	869	1220	203	0	188	244	205
	Jun	2558	2334	1709	786	1196	210	0	100	161	216
	Jul	1542	1422	926	226	881	201	0	40	81	24
	Aug	173	282	138	0	557	231	231	180	159	54
	Sep	75	139	75	0	181	66	66	38	32	0
	Oct	5	70	65	74	151	130	130	138	106	39
	Nov	0	43	43	64	122	0	0	27	24	4
	Dec	0	26	26	40	88	0	0	14	15	9

Figure 9-10
Monthly Average Rio Grande Flows
Integrated LRG Model - Historical Base Run
1940 - 2017 (cfs)

Flow Legend (CFS)

⬜	0	10
🟩	10	100
🟦	100	200
🟦	200	500
🟦	500	Max

	Month	Below Caballo	Below Percha Dam	Below Leasburg Dam	Below Mesilla Dam	At Courchesne	Below American Dam	Below Intern'l Dam	Below Riverside Dam	At County Line	At Fort Quitman
1975	Jan	0	27	27	36	93	0	0	0	10	30
	Feb	0	26	26	31	86	0	0	0	10	51
	Mar	1555	1325	1072	492	515	155	0	0	27	13
	Apr	1064	926	718	189	424	84	0	0	16	1
	May	874	783	621	226	431	74	0	10	25	0
	Jun	1156	1014	791	266	447	97	0	0	14	1
	Jul	2840	2478	1947	927	1068	203	0	300	288	147
	Aug	2813	2535	1938	976	1313	203	0	199	221	102
	Sep	283	386	301	104	583	79	0	0	31	0
	Oct	24	121	92	31	245	62	62	40	46	4
	Nov	0	56	56	81	149	24	24	61	58	8
	Dec	0	35	35	53	110	0	0	40	40	11
1976	Jan	0	32	32	46	107	0	0	0	15	21
	Feb	0	29	29	37	95	0	0	0	14	49
	Mar	1589	1371	1097	488	517	130	0	0	31	18
	Apr	2210	1862	1331	322	554	210	0	0	19	1
	May	1182	1105	878	299	638	187	0	39	54	2
	Jun	909	909	771	351	621	63	0	0	31	13
	Jul	2421	2194	1802	951	1060	164	0	342	340	196
	Aug	789	790	629	298	696	57	0	116	128	37
	Sep	87	141	125	25	248	0	0	0	26	29
	Oct	90	110	110	27	98	0	0	0	18	37
	Nov	0	22	22	39	87	0	0	9	19	46
	Dec	0	17	17	26	70	0	0	0	14	64
1977	Jan	0	19	19	25	73	0	0	0	14	52
	Feb	0	20	20	22	69	0	0	0	13	59
	Mar	1118	951	761	305	327	106	0	0	21	33
	Apr	785	700	574	200	295	59	0	0	19	2
	May	1476	1290	1069	495	514	115	0	31	49	4
	Jun	553	520	420	154	293	40	0	0	19	0
	Jul	477	434	378	213	231	24	0	11	15	0
	Aug	466	401	343	179	159	27	0	0	3	1
	Sep	112	88	78	34	32	0	0	8	2	0
	Oct	27	21	17	0	7	0	0	23	8	0
	Nov	0	3	3	6	6	0	0	0	0	0
	Dec	0	3	3	5	5	0	0	0	0	0
1978	Jan	0	3	3	5	5	0	0	0	0	0
	Feb	0	3	3	5	5	0	0	0	0	0
	Mar	0	6	6	6	6	6	6	28	11	0
	Apr	376	310	269	123	85	26	0	1	0	0
	May	1308	1111	925	437	372	100	0	0	11	0
	Jun	647	551	474	235	181	28	0	0	5	1
	Jul	2158	1867	1526	782	696	161	0	129	113	32
	Aug	1963	1726	1432	777	692	125	0	95	78	7
	Sep	86	109	75	0	52	0	0	0	0	0
	Oct	87	97	96	0	14	0	0	0	0	0
	Nov	0	18	18	20	12	0	0	0	0	0
	Dec	0	19	19	16	9	0	0	0	0	0
1979	Jan	0	20	20	17	12	0	0	0	0	0
	Feb	0	21	21	16	11	0	0	0	0	0
	Mar	389	337	284	129	103	33	0	0	1	0
	Apr	1184	1017	842	364	319	93	0	0	2	0
	May	1512	1317	1093	531	494	112	0	34	32	0
	Jun	2610	2277	1811	809	854	210	0	0	25	1
	Jul	3234	2925	2300	1253	1387	203	0	454	441	266
	Aug	2568	2337	1919	1074	1345	203	0	283	288	159
	Sep	1144	1164	967	485	849	136	0	0	37	62
	Oct	14	178	159	96	396	218	218	195	162	66
	Nov	0	96	96	125	230	105	105	149	121	40
	Dec	0	64	64	82	144	19	19	75	62	28

Figure 9-10
Monthly Average Rio Grande Flows
Integrated LRG Model - Historical Base Run
1940 - 2017 (cfs)

Flow Legend (CFS)

0	10
10	100
100	200
200	500
500	Max

	Month	Below Caballo	Below Percha Dam	Below Leasburg Dam	Below Mesilla Dam	At Courchesne	Below American Dam	Below Intern'l Dam	Below Riverside Dam	At County Line	At Fort Quitman
1980	Jan	0	51	51	64	120	0	0	0	12	9
	Feb	0	42	42	49	100	0	0	0	15	43
	Mar	1739	1559	1308	824	788	147	0	174	203	108
	Apr	1541	1391	1105	594	713	210	0	45	76	10
	May	2165	1924	1506	765	914	203	0	125	166	65
	Jun	2251	2023	1579	782	1060	210	0	81	143	125
	Jul	2395	2177	1715	888	1201	203	0	97	174	173
	Aug	1314	1259	982	491	877	16	0	87	151	155
	Sep	107	220	197	147	418	0	0	0	52	86
	Oct	0	70	70	8	148	40	40	36	47	64
	Nov	0	36	36	60	121	0	0	38	43	70
	Dec	0	27	27	44	98	0	0	24	31	72
1981	Jan	0	26	26	37	93	0	0	0	15	78
	Feb	0	25	25	31	84	0	0	0	17	72
	Mar	1796	1600	1347	840	798	161	0	173	203	139
	Apr	1659	1481	1178	622	726	210	0	45	70	37
	May	2274	2008	1570	784	925	203	0	125	164	100
	Jun	2256	2035	1610	832	1095	210	0	84	144	154
	Jul	2321	2104	1661	853	1184	203	0	95	168	197
	Aug	1071	1035	783	332	752	2	0	76	129	162
	Sep	165	274	253	194	456	0	0	0	57	82
	Oct	0	66	66	0	137	23	23	25	45	85
	Nov	0	33	33	57	116	0	0	35	44	76
	Dec	0	20	20	33	85	0	0	15	26	74
1982	Jan	0	21	21	31	85	0	0	0	16	72
	Feb	0	22	22	27	80	0	0	0	15	83
	Mar	1273	1128	938	563	533	161	0	0	29	37
	Apr	1276	1130	906	500	530	210	0	0	23	16
	May	1621	1435	1157	631	658	203	0	33	51	13
	Jun	1802	1620	1310	736	804	196	0	0	39	16
	Jul	2432	2240	1931	1328	1365	203	0	439	448	273
	Aug	2048	1899	1621	1112	1220	15	0	295	327	272
	Sep	1553	1343	1000	278	538	0	0	0	50	62
	Oct	669	617	401	0	376	249	249	240	216	161
	Nov	0	129	129	186	392	267	267	313	280	232
	Dec	0	77	77	111	223	98	98	157	143	144
1983	Jan	0	58	58	83	175	0	0	26	42	122
	Feb	0	46	46	63	143	0	0	0	27	135
	Mar	1240	1091	870	456	490	106	0	109	128	132
	Apr	1197	1066	815	369	509	187	0	33	61	90
	May	1927	1689	1302	603	768	203	0	96	133	118
	Jun	1935	1728	1328	595	883	210	0	63	118	132
	Jul	1945	1757	1357	632	965	203	0	73	136	149
	Aug	1829	1663	1268	564	919	79	0	81	155	203
	Sep	378	471	408	260	609	0	0	0	78	131
	Oct	0	86	86	39	189	63	63	60	74	108
	Nov	0	48	48	77	154	29	29	77	78	111
	Dec	0	38	38	60	128	3	3	59	62	107
1984	Jan	0	32	32	48	114	0	0	0	20	56
	Feb	0	31	31	40	100	0	0	0	20	105
	Mar	1626	1438	1194	704	688	135	0	152	178	131
	Apr	1532	1363	1086	571	685	210	0	47	76	47
	May	2132	1879	1491	785	908	204	0	126	167	117
	Jun	1877	1680	1304	620	896	210	0	67	117	151
	Jul	2126	1915	1504	749	1042	204	0	80	146	147
	Aug	1170	1095	805	325	695	28	0	68	123	173
	Sep	1417	1219	843	193	557	0	0	0	71	107
	Oct	19	178	153	104	451	357	357	357	325	306
	Nov	0	113	113	158	342	217	217	266	241	310
	Dec	0	79	79	113	219	94	94	151	141	259

Figure 9-10
Monthly Average Rio Grande Flows
Integrated LRG Model - Historical Base Run
1940 - 2017 (cfs)

Flow Legend (CFS)

⬜	0	10
🟩	10	100
🟩	100	200
🟦	200	500
🟦	500	Max

	Month	Below Caballo	Below Percha Dam	Below Leasburg Dam	Below Mesilla Dam	At Courchesne	Below American Dam	Below Intern'l Dam	Below Riverside Dam	At County Line	At Fort Quitman
1985	Jan	0	61	61	88	189	0	0	34	54	215
	Feb	0	48	48	68	156	0	0	0	32	179
	Mar	1006	884	692	341	401	108	0	84	104	111
	Apr	1349	1206	948	488	609	210	0	32	74	88
	May	2012	1767	1366	653	830	203	0	109	156	119
	Jun	1950	1736	1329	601	898	210	0	65	130	148
	Jul	1837	1657	1268	575	917	203	0	68	137	123
	Aug	1643	1494	1126	480	843	54	0	75	153	139
	Sep	1051	899	553	0	453	2	2	0	67	140
	Oct	16	177	154	115	441	347	347	344	314	280
	Nov	0	114	114	158	341	216	216	259	236	299
	Dec	0	80	80	116	241	116	116	167	155	258
1986	Jan	0	60	60	87	193	0	0	36	54	186
	Feb	0	47	47	67	160	0	0	0	29	166
	Mar	1908	1645	1277	372	514	159	0	50	77	104
	Apr	1559	1323	878	211	558	210	0	0	42	92
	May	1570	1401	1062	214	606	203	0	0	46	98
	Jun	1495	1281	886	218	642	210	0	0	47	66
	Jul	1585	1397	980	235	683	203	0	0	51	40
	Aug	1723	1677	1443	951	1315	774	770	600	573	518
	Sep	1115	1217	1197	1107	1363	923	923	761	721	661
	Oct	2033	2077	2077	1941	2032	1898	1898	1861	1735	1643
	Nov	2296	2314	2314	2237	2261	2136	2136	2152	2018	2055
	Dec	2168	2193	2193	2128	2183	2058	2058	2075	1957	2058
1987	Jan	1314	1363	1363	1344	1474	1228	1228	1293	1228	1439
	Feb	2779	2766	2766	2655	2627	1880	1880	2093	2036	2267
	Mar	2400	2206	1844	1084	1346	1070	937	990	950	1144
	Apr	2083	1874	1417	767	1200	881	671	659	639	744
	May	3509	3318	2976	2061	2390	2005	1802	1720	1632	1572
	Jun	2895	2680	2271	1547	2016	1654	1444	1339	1275	1382
	Jul	3861	3635	3112	2145	2598	2123	1920	1775	1703	1653
	Aug	1194	1242	1070	806	1379	863	832	692	698	860
	Sep	11	184	170	180	597	198	198	61	121	331
	Oct	0	115	115	88	362	223	223	202	207	234
	Nov	540	566	566	554	628	506	506	533	494	528
	Dec	953	956	956	913	929	807	807	840	777	828
1988	Jan	1133	1139	1139	1088	1116	869	869	940	885	983
	Feb	2272	2246	2246	2134	2082	1335	1335	1553	1514	1700
	Mar	1515	1286	874	68	426	140	0	66	115	412
	Apr	2118	1876	1411	718	1062	741	531	506	487	462
	May	1421	1272	914	83	599	203	0	0	62	196
	Jun	1638	1430	974	190	669	210	0	0	62	123
	Jul	1586	1395	952	163	697	203	0	0	65	58
	Aug	217	311	186	43	528	23	0	0	68	72
	Sep	103	219	211	196	456	0	0	0	60	64
	Oct	0	97	97	75	281	108	108	82	91	83
	Nov	0	64	64	96	228	106	106	148	136	170
	Dec	510	509	509	476	498	376	376	417	372	346
1989	Jan	8	57	57	84	193	0	0	32	50	199
	Feb	663	650	650	598	599	0	0	92	134	320
	Mar	1789	1507	1101	218	416	132	0	50	79	152
	Apr	1700	1450	983	286	645	294	84	64	93	120
	May	1574	1401	1048	180	594	203	0	0	50	76
	Jun	1902	1679	1182	310	758	210	0	0	60	52
	Jul	1910	1707	1224	316	826	203	0	0	66	31
	Aug	124	257	203	140	603	31	0	0	63	47
	Sep	65	178	178	143	407	0	0	0	49	59
	Oct	1	67	66	18	193	64	64	63	69	123
	Nov	0	36	36	61	149	28	28	74	74	118
	Dec	0	26	26	45	119	0	0	52	56	113

Figure 9-10
Monthly Average Rio Grande Flows
Integrated LRG Model - Historical Base Run
1940 - 2017 (cfs)

Flow Legend (CFS)

⬜	0	10
🟩	10	100
🟦	100	200
🟦	200	500
🟦	500	Max

	Month	Below Caballo	Below Percha Dam	Below Leasburg Dam	Below Mesilla Dam	At Courchesne	Below American Dam	Below Intern'l Dam	Below Riverside Dam	At County Line	At Fort Quitman
1990	Jan	0	27	27	42	116	0	0	0	21	129
	Feb	0	26	26	36	103	0	0	0	20	129
	Mar	1850	1571	1197	371	474	105	0	47	72	108
	Apr	1628	1365	910	237	527	202	0	0	38	88
	May	1574	1400	1079	244	585	203	0	0	42	71
	Jun	1884	1653	1158	295	715	210	0	0	51	69
	Jul	1646	1446	1004	207	705	203	0	0	51	48
	Aug	480	523	364	85	552	66	0	0	50	52
	Sep	11	148	133	127	408	135	135	36	58	149
	Oct	0	98	98	71	266	171	171	171	153	134
	Nov	0	53	53	82	185	63	63	115	108	136
	Dec	0	40	40	61	143	22	22	79	78	139
1991	Jan	0	35	35	50	128	0	0	0	30	76
	Feb	0	31	31	42	113	0	0	0	31	145
	Mar	2018	1700	1282	358	479	98	0	49	86	123
	Apr	1779	1499	992	230	564	210	0	0	51	88
	May	1705	1518	1169	278	645	203	0	0	56	91
	Jun	1882	1661	1154	267	723	210	0	0	62	79
	Jul	1588	1397	987	261	752	203	0	0	66	58
	Aug	424	489	344	131	582	65	0	0	67	74
	Sep	10	146	133	122	403	8	8	0	57	80
	Oct	0	96	96	54	254	80	80	76	95	53
	Nov	0	60	60	89	203	81	81	131	131	155
	Dec	0	39	39	61	147	25	25	85	92	153
1992	Jan	0	38	38	55	143	0	0	0	33	173
	Feb	0	34	34	45	125	0	0	0	34	146
	Mar	1727	1472	1132	382	479	76	0	48	89	137
	Apr	2073	1796	1336	622	860	458	280	251	261	258
	May	4164	3954	3681	2814	2932	2543	2340	2247	2131	1928
	Jun	1902	1704	1207	369	934	412	202	70	143	476
	Jul	1823	1629	1105	218	787	203	0	0	86	92
	Aug	1007	933	685	237	747	118	0	0	90	112
	Sep	83	231	212	171	521	0	0	0	81	101
	Oct	0	113	113	77	313	114	114	77	107	118
	Nov	0	58	58	91	208	87	87	131	139	178
	Dec	0	40	40	65	155	33	33	87	100	184
1993	Jan	256	268	268	255	302	56	56	152	165	247
	Feb	907	888	888	822	791	44	44	276	329	489
	Mar	1651	1420	1074	334	496	113	0	64	119	247
	Apr	1949	1721	1299	652	920	530	320	301	318	319
	May	3348	3135	2814	1912	2135	1622	1418	1320	1270	1176
	Jun	3749	3496	2974	1988	2394	1782	1572	1392	1357	1442
	Jul	1498	1337	904	167	841	203	0	0	110	292
	Aug	1005	948	673	162	698	50	0	0	103	143
	Sep	67	214	194	149	521	0	0	0	85	102
	Oct	0	105	105	66	300	131	131	122	144	185
	Nov	282	311	311	310	383	262	262	308	299	309
	Dec	1140	1124	1124	1055	1021	899	899	939	876	843
1994	Jan	777	794	794	759	793	547	547	627	606	733
	Feb	701	718	718	684	729	0	0	220	289	536
	Mar	1864	1586	1170	294	512	118	0	64	127	268
	Apr	1773	1517	993	217	624	210	0	0	75	161
	May	3146	2928	2601	1675	1956	1474	1270	1170	1123	992
	Jun	3422	3186	2609	1643	2080	1416	1206	1012	1005	1120
	Jul	1781	1609	1139	276	917	203	0	0	113	244
	Aug	455	570	515	349	821	45	0	0	112	139
	Sep	164	256	256	199	469	0	0	0	79	143
	Oct	36	77	77	28	175	0	0	0	50	122
	Nov	0	27	27	54	138	17	17	68	87	118
	Dec	641	615	615	564	544	423	423	469	436	394

Figure 9-10
Monthly Average Rio Grande Flows
Integrated LRG Model - Historical Base Run
1940 - 2017 (cfs)

Flow Legend (CFS)

⬜	0	10
🟩	10	100
🟦	100	200
🟦	200	500
🟦	500	Max

	Month	Below Caballo	Below Percha Dam	Below Leasburg Dam	Below Mesilla Dam	At Courchesne	Below American Dam	Below Intern'l Dam	Below Riverside Dam	At County Line	At Fort Quitman
1995	Jan	902	880	880	821	793	555	555	641	607	658
	Feb	1054	1042	1042	977	951	211	211	442	485	677
	Mar	2022	1719	1272	352	551	123	0	71	135	302
	Apr	1724	1471	963	205	615	210	0	0	75	171
	May	2501	2267	1872	892	1230	709	506	410	426	403
	Jun	3927	3673	3133	2132	2481	1889	1679	1492	1442	1403
	Jul	3870	3647	3242	2340	2788	2087	1884	1677	1642	1685
	Aug	698	843	805	667	1177	437	397	197	288	629
	Sep	386	467	467	403	641	254	254	120	201	315
	Oct	217	256	256	156	298	149	149	120	172	229
	Nov	987	951	951	886	840	727	727	760	716	672
	Dec	951	923	923	867	826	714	714	750	691	770
1996	Jan	855	850	850	801	795	558	558	639	620	730
	Feb	1124	1113	1113	1044	1027	288	288	519	561	811
	Mar	2025	1706	1235	274	502	140	0	65	146	294
	Apr	1729	1479	936	153	571	210	0	0	87	162
	May	1850	1626	1198	263	703	203	0	0	92	115
	Jun	1927	1720	1210	311	787	210	0	0	79	89
	Jul	1569	1385	1037	329	820	203	0	0	71	55
	Aug	124	262	221	126	528	22	0	0	66	92
	Sep	169	242	242	186	372	0	0	0	66	105
	Oct	10	54	54	0	136	16	16	20	74	109
	Nov	0	20	20	41	103	0	0	40	63	110
	Dec	0	15	15	30	86	0	0	29	52	111
1997	Jan	0	17	17	28	87	0	0	0	32	118
	Feb	0	19	19	27	82	0	0	0	30	119
	Mar	2321	1984	1558	614	669	123	0	73	106	145
	Apr	1851	1566	1089	365	627	210	0	0	51	119
	May	1848	1654	1308	411	728	203	0	0	57	118
	Jun	1873	1655	1204	400	793	210	0	0	62	95
	Jul	1970	1767	1312	470	921	203	0	0	75	60
	Aug	624	672	520	229	693	40	0	0	75	103
	Sep	46	179	167	133	429	0	0	0	54	129
	Oct	0	89	89	34	218	70	70	65	76	122
	Nov	0	41	41	66	138	25	25	82	84	133
	Dec	0	28	28	47	105	0	0	54	75	146
1998	Jan	705	683	683	620	580	343	343	428	407	395
	Feb	799	785	785	729	693	0	0	193	250	502
	Mar	1803	1525	1126	270	435	112	0	56	108	212
	Apr	1779	1514	1013	265	597	210	0	0	54	125
	May	1786	1603	1262	381	725	203	0	0	59	101
	Jun	2017	1798	1291	400	818	210	0	0	66	104
	Jul	1815	1620	1176	372	865	203	0	0	70	76
	Aug	731	781	659	373	805	51	0	0	83	95
	Sep	236	354	348	282	562	0	0	0	63	62
	Oct	0	65	65	39	179	28	28	21	41	103
	Nov	0	51	51	77	175	63	63	103	114	129
	Dec	0	31	31	50	119	7	7	55	58	120
1999	Jan	0	30	30	43	109	0	0	0	32	122
	Feb	0	27	27	36	97	0	0	92	99	122
	Mar	2517	2172	1733	746	799	143	0	164	188	203
	Apr	1967	1684	1174	386	711	210	0	62	97	155
	May	2082	1855	1481	531	879	203	0	110	150	157
	Jun	1984	1772	1320	505	923	210	0	30	93	174
	Jul	1800	1609	1208	486	953	203	0	94	151	122
	Aug	774	842	726	456	863	20	0	161	222	165
	Sep	163	289	281	246	528	0	0	113	149	134
	Oct	0	86	86	49	222	47	47	154	166	164
	Nov	0	48	48	73	163	51	51	175	178	197
	Dec	0	32	32	51	121	8	8	143	148	189

Figure 9-10
Monthly Average Rio Grande Flows
Integrated LRG Model - Historical Base Run
1940 - 2017 (cfs)

Flow Legend (CFS)

⬜	0	10
🟩	10	100
🟩	100	200
🟦	200	500
🟦	500	Max

	Month	Below Caballo	Below Percha Dam	Below Leasburg Dam	Below Mesilla Dam	At Courchesne	Below American Dam	Below Intern'l Dam	Below Riverside Dam	At County Line	At Fort Quitman
2000	Jan	0	31	31	45	114	0	0	124	131	173
	Feb	0	28	28	36	99	0	0	97	94	129
	Mar	2631	2285	1852	866	912	149	0	195	219	230
	Apr	1967	1686	1198	433	756	210	0	69	101	155
	May	2121	1910	1535	584	926	203	0	119	160	164
	Jun	1363	1197	937	487	866	210	0	28	87	182
	Jul	2313	2107	1605	648	1019	203	0	101	162	106
	Aug	884	901	712	302	789	14	0	150	203	152
	Sep	77	218	203	156	482	0	0	106	135	137
	Oct	0	80	80	47	197	69	69	166	187	182
	Nov	0	48	48	72	154	43	43	168	176	211
	Dec	0	41	41	59	134	23	23	152	156	204
2001	Jan	0	35	35	49	119	0	0	126	133	175
	Feb	0	32	32	40	104	0	0	100	93	142
	Mar	2367	2039	1623	705	760	107	0	168	205	205
	Apr	1893	1615	1114	370	681	210	0	59	104	136
	May	1912	1715	1380	505	829	203	0	103	146	136
	Jun	2132	1911	1392	487	904	210	0	29	96	128
	Jul	1986	1787	1315	467	960	203	0	94	158	91
	Aug	479	563	480	321	765	56	0	136	193	129
	Sep	94	210	205	184	452	0	0	98	134	107
	Oct	0	58	58	21	155	18	18	117	118	107
	Nov	0	25	25	47	107	0	0	123	133	147
	Dec	0	18	18	33	89	0	0	111	124	165
2002	Jan	0	20	20	31	89	0	0	98	104	139
	Feb	0	21	21	28	84	0	0	94	87	137
	Mar	2417	2077	1668	718	764	104	0	167	188	212
	Apr	1969	1675	1204	460	707	210	0	61	110	148
	May	2054	1832	1468	517	846	203	0	104	176	147
	Jun	2268	2043	1512	560	969	210	0	31	129	131
	Jul	1806	1614	1185	347	852	203	0	81	164	102
	Aug	472	568	507	381	789	58	0	138	228	169
	Sep	122	233	230	206	456	0	0	97	159	142
	Oct	0	56	56	38	158	38	38	117	128	112
	Nov	0	35	35	59	131	16	16	138	148	168
	Dec	0	24	24	42	104	0	0	125	136	166
2003	Jan	0	25	25	39	102	0	0	107	105	165
	Feb	0	25	25	34	92	0	0	90	77	135
	Mar	1478	1318	1132	761	723	83	0	172	203	265
	Apr	1198	1048	801	381	489	210	0	39	61	141
	May	1800	1550	1176	533	657	203	0	77	109	132
	Jun	2347	2115	1744	1053	1224	210	0	42	140	286
	Jul	2238	2036	1652	955	1207	203	0	125	217	286
	Aug	2316	2127	1734	1041	1322	80	0	223	356	310
	Sep	1601	1397	969	306	705	0	0	143	226	243
	Oct	63	196	129	24	421	299	299	381	346	335
	Nov	0	123	123	170	334	219	219	332	315	357
	Dec	0	80	80	113	212	97	97	222	206	284
2004	Jan	0	60	60	85	173	0	0	168	163	235
	Feb	0	47	47	66	146	0	0	133	117	193
	Mar	957	849	691	413	431	100	0	90	93	157
	Apr	878	788	619	345	423	197	0	32	66	118
	May	1200	1039	780	337	424	56	0	63	74	90
	Jun	1569	1405	1142	671	747	129	0	24	62	59
	Jul	1595	1427	1142	642	758	103	0	76	105	62
	Aug	1841	1700	1463	1031	1095	32	0	206	243	256
	Sep	648	621	507	271	474	0	0	98	131	96
	Oct	12	77	62	30	183	45	45	143	141	122
	Nov	0	38	38	60	129	13	13	140	136	133
	Dec	0	32	32	47	108	0	0	124	119	171

Figure 9-10
Monthly Average Rio Grande Flows
Integrated LRG Model - Historical Base Run
1940 - 2017 (cfs)

Flow Legend (CFS)

⬜	0	10
🟩	10	100
🟦	100	200
🟦	200	500
🟦	500	Max

	Month	Below Caballo	Below Percha Dam	Below Leasburg Dam	Below Mesilla Dam	At Courchesne	Below American Dam	Below Intern'l Dam	Below Riverside Dam	At County Line	At Fort Quitman
2005	Jan	0	29	29	38	98	0	0	103	101	144
	Feb	0	28	28	34	90	0	0	91	100	153
	Mar	0	27	27	29	84	83	2	7	9	80
	Apr	1162	1010	826	471	429	98	0	42	49	55
	May	1328	1148	912	471	483	91	0	67	73	65
	Jun	1705	1510	1223	687	728	143	0	24	56	71
	Jul	1856	1659	1358	798	853	203	0	77	103	61
	Aug	1929	1761	1499	1002	1049	203	0	171	196	220
	Sep	1518	1326	1035	409	578	170	0	89	100	99
	Oct	673	602	377	0	323	241	241	284	260	228
	Nov	0	125	125	171	350	233	233	349	336	345
	Dec	0	82	82	109	209	92	92	217	220	281
2006	Jan	0	60	60	79	157	0	0	153	151	191
	Feb	0	47	47	60	127	0	0	116	125	165
	Mar	1693	1519	1303	881	843	108	0	193	233	289
	Apr	1375	1224	966	501	628	210	0	50	86	138
	May	2047	1781	1390	683	823	203	0	99	143	137
	Jun	1471	1461	1369	1121	1262	129	0	49	157	399
	Jul	1261	1199	1099	832	855	0	0	111	187	297
	Aug	721	673	595	423	459	0	0	93	146	144
	Sep	137	163	154	132	211	0	0	46	80	121
	Oct	10	47	47	22	101	0	0	72	88	116
	Nov	0	24	24	31	79	0	0	89	94	122
	Dec	0	15	15	20	53	0	0	73	77	126
2007	Jan	0	18	18	21	54	0	0	65	70	112
	Feb	0	21	21	22	55	0	0	62	59	133
	Mar	1169	1035	884	566	508	109	0	104	102	115
	Apr	1159	1034	865	534	540	210	0	42	53	87
	May	1423	1260	1030	576	595	186	0	68	78	76
	Jun	1246	1146	978	616	673	100	0	24	57	64
	Jul	1474	1325	1121	699	696	166	0	65	87	58
	Aug	1917	1785	1618	1226	1199	70	0	225	264	303
	Sep	548	563	548	447	507	0	0	113	134	154
	Oct	126	137	137	97	137	0	0	74	93	135
	Nov	0	14	14	25	60	0	0	75	86	120
	Dec	0	13	13	19	51	0	0	69	72	127
2008	Jan	0	16	16	20	51	0	0	63	65	107
	Feb	0	18	18	20	49	0	0	55	42	103
	Mar	1349	1193	1016	650	570	108	0	117	118	111
	Apr	1399	1241	1037	641	601	210	0	47	62	97
	May	1684	1485	1224	712	680	203	0	76	87	81
	Jun	1128	1098	1056	878	858	210	0	26	61	57
	Jul	1434	1270	1065	659	598	203	0	51	65	45
	Aug	1634	1486	1273	844	842	55	0	157	178	161
	Sep	391	423	405	308	412	0	0	88	102	104
	Oct	144	156	156	108	141	0	0	104	97	91
	Nov	0	16	16	26	48	0	0	54	77	97
	Dec	0	11	11	17	32	0	0	51	66	109
2009	Jan	0	15	15	18	35	0	0	48	44	93
	Feb	0	17	17	19	34	0	0	41	44	90
	Mar	2041	1826	1609	1133	1008	109	0	234	282	301
	Apr	1556	1368	1115	628	641	210	0	55	88	159
	May	1980	1707	1347	684	742	203	0	89	127	141
	Jun	1494	1443	1311	983	1083	210	0	38	124	291
	Jul	2370	2100	1736	1046	1070	203	0	110	188	207
	Aug	1741	1605	1339	828	1021	54	0	188	269	257
	Sep	239	318	293	241	415	0	0	91	148	223
	Oct	0	64	64	40	129	22	22	83	82	152
	Nov	0	30	30	46	91	0	0	106	93	134
	Dec	0	29	29	40	79	0	0	98	113	166

Figure 9-10
Monthly Average Rio Grande Flows
Integrated LRG Model - Historical Base Run
1940 - 2017 (cfs)

Flow Legend (CFS)

⬜	0	10
🟩	10	100
🟦	100	200
🟦	200	500
🟦	500	Max

	Month	Below Caballo	Below Percha Dam	Below Leasburg Dam	Below Mesilla Dam	At Courchesne	Below American Dam	Below Intern'l Dam	Below Riverside Dam	At County Line	At Fort Quitman
2010	Jan	0	27	27	33	68	0	0	81	96	154
	Feb	0	27	27	29	63	0	0	69	56	131
	Mar	1651	1477	1279	854	780	72	0	186	236	256
	Apr	1366	1200	941	465	538	178	0	47	77	144
	May	2061	1779	1381	658	745	203	0	89	129	126
	Jun	1276	1305	1269	1103	1187	210	0	42	138	325
	Jul	2350	2085	1749	1121	1094	203	0	114	196	252
	Aug	1786	1665	1444	986	1134	122	0	197	284	297
	Sep	397	457	435	367	519	0	0	113	163	211
	Oct	45	84	84	54	127	0	0	95	103	165
	Nov	0	23	23	38	79	0	0	91	100	142
	Dec	0	14	14	22	49	0	0	74	94	140
2011	Jan	0	17	17	22	49	0	0	66	68	126
	Feb	0	18	18	21	46	0	0	57	58	116
	Mar	1256	1100	929	587	516	94	0	111	126	121
	Apr	1406	1233	1030	647	609	210	0	47	62	92
	May	1059	985	918	712	651	149	0	78	89	71
	Jun	915	862	862	749	637	2	0	26	58	48
	Jul	983	912	912	791	646	14	0	77	99	59
	Aug	1211	1130	1130	1005	832	18	0	155	178	111
	Sep	191	161	161	139	91	0	0	17	23	39
	Oct	0	1	1	9	10	16	16	29	19	27
	Nov	0	0	0	10	9	0	0	18	22	30
	Dec	0	0	0	9	7	0	0	30	31	52
2012	Jan	0	0	0	9	6	0	0	30	31	80
	Feb	0	0	0	9	6	0	0	25	15	72
	Mar	1080	918	754	448	364	84	0	77	70	88
	Apr	1207	1024	834	482	397	185	0	28	32	70
	May	1342	1112	857	395	335	65	0	48	50	50
	Jun	830	773	773	666	533	72	0	18	43	37
	Jul	766	703	703	601	473	22	0	52	68	43
	Aug	777	712	712	617	485	2	0	91	101	60
	Sep	49	33	33	33	18	0	0	6	11	23
	Oct	0	1	1	9	7	13	13	27	18	17
	Nov	0	0	0	9	7	0	0	23	29	22
	Dec	0	0	0	8	6	0	0	25	39	45
2013	Jan	0	0	0	8	6	0	0	29	33	61
	Feb	0	0	0	9	6	0	0	26	13	65
	Mar	1069	908	757	444	362	53	0	84	76	86
	Apr	1086	901	708	329	272	39	0	32	35	70
	May	769	674	618	416	324	21	0	54	56	60
	Jun	433	386	386	312	224	7	0	8	21	31
	Jul	0	1	1	9	8	19	19	19	10	17
	Aug	79	57	57	44	22	6	0	6	1	14
	Sep	0	0	0	9	7	16	16	20	6	12
	Oct	0	1	1	9	6	15	15	28	11	9
	Nov	0	0	0	8	6	0	0	17	27	15
	Dec	0	0	0	8	6	0	0	19	20	18
2014	Jan	0	0	0	8	6	0	0	21	21	26
	Feb	0	0	0	8	6	0	0	23	9	35
	Mar	1170	1003	841	510	419	88	0	91	79	74
	Apr	1210	1025	838	466	385	143	0	34	31	50
	May	1179	991	817	430	355	31	0	59	56	47
	Jun	721	655	651	537	417	2	0	17	35	24
	Jul	547	481	466	360	269	22	0	26	32	15
	Aug	335	294	294	242	169	7	0	27	21	6
	Sep	0	0	0	9	8	20	20	22	7	3
	Oct	0	1	1	9	7	19	19	30	12	3
	Nov	0	0	0	8	6	0	0	20	18	6
	Dec	0	0	0	8	6	0	0	21	8	6

Figure 9-10
Monthly Average Rio Grande Flows
Integrated LRG Model - Historical Base Run
1940 - 2017 (cfs)

Flow Legend (CFS)

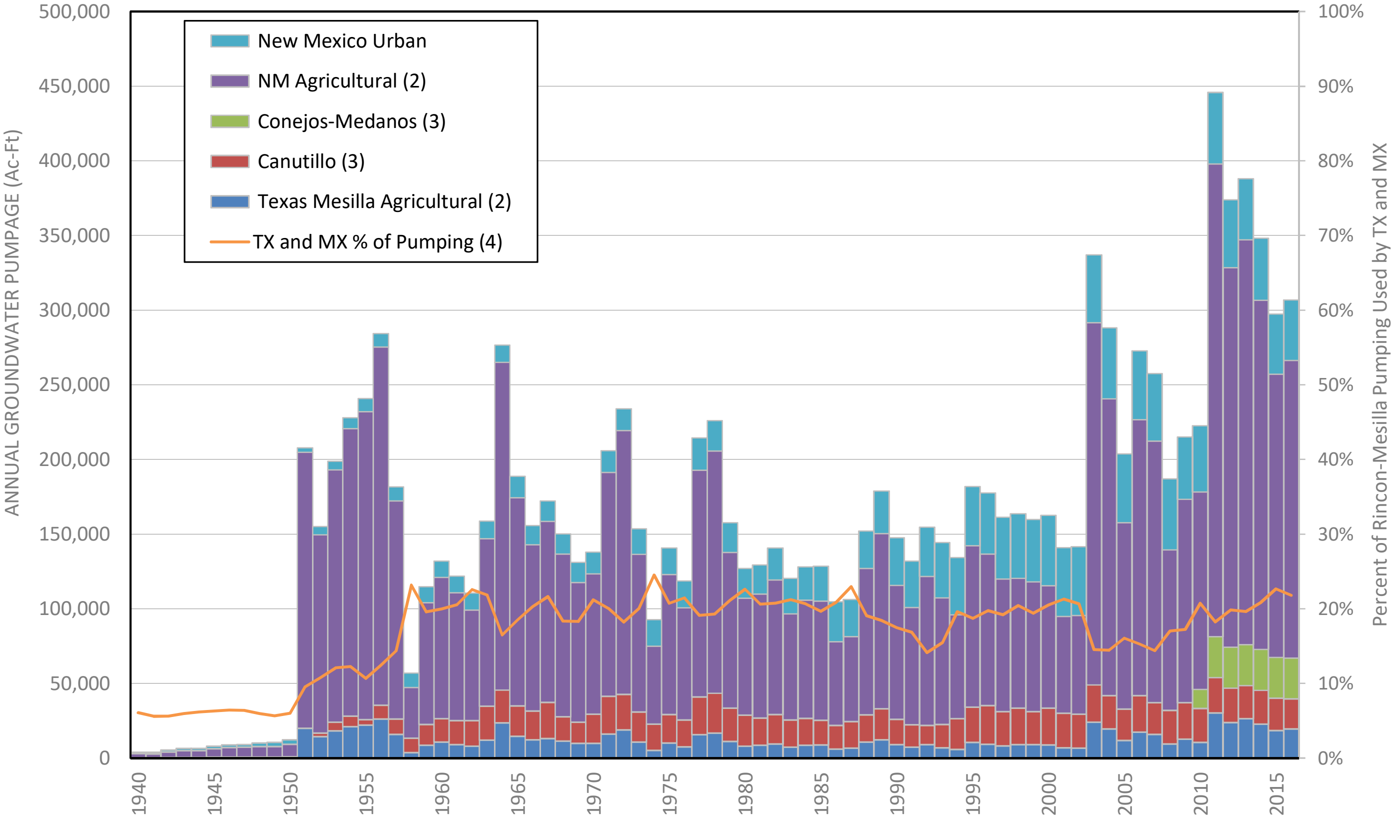
⬜	0	10
🟩	10	100
🟩	100	200
🟦	200	500
🟦	500	Max

	Month	Below Caballo	Below Percha Dam	Below Leasburg Dam	Below Mesilla Dam	At Courchesne	Below American Dam	Below Intern'l Dam	Below Riverside Dam	At County Line	At Fort Quitman
2015	Jan	0	0	0	8	6	0	0	25	22	20
	Feb	0	0	0	8	5	0	0	24	21	38
	Mar	1017	869	727	448	362	72	0	82	69	69
	Apr	1145	972	799	466	381	165	0	32	27	51
	May	1433	1203	954	478	407	120	0	53	49	43
	Jun	1100	973	889	636	516	39	0	20	40	27
	Jul	881	815	815	700	557	78	0	58	70	33
	Aug	1615	1521	1521	1351	1140	90	0	207	235	134
	Sep	293	257	257	205	142	0	0	23	30	27
	Oct	0	0	0	9	8	15	15	30	30	25
	Nov	0	0	0	9	7	0	0	28	23	35
	Dec	0	0	0	9	6	0	0	31	23	43
2016	Jan	0	1	1	9	6	0	0	20	15	64
	Feb	0	1	1	9	6	0	0	18	13	61
	Mar	1241	1073	909	574	473	75	0	103	95	93
	Apr	1264	1094	925	577	477	172	0	38	42	71
	May	1532	1338	1150	730	616	166	0	71	78	70
	Jun	960	908	908	779	627	39	0	24	52	58
	Jul	1169	1096	1096	948	778	81	0	86	108	68
	Aug	1641	1509	1448	1185	1002	143	0	172	192	212
	Sep	686	630	625	508	398	0	0	86	93	92
	Oct	297	265	265	191	135	0	0	96	103	103
	Nov	0	1	1	9	8	0	0	25	49	80
	Dec	0	1	1	9	7	0	0	32	49	74
2017	Jan	0	1	1	9	6	0	0	28	44	70
	Feb	0	2	2	9	6	0	0	22	24	69
	Mar	1163	1004	852	546	447	96	0	94	84	90
	Apr	1233	1057	876	522	431	145	0	38	41	67
	May	1237	1084	954	633	521	107	0	68	73	62
	Jun	1310	1213	1174	959	793	210	0	24	53	43
	Jul	1336	1203	1121	859	713	203	0	63	80	47
	Aug	1798	1680	1637	1409	1201	203	0	199	228	229
	Sep	902	847	846	723	585	24	0	124	136	121
	Oct	282	251	251	193	136	0	0	90	80	107
	Nov	0	2	2	10	8	0	0	24	18	58
	Dec	0	1	1	9	7	0	0	30	19	54

Model Version: LRG Model v106 Operational Run - Base Run (All Pumping On).

Figure 11-1

Total Annual Groundwater Pumpage for Irrigation and Urban Uses (Texas Estimates) in Rincon and Mesilla Basins
1940 - 2016

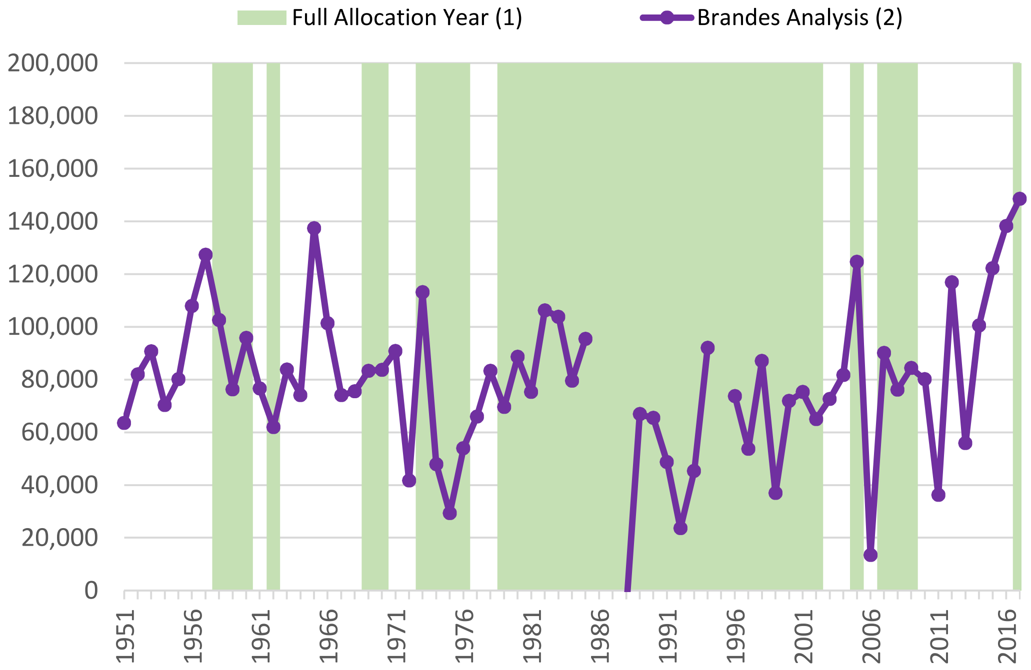


<u>Notes:</u>

(1) Data from Figure 4.5 in Expert Report of Robert J. Brandes disaggregated into NM, TX, and MX portions.
(2) Agriculture groundwater pumping split based on acreage according to Montgomery and Associates file FD_disagg_RinMes.xlsx.
(3) Canutillo and Conejos-Medanos data from Montgomery and Associates file tbl4.3_M&I_Pumping_Summary.xlsx.
(4) Calculated as sum of Texas Mesilla Agricultural, Canutillo, and Conejos-Medanos pumping by total Rincon-Mesilla Pumping.

Figure 11-2

Annual Impact of Pumping on Rio Grande at El Paso Flows
Brandes Double-Mass Curve Analysis
1951 - 2017
(acre-feet)



Averages	Annual Average	
1985 - 2016	71,996	(3)
1951 - 2017	78,667	(3)

Notes:

(1) Difference between historical flows and estimates flows without effects of pumping from Figure 5.5 of the Brandes report.

(2) See Section 4.3 of SWE report for description of how full allocation years are defined.

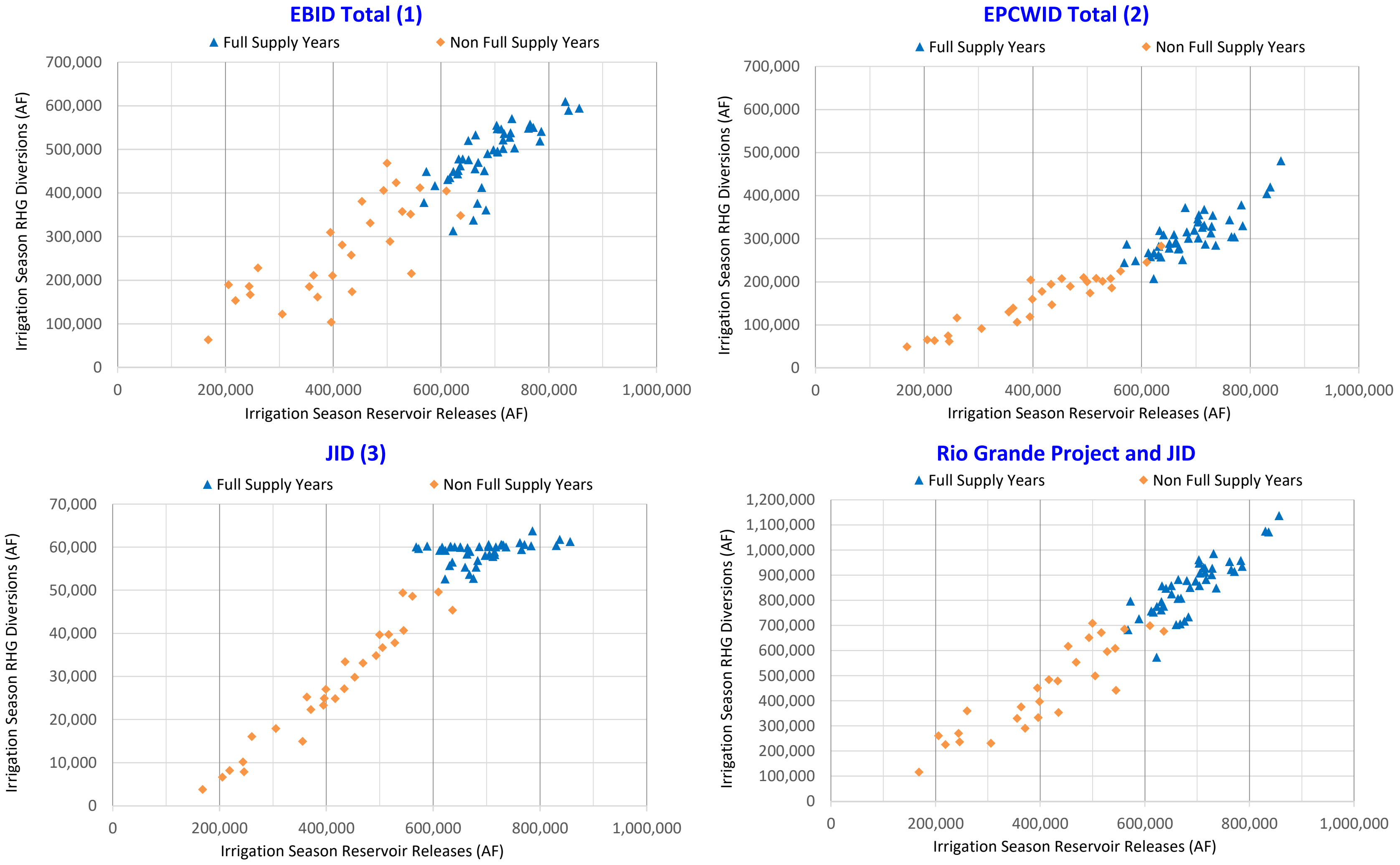
(3) Annual average values exclude spill years (1986, 1987, and 1995).

Figure 11-3

River Headgate Diversions v. Reservoir Releases

Historical Project Data

March-October 1940 - 2017 (acre-feet)



***Note different scales.**

Notes:

(1) EBID Total RHG Diversions include diversions at Percha, Leasburg and Mesilla Dams minus Mesilla flows to TX.

(2) EPCWID Total RHG Diversions include Mesilla flows to TX, Franklin Canal minus Ascarate Wasteway (pre-ACE), Riverside Canal, and EPW diversions.

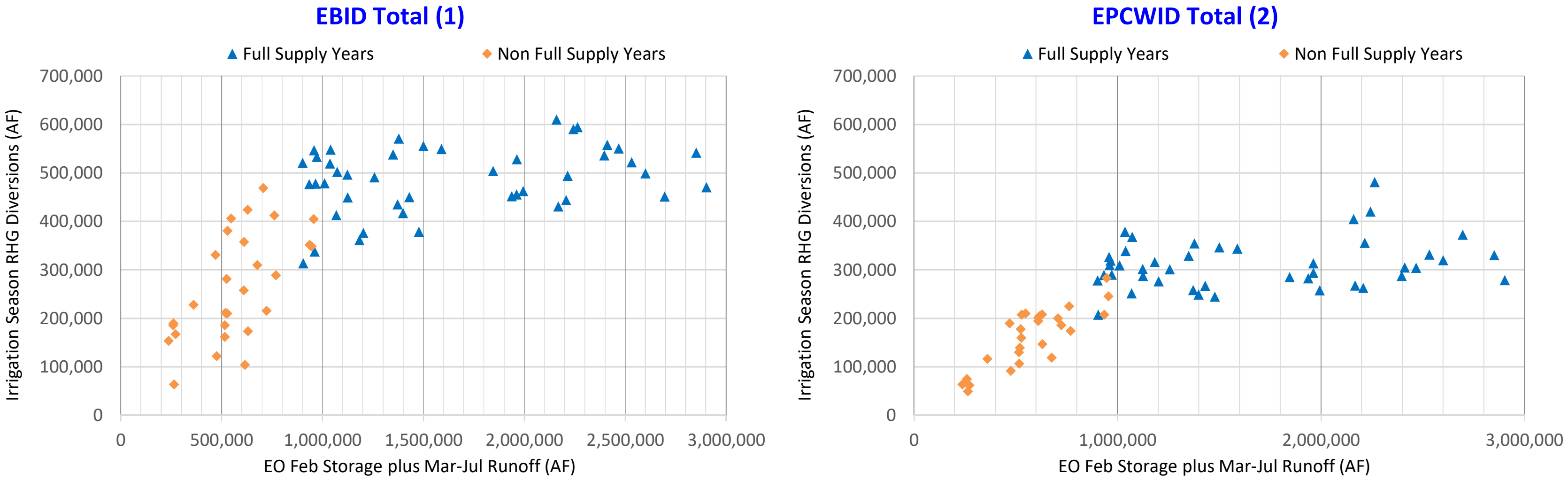
(3) JID RHG Diversions consist of Acequia Madre diversions only.

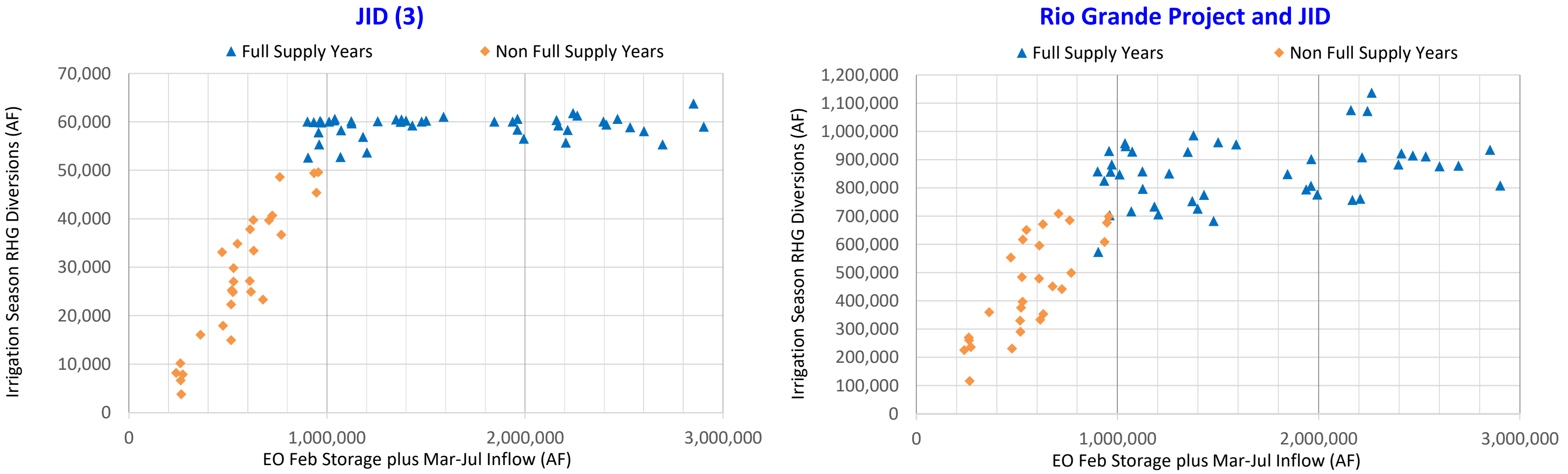
Figure 11-4

River Headgate Diversions v. Project Supply

Historical Project Data

March-October 1940 - 2017 (acre-feet)





***Note different scales.**

Notes:

(1) EBID Total RHG Diversions include diversions at Percha, Leasburg and Mesilla Dams minus Mesilla flows to TX.

(2) EPCWID Total RHG Diversions include Mesilla flows to TX, Franklin Canal minus Ascarate Wasteway (pre-ACE), Riverside Canal, and EPW diversions.

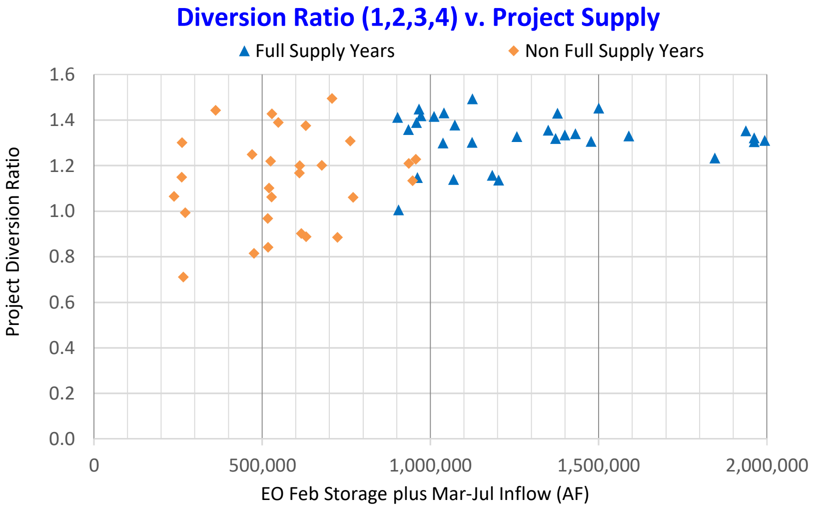
(3) JID RHG Diversions consist of Acequia Madre diversions only.

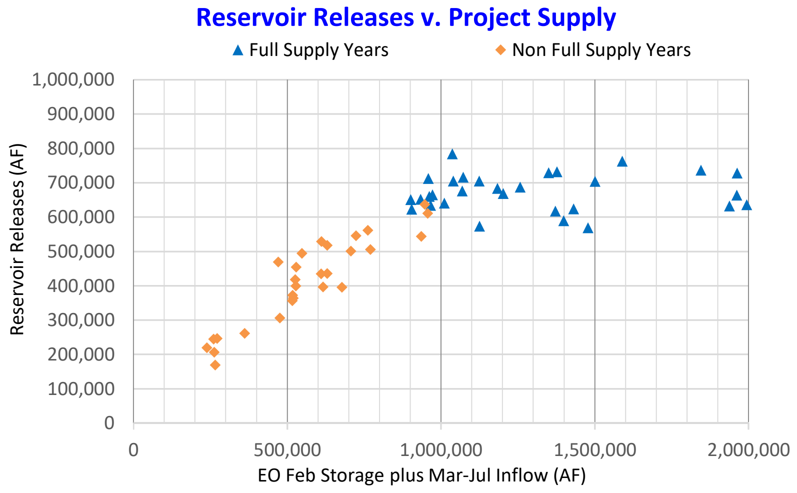
Figure 11-5

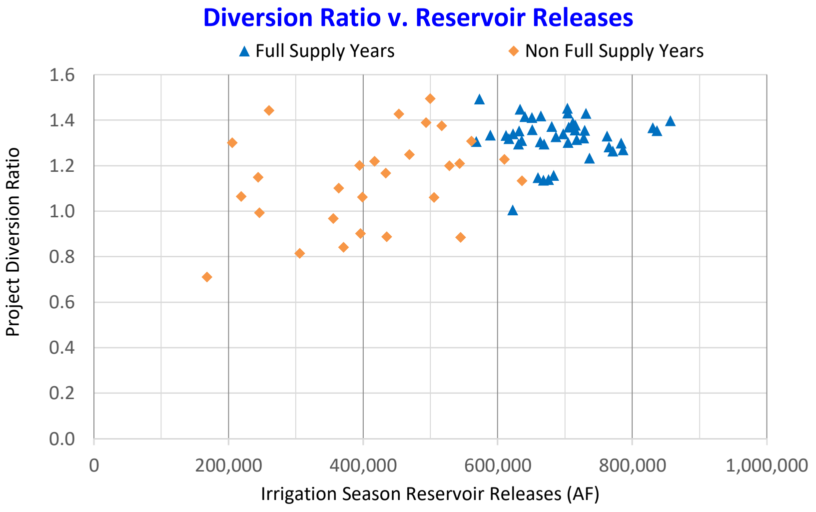
Comparison of Diversion Ratio, Project Supply, and Reservoir Releases

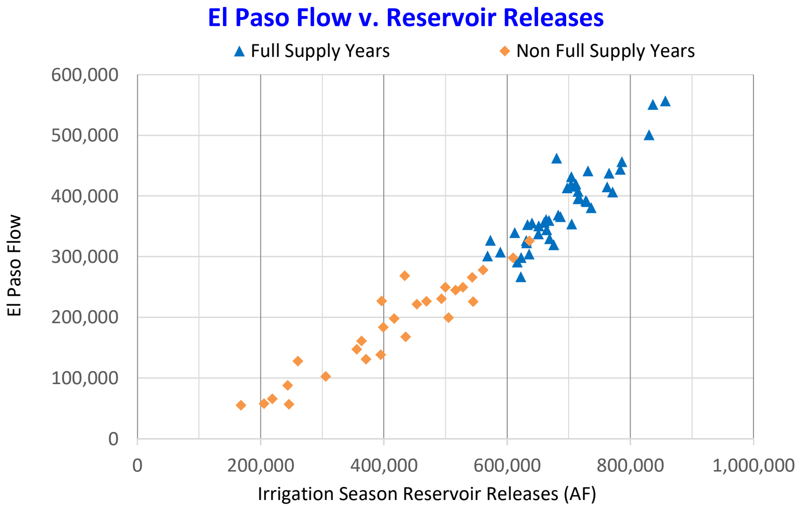
Historical Project Data

March-October 1940 - 2017 (acre-feet)


Diversion Ratio (1,2,3,4) v. Project Supply


Reservoir Releases v. Project Supply


Diversion Ratio v. Reservoir Releases


El Paso Flow v. Reservoir Releases

Notes:

(1) Diversion ratio is computed as the total RHG diversions (EBID, EPCWID, and JID) divided by Caballo Reservoir releases.

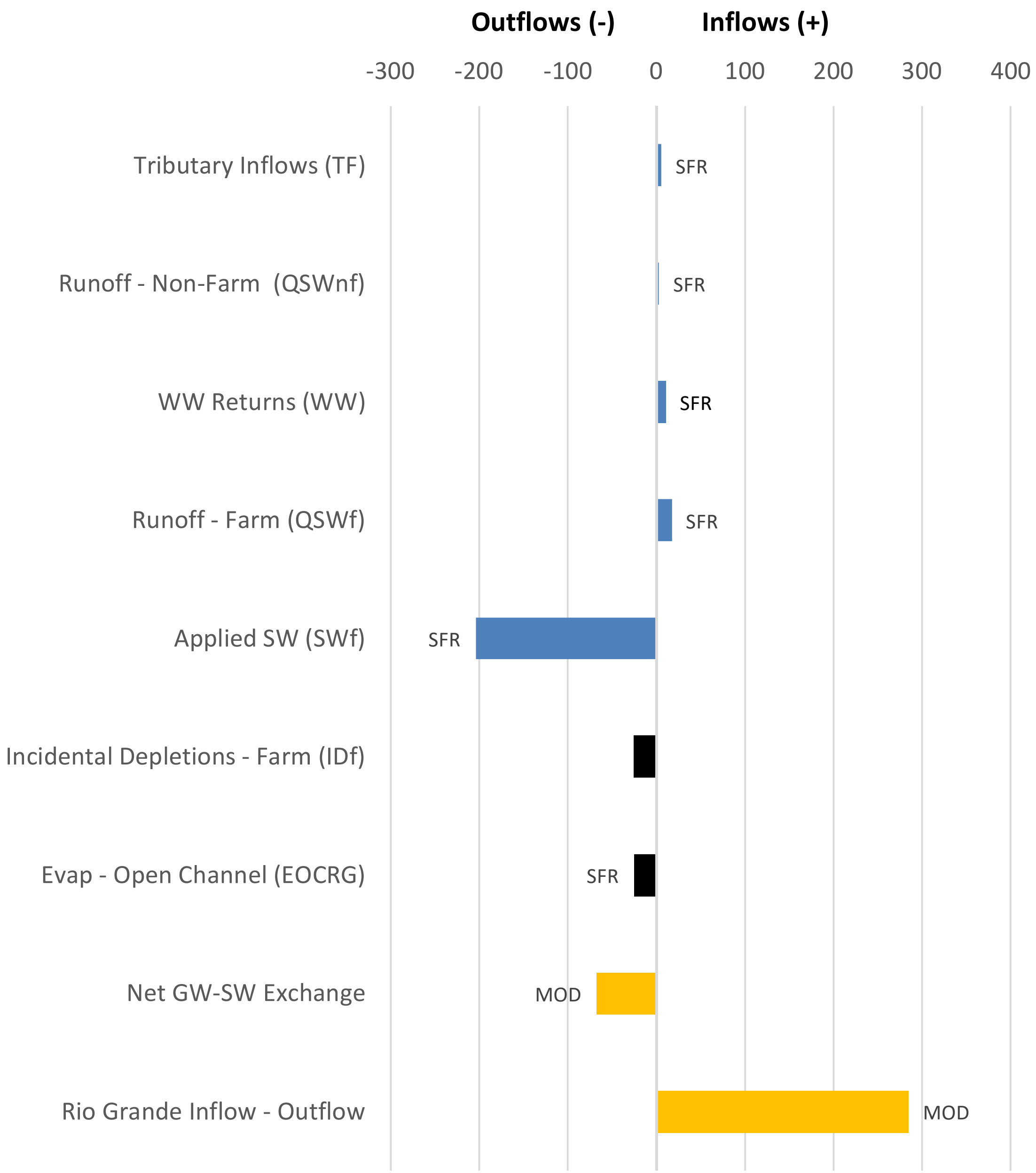
(2) EBID Total RHG Diversions include diversions at Percha, Leasburg and Mesilla Dams minus Mesilla flows to TX.

(3) EPCWID Total RHG Diversions include Mesilla flows to TX, Franklin Canal minus Ascarate Wasteway (pre-ACE), Riverside Canal, and EPW diversions.

(4) JID RHG Diversions consist of Acequia Madre diversions only.

Figure 12-1

Summary of Texas WaterBudget (M&A)
Surface Water Budget
Rincon and Mesilla Basins
1985 - 2016 Average Annual (1,000 acre-feet)



Legend

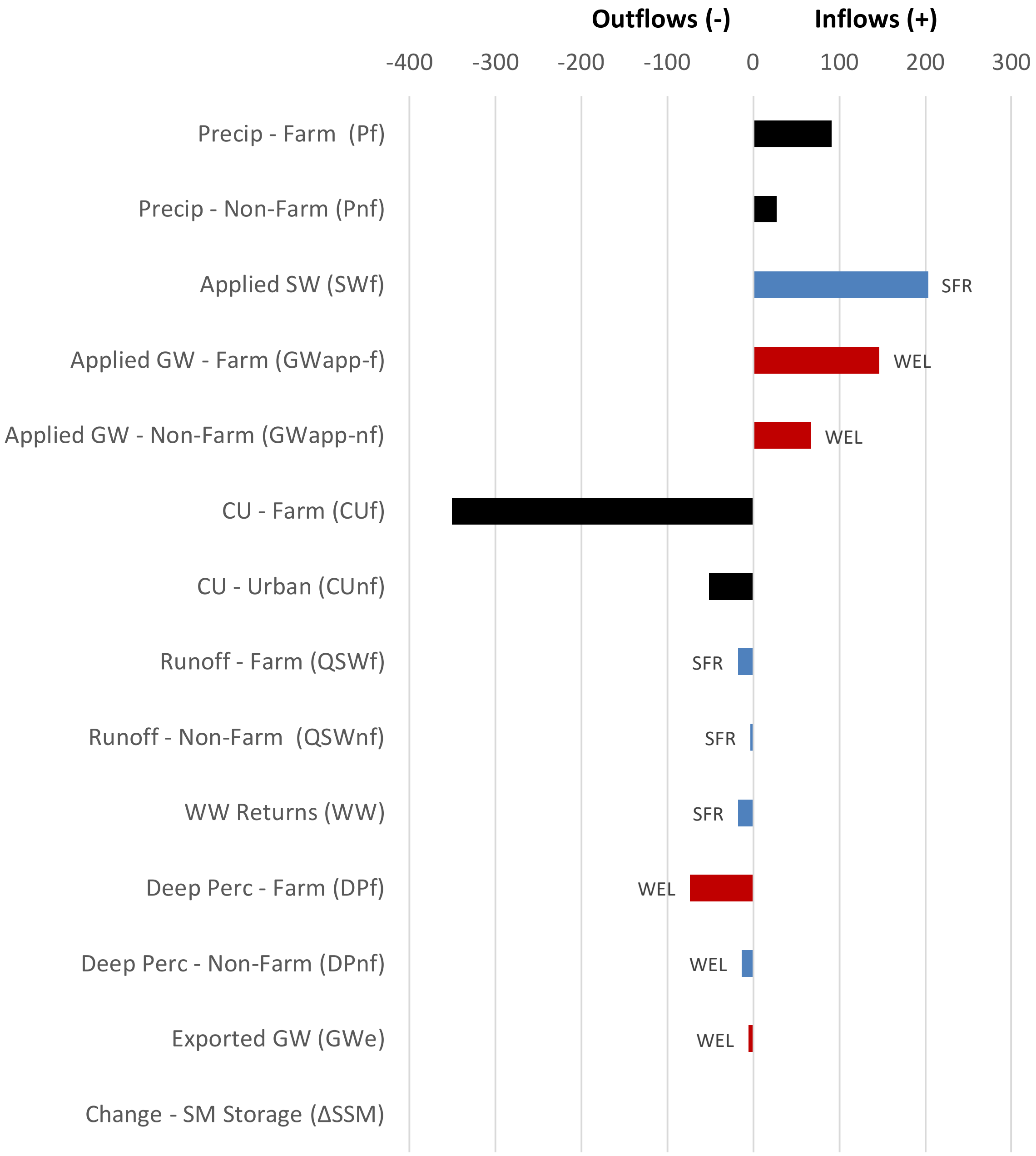
🟥	TX Model Input - Changes in Alt Runs	🟨	Simulated in TX Model
🟦	TX Model Input - Unchanging	⬛	Not in TX Model

<u>MODFLOW Simulation:</u>

WEL - Input in WEL Package; SFR - Input in SFR Package; MOD - Simulated in model

Figure 12-2

Summary of Texas WaterBudget (M&A)
Land Surface Budget
Rincon and Mesilla Basins
1985 - 2016 Average Annual (1,000 acre-feet)



Legend

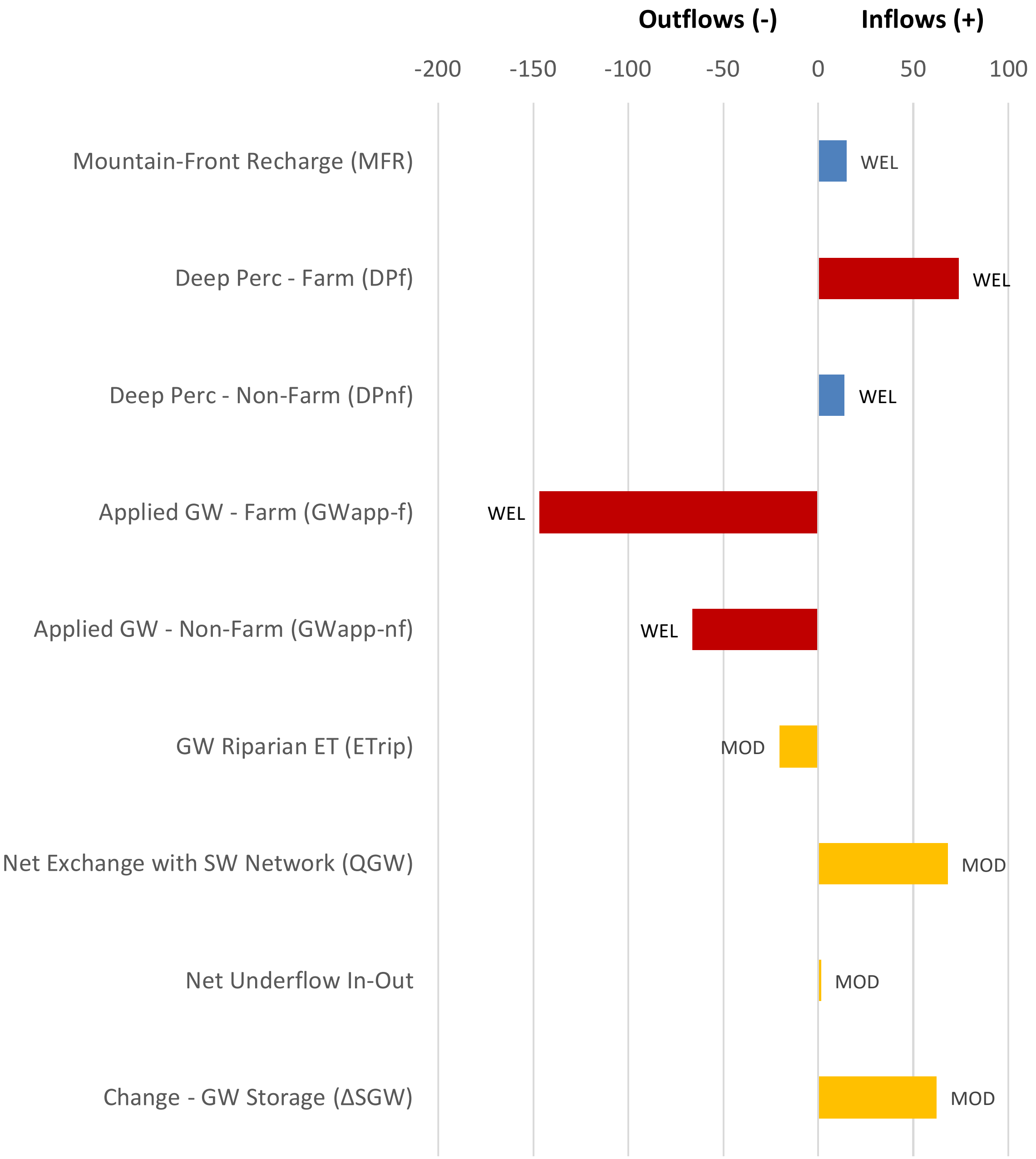
🟥 TX Model Input - Changes in Alt Runs
🟨 Simulated in TX Model
🟦 TX Model Input - Unchanging
⬛ Not in TX Model

MODFLOW Simulation:

WEL - Input in WEL Package; SFR - Input in SFR Package; MOD - Simulated in model

Figure 12-3

Summary of Texas WaterBudget (M&A)
Ground Water Budget
Rincon and Mesilla Basins
1985 - 2016 Average Annual (1,000 acre-feet)



Legend

🟥 TX Model Input - Changes in Alt Runs	🟨 Simulated in TX Model
🟦 TX Model Input - Unchanging	⬛ Not in TX Model

MODFLOW Simulation:

WEL - Input in WEL Package; SFR - Input in SFR Package; MOD - Simulated in model

Figure 12-4

Monthly Soil Moisture Simulation (ft/ft)
M&A Soil Water Balance Model

(Theta Max, Theta Min, Theta Computed, and Soil Properties)

1938-2016

Rincon In District

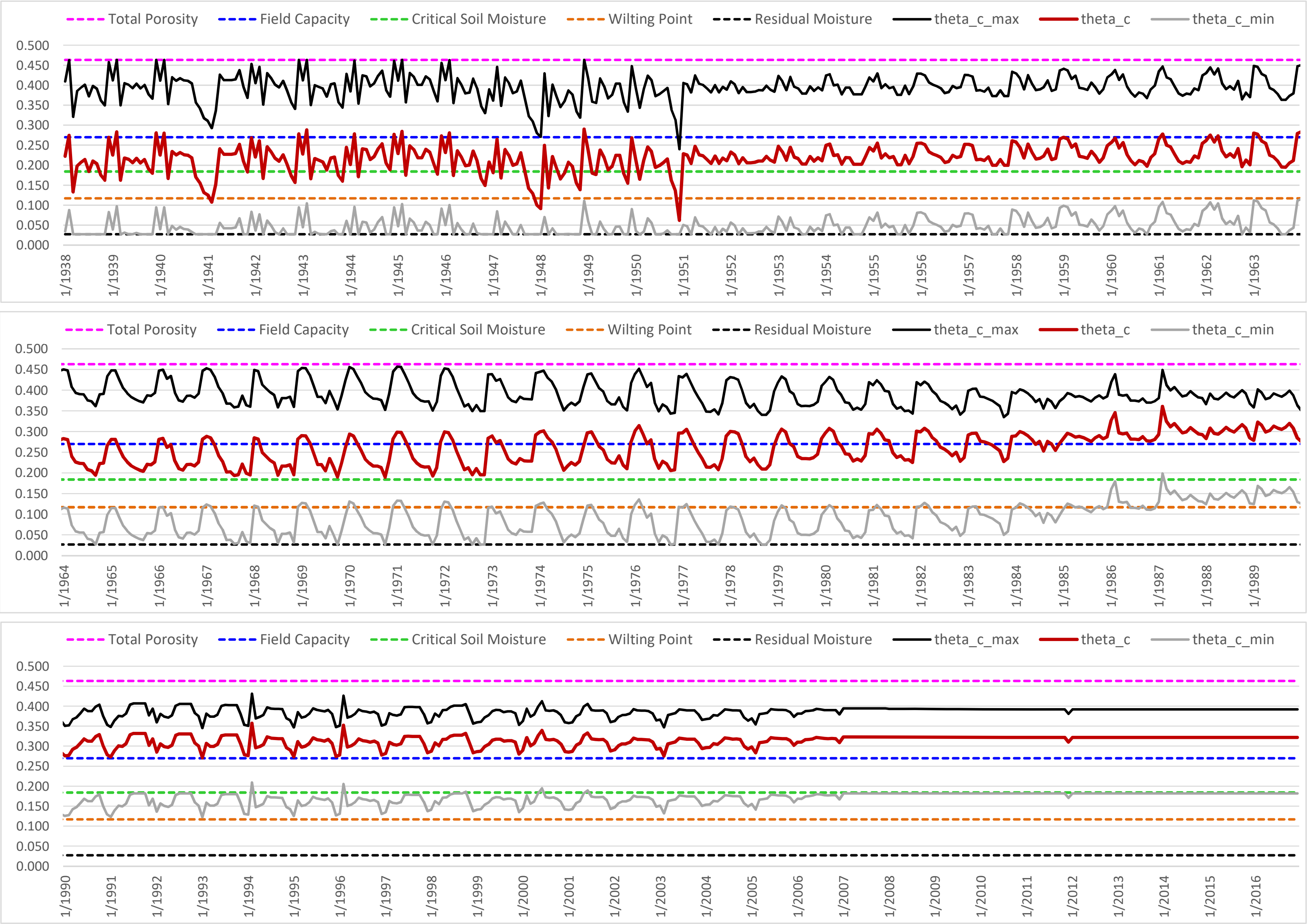


Figure 12-5

Monthly Soil Moisture Simulation (ft/ft)
M&A Soil Water Balance Model

(Theta Max, Theta Min, Theta Computed, and Soil Properties)

1938-2016

Mesilla In District

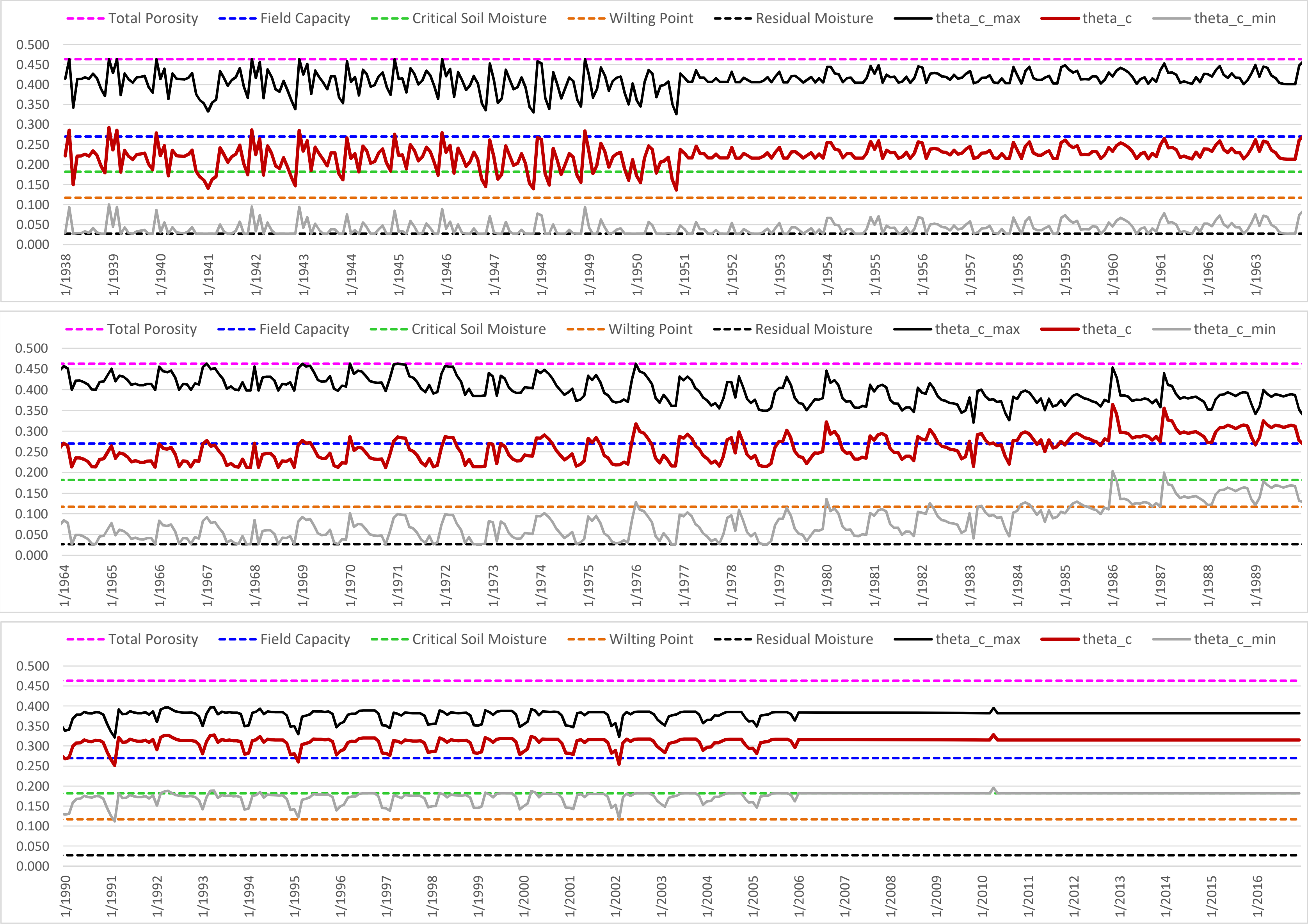
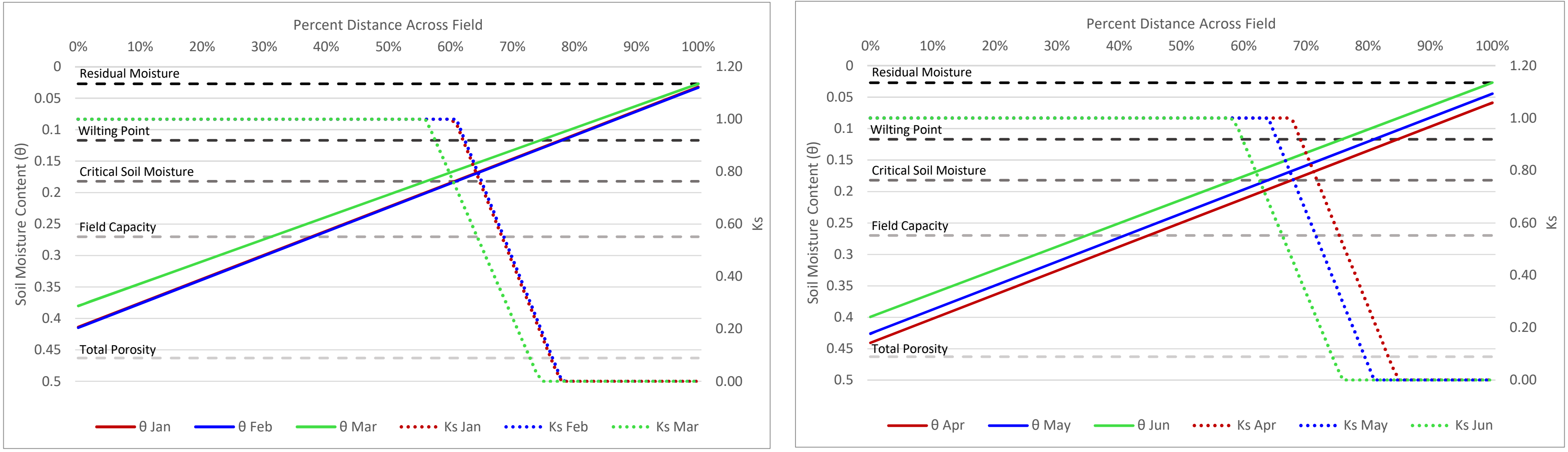


Figure 12-6

Monthly Simulated Soil Moisture (θ) and Water Stress Coefficient (Ks) Across Virtual Field
M&A Soil Water Balance Model
Mesilla In District
1945

January - March **April - June**



July - September **October - December**

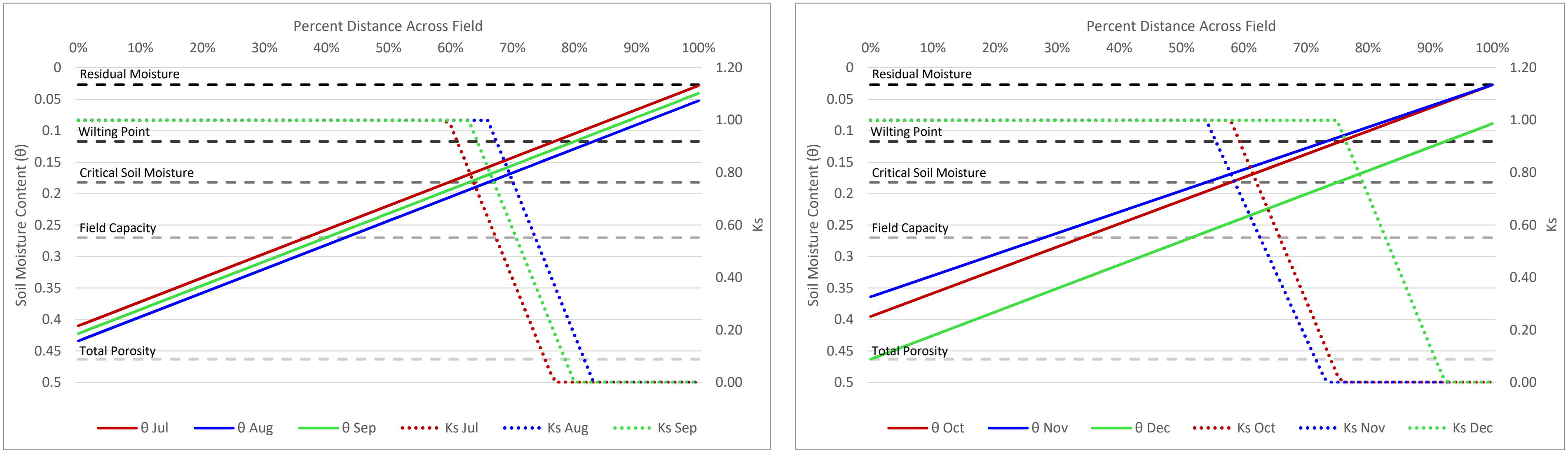
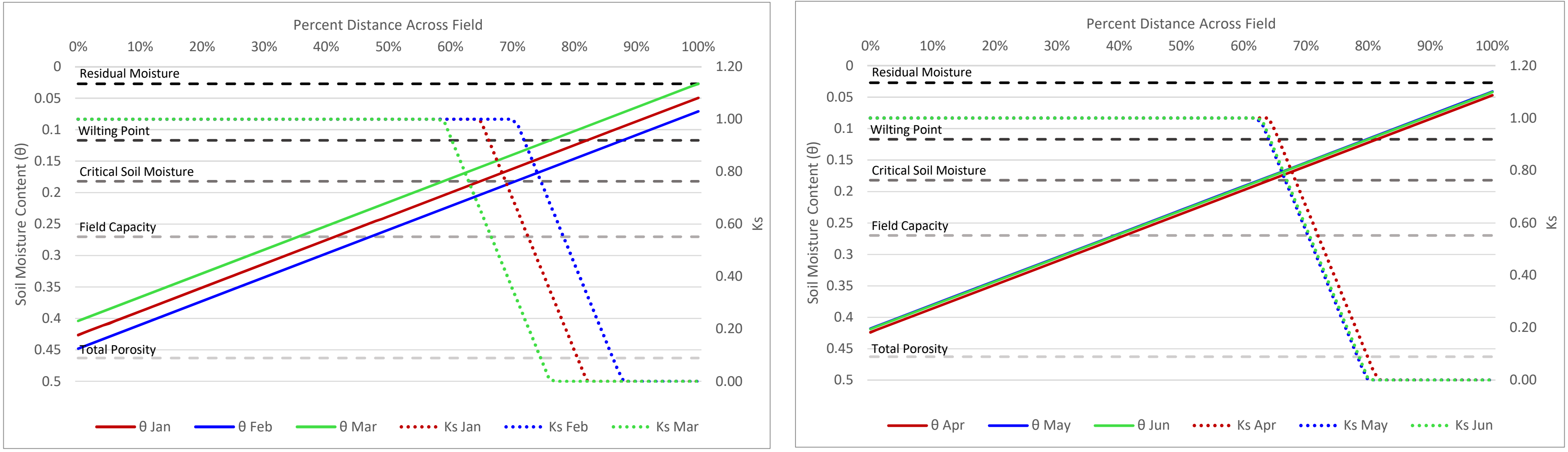
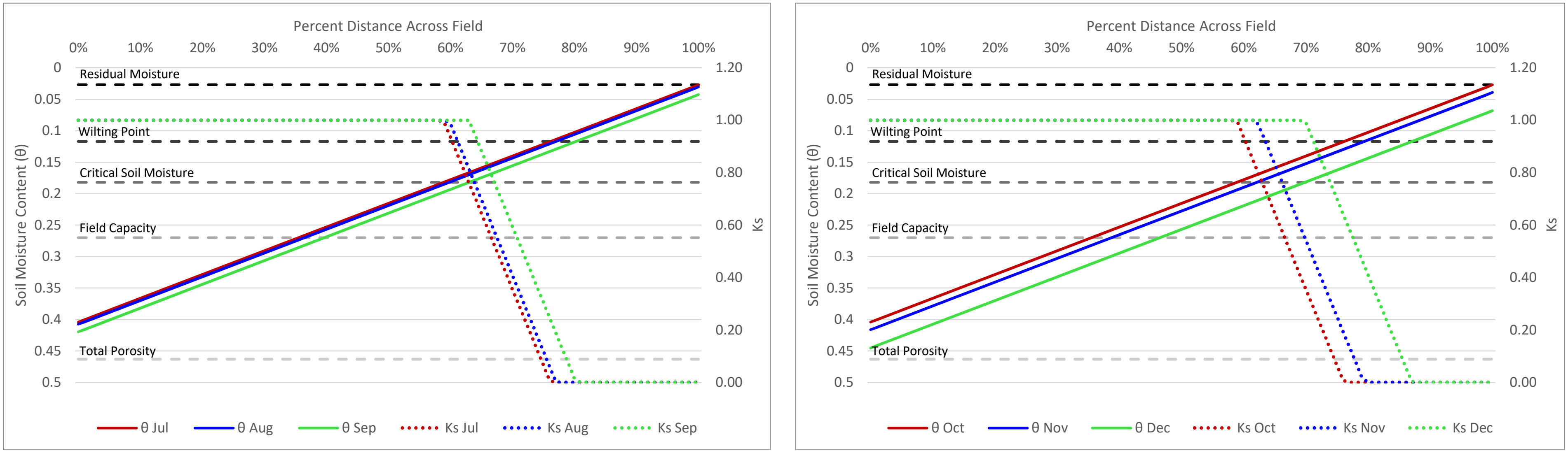


Figure 12-6

Monthly Simulated Soil Moisture (θ) and Water Stress Coefficient (Ks) Across Virtual Field
M&A Soil Water Balance Model
Mesilla In District
1955


January - March

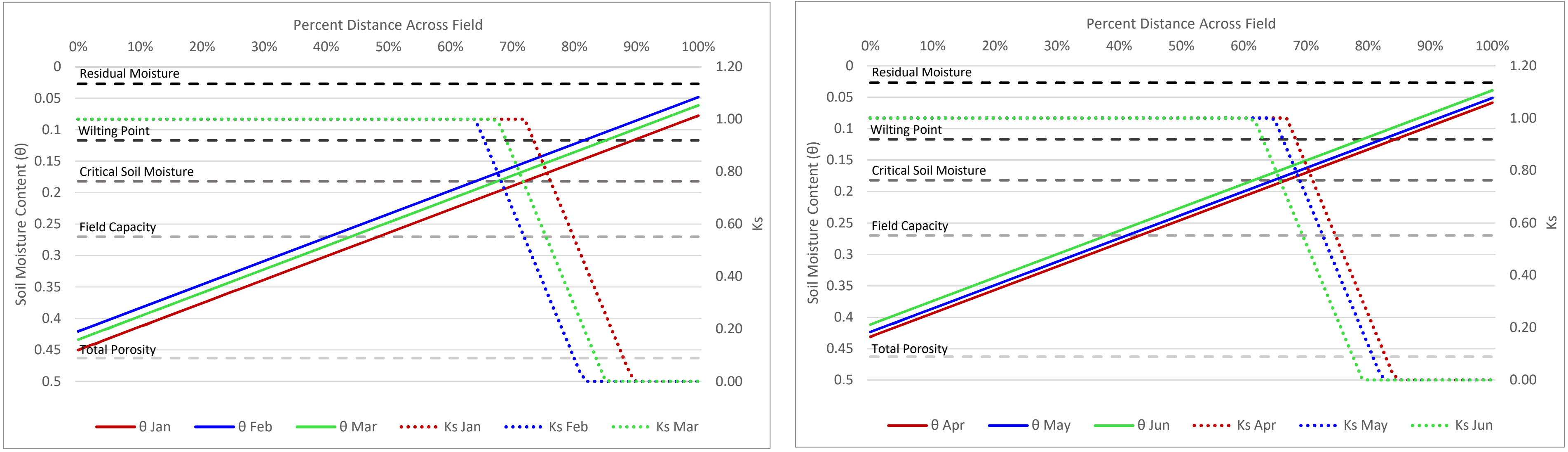
April - June


July - September

October - December

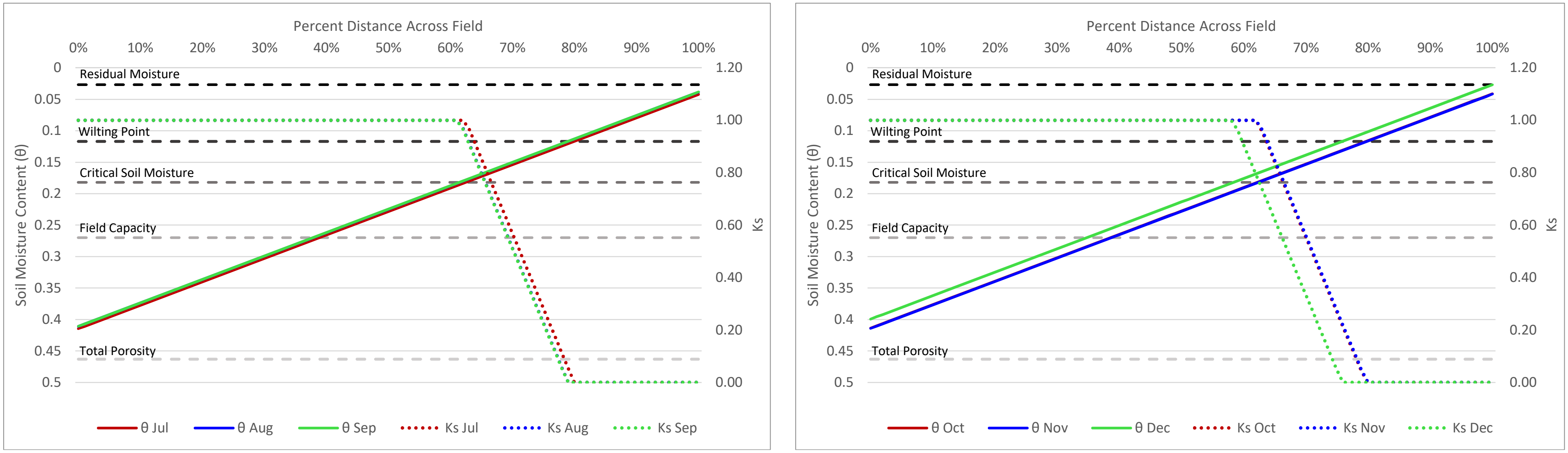
Figure 12-6

Monthly Simulated Soil Moisture (θ) and Water Stress Coefficient (Ks) Across Virtual Field
M&A Soil Water Balance Model
Mesilla In District
1965



January - March

April - June



July - September

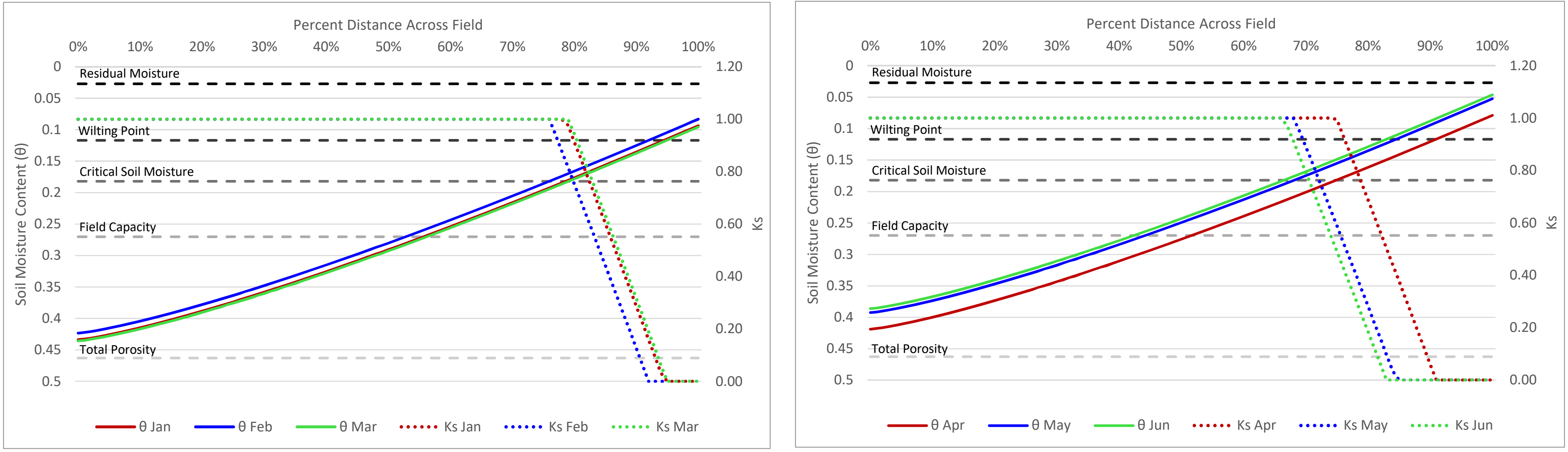
October - December

Figure 12-6

Monthly Simulated Soil Moisture (θ) and Water Stress Coefficient (Ks) Across Virtual Field
M&A Soil Water Balance Model
Mesilla In District
1975

January - March

April - June



July - September

October - December

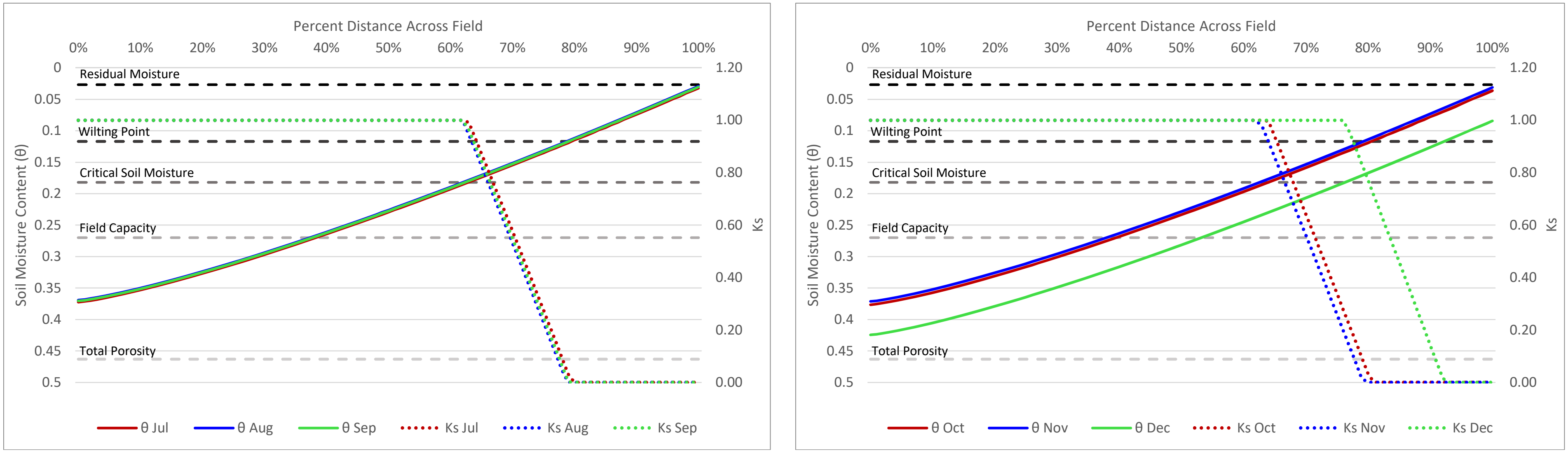
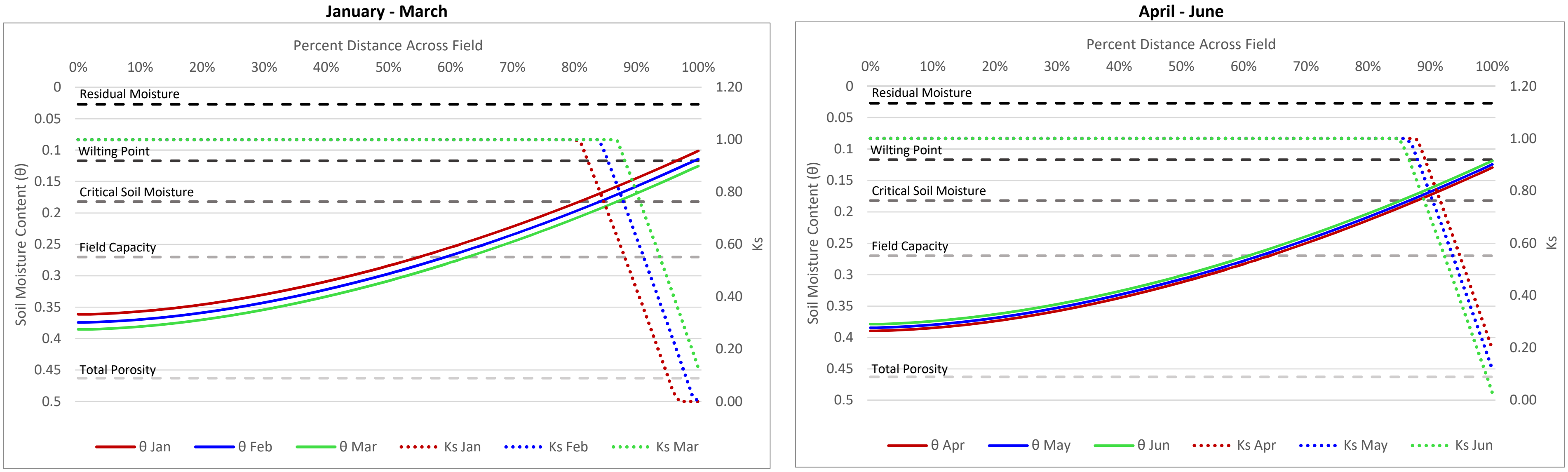


Figure 12-6

Monthly Simulated Soil Moisture (θ) and Water Stress Coefficient (Ks) Across Virtual Field
M&A Soil Water Balance Model
Mesilla In District
1985



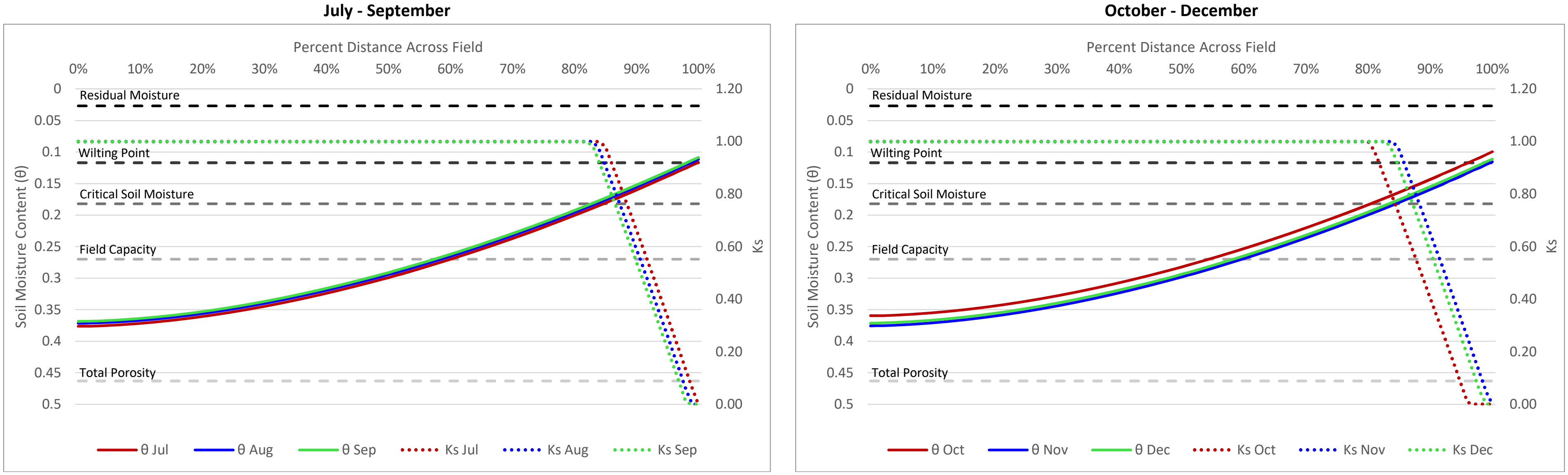
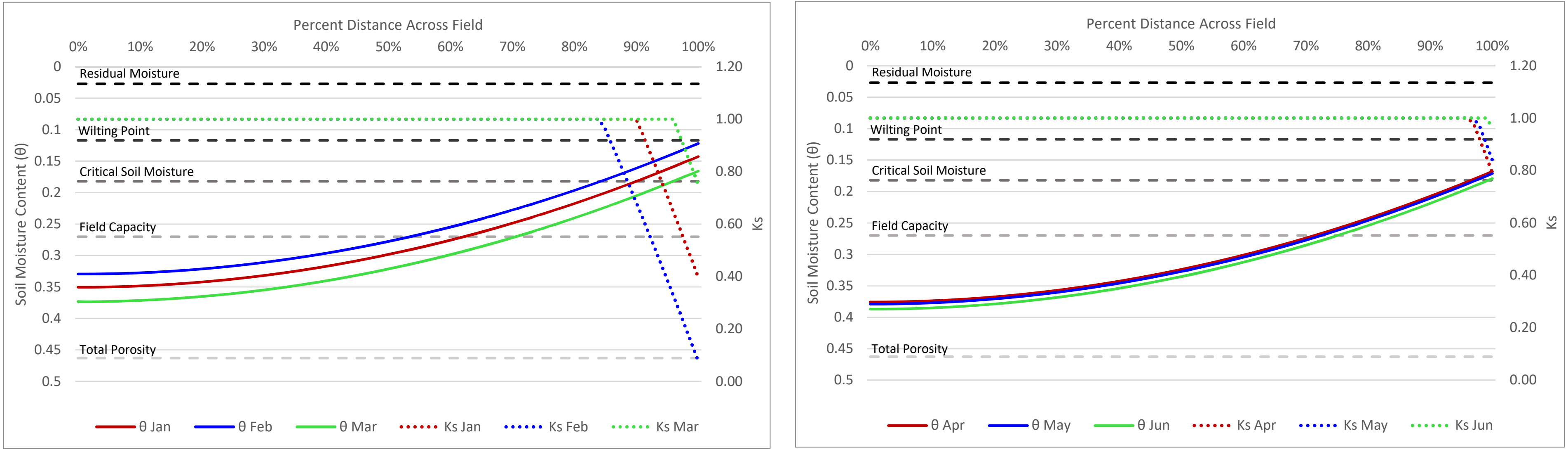


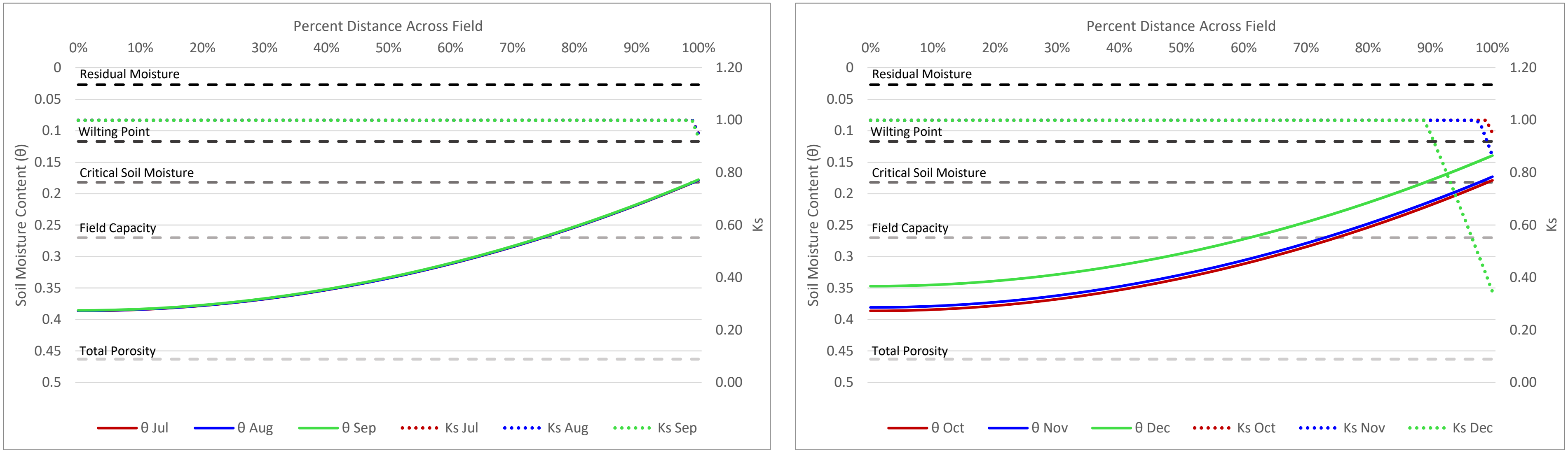
Figure 12-6

Monthly Simulated Soil Moisture (θ) and Water Stress Coefficient (Ks) Across Virtual Field
M&A Soil Water Balance Model
Mesilla In District
1995



January - March

April - June

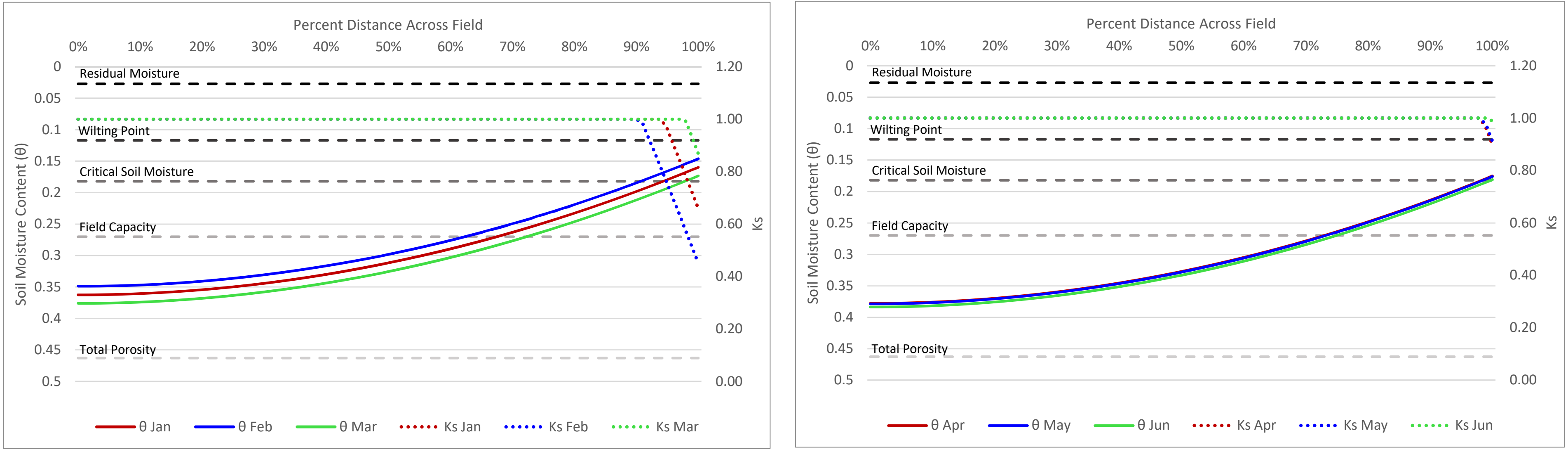


July - September

October - December

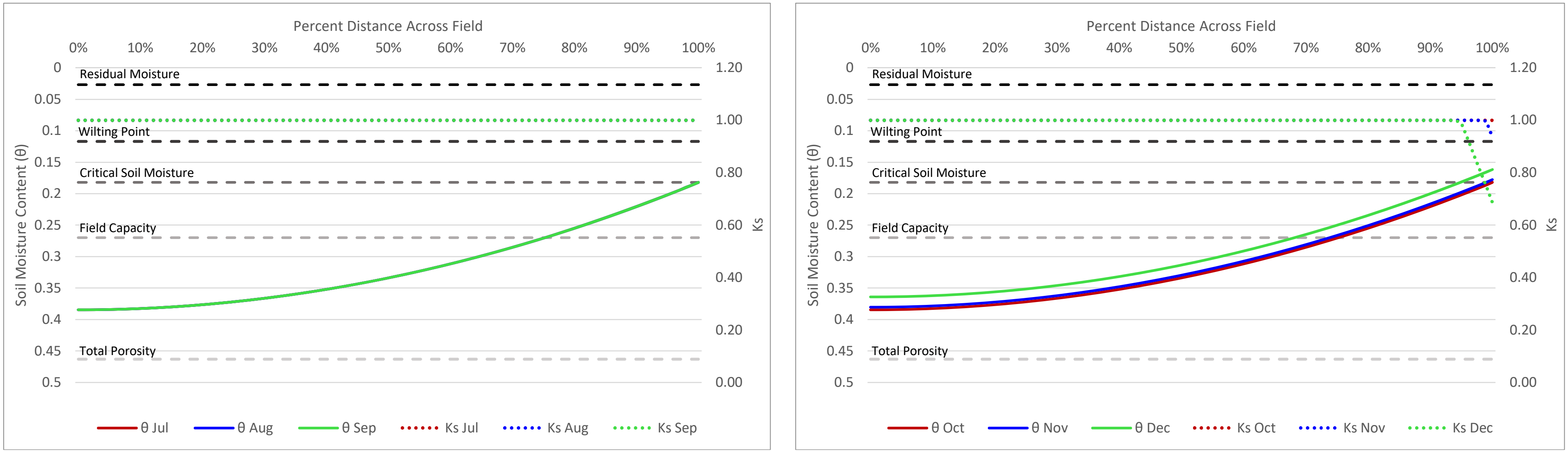
Figure 12-6

Monthly Simulated Soil Moisture (θ) and Water Stress Coefficient (Ks) Across Virtual Field
M&A Soil Water Balance Model
Mesilla In District
2005



January - March

April - June



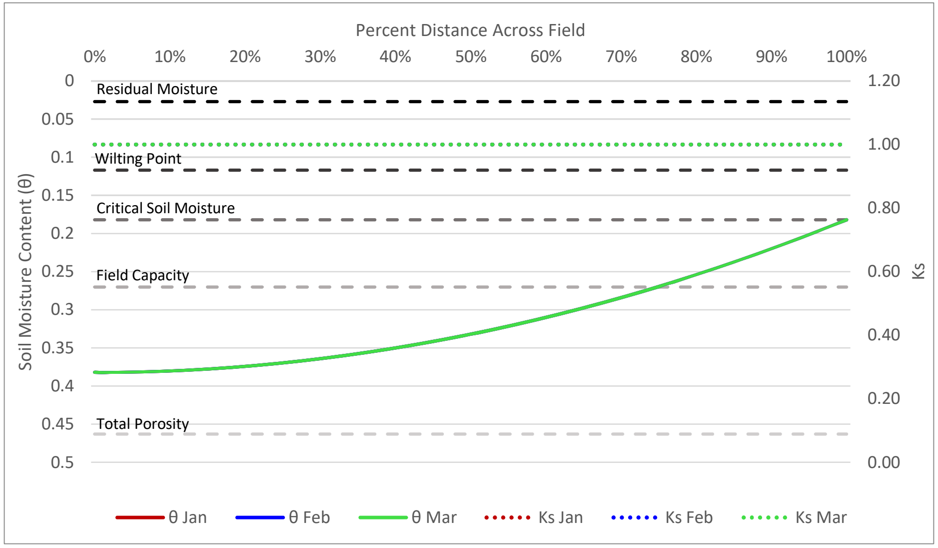
July - September

October - December

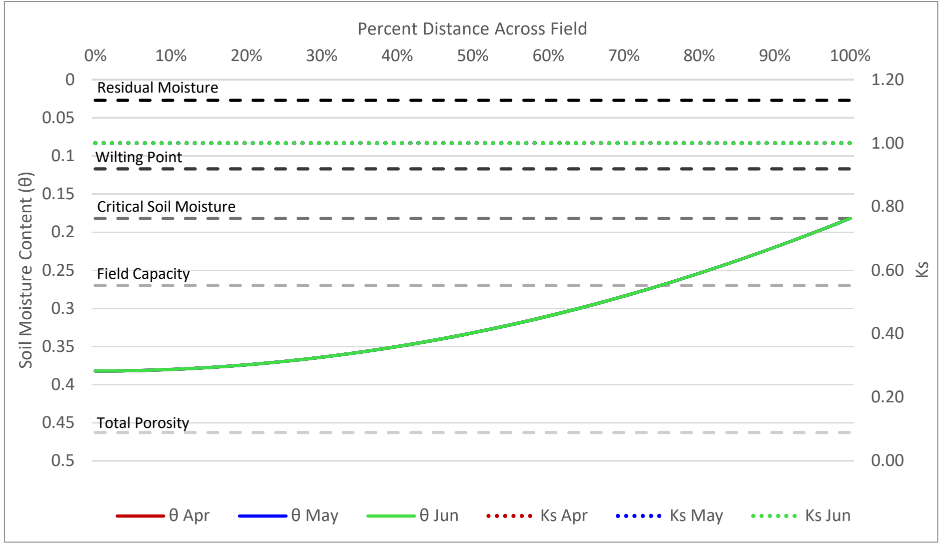
Figure 12-6

Monthly Simulated Soil Moisture (θ) and Water Stress Coefficient (Ks) Across Virtual Field
M&A Soil Water Balance Model
Mesilla In District
2015

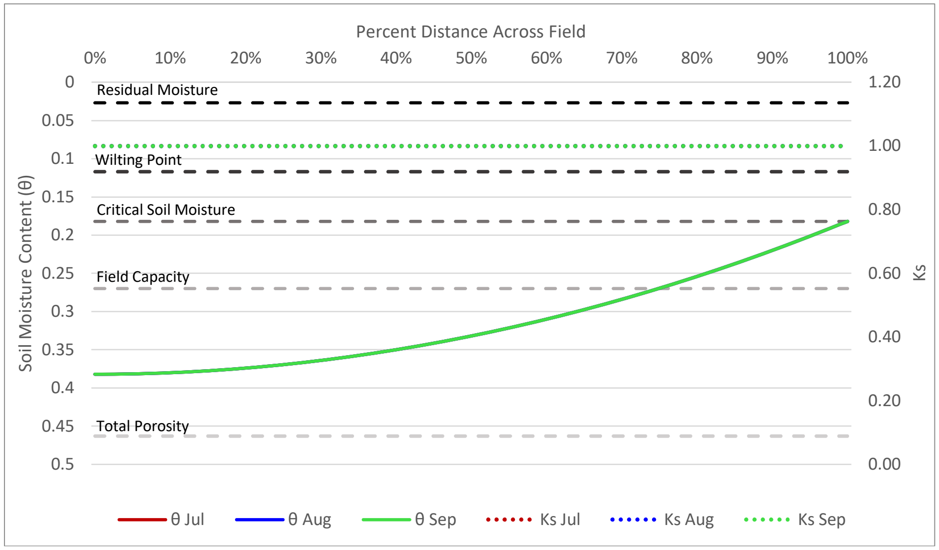
January - March



April - June



July - September



October - December

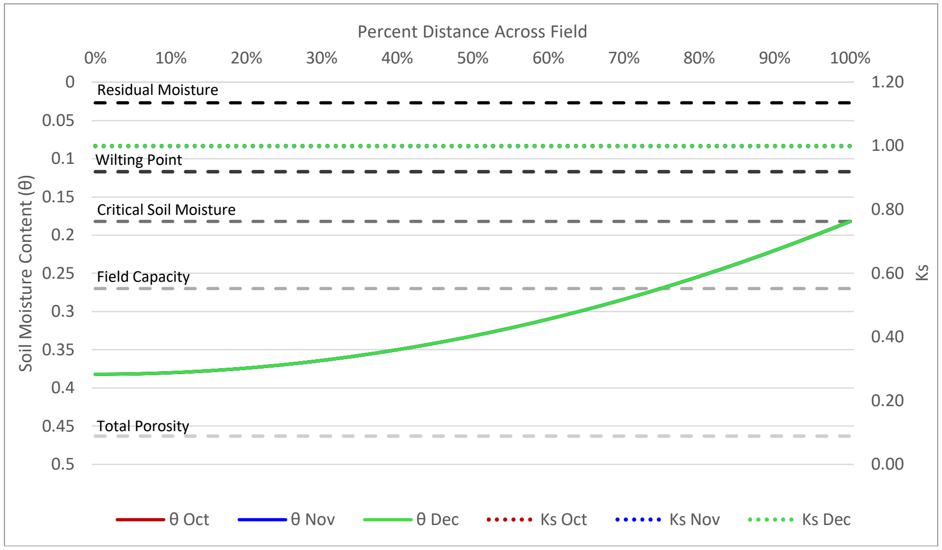
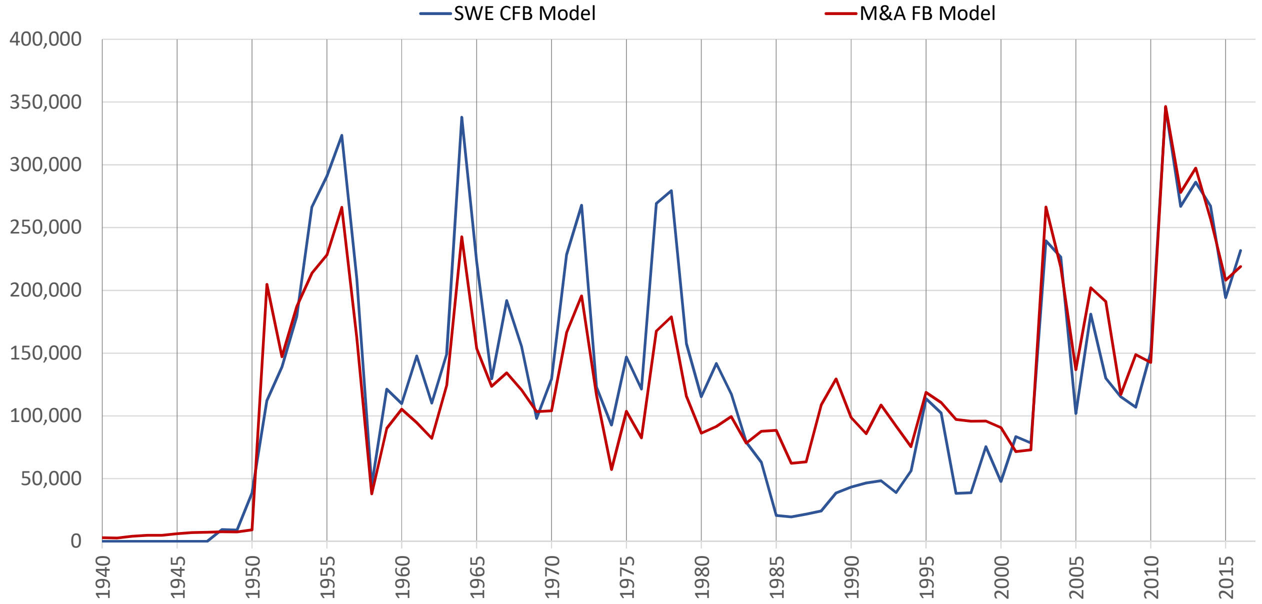


Figure 12-7

Comparison of Annual Quantities
SWE Farm Budget vs. M&A Farm Budget
1940-2016
Rincon-Mesilla

Total Irrigation Pumping (AF/y) [1]



	SWE	M&A	Difference	% Diff
Average 1951-2016	143,207	140,127	-3,080	-2.2%
Average 1951-1984	166,825	133,926	-32,900	-19.7%
Average 1985-2016	118,113	146,715	28,602	24.2%

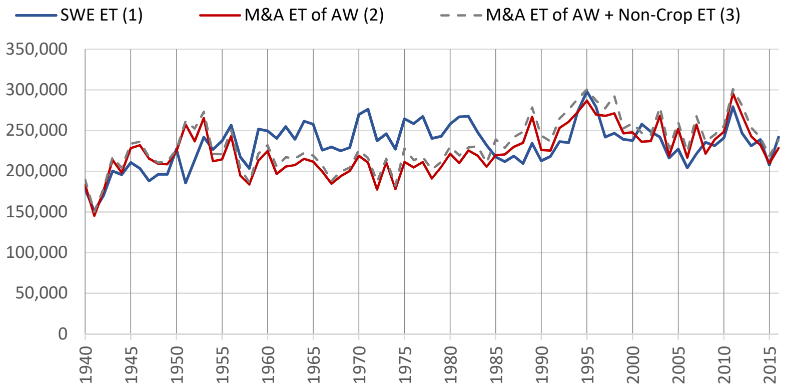
Note:

(1) Sum of supplemental and primary groundwater pumping for Rincon Basin and Mesilla Basin, including Texas Mesilla.

Figure 12-8

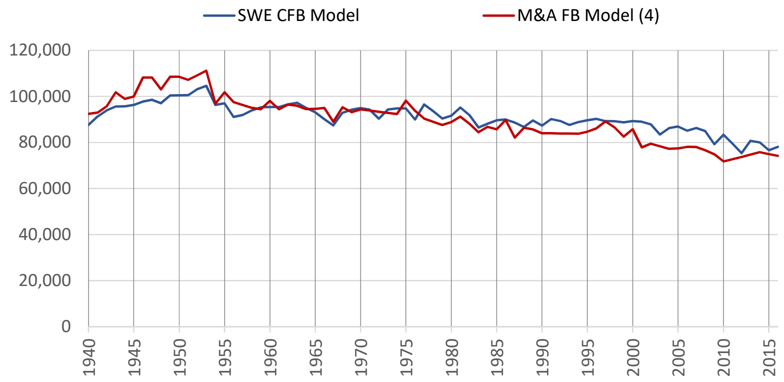
Comparison of Annual Quantities
SWE Farm Budget vs. M&A Farm Budget
1940-2016
Rincon-Mesilla

Actual ET Volume (AF/y)



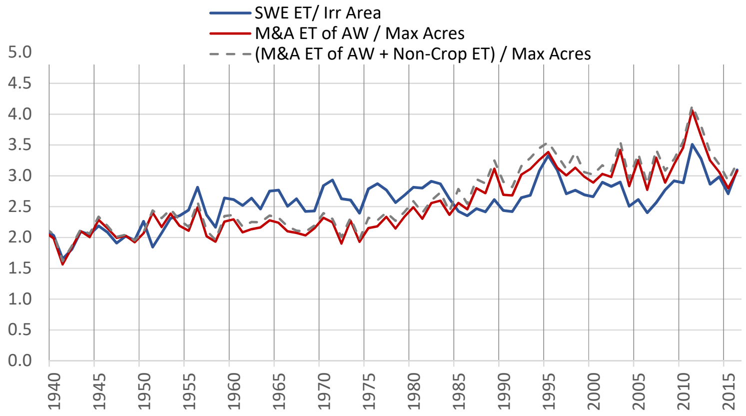
	(1) SWE	(3) M&A	Difference	% Diff
Average 1951-2016	239,858	237,240	-2,618	-1.1%
Average 1951-1984	242,628	218,300	-24,329	-10.0%
Average 1985-2016	236,916	257,364	20,449	8.6%

Irrigated Area (acres)



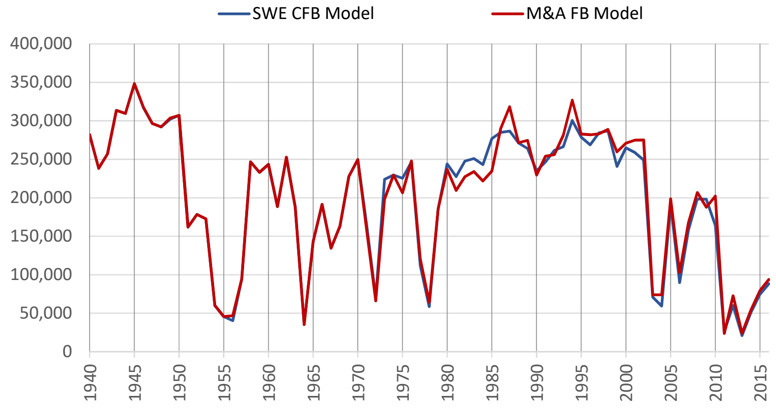
	SWE	M&A	Difference	% Diff
Average 1951-2016	90,092	87,907	-2,185	-2.4%
Average 1951-1984	94,077	94,747	670	0.7%
Average 1985-2016	85,857	80,639	-5,218	-6.1%

Unit ET (ft/y)



	(1) SWE	(3) M&A	Difference	% Diff
Average 1951-2016	2.67	2.74	0.07	2.5%
Average 1951-1984	2.58	2.31	-0.28	-10.8%
Average 1985-2016	2.77	3.20	0.43	15.7%

FHG Deliveries (AF/y)



	SWE	M&A	Difference	% Diff
Average 1951-2016	185,731	187,587	1,856	1.0%
Average 1951-1984	175,855	172,451	-3,404	-1.9%
Average 1985-2016	196,225	203,669	7,444	3.8%

Notes:

(1) SWE ET calculated as sum of Consumptive Use (CU) of Surface Water and Groundwater.

(2) M&A ET is CU of applied water.

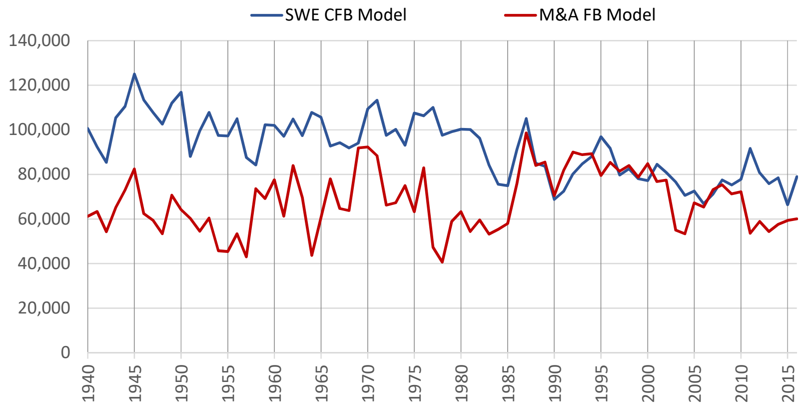
(3) Volume of bare ground ET within footprint of maximum monthly crop acres.

(4) M&A FB irrigated area is the maximum monthly crop acreage during each year.

Figure 12-9

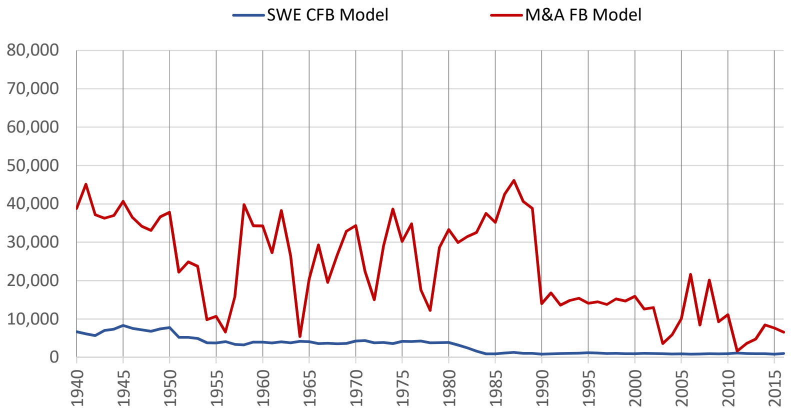
Comparison of Annual Quantities
SWE Farm Budget vs. M&A Farm Budget
1940-2016
Rincon-Mesilla

Deep Percolation of Applied Water (AF/y)



	SWE	M&A	Difference	% Diff
Average 1951-2016	89,588	68,435	-21,153	-23.6%
Average 1951-1984	98,442	63,802	-34,640	-35.2%
Average 1985-2016	80,182	73,358	-6,824	-8.5%

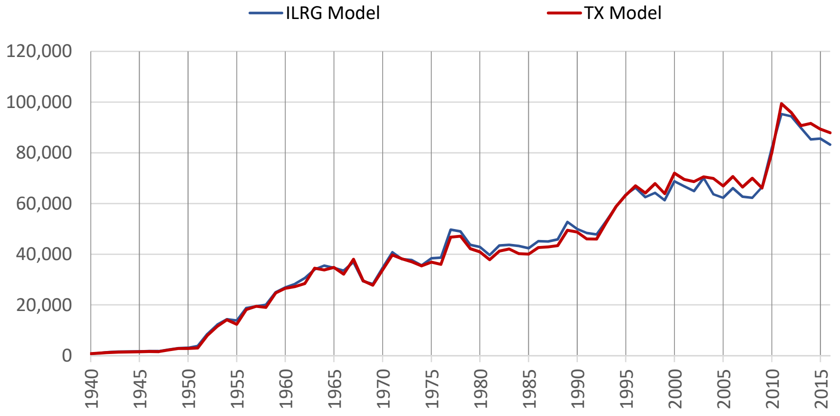
Surface Runoff of Applied Water (AF/y)



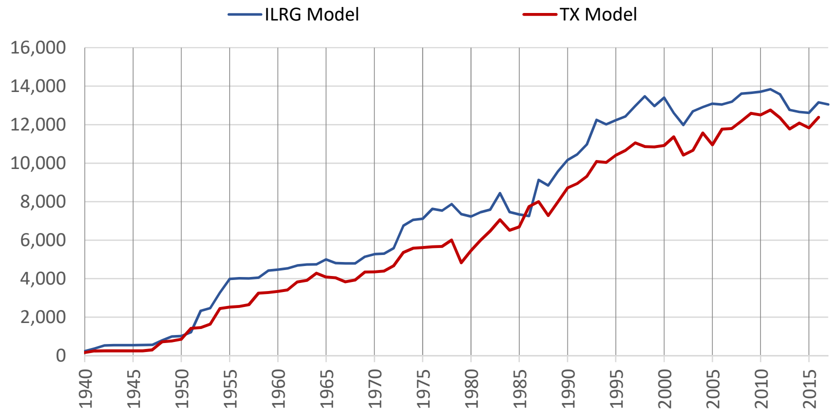
	SWE	M&A	Difference	% Diff
Average 1951-2016	2,442	21,072	18,630	762.9%
Average 1951-1984	3,785	25,771	21,985	580.8%
Average 1985-2016	1,015	16,080	15,065	1484.3%

Figure 12-10

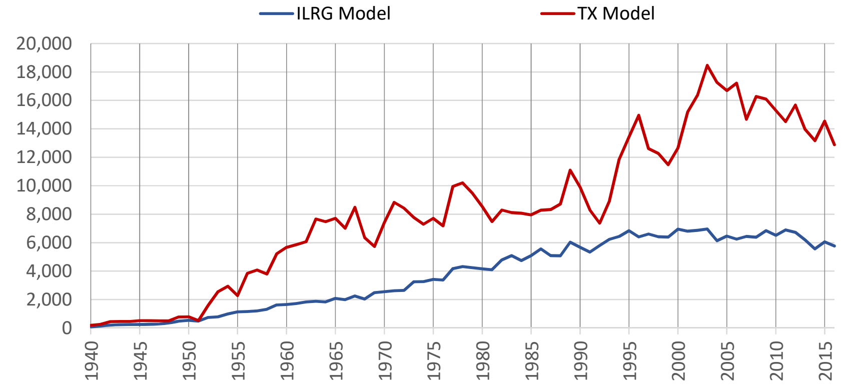
Comparison of Annual Quantities
Integrated LRG Model vs. Texas Model
1940-2016
Rincon-Mesilla


Non-Irrigation Pumping (AF/y)

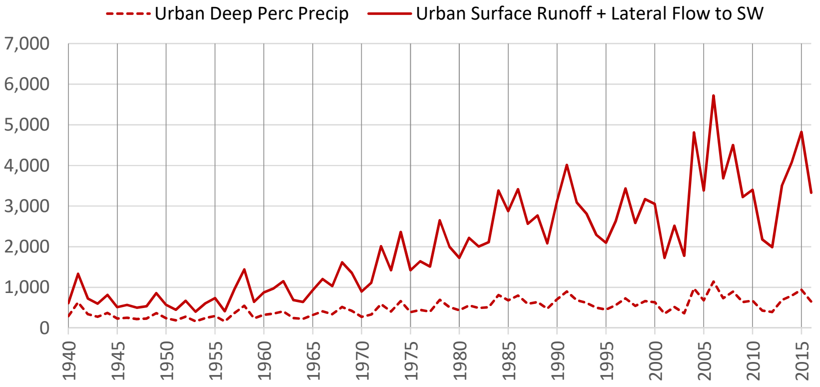
Averages	ILRG Model	TX Model	Difference	% Diff
1951-2016	47,729	47,889	161	0.3%
1951-1984	31,577	30,544	-1,033	-3.3%
1985-2016	64,890	66,319	1,429	2.2%


WWTP Discharge (AF/y)[1]

Averages	ILRG Model	TX Model	Difference	% Diff
1951-2016	8,601	7,310	-1,291	-15.0%
1951-1984	5,385	4,232	-1,153	-21.4%
1985-2016	12,017	10,580	-1,437	-12.0%


Urban Deep Percolation (AF/y)

Averages	ILRG Model	TX Model	Difference	% Diff
1951-2016	4,313	9,637	5,324	123.5%
1951-1984	2,527	6,458	3,931	155.6%
1985-2016	6,211	13,016	6,805	109.6%


Urban Deep Percolation and SurfaceRunoff from Precipitation (TX Model) (AF/y)

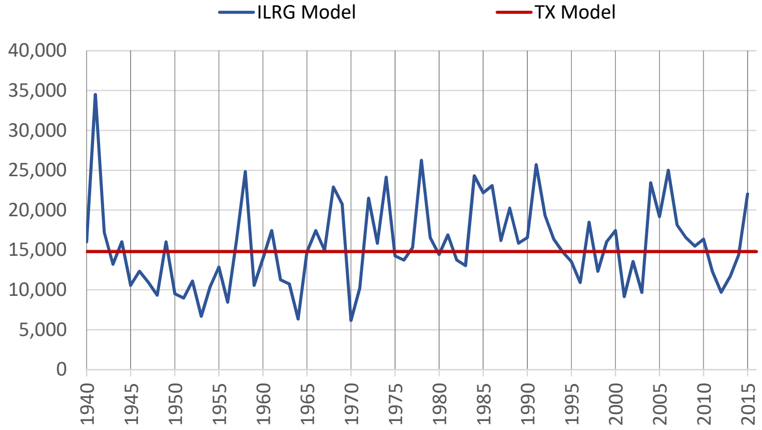
Averages	Urban DP Precip (TX Model)	Urban SRO (TX Model)
1951-2016	524	2,211
1951-1984	398	1,331
1985-2016	657	3,146

Note:

(1) WWTP discharges does not include Northwest Plant.

Figure 12-11

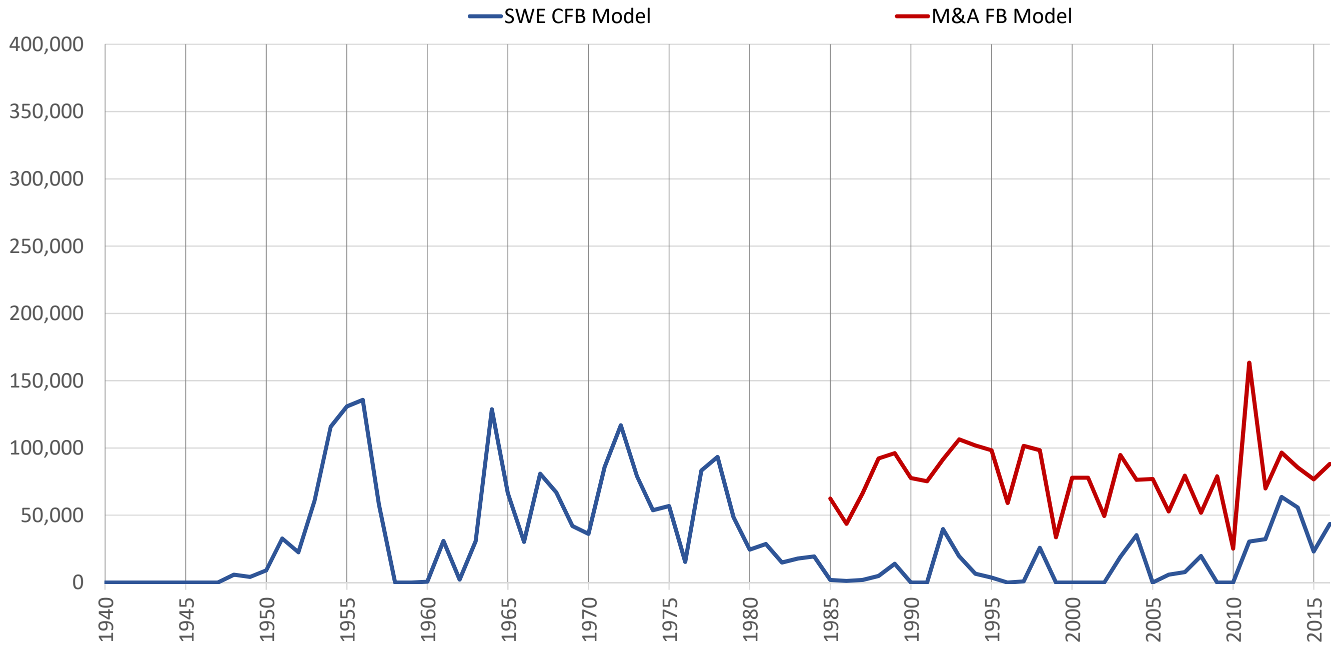
Comparison of Annual Quantities
Integrated LRG Model vs. Texas Model
1940-2016
Rincon-Mesilla
Mountain Front Recharge (AF)



	ILRG Model	Difference	% Diff
Average 1951-2016	15,724	-932	-5.9%
Average 1951-1984	14,912	-120	-0.8%
Average 1985-2016	16,587	-1,795	-10.8%

Figure 12-12

Comparison of Annual Quantities
SWE Farm Budget vs. M&A Farm Budget
1940-2016
El Paso Valley
Total Irrigation Pumping (AF/y) [1]



Averages	SWE	M&A	Difference	% Diff
1951-2016	34,340			
1985-2016	14,258	78,941	64,683	453.7%

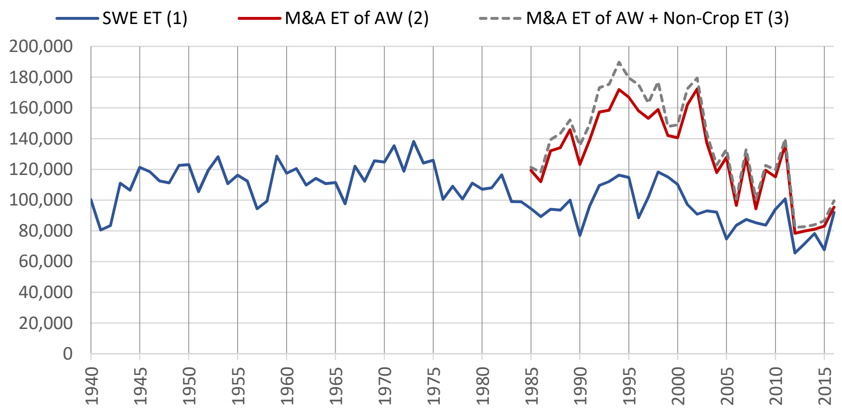
Note:

(1) Supplemental pumping for El Paso Valley.

Figure 12-13

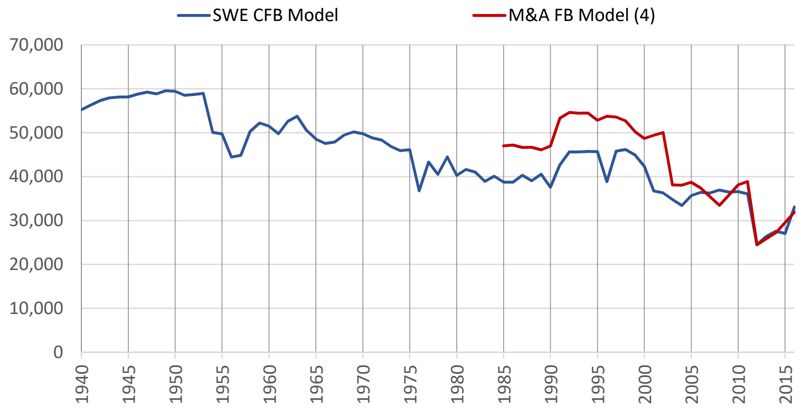
Comparison of Annual Quantities
SWE Farm Budget vs. M&A Farm Budget
1940-2016
El Paso Valley

Actual ET Volume (AF/y)



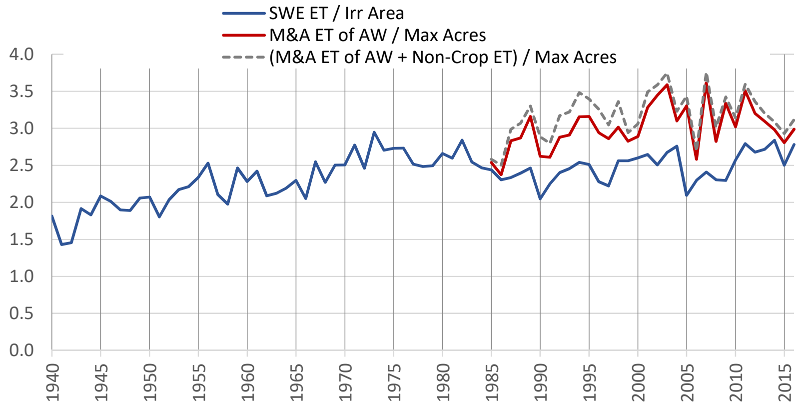
	(1)	(3)		
Averages	SWE	M&A	Difference	% Diff
1951-2016	103,997			
1985-2016	93,408	137,228	43,820	46.9%

Irrigated Area (acres)



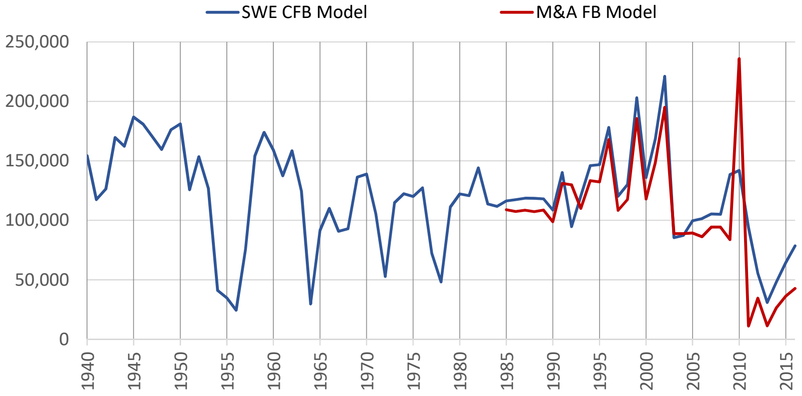
Averages	SWE	M&A	Difference	% Diff
1951-2016	42,952			
1985-2016	37,895	43,174	5,279	13.9%

Unit ET (ft/y)



	(1)	(3)		
Averages	SWE	M&A	Difference	% Diff
1951-2016	2.44			
1985-2016	2.48	3.18	0.71	28.6%

FHG Deliveries (AF/y)



Averages	SWE	M&A	Difference	% Diff
1951-2016	112,196			
1985-2016	116,818	104,402	-12,417	-10.6%

Notes:

(1) SWE ET calculated as sum of Consumptive Use (CU) of Surface Water and Groundwater.

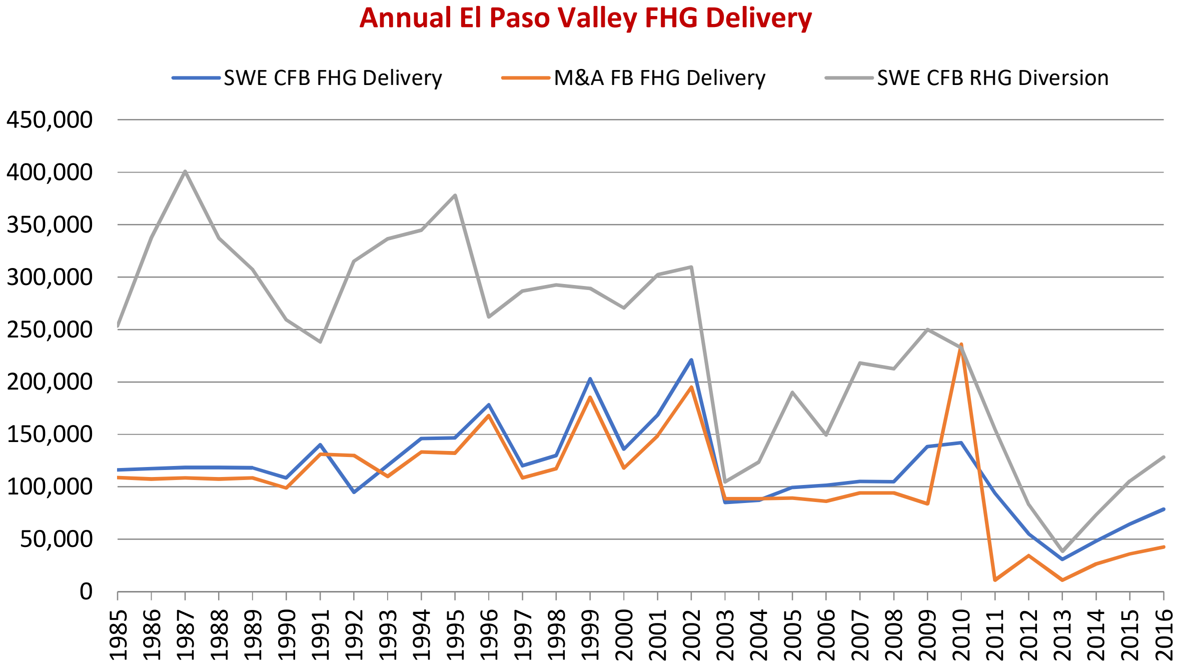
(2) M&A ET is CU of applied water.

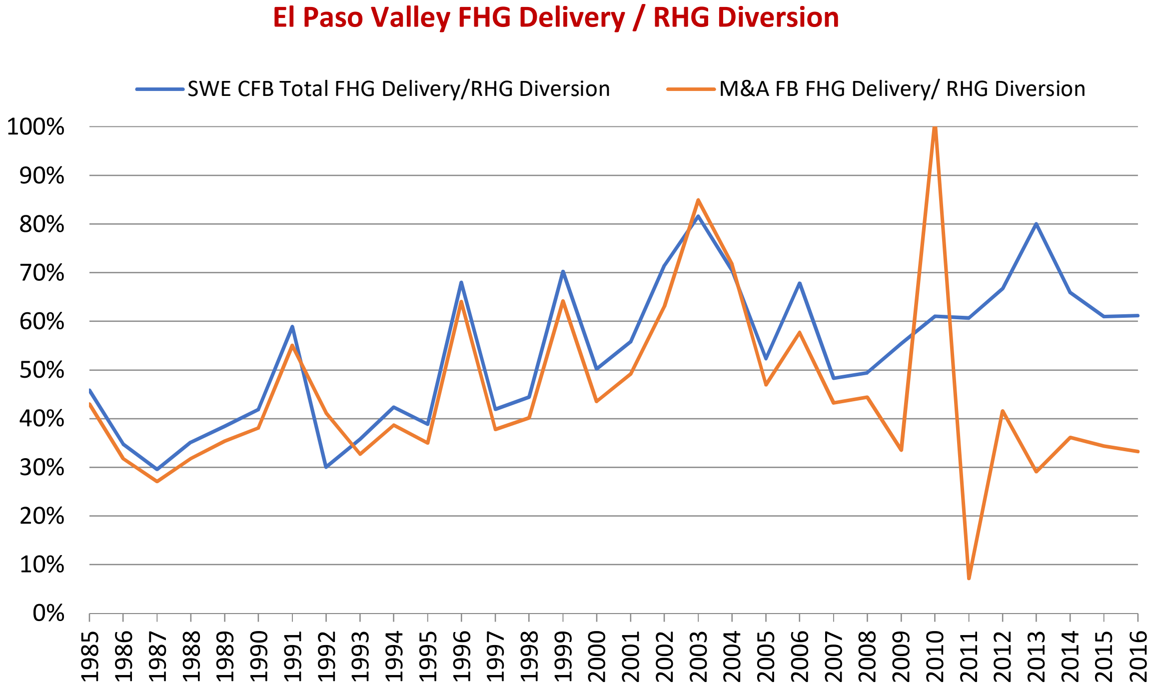
(3) Volume of bare ground ET within footprint of maximum monthly crop acres.

(4) M&A FB irrigated area is the maximum monthly crop acreage during each year.

Figure 12-14

Comparison of Annual FHG Deliveries
SWE Farm Budget vs. M&A Farm Budget
1985 - 2016





Notes:

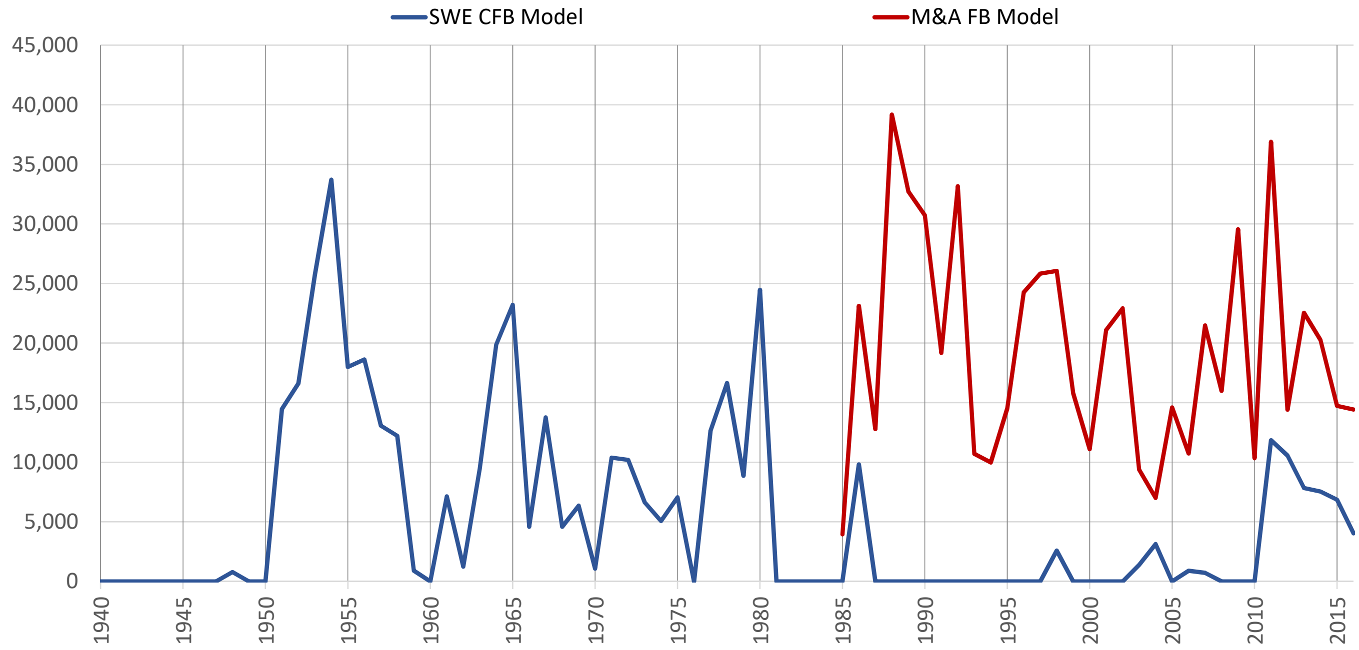
El Paso RHG Diversion is equal to Franklin Canal diversions minus Ascarate Wasteway (Pre-1999) plus Riverside Canal diversions.

Figure 12-15

Comparison of Annual Quantities
SWE Farm Budget vs. M&A Farm Budget
1940-2016

Hudspeth

Total Irrigation Pumping (AF/y) [1]



Averages	SWE	M&A	Difference	% Diff
1951-2016	6,270			
1985-2016	2,100	19,356	17,255	821.5%

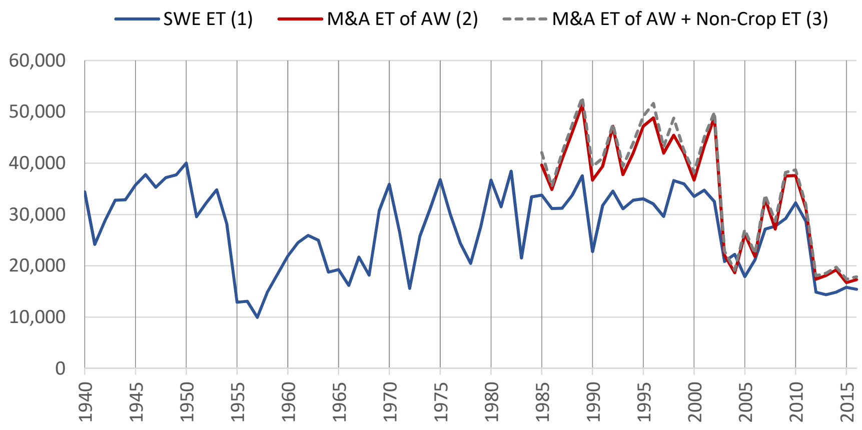
Notes:

(1) Supplemental pumping for Hudspeth.

Figure 12-16

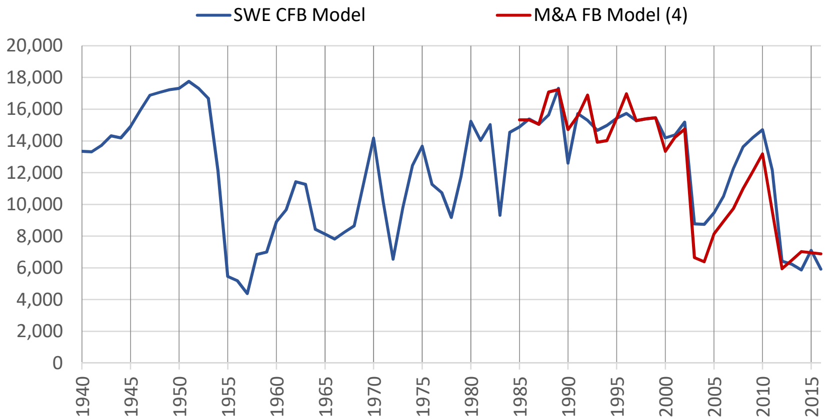
Comparison of Annual Quantities
SWE Farm Budget vs. M&A Farm Budget
1940-2016
Hudspeth

Actual ET Volume (AF/y)



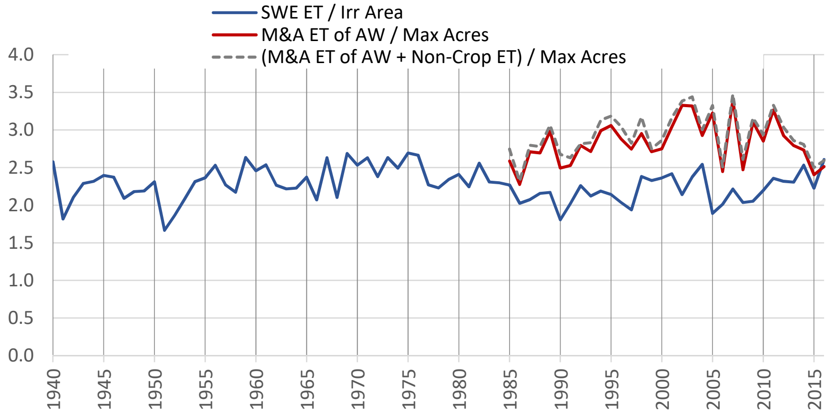
	(1)	(3)		
Averages	SWE	M&A	Difference	% Diff
1951-2016	26,402			
1985-2016	27,840	36,050	8,210	29.5%

Irrigated Area (acres)



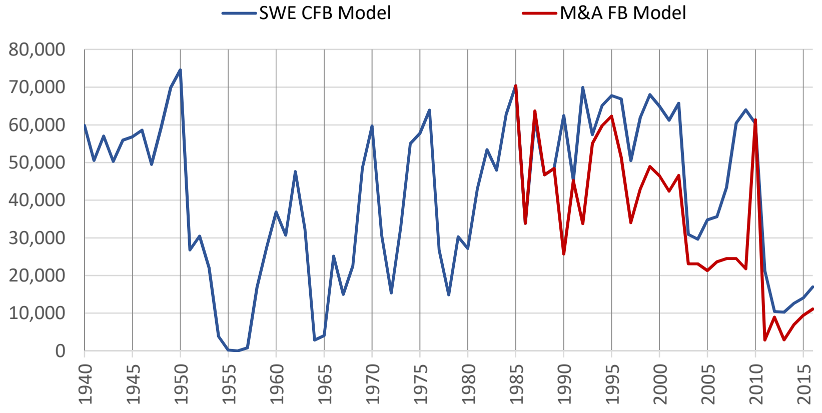
Averages	SWE	M&A	Difference	% Diff
1951-2016	11,713			
1985-2016	12,766	12,341	-426	-3.3%

Unit ET (ft/y)



	(1)	(3)		
Averages	SWE	M&A	Difference	% Diff
1951-2016	2.28			
1985-2016	2.20	2.93	0.73	33.0%

FHG Deliveries (AF/y)



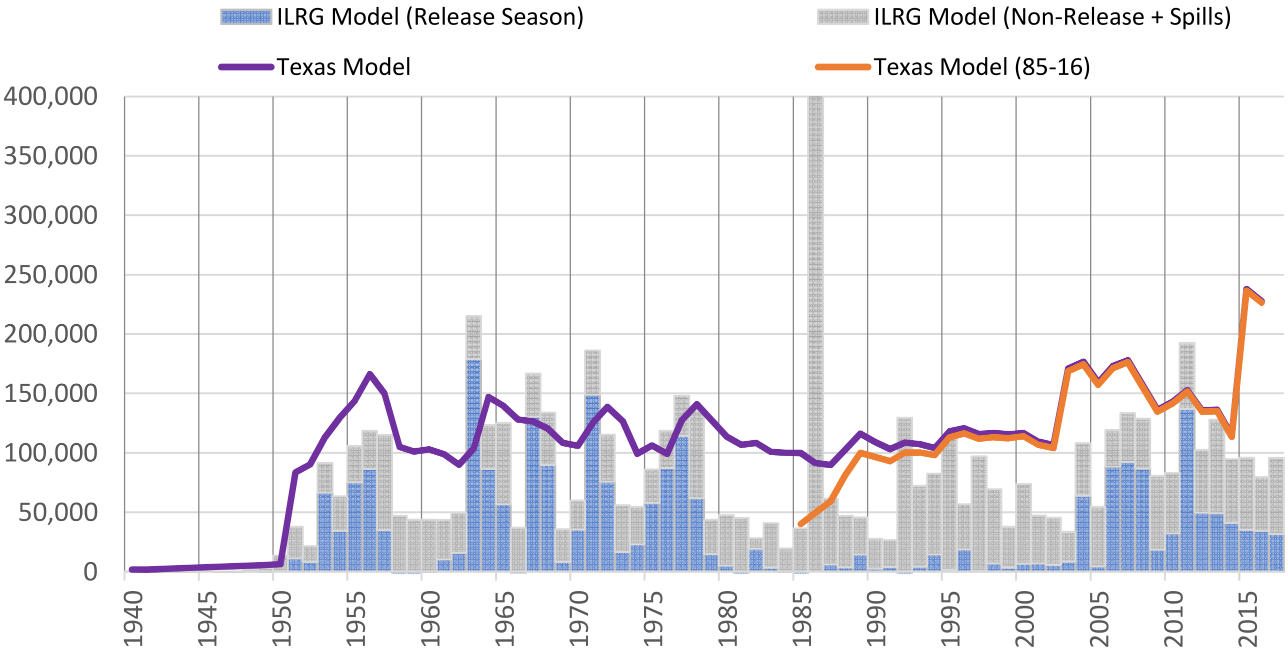
Averages	SWE	M&A	Difference	% Diff
1951-2016	38,307			
1985-2016	47,270	35,095	-12,175	-25.8%

Notes:

(1) SWE ET calculated as sum of Consumptive Use (CU) of Surface Water and Groundwater.
(2) M&A ET is CU of applied water.
(3) Volume of bare ground ET within footprint of maximum monthly crop acres.
(4) M&A FB irrigated area is the maximum monthly crop acreage during each year.

Figure 13-1

Annual Impact of Pumping on Rio Grande at El Paso Flows
Integrated LRG Model (No R-M Pumping)
vs.
Texas Model (100% Reduction in R-M Pumping)
(acre-feet)



Averages	(1) ILRG Model (No R-M Pump)	(2) Texas Model (100% Reduction)	(3) Texas Model 85-16 (100% Reduction)
1985 - 2016 Annual (af):	93,910	132,866	124,658
1951 - 2016 Annual (af):	87,697	124,667	
1985 - 2016 Release Season (af):	25,098		
1951 - 2016 Release Season (af):	35,448		

Notes:

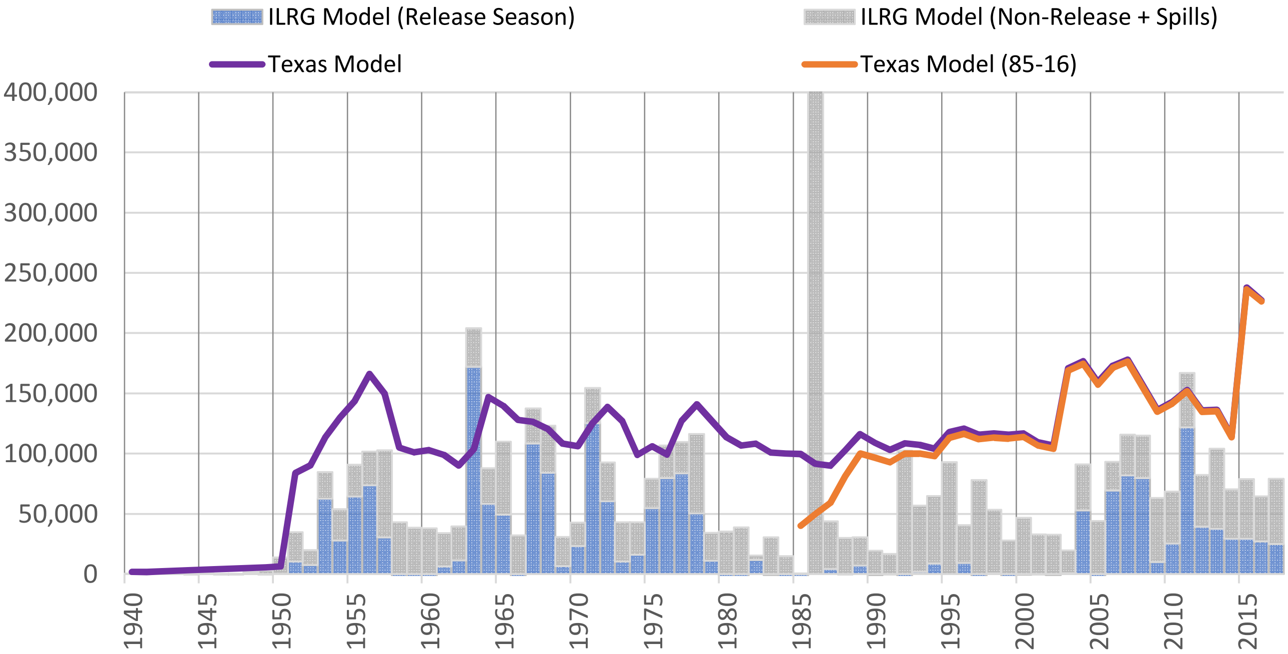
(1) ILRG Model change is computed as flows in Run 6 (no Rincon-Mesilla pumping) minus Run 1 (Historical Base Run).

(2) Texas Model (1938 - 2016 run) change is computed as the simulated flows with reduced pumping (100%) minus flows with no pumping reduction (historical simulation).

(3) Texas Model (1985 - 2016 run) change is computed as the simulated flows with reduced pumping (100%) minus flows with no pumping reduction (historical simulation).

Figure 13-2

Annual Impact of Pumping on Rio Grande at El Paso Flows
Integrated LRG Model (No NM Pumping)
vs.
Texas Model (100% Reduction in R-M Pumping)
(acre-feet)



Averages	(1) ILRG Model (No NM Pump)	(2) Texas Model (100% Reduction)	(3) Texas Model 85-16 (100% Reduction)
1985 - 2016 Annual (af):	74,402	132,866	124,658
1951 - 2016 Annual (af):	71,169	124,667	
1985 - 2016 Release Season (af):	17,560		
1951 - 2016 Release Season (af):	27,523		

Notes:

(1) ILRG Model change is computed as flows in Run 3 (no New Mexico pumping) minus Run 1 (Historical Base Run).

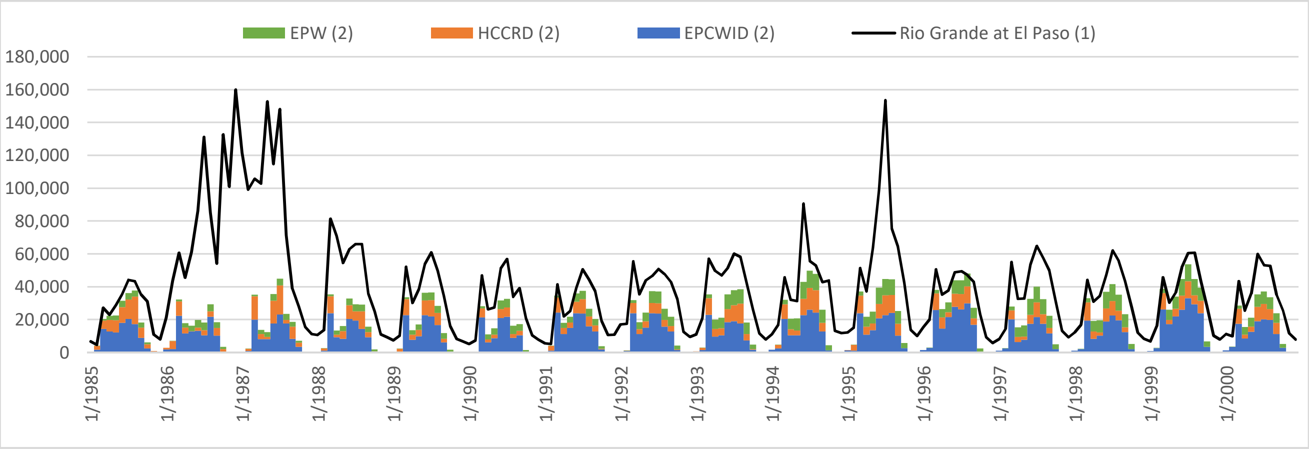
(2) Texas Model (1938 - 2016 run) change is computed as the simulated flows with reduced pumping (100%) minus flows with no pumping reduction (historical simulation).

(3) Texas Model (1985 - 2016 run) change is computed as the simulated flows with reduced pumping (100%) minus flows with no pumping reduction (historical simulation).

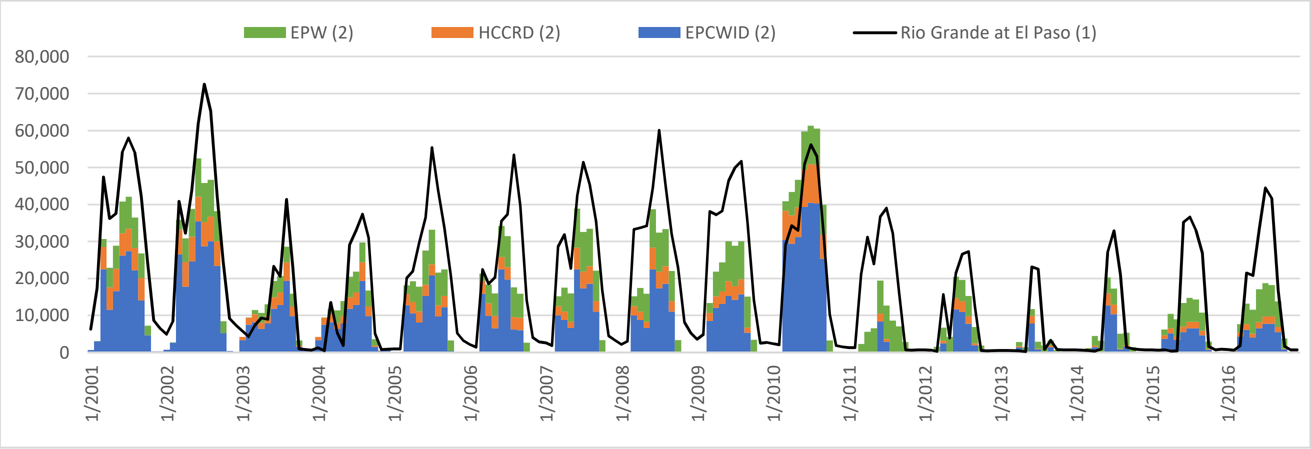
Figure 14-1

Historical Adjusted Rio Grande at El Paso Flows and Texas Deliveries
Dorrance Analysis
(acre-feet)

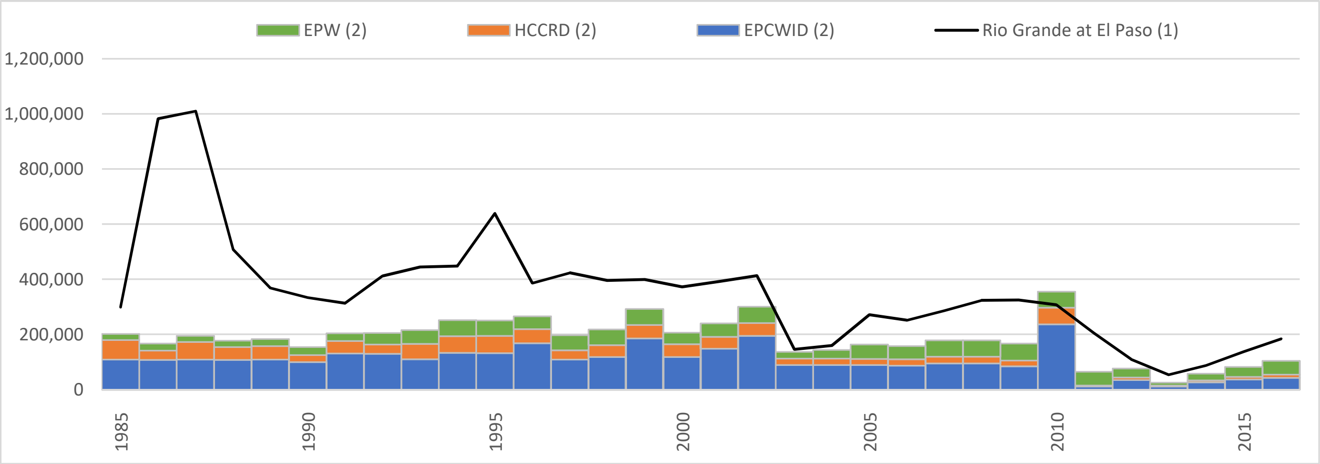
Monthly (1985-2000)



Monthly (2001-2016)



Annual (1985-2016)



Notes:

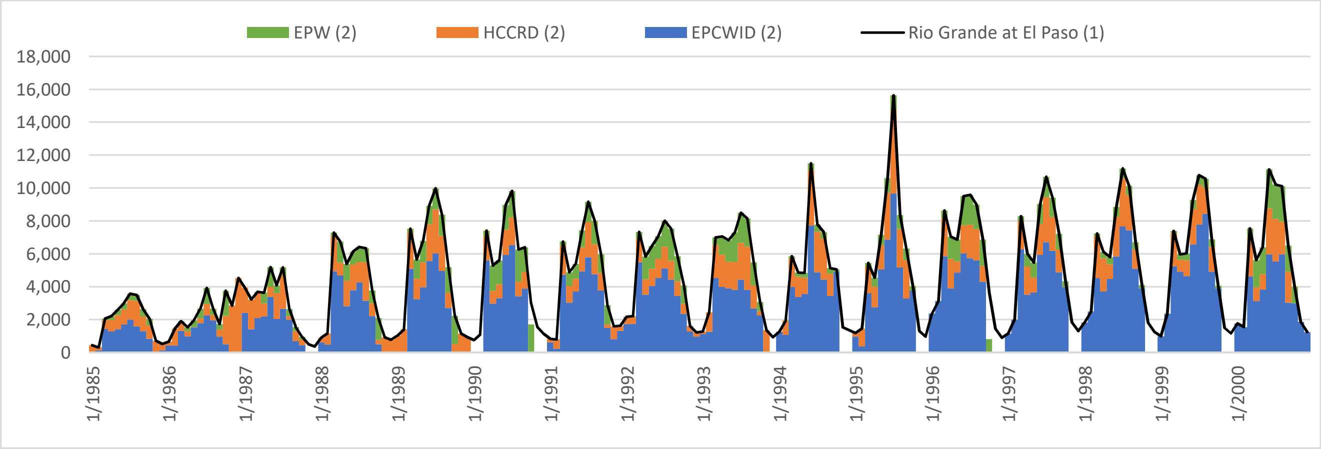
(1) Rio Grande at El Paso is equal to historical Rio Grande at El Paso flow minus Acequia Madre diversions.

(2) Actual and estimated deliveries to Texas water users.

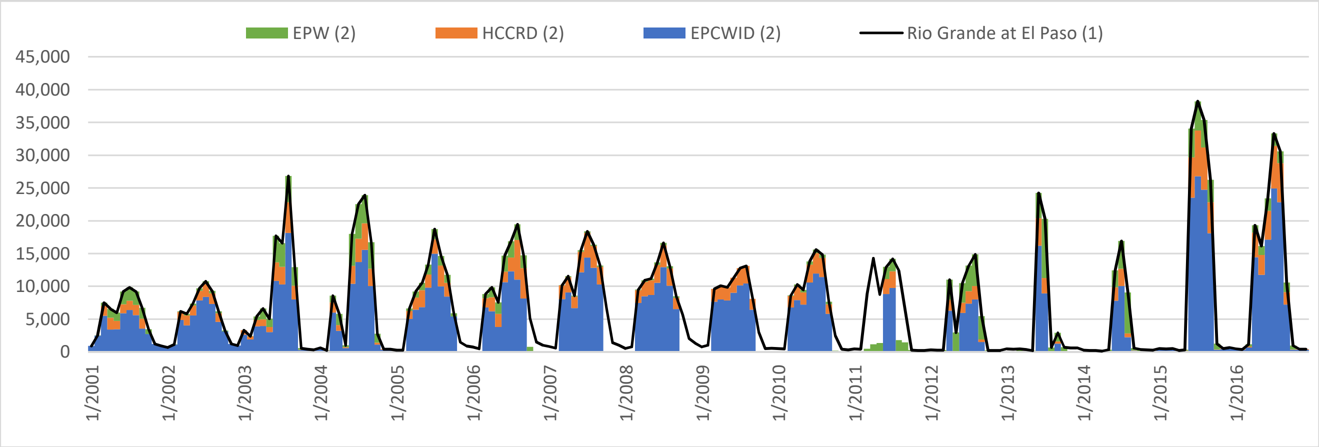
Figure 14-2

Increased Rio Grande at El Paso Flow and Amounts Made Available to Texas Water Users
Dorrance Analysis
(acre-feet)

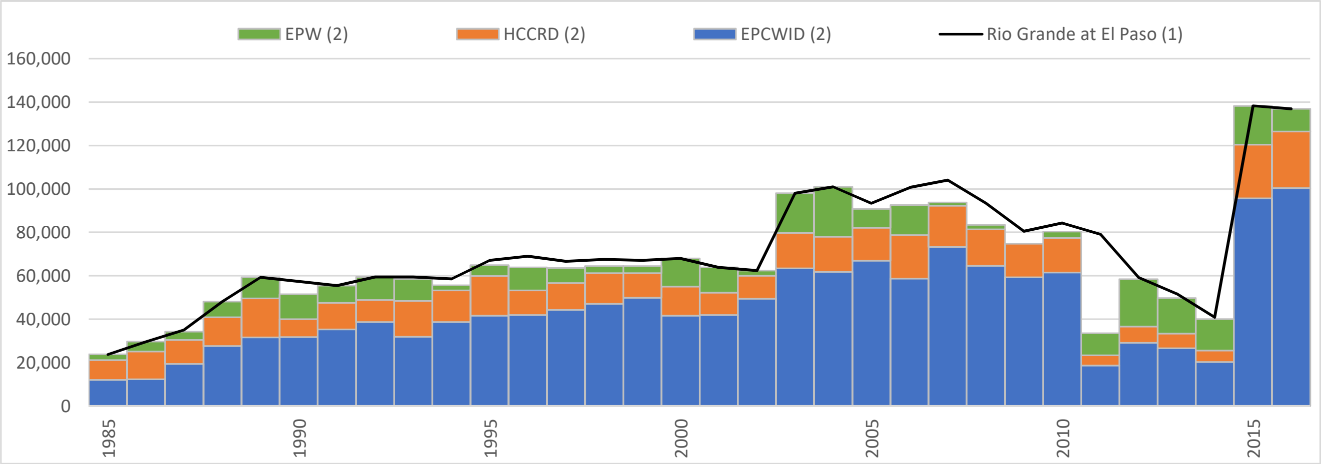
Monthly (1985-2000)



Monthly (2001-2016)



Annual (1985-2016)



Notes:

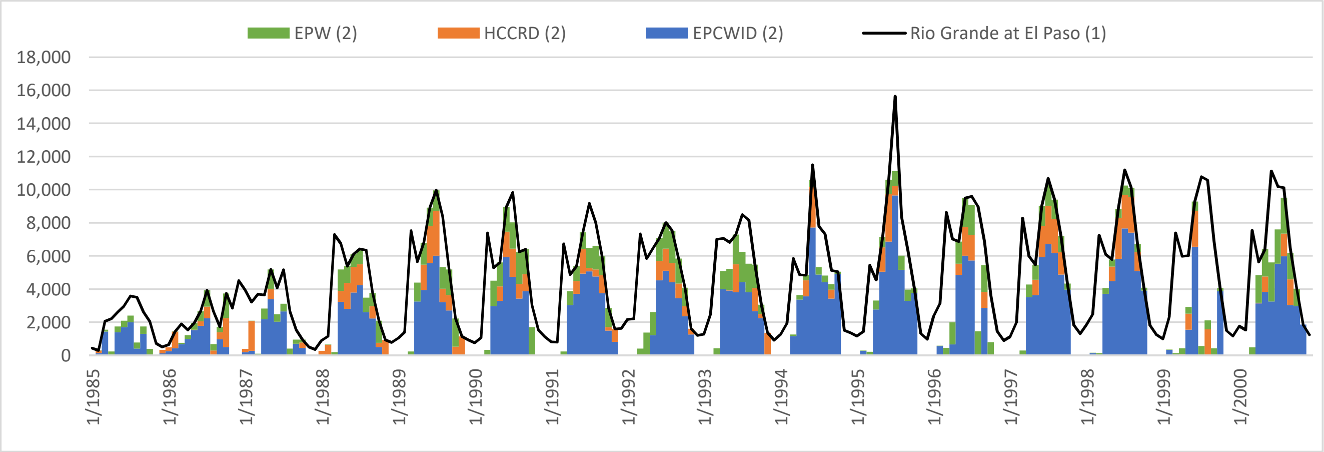
(1) Increased Rio Grande at El Paso flow in 60% Rincon-Mesilla pumping reduction scenario simulated in Texas Model.

(2) Amounts of increased Rio Grande at El Paso flow made available for delivery to Texas water users.

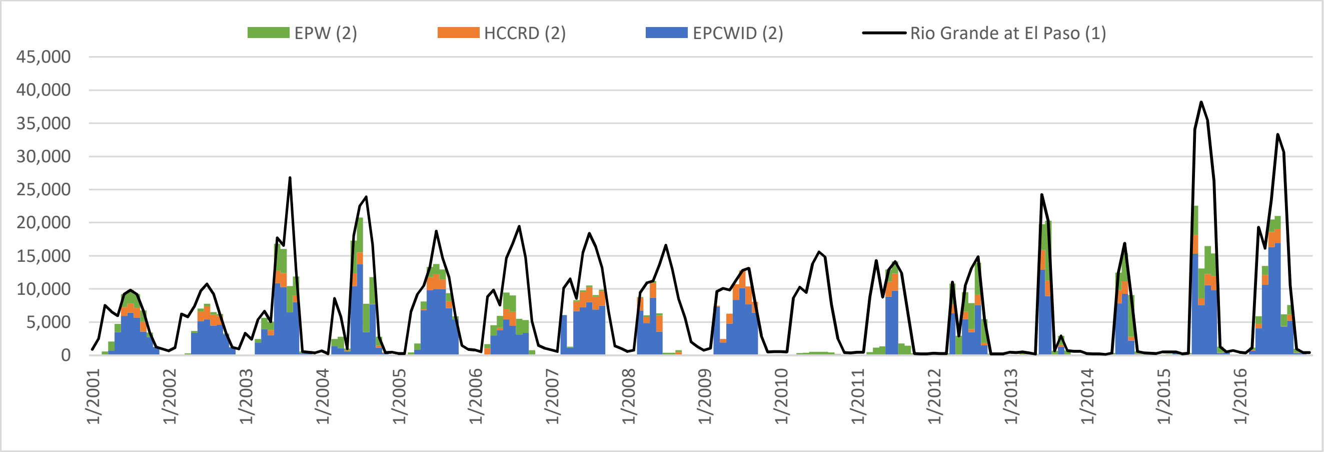
Figure 14-3

Increased Rio Grande at El Paso Flow and Increased Deliveries to Texas Water Users
Dorrance Analysis
(acre-feet)

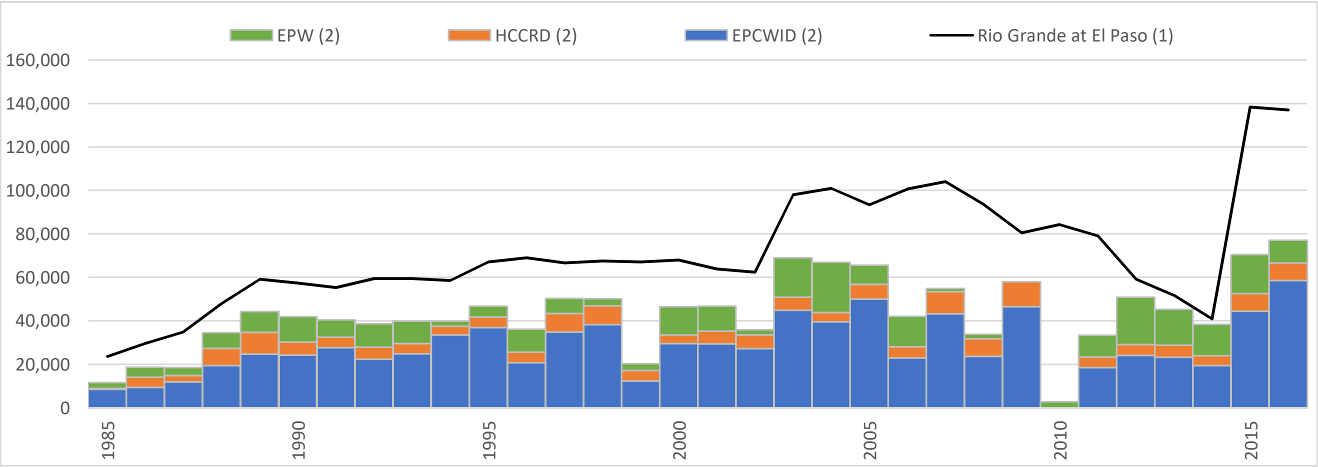
Monthly (1985-2000)



Monthly (2001-2016)



Annual (1985-2016)



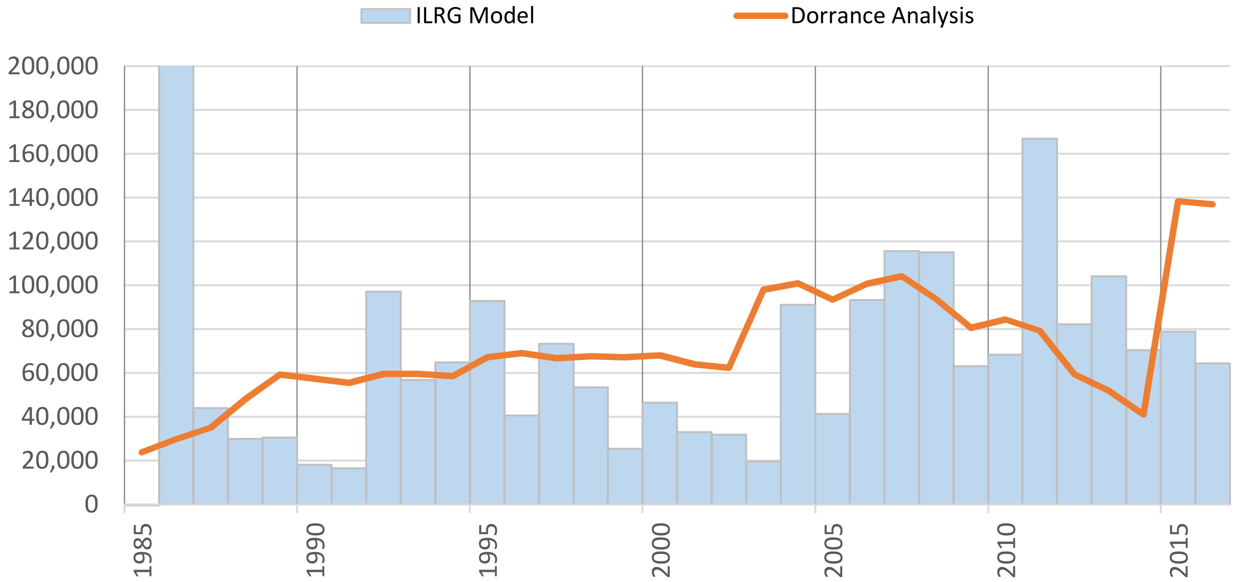
Notes:

(1) Increased Rio Grande at El Paso flow in 60% Rincon-Mesilla pumping reduction scenario simulated in Texas Model.

(2) Amounts of increased Rio Grande at El Paso flow assumed delivered to Texas water users to replace historical pumping.

Figure 14-4

Annual Impact of Pumping on Rio Grande at El Paso Flows
Integrated LRG Model (No NM Pumping)
vs.
Dorrance (60% Reduction in R-M Pumping)
(acre-feet)



	(1) ILRG Model (No NM Pump)	(2) Dorrance (60% Reduction)
1985 - 2016 Average Annual (af):	74,402	71,232

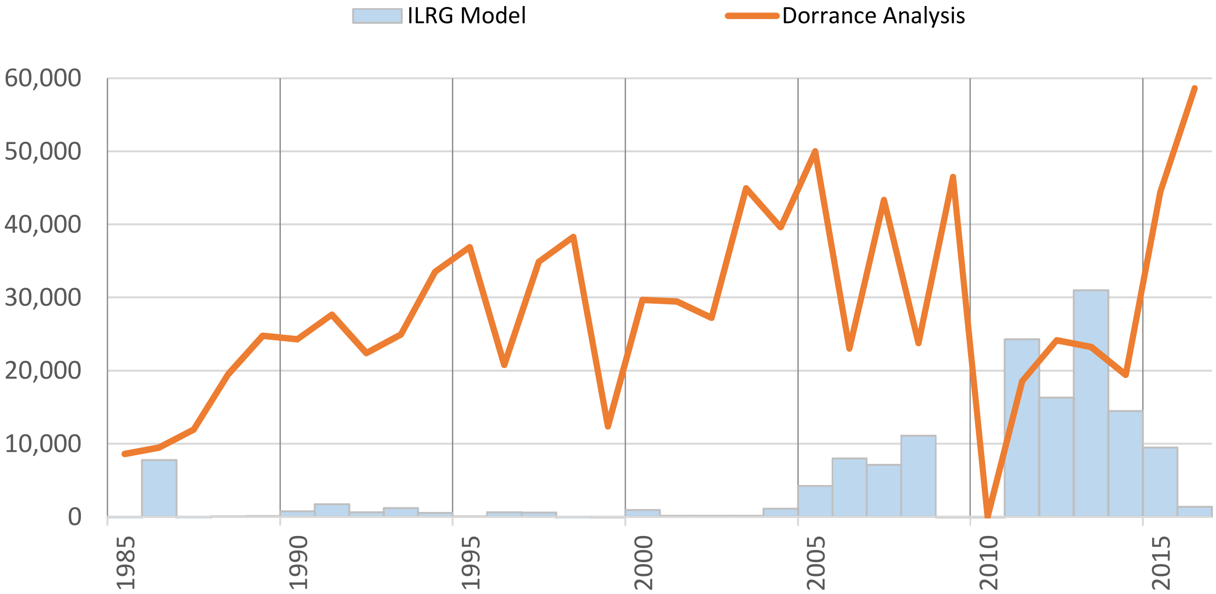
Notes:

(1) ILRG Model change computed as flows in Run 3 (no New Mexico pumping) minus Run 1 (all pumping on).

(2) Dorrance change computed as the increase in El Paso gage flows (Texas Model simulation of 60% reduction in R-M pumping minus historical El Paso gage flows) from 1985 - 2016 only.

Figure 14-5

Annual Impact of Pumping on EPCWID Irrigation Deliveries
Integrated LRG Model (No NM Pumping)
vs.
Dorrance (60% Reduction in R-M Pumping)
(acre-feet)



	(1) ILRG Model (No NM Pump)	(2) Dorrance (60% Reduction)
1985 - 2016 Average Annual (af):	4,084	28,007

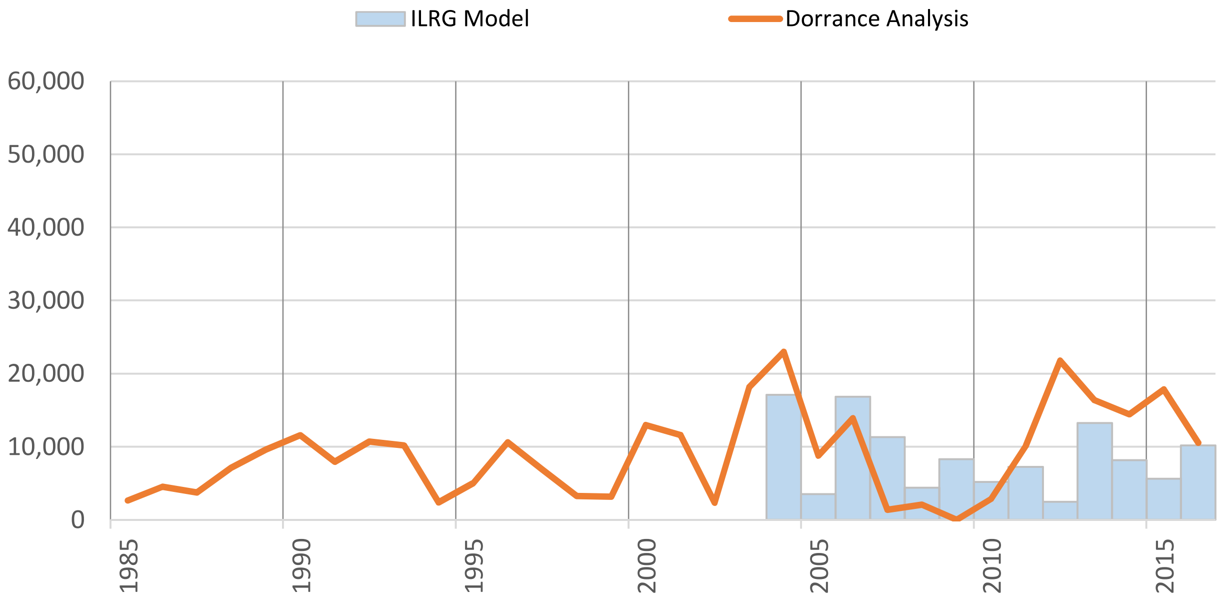
Notes:

(1) ILRG Model change computed as the El Paso Valley EPCWID farm deliveries in Run 3 (no New Mexico pumping) minus Run 1 (all pumping on).

(2) Dorrance change computed as the increase in El Paso gage flows (Texas Model simulation of 60% reduction in R-M pumping minus historical El Paso gage flows) distributed monthly using historical ratios of monthly to annual El Paso flows and ratios to historical EPCWID El Paso Valley deliveries.

Figure 14-6

Annual Impact of Pumping on EPW Deliveries
Integrated LRG Model (No NM Pumping)
vs.
Dorrance (60% Reduction in R-M Pumping)
(acre-feet)



	(1) ILRG Model (No NM Pump)	(2) Dorrance (60% Reduction)
1985 - 2016 Average Annual (af):	3,547	8,984

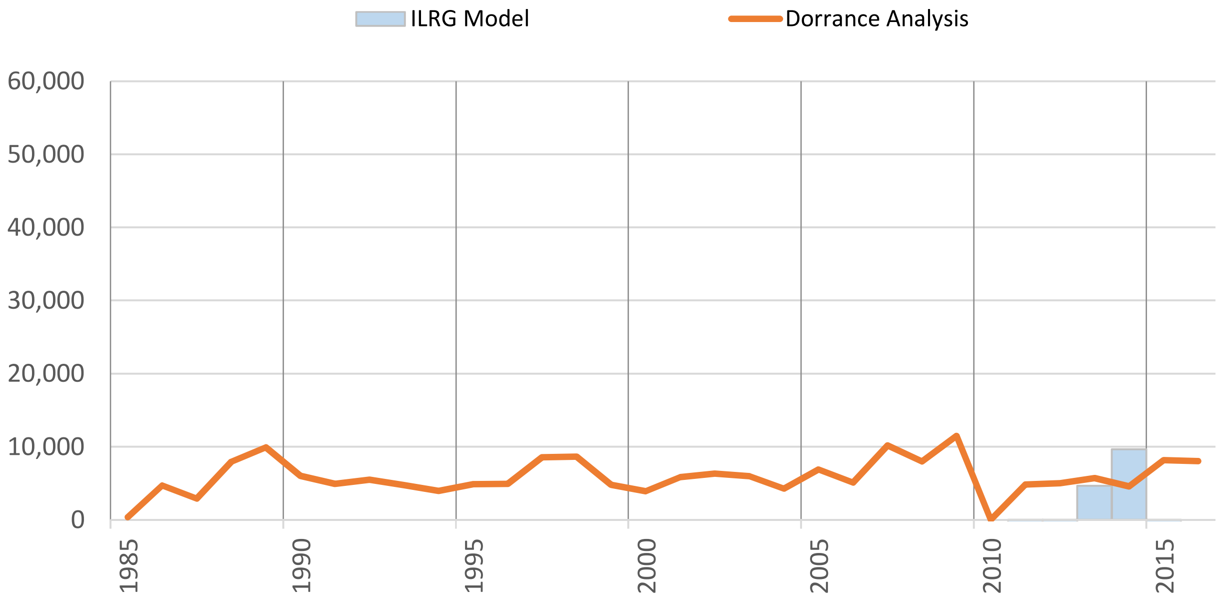
Notes:

(1) ILRG Model change computed as flows in Run 3 (no New Mexico pumping) minus Run 1 (all pumping on).

(2) Dorrance change computed as the increase in El Paso gage flows (Texas Model simulation of 60% reduction in R-M pumping minus historical El Paso gage flows) distributed monthly using historical ratios of monthly to annual El Paso flows and ratios to historical EPW deliveries. EPW deliveries limited maximum historical monthly deliveries.

Figure 14-7

Annual Impact of Pumping on HCCRD Deliveries
Integrated LRG Model (No NM Pumping)
vs.
Dorrance (60% Reduction in R-M Pumping)
(acre-feet)



	(1) ILRG Model (No NM Pump)	(2) Dorrance (60% Reduction)
1985 - 2016 Average Annual (af):	223	5,844

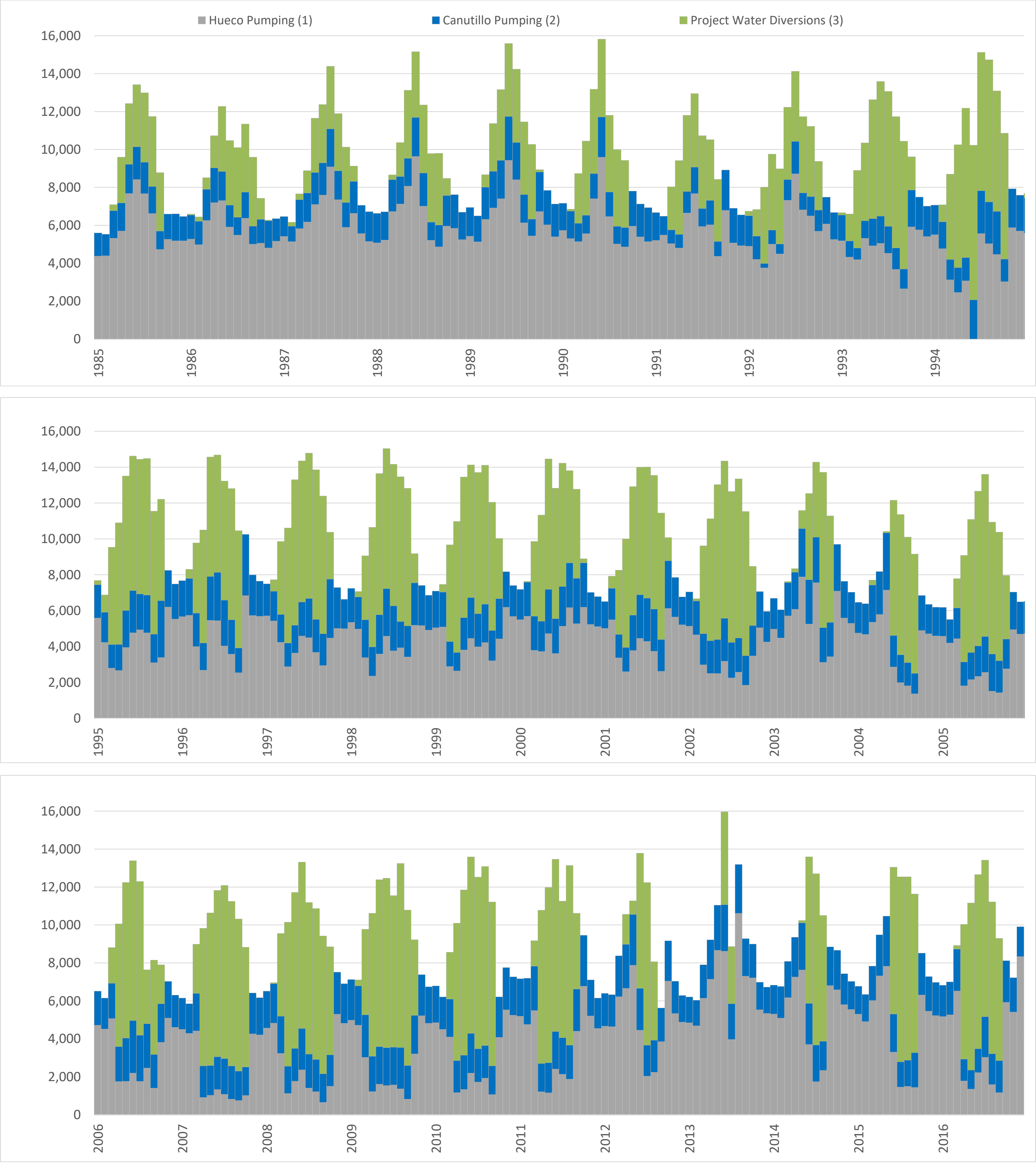
Notes:

(1) ILRG Model change computed as the HCCRD farm deliveries in Run 3 (no New Mexico pumping) minus Run 1 (all pumping on).

(2) Dorrance change computed as the increase in El Paso gage flows (Texas Model simulation of 60% reduction in R-M pumping minus historical El Paso gage flows) distributed monthly using historical ratios of monthly to annual El Paso flows and ratios to historical HCCRD deliveries.

Figure 15-1

Historical Monthly EPW Diversions
1985 - 2016
(acre-feet)



<u>Notes:</u>
(1) Data supplied by MMA (6/25/2019).
(2) Data supplied by SSPA (7/2/2019).
(3) Data from LRG SWDataSet.

TABLES

Table 3-1
Summary of Flow Measurement Sites for Surface Water Dataset
Rio Grande Project, Hudspeth County, and Mexico

Location/ Basin	(1) Measurement Site	(2) Gage No. /NPDES	(3) OSE SW Dataset Site No.	(4) Avail. Period of Record	(5) Location Known	(6) Start Date	(7) Avg Ann Flow (af)	(cfs)	(8) Estimated Records
	River Gages								
Project Inflows	Rio Grande at San Marcial (old)	8358500	1R-42.0	1899-1964	Y		802,827	1,109	
	Rio Grande at San Marcial (conveyance)	8358300		1951-2017	Y		242,759	335	
	Rio Grande at San Marcial (flood)	8358400		1949-2017	Y		469,281	648	
	Rio Grande below Elephant Butte Dam	8361000	1R1.1	1913-2017	Y		712,431	984	
	Rio Grande below Caballo Dam	8362500	1R28.3	1938-2017	Y		651,805	900	
Rincon	Rio Grande below Percha Dam		2R30.0	1922-1937	Y		832,210	1,149	
	Rio Grande at Haynor Bridge	8363300	4R200.1	2000-2005	Y		580,351	802	
	Rio Grande at Tonuco		2R62.0	2000-2003			639,175	883	
Leasburg	Rio Grande above Leasburg Dam		2R74.6	1924-1983			642,435	887	
	Rio Grande below Leasburg Dam	8363500	3R75.1	1919-2017	Y		497,755	688	
	Rio Grande at Picacho Bridge		3R89.2	1991-2005	Y		569,053	786	
	Las Cruces Arroyo near Las Cruces	8363600	LCA.1A	1958-1966	Y		58	0	
Mesilla	Rio Grande below Mesilla Dam	RGBMES	4R96.6	1980-2017	Y		269,811	373	
	Rio Grande at Vado Bridge		4R107.2	1985-1995	Y		451,721	624	
	Rio Grande at Anthony		4R115.8	1986-2011	Y		428,648	592	
	Rio Grande at Vinton Bridge	8363840	4R119.2	1970-1991	Y		401,138	554	
	Rio Grande at Canutillo Bridge	8363900	4R122.3	1985-2017	Y		364,945	504	
El Paso	Rio Grande at El Paso (Courchesne)	8364000	4R133.4	1889-2017	Y		515,875	713	
	Rio Grande below American Dam	8365000	5R135.1	1938-2017	Y		104,489	144	
	Rio Grande at Juarez Station			1938-1956	*		286,343	396	
	Rio Grande at Island Station			1938-1984	Y		52,578	73	
	Rio Grande at Tornillo Bridge Station			1931-1938	Y		140,691	194	
Hudspeth	Rio Grande at County Line Station			1938-1984	*		85,380	118	
	Rio Grande at Fort Quitman	8370500	8370500	1923-2017	Y		148,854	206	
El Paso	Rio Grande at Coffer Dam		5R000.0	1988-2009			28,026	39	
	Canals and Laterals								
Other	Bonita Lateral		1C27.5	1938-2017	Y		1,050	2	
Rincon	Arrey Canal		2C29.5A	1918-2017	Y		79,399	163	
	Percha Canal (Lateral)		2C29.5B	1953-2017	Y		713	1	
	Hatch Main Canal		2C44.4	2001-2002	Y		29,094	60	
Leasburg	Irrigation above Leasburg Heading		3CA	1984-1988			1,061	2	
	Leasburg Canal (above or below 1st check)			1908-1935	n/a		214,410	441	
	Leasburg Canal Above 1st Check		3C73.1	1936-1998	Y		218,561	450	
	Leasburg Canal (net diversion blw 1st check)		3C74.8	1936-2017	Y		126,160	260	
	Las Cruces Lateral		3C87.3	2001-2002	Y		13,425	28	
	California Extension		3C94.5	1985-2017	*		284	1	
	Green and Duran River Pumps		P	1985-2017			259	1	
Mesilla	Westside Canal		4C95.8A	1916-2017	Y		176,021	362	
	Eastside Canal		4C95.8B	1916-2017	Y		68,078	140	
	Del Rio Lateral		4C95.8C	1955-2017	Y		2,905	6	
	Three Saints Lateral		4C108.6	1979-2017	Y		33,010	68	
	La Union East Lateral		4C115.3A	1979-2017	Y		46,680	96	
	La Union West Lateral		4C115.3B	1979-2017	Y		5,595	12	
	Three Saints West Lateral		4C118.6	1979-2005	Y		5,703	12	
	Canutillo Lateral		4C130.4	1979-1982	*		15,686	32	
El Paso	American Canal	8364500	5C135.1A	1938-2017	Y	1938	277,804	572	1990
	Franklin Canal		5C135.1B	1903-2017	*	1889	95,611	197	1903-1913, 1917**
	Riverside Canal	8366400	5C151.8A	1928-2017	Y	1928	184,356	379	**
Mexico	Acequia Madre		5C137.2	1903-2017	Y	1800s?	60,655	125	1903-1923,1926-1929, 1937
	River Diversions			1903-1984			25,342	52	1903-1929, 1937, 1948-1949
Mexico	Acequia Madre en el Sauzal			1938-1956			5,581	11	
Hudspeth	Tornillo Canal at Alamo Alto		9TC.1A	1947-2017	Y	1947	18,601	38	1995-1996**
	Hudspeth Feeder Canal	8368900	6C	1947-2017	Y	1947	42,960	88	2011-2012**
	Tornillo Canal	8368300	9TC.1B	1924-1999	Y	1924	78,160	161	
	Tornillo Waste End			1924-1947		1924	16,923	35	

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Canals and Laterals (cont.)									
Hudspeth	Tornillo Canal near Alamo Check			1947-1949		1947	26,056	54	
(cont.)	End of Tornillo Canal			1925-1955		1925	42,721	88	1925-1934
Drains									
Rincon	Garfield Drain		2D48.4	1923-2005	Y		6,300	0	
	Hatch Drain		2D54.2	1923-2005	Y		6,156	12	
	Angostura Drain		2D58.8	1926-1983	Y		1,257	11	
	Rincon Drain		2D65.0	1925-2005	Y		6,616	2	
Leasburg	Selden Drain		3D79.2	1923-1983	Y		1,785	12	
	Leasburg Drain		Leasburg Drain	1923-1983	Y		4,595	3	
	Picacho Drain		3D94.4	1923-2005	Y		3,905	8	
	Mesilla Drain		4D108.2B	1923-1983	Y		4,048	7	
Mesilla	Santo Tomas River Drain		4D102.0	1985-1990	Y		1,449	7	
	Santo Tomas Drain		4D102.1	1980-1985			494	3	
	La Mesa Drain		4D112.8A	1923-2013	Y		19,583	1	
	Chamberino Drain		4D112.8B	1923-2013	Y		18,045	36	
	Del Rio Drain		4D108.2A	1923-1983	Y		1,784	33	
	Mesquite Drain		4D109.5	1923-2013	Y		9,102	3	
	East Drain		4D118.6C	1923-2013	Y		43,602	17	
	Anthony Drain		4D118.6B	1997-2001	Y		4,012	80	
	East Drain (EPCWID)		4D118.6A	1930-2013	Y		12,566	7	
	West Drain		4D131.8A	1923-2005	Y		2,207	23	
	Nemexas Drain		4D131.8B	1923-2017	Y		41,603	4	
	Montoya Drain		4D133.0A	1923-2017	Y		14,244	76	
	Montoya Intercepting Drain		4D133.0C	1985-1990			3,111	26	
El Paso	Franklin Drain		Franklin Drain	1921-1983	Y	1918	17,082	6	
	Playa Drain		Playa Drain	1923-1983	Y	1920	11,824	31	
	Middle Drain		Middle Drain	1921-1983	Y	1917	26,446	22	
	River Drain		River Drain	1923-1983	Y	1917	9,964	48	
	Cuadrilla Drain		Cuadrilla drain	1931-1983	Y	1924	3,100	18	
	Mesa Drain		Mesa Drain	1921-1983	Y	1918	9,054	6	
	Fabens Intercepting Drain		Fabens Intercepting	1931-1971	Y	1928	2,405	0	
	Border Drain		Border Drain	1923-1983	Y		6,809	4	
	Island Drain		Island Drain	1921-1983	Y	1920	8,424	12	
	Island Syphon Drain		Island Syphon Drain	1936-1983	Y	1920?	17,874	15	
	Alamo Alto Drain		Alamo Alto Drain	1925-1983	Y	1924	6,628	33	
	Drain Water Diverted at Fabens			1945-1982		1945	6,309	12	Est. monthly
Hudspeth	Fabens Waste Drain		10CFWD.1A	1984-2017	Y	1936?	32,401	12	
	Fabens Drain		Fabens Drain	1923-1983	Y	6/1921	5,571	59	
	Tornillo Drain	8368000	9TD.1A	1923-2017	Y	12/1922	31,067	10	
Juarez	Dren de Descarga			1938-1956			4,489	57	
	Dren de Interceptacion			1938-1956			12,814	8	
Wasteways									
Rincon	WW No. 5 – Hatch Siphon		2W44.4	1979-2017	Y		4,575	9	
	WW No. 16 – Hatch Canal		2W52.9	1979-2017	Y		2,942	6	
	WW No. 18 – Rincon Lateral		2W61.2	1979-2017	Y		1,940	4	
Leasburg	WW No. 1A – Leasburg Canal			1989-2002			76,765	158	
	WW No. 1 – Leasburg Canal		3W74.8	1992-2002	*		14,662	30	
	WW No. 3 – Picacho Lateral		3W84.0	2001-2017	*		2,338	5	
	WW No. 5 – Leasburg Canal		3W85.0	1979-2017	Y		2,559	5	
	WW No. 8 – Leasburg Canal		3W87.3	1979-2017	Y		6,610	14	
	WW No. 40 – Picacho Lateral		3W91.6	1991-2017	Y		2,008	4	
	WW No. 13 – California Extension		3W94.5A	1984-1991	Y		597	1	
Mesilla	WW 25 – Santo Tomas Lateral		4W98.4	1985-2001	Y		1,507	3	
	WW 26 – Upper Chamberino Lateral		4W102.0	1979-2003	Y		1,288	3	
	WW 30 – Chamberino East Lateral		4W102.8	1985-2003	*		2,840	6	
	WW 31 – La Union Main Canal		4W103.2	1981-2003	Y		3,230	7	
	WW 31B – Jimenez Lateral		4W105.8	1985-2003	Y		455	1	
	WW 32 – La Union East Lateral		4W109.2	1979-2017	Y		11,279	23	

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	Wasteways (cont.)								
Mesilla (cont.)	WW 32A – Rowley Lateral		4W111.0	1985-1988	*		242	0	
	WW 32B – Vinton Cutoff Lateral		4W113.0	1985-2017	*		2,288	5	
	WW 34 – Canutillo Lateral		4W113.1	1983-2017	*		2,619	5	
	WW 34A – Pence Lateral		4W115.2	1985-1988	Y		329	1	
	WW 35 – Westside Canal		4W115.3	1980-2017	Y		5,639	12	
	WW 35C – Schutz Lateral		4W116.1	1985-1988	Y		638	1	
	WW 15 – Eastside Canal		4W117.1	1985-2003	*		2,336	5	
	WW 16B – Brazito Lateral		4W118.5	1985-1990	Y		1,869	4	
	WW 18 – Eastside Canal		4W121.0	1985-2003	*		2,671	5	
	WW 19 – Three Saints Lateral		4W124.5	1982-2003	Y		823	2	
	WW 20 – Three Saints West Lateral		4W125.2	1979-1988	Y		262	1	
	WW 21 – Three Saints West Lateral		4W125.7	1985-2003	*		2,747	6	
	WW 23A – Three Saints Lateral		4W127.2	1985-2017	Y		2,333	5	
	WW 36 – Montoya Lateral		4W129.1	1985-2017	Y		1,078	2	
	WW 38 – Montoya Lateral		4W133.0B	1985-2017	*		2,027	4	
El Paso	Leon Street WW			1938-1999	*	1938?	87,427	180	6/1938-2/1999
	Franklin Settling Basin WW			1938-1999	*	1938?	87,427	180	6/1938-2/1999
	Santa Fe WW (El Paso Electric)			1940-1960	*	1938?	528	1	
	Ascarate WW		5W144.1	1916-2017	Y	1916?	27,722	57	1916-1937**
	Riverside WW No. 1		4W10.RC1	1928-2017	*	1928?	11,572	24	1928-1937, 1956-1980, 1985-1992, 2004**
	Riverside WW No. 2		4W10.RC2	1930-2017	*	1930?	9,691	20	1930-1937, 1956-1980, 1985-1992, 2004**
Hudspeth	Fabens Waste Channel		10CFWC.1	1935-2017	*	1935?	48,954	101	1935-1937**
	Tornillo Canal WW No. 1		9TC.1W	1981-2017	*	1936?	47,612	98	
	Municipal								
Rincon	Hatch WWTP	NM0020010		1940-2017	Y		153	0	1940-1999**
	Salem WWTP	NM0030457		2003-2017	Y	2003	41	0	
Leasburg	City of Las Cruces WWTP	NM0023311	3D90.5	1976-2017	Y		7,631	11	**
	Las Cruces East Mesa WRF	NM0030872		2010-2017	Y	2010	232	0	
	Total Las Cruces WWTP			**1940-2017**			**5,011**	**7**	**1940-1975**
Mesilla	South Central Regional WWTP	NM0030490		2003-2017	Y	2003	309	0	
	Anthony WWTP	NM0029629		1989-2017	Y	1989?	510	1	1989-2001**
	Sunland Park WWTP	NM0000108		1987-2017	Y	2002?	1,205	2	**
	El Paso Electric	NM0029483		1950-2017	Y	1950?	1,053	1	1950-2003**
	Gadsden Independent School District	NM0028487		1992-2017	Y	1992?	12	0	1992-2002**
	Total Sunland Park + Santa Teresa			**1972-2017**		**1972?**	**1,414**	**2**	**1972-2003**
El Paso	Northwest WWTP	TX0087149		1987-2017	Y	1987	5,663	8	1987-8/2002**
	Umbenhauer-Robertson WTP	n/a		1943-2017	*	11/1943	12,710	18	11/1943-2006**
	Haskell WWTP to Rio Grande	TX0026751		1923-2017	Y	1923	14,969	21	1923-1935, 1976, 1998**
	Jonathan Rogers WTP	n/a		1993-2017	*	1993	27,209	56	1993-2006**
	Total City of El Paso WTP	**n/a**		**1943-2017**		**1943**	**21,024**	**43**	
	Bustamante WWTP to Rio Grande/Drain	TX0101605		1991-2017	Y	1991	9,569	13	1991-8/1995**
	Fabens WWTP	TX0065013		2001-2017	Y		528	1	
	Haskell WWTP to ACE	TX0026751		1998-2017	Y	10/1998	16,411	23	**
	Total Haskell WWTP	**TX0026751**		**1923-2017**		**11/1943**	**16,522**	**23**	
	Bustamante WWTP to Riverside Canal	TX0101605		1991-2017	Y	1991	20,564	28	1991-8/1995**
	Total Bustamante WWTP	**TX0101605**		**1991-2017**		**1991**	**30,133**	**42**	
	Socorro WWTP	TX0026778		1967-1993	*	1967?	20,232	28	1967 - 1988**
	Total City of El Paso WWTP	**n/a**		**1923-2017**			**32,043**	**44**	
	Anthony TX WWTP	TX0090522		1953-2017	Y	1953?	235	0	1953-2004**
Mexico	Juarez Sewage to Rio Grande			1940-1950			344	0	
	Juarez Sewage to Canals			1926-2017			24,624	34	1926-1949, 1985-2017
	Juarez North Plant & South Plant								

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	Reservoir								
Elephant Butte Reservoir	Elephant Butte Reservoir End-of-Month Storage			1915 - 2017	n/a		888,827		
	Elephant Butte Reservoir Releases			1940 - 2017	n/a		658,362	1,355	
	Elephant Butte Reservoir Pan Evaporation (inches)			1940 - 2017	n/a		117		
	Elephant Butte Reservoir Precipitation (inches)			1940 - 2017	n/a		9		
Caballo Reservoir	Caballo Reservoir End-of-Month Storage			1938 - 2017	n/a		76,175		
	Caballo Reservoir Releases			1940 - 2017	n/a		648,257	1,334	
	Caballo Reservoir Pan Evaporation (inches)			1940 - 2017	n/a		111		
	Caballo Reservoir Precipitation (inches)			1940 - 2017	n/a		10		
	Bonito Ditch Blw Caballo			1940 - 2017	n/a		1,036	2	
New Mexico	Annual Otowi Index Supply			1940 - 2017	n/a		990,377		
	New Mexico Annual EOY Accrued Debit/Credit			1940 - 2017	n/a		49,662		
	New Mexico Annual Credit Water Relinquishment			1940 - 2017	n/a		11,759		
Colorado	Colorado Annual EOY Accrued Debit/Credit			1940 - 2017	n/a		-159,910		
	Colorado Annual Credit Water Relinquishment			1940 - 2017	n/a		205		
San Juan Chama Pool	San Juan Chama Deliveries			1975 - 2017	n/a		5,232		
	San Juan Chama Evaporative Losses			1975 - 2017	n/a		2,506		
	San Juan Chama EOY Pool Storage			1975 - 2017	n/a		23,099		
	Irrigation Pumping								
New Mexico	EBID Annual Irrigation Pumping			2009 - 2018	n/a		218,800		
Texas	EPCWID Annual Irrigation Pumping								
	HCCRD Annual Irrigation Pumping								
Mexico	Juarez Annual Irrigation Pumping								

Notes:

Data from Bureau of Reclamation accounting is typically irrigation season only and may not contain any winter diversions.

(1) Availability of data has not yet been determined.

Annual data only or only annual data available for certain years.

Blue text indicates that records for this gage have been updated through 2017.

(2) Gage numbers from U.S.G.S. or IBWC for river gages and some canals and NPDES permit numbers for WWTP returns

(3) Unique identifier from the NM OSE database.

(4) Period of data record in data compilation. There may be missing data within the available period of record.

(5) Y = location known from USGS, EBID, IBWC, or GPS coordinates.
* = approximate location known.

(6) Approximate start date of site (structure/gage/outfall).

(7) Average annual volume throughout period of available records. Annual volume converted to a rate assuming the volumes for river gages and WWTP returns are year-round (365 days); canal diverisons, wasteways, WTP diversions, and reservoir releases occur for an average of 245 days per year; and, drain flows occur for an average of 275 days per year.

(8) Records for periods of missing data estimated for use in modeling. Efforts are ongoing to obtain actual flow data for the missing records.
** = one or more additional missing months in dataset.

Table 3-2
Summary of Backup Data Sources for Surface Water DataSet

Source Code	Entity	Period of Record	Summary	Location
LRG.Doc.SW001	EBID	1993 - 2000	Daily flow records	NM
LRG.Doc.SW002	EBID	1930 - 2000	Monthly drain flow data	NM
LRG.Doc.SW003	USBR	1995 - 2002	Daily flow and storage data	NM, TX
LRG.Doc.SW004	USGS	1916 - 2004	Daily flow data	NM, TX
LRG.Doc.SW005	IBWC	1889 - 2004	Daily flow data	NM, TX
LRG.Doc.SW006	USBR	1923 - 1983	Monthly drain flow data	NM, TX
LRG.Doc.SW007	Boyle-Parsons/SSPA	1889 - 1996	Boyle-Parsons data compilation with SSPA updates	NM, TX, Mexico
LRG.Doc.SW008	EBID	2001 - 2002	Annual allotment charges (accounting)	NM, TX
LRG.Doc.SW016	NMSU	1889 - 2004	Daily flow data (NMSU, 2004)	NM, TX, Mexico
LRG.Doc.SW020	USGS	1899 - 2007	Daily flow data	NM, TX
LRG.Doc.SW022	EBID	2004 - 2005	Daily flow data	NM
LRG.Doc.SW025	NMOSE	1900 - 2005	Daily flow data with monthly aggregation	NM, TX, Mexico
LRG.Doc.SW026	EBID	2004 - 2005	Daily flow data	NM
LRG.Doc.SW027	EPCWID	2003 - 2006	Daily flow data	TX
LRG.Doc.SW100	USGS	1899 - 2014	Daily river flow data	NM, TX
LRG.Doc.SW101	IBWC	1889 - 2017	Daily flow data	NM, TX, Mexico
LRG.Doc.SW102	IBWC	1931 - 2017	Monthly and annual flow data	NM, TX, Mexico
LRG.Doc.SW103	USBR	1999 - 2010	Monthly accounting data	NM, TX
LRG.Doc.SW104	USBR	2006 - 2011	Daily and monthly accounting data	NM, TX
LRG.Doc.SW105	USBR	2011 - 2018	Daily and monthly accounting data	NM, TX
LRG.Doc.SW106	USBR	1979 - 2010	Daily and monthly accounting data	NM, TX
LRG.Doc.SW107	EPA	1995 - 2017	Average monthly discharge data	NM, TX
LRG.Doc.SW108	RGCC	1940 - 2017	Monthly reservoir data	NM
LRG.Doc.SW109	USBR	1938 - 2016	Monthly Water Distribution Report data	NM, TX
LRG.Doc.SW110	EBID	2008 - 2018	Daily telemetry flow data	NM
LRG.Doc.SW111	USBR	1923 - 1983	Drain flow data	NM, TX
LRG.Doc.SW112	NMOSE	1947 - 2010	Hudspeth Feeder Canal daily flow data	TX
LRG.Doc.SW113	PDNWC	1942 - 2008	Daily flow data	TX
LRG.Doc.SW114	IBWC	1950 - 1984	Monthly data	TX, Mexico
LRG.Doc.SW115	NMSU Vol. 3	1950 - 1984	Annual data	NM, TX, Mexico
LRG.Doc.SW116	SHRA	1924 - 1925	Data from SHRA archive research	Mexico
LRG.Doc.SW117	U.S. NRC	1900s - 1937	Data from the RGJI (U.S. NRC, February 1938)	NM, TX, Mexico
LRG.Doc.SW118	SWE	1903 - 2017	Missing data calculations	NM, TX, Mexico
LRG.Doc.SW119	NMOSE	1908 - 2013	Correction/clarification on Leasburg Canal data	NM
LRG.Doc.SW120	MMA	1925 - 2004	Correction of Tornillo Canal at Alamo Alto data	TX
LRG.Doc.SW121	Carreno 1957	1938 - 1947	Annual river diversions	Mexico
LRG.Doc.SW122	USBR	1923 - 1983	Drain notes and drain flow data (USBR).	NM, TX
LRG.Doc.SW123	USACE	1975 - 2011	USACE - URGWOM data provided by Hydros Consulting.	NM
LRG.Doc.SW124	USGS	1940 - 2015	Flow input data from USGS RGTIHM GW model.	NM
LRG.Doc.SW125	United States	1908 - 2017	Flow data from from U.S. disclosures.	NM, TX, Mexico
LRG.Doc.SW126	U.S. NRC	1930 - 1939	Flow data from Rio Grande Project Histories.	NM, TX, Mexico
LRG.Doc.SW127	EPCWID	2004 - 2018	Flow & accounting data from EPCWID disclosures.	TX
LRG.Doc.SW128	EPW	2005 - 2018	Flow data from EPW disclosures.	TX
LRG.Doc.SW129	City of Las Cruces	2009 - 2017	Flow data from City of Las Cruces.	NM
LRG.Doc.SW130	NMOSE	2009 - 2018	Irrigation pumping data from NMOSE.	NM

Acronym	Full Name
EBID	Elephant Butte Irrigation District
EPCWID	El Paso County Water Improvement District No. 1
EPA	Environmental Protection Agency
EPW	El Paso Water
IBWC	International Boundary and Water Commission
MMA	McDonald-Morrissey and Associates, Inc.
NM	New Mexico
NMSU	New Mexico State University
NMOSE	New Mexico Office of the State Engineer
NMISC	New Mexico Interstate Stream Commission
NRC	Natural Resource Committee, Department of Interior
PDNWC	Paso del Norte Watershed Council
RGTIHM	Rio Grande Transboundary Integrated Hydrologic Model

Acronym	Full Name
RGCC	Rio Grande Compact Commission
PDNWC	Paso del Norte Watershed Council
RGCC	Rio Grande Compact Commission
RGJI	Rio Grande Joint Investigation
SHRA	Stevens Historical Research Associates
SSPA	S.S. Papadopoulos and Associates, Inc.
SWE	Spronk Water Engineers, Inc.
TX	Texas
USACE	United State Army Corps of Engineers
USBR	United States Bureau of Reclamation
USGS	United States Geological Survey
URGWOM	Upper Rio Grande Water Operations Model

Table 3-3
Summary of Estimated Data for Surface Water Dataset
Rio Grande Project, Hudspeth County, and Mexico
1903 - 2017

Structure	Start	Period of Record	Missing Data	Method for Estimating Missing Data
Canals - Hueco				
Acequia Madre	Pre-1903	1924 - 1925, 1930 - 1936, 6/1938 - 2006, 2008 - 2017	1903 - 1923, 1926 - 1929, 1937 - 5/1938, 2007	1903 -1923: Used 1924 - 1925 monthly regression with Courchesne gage capped at an estimated diversion capacity (300 cfs) and limited to season of use Mar 1 – Nov 30.
				1926 - 1929 and 1937: Used 1930 - 1936 monthly regression with Courchesne gage capped at an estimated diversion capacity (300 cfs) and limited to season of use Mar 1 – Nov 30.
				1/1938 – 5/1938: Used 1938 annual value less data for period of record in 1938 distributed from Mar - May using Franklin Canal flows.
				2007: Used reported 2007 annual diversion in Rio Grande Compact Commission Report distributed monthly using Franklin Canal diversions.
Franklin Canal	1889	1914 -1916, 1918 - 2017*	1903 – 1913, 1917	1903 -1913 and 1917: Used 1918 - 1938 monthly regression with Courchesne gage capped at an estimated diversion capacity (320 cfs) and limited to season of use Mar 1 – Nov 30. Do not have complete winter diversions in recent years - these winter diversions were not estimated.
Tornillo Canal at Alamo Alto	1947	1947 - 2017*	Various months 1995 – 1996 and 2004 – 2005	Various months 1995 - 1996 and 2004 - 2005: Used 1985 - 1994 monthly regression with Riverside Canal.
Hudspeth Feeder Canal	May-47	1947 - 2017*	2011 - 2012	2011 - 2012: Used 2005 - 2010 monthly regression with Franklin Canal.
Hudspeth Canal (Tornillo End)	1925	1935 - 1955 (ann)	1925 - 1934	1925 - 1934: Estimated flow using water balance (Tornillo Canal heading flow less seepage loss (15%*Tornillo Canal heading) less crop demand for Tornillo acres (CIR*acres/irrigation efficiency) less Tornillo Waste End flows).
				1935 - 1955: Annual data distributed monthly using Tornillo Canal heading flows.

Table 3-3
Summary of Estimated Data for Surface Water Dataset
Rio Grande Project, Hudspeth County, and Mexico
1903 - 2017

Structure	Start	Period of Record	Missing Data	Method for Estimating Missing Data
Canals - Hueco (cont.)				
Juarez River Diversions (below International Dam)	Pre-1903	Annual estimates 1930-1936, 1938-1947, and 1950-1984	1903 - 1929, 1937, 1948-1949, 1985 - 2017	1903 - 1929: Estimated flows based minimum of unmet demand (Farm Budget spreadsheet) limited by estimated flow below International Dam (Courchesne minus Franklin Canal minus Acequia Madre) minus Riverside Canal when applicable.
				1930-1936, 1938-1947, and 1950-1984: Distributed annual estimates monthly using Acequia Madre flows.
				1937: Set equal to 1936 annual estimate.
				1948 - 1949: Estimated flows based on gage differences from Island Station to Fort Quitman.
				1985 - 2017: Did not estimate because there are no gage records.
Wasteways - Hueco				
Franklin Settling Basin WW	1938?	No data		6/1938 – 2/1999: Data provided by Peggy Barroll, NMOSE. Computed using water balance approach (American Canal diversions less Franklin Canal diversions less City of El Paso municipal diversions). Split total computed waste 50/50 between Franklin Settling Basin and Leon St. wasteways. Estimates do not consider transit losses.
Leon St WW	1938?	No data		
Ascarate WW	1916?	1938 - 1954 (ann), 1955 - 2005*	1916 - 1937, 2011 - 2012	1916 - 1937: Used annual regression (1938 - 1949) with Franklin Canal and distributed annual data into monthly values proportional to Franklin Canal flows.
				1938 - 1955: Distributed annual data into monthly values proportional to Franklin Canal flows.
				2011 - 2012: Assumed no Ascarate Wasteway flows until more data become available due to little to zero flows reported since the completion of the American Canal Extension.

Table 3-3
Summary of Estimated Data for Surface Water Dataset
Rio Grande Project, Hudspeth County, and Mexico
1903 - 2017

Structure	Start	Period of Record	Missing Data	Method for Estimating Missing Data
Wasteways - Hueco (cont.)				
Riverside WW#1	1928?	1938 - 1955 (ann combined)**, 1981 - 1984, 1993 - 2017*	Pre-1938, 1956 - 1980,1985 - 1982	1928 – 1937: Used annual regression for combined Riverside WW#1 and WW#2 with Riverside Canal (1938 - 1949) and distributed annual data into monthly values using Riverside Canal diversions. Split between WW#1 and WW#2 using 1981 - 2013 average annual split. Assumed Riverside WW#2 flows do not start until 1930. 1938 – 1955: Distributed annual data into monthly values proportional to Riverside Canal diversions. Split between WW#1 and WW#2 using 1981 – 2013 average annual split.
Riverside WW#2	1930?			1956 - 1980 and 1985 - 1992: Used annual regression for combined Riverside WW#1 and WW#2 with Riverside Canal (1993 - 2003) and distributed annual data into monthly values using Riverside Canal diversions. Split between WW#1 and WW#2 using 1981 - 2013 average annual split.
Municipal - Hueco				
Northwest WWTP Returns	1987	9/2002 - 2017*	1987 - 8/2002	1987 - 8/2002: Data provided by Nabil Shafike, NMISC - computed using regression with Mesilla EPWU ground water pumping.
Haskell WWTP Returns (1)	1923	1936 - 1939, 1940 - 1948**, 1949 - 1959, 1960 - 1975**, 1977 - 2017*	1923 - 1935, 1976, 1/1998 - 9/1998	1923 - 1935: Used annual 1936 - 1940 regression with EPWU pumping. Distributed annual data evenly in each month (divide by 12). 1976: Used average 1975 and 1977 monthly flow data (i.e., Jan 1976 flow = average Jan 1975 and Jan 1977). 1/1998 - 9/1998: Used average 1997 and 1999 monthly flow data.
Bustamante WWTP Returns	1991	9/1995 - 2017*	1991 – 8/1995	1991 - 1994: Annual volume derived from reported 1996 influent in gallons per day per capita scaled to Bustamante service area proportion of total City of El Paso population and subtracted Socorro WWTP flows (1991 - 1993). Annual volume divided by 12 to obtain monthly values. 1/1995 - 8/1995: Annual reported value minus sum of remainder monthly flows (9/1995-12/1995) divided by 8.

Table 3-3
Summary of Estimated Data for Surface Water Dataset
Rio Grande Project, Hudspeth County, and Mexico
1903 - 2017

Structure	Start	Period of Record	Missing Data	Method for Estimating Missing Data
Municipal - Hueco (cont.)				
Socorro WWTP	1967?	1989 - 2/1993	1967 - 1988; 10/1991	1967 - 1988: Annual volume derived from reported 1996 influent in gallons per day per capita scaled to Bustamante service area proportion of total City of El Paso population. Annual volume divided by 12 to estimate monthly values.
				10/1991: Computed as average 9/1991 and 11/1991 flows.
Juarez Sewage to river	1926?	1940 - 1950 ann	1926 - 1939; 1951 - 2017	1926 - 1939: Data not estimated (not enough information available to estimate).
				1940 - 1950: Distributed annual reported estimates evenly into each month (divided by 12).
				1951 - 2017: Assume zero (discharge zero by late 1940s).
Juarez Sewage to canals	1926	1950 - 1984	1926 - 1949 and 1985 - 2017	1950 - 1984: Annual reported estimates divided by 12.
				1926 - 1949 and 1985 - 2017: Used JMAS pumping provided by MMA multiplied by 49% (same methodology as IBWC 1989 report) minus Juarez Sewage to river (1940 - 1950).
Robertson-Umbenhauer WTP (aka Canal St. WTP)	Nov-43	11/1943 - 2017**	Records for total El Paso WTP prior to 2007	1943 - 1992: Robertson-Umbenhauer WTP equal to total City of El Paso until Jonathan Rogers comes online in 1993.
Jonathan Rogers WTP	1993	1993 - 2017**		1993 - 2006: Split total City of El Paso into each WTP using distribution from available data from 2007 - 2013.
Fabens WWTP	2001	2001 - 2017**	1/2001 - 5/2001, 7/2004, 10/2004	1/2001 - 5/2001 , 7/2004, and 10/2004: Computed using monthly averages from prior and subsequent year.
Municipal - Rincon-Mesilla				
Hatch WWTP	1940	2000 - 2017*	1940 - 1999	1940 - 1999: Computed using regression with population (no pumping data available).
			1/2000 - 9/2000, 11/2005, 10/2013	1/2000 - 9/2000, 11/2005, and 10/2013: Computed using monthly averages from prior and subsequent year.
Las Cruces WWTP	1940	1976 - 2017*	1940 - 3/1976, 5/1979 - 6/1979, 4/1985, 9/1985 - 10/1985	1940 - 3/1976, 5/1979 - 6/1979, 4/1985, and 9/1985 - 10/1985: Computed using regression with pumping.
Anthony NM WWTP	1989	2002 - 2017*	1989 - 1995	1989 - 1995: Computed using regression with pumping.

Table 3-3
Summary of Estimated Data for Surface Water Dataset
Rio Grande Project, Hudspeth County, and Mexico
1903 - 2017

Structure	Start	Period of Record	Missing Data	Method for Estimating Missing Data
Municipal - Rincon-Mesilla (cont.)				
Anthony TX WWTP	1953	2005 - 2017*	1953-2004, 1/2005-4/2005, 2/2006, 11/2006, 8/2007, 8/2016-12/2017	1953 - 2004: Computed using regression with pumping. 1/2005 - 4/2005, 2/2006, 11/2006, 8/2007, and 8/2016 - 12/2017: Computed using monthly averages from prior and subsequent year.
El Paso Electric WWTP	1950	2004 - 2017*	1950 - 2003, 2/2005, 10/2005 - 12/2005, 8/2006, 5/2009	1950 - 2003: Computed using regression with pumping. 2/2005, 10/2005 - 12/2005, 8/2006, and 5/2009: Computed using monthly averages from prior and subsequent year.
Gadsden School District WWTP	1991	1991 - 2017*	1/2016 - 4/2016, 11/2016, 1/2017, 6/2017, 12/2017	1/2016 - 4/2016, 11/2016, 1/2017, 6/2017, 12/2017: Computed using monthly averages from prior and subsequent year.
Total Sunland Park + Santa Teresa	1972	2004 - 2017	1972 - 2003	1972 - 2003: Computed using monthly averages from prior and subsequent year.

Notes:
All estimated data calculations in source folder: LRG.Doc.SW118.
*Missing months of data within period of record.
**Records combined with other flows, split total diversions out by structure.
(1) Records from 1940 - 1948 and 1960 - 1975 include Ascarate and Yselta EPCWID plant discharges.
(2) Annual estimates from Rio Grande Joint Investigations (1938), Carreno (1957), and IBWC (1989).

Table 4-1

Annual Farm Headgate Deliveries

Water Distribution Report Data

1938 - 2017 (acre-feet)

Year	Rincon (EBID)	Leasburg (EBID)	Mesilla (EBID + EPCWID)	Total Leasburg-Mesilla (EBID)	Mesilla East (EBID)	Mesilla West (EBID)	Total EBID	Mesilla East TX (EPCWID)	Mesilla West TX (EPCWID)	El Paso Valley (EPCWID)	Total EPCWID	HCCRD
1938	33,707	79,893	133,086	192,852	38,172	74,786	226,559	2,206	17,921	122,842	142,969	
1939	39,913	94,143	153,707	224,180	45,052	84,985	264,093	2,683	20,987	148,996	172,666	
1940	41,123	89,823	151,043	217,728	44,807	83,098	258,851	2,662	20,475	154,284	177,422	
1941	35,145	74,238	128,967	183,629	36,909	72,482	218,774	2,141	17,435	117,414	136,990	
1942	41,593	79,425	136,299	195,449	40,489	75,535	237,042	2,321	17,954	126,240	146,515	
1943	49,339	100,990	163,144	240,129	49,307	89,832	289,468	2,806	21,199	169,683	193,688	
1944	47,873	98,394	163,346	237,623	49,069	90,160	285,496	2,798	21,319	162,200	186,317	
1945	50,820	113,430	184,150	270,606	55,890	101,286	321,426	3,168	23,806	186,850	213,824	
1946	47,500	99,630	170,810	245,169	49,472	96,068	292,669	2,792	22,479	181,020	206,291	
1947	43,493	95,210	157,830	229,473	44,157	90,105	272,966	2,491	21,077	170,370	193,937	
1948	40,960	93,730	157,440	227,723	46,050	87,943	268,683	2,629	20,818	159,620	183,067	
1949	44,960	95,140	163,440	234,775	49,312	90,322	279,735	2,770	21,036	176,050	199,855	
1950	48,038	100,290	158,691	235,769	47,140	88,339	283,807	2,647	20,566	181,004	204,216	
1951	24,702	49,982	87,227	124,355	24,865	49,508	149,057	1,389	11,466	125,707	138,561	
1952	28,181	54,828	95,340	136,445	28,402	53,215	164,626	1,565	12,158	153,497	167,220	
1953	26,638	51,494	94,579	132,316	26,721	54,101	158,954	1,464	12,293	137,729	151,486	
1954	8,021	18,383	33,932	47,675	9,358	19,934	55,696	472	4,168	41,934	46,574	
1955	5,563	14,843	25,278	36,540	5,797	15,901	42,103	289	3,291	34,779	38,360	
1956	5,610	12,386	22,300	31,747	5,559	13,803	37,357	260	2,679	29,162	32,101	
1957	12,041	30,963	51,412	75,365	10,980	33,422	87,406	515	6,495	75,568	82,578	
1958	38,245	73,232	135,383	189,478	35,857	80,388	227,723	1,859	17,279	153,927	173,064	
1959	36,595	75,164	121,247	179,433	35,961	68,308	216,028	1,912	15,057	173,983	190,951	
1960	41,068	75,032	127,321	184,710	37,312	72,366	225,778	1,951	15,692	158,979	176,622	
1961	26,833	57,745	104,043	147,635	29,210	60,680	174,468	1,472	12,681	137,360	151,513	
1962	38,424	77,027	137,436	195,421	41,315	77,078	233,845	2,180	16,863	158,533	177,575	
1963	27,886	56,665	103,541	145,379	29,061	59,653	173,265	1,559	13,268	124,914	139,741	
1964	5,304	10,865	19,117	27,131	3,829	12,437	32,435	197	2,654	29,682	32,533	
1965	22,328	41,203	79,473	109,740	21,363	47,174	132,068	1,077	9,859	91,596	102,532	
1966	32,192	58,937	100,412	145,653	29,147	57,569	177,845	1,490	12,206	109,927	123,623	
1967	20,788	40,826	72,867	103,419	21,231	41,361	124,207	1,132	9,143	90,788	101,062	
1968	29,334	47,035	86,440	121,437	23,822	50,581	150,771	1,228	10,810	92,912	104,950	
1969	37,184	66,662	123,908	173,074	32,304	74,108	210,258	1,664	15,832	136,314	153,810	
1970	40,581	76,274	132,824	190,655	35,084	79,297	231,236	1,778	16,665	138,870	157,313	
1971	27,548	48,425	87,663	124,112	23,677	52,010	151,660	1,185	10,791	105,454	117,430	
1972	11,354	20,258	38,342	53,076	9,385	23,433	64,430	487	5,038	52,698	58,222	
1973	38,282	65,034	120,648	170,010	34,184	70,792	208,292	1,635	14,038	114,805	130,477	
1974	38,463	66,013	125,089	175,244	35,531	73,700	213,707	1,652	14,207	122,339	138,197	
1975	38,542	67,073	119,992	171,892	34,961	69,858	210,434	1,634	13,539	120,079	135,252	
1976	44,460	71,673	130,553	180,573	37,038	71,861	225,033	3,208	18,445	127,261	148,914	
1977	19,969	35,614	56,311	82,397	13,758	33,025	102,366	1,269	8,258	72,279	81,807	
1978	11,786	18,006	28,766	42,087	7,385	16,696	53,873	657	4,027	48,165	52,850	
1979	36,187	49,763	99,038	133,191	26,774	56,654	169,378	4,522	11,088	111,215	126,825	30,297
1980	46,320	68,226	126,684	177,389	34,717	74,446	223,709	4,972	12,548	122,183	139,704	27,199
1981	43,367	61,204	122,135	165,495	33,860	70,431	208,862	5,240	12,605	120,730	138,574	43,038
1982	47,372	66,019	136,614	179,351	35,773	77,559	226,723	6,625	16,656	144,054	167,336	53,392
1983	44,435	68,830	137,639	183,541	34,370	80,341	227,976	6,031	16,897	113,809	136,737	47,978
1984	45,039	67,428	127,604	177,406	36,360	73,619	222,445	5,227	12,398	111,766	129,391	62,832
1985	58,080	74,772	140,327	197,135	40,152	82,210	255,215	5,323	12,642	116,255	134,220	70,370
1986	60,847	80,676	137,723	202,736	42,886	79,174	263,583	4,982	10,681	117,344	133,007	33,868
1987	58,647	83,177	136,997	205,259	41,310	80,772	263,906	4,571	10,344	118,556	133,471	63,688

Table 4-1
Annual Farm Headgate Deliveries
Water Distribution Report Data
1938 - 2017 (acre-feet)

Year	Rincon (EBID)	Leasburg (EBID)	Mesilla (EBID + EPCWID)	Total Leasburg-Mesilla (EBID)	Mesilla East (EBID)	Mesilla West (EBID)	Total EBID	Mesilla East TX (EPCWID)	Mesilla West TX (EPCWID)	El Paso Valley (EPCWID)	Total EPCWID	HCCRD
1988	53,563	78,939	132,481	197,111	38,314	79,859	250,674	4,190	10,118	118,483	132,791	46,714
1989	54,588	73,688	132,489	189,738	38,068	77,981	244,326	4,879	11,561	118,088	134,528	48,406
1990								4,148	10,820	108,658	123,626	
1991	48,576	73,202	127,266	178,827	32,975	72,651	227,403	5,999	15,642	140,160	161,801	45,252
1992								3,455	10,479	94,696	108,630	
1993	49,527	73,178	139,471	192,364	35,736	83,450	241,891	5,276	15,008	120,429	140,713	55,071
1994	60,037	81,338	158,292	213,988	42,142	90,509	274,025	7,184	18,457	146,048	171,690	59,659
1995	60,533	72,806	144,336	194,316	39,325	82,185	254,849	6,540	16,285	146,765	169,591	62,302
1996	51,325	67,736	160,207	196,048	41,532	86,780	247,373	9,237	22,659	178,169	210,064	51,348
1997	52,362	74,527	153,930	208,169	43,516	90,126	260,531	5,842	14,447	120,217	140,505	34,010
1998	61,914	73,877	149,291	201,811	41,652	86,282	263,725	6,095	15,263	129,957	151,315	42,895
1999	51,695	60,656	138,790	169,560	34,690	74,214	221,255	8,426	21,460	203,138	233,024	48,942
2000	55,585	69,008	140,709	189,698	40,198	80,492	245,283	5,926	14,093	135,916	155,935	46,466
2001	57,194	68,540	137,028	186,696	38,563	79,594	243,890	5,510	13,362	168,480	187,351	42,378
2002	55,628	63,490	139,418	178,990	36,951	78,549	234,618	6,834	17,085	221,097	245,015	46,606
2003	12,342	12,975	39,011	43,377	8,768	21,634	55,719	2,232	6,376	98,112	106,721	23,391
2004	12,967	12,283	39,340	42,678	8,473	21,922	55,645	2,206	6,739	102,320	111,264	20,077
2005	41,213	45,685	105,729	139,144	28,613	64,846	180,357	3,386	8,884	99,595	111,866	21,333
2006	19,206	19,345	56,370	65,277	13,967	31,966	84,483	2,894	7,544	101,333	111,771	23,667
2007	35,117	32,834	90,336	113,375	24,475	56,066	148,492	2,700	7,095	105,310	115,105	27,826
2008	43,081	45,045	109,874	144,820	30,578	69,197	187,901	2,822	7,277	105,006	115,105	
2009	43,797	46,214		143,897	30,601	67,082	187,694					
2010	33,647	36,415	107,088	121,770	25,743	59,611	155,417	5,879	15,854	263,031	284,765	
2011	5,139	4,993		19,010	3,785	10,232	24,149					
2012	12,570	11,208			10,096	23,140	57,014					
2013	4,157	4,086			3,230	8,238	19,711					
2014	9,271	11,050			8,274	19,540	48,135					
2015	13,701	15,144			12,607	28,963	70,416					
2016	15,670	17,479			14,298	35,656	83,103					
2017												
Avg	35,806	57,946	114,995	158,115	30,290	62,509	186,550	3,201	13,588	126,621	143,410	43,667
Max	61,914	113,430	184,150	270,606	55,890	101,286	321,426	9,237	23,806	263,031	284,765	70,370
Min	4,157	4,086	19,117	19,010	3,230	8,238	19,711	197	2,654	29,162	32,101	20,077
Avg 38-78	31,766	63,317	109,351	156,881	31,193	62,371	188,646	1,739	14,048	122,337	138,124	
Avg 79-05	48,774	64,881	128,102	173,761	35,029	73,851	222,534	5,365	13,504	130,601	149,470	45,100
Avg 06-17	21,396	22,165	90,917	101,358	16,150	37,245	96,956	3,574	9,443	143,670	156,687	25,747
Avg 40-17	35,780	57,170	114,159	156,675	29,988	62,045	184,983	3,222	13,420	126,356	142,998	43,667

Notes:

Values in black text are reported values.

Values in blue text are computed values.

Gray-highlighted cells indicate no data.

Table 4-2

Annual Allotments
Rio Grande Project
1951 - 1978 (AF/acre)

Year	(1) Full Supply Year?	Initial Allotment to Project Lands	Final Allotment to Project Lands	Initial Release Date from Caballo
1951	No	1.00	1.75	6-Mar
1952	No	0.21	2.50	20-Mar
1953	No	1.00	1.90	10-Mar
1954	No	0.42	0.50	20-Mar
1955	No	0.21	0.42	20-Mar
1956	No	0.33	0.39	18-Mar
1957	No	0.10	1.17	20-Mar
1958	Yes	1.75	4.00	1-Mar
1959	Yes	3.00	3.50	2-Mar
1960	Yes	2.25	3.25	2-Mar
1961	No	1.25	2.45	10-Mar
1962	Yes	1.75	3.25	5-Mar
1963	No	1.85	2.00	5-Mar
1964	No	0.25	0.33	15-Mar
1965	No	0.17	1.85	20-Mar
1966	No	1.75	2.50	5-Mar
1967	No	1.25	1.50	27-Feb
1968	No	1.00	2.00	27-Feb
(2) 1969	Yes	1.25	3.00	27-Feb
1970	Yes	2.00	3.00	23-Feb
1971	No	1.50	1.75	26-Feb
1972	No	0.60	0.80	1-Mar
1973	Yes	1.00	3.00	9-Mar
1974	Yes	3.00	3.00	2-Mar
1975	Yes	1.00	3.00	24-Jan
1976	Yes	2.50	3.00	16-Jan
1977	No	1.00	1.25	3-Mar
1978	No	0.25	0.75	10-Mar
Avg		1.20	2.06	4-Mar
Max		3.00	4.00	20-Mar
Min		0.10	0.33	16-Jan

Source: USBR handout in DC_11282012.pdf.

Note: (1) Full supply years are years with final allotment greater than or equal to 3.00 AF/ac.

(2) Annual allotment value in the USBR 1986 Annual Operating Plan for this year is 1.33.

Table 4-3

Annual Allocations and Deliveries
Rio Grande Project
1979 - 2018 (acre-feet)

		(1)	EBID				EPCWID				Mexico		Total
	Year	Full Supply Year?	Allocation	Delivery	First Month Used	Last Month Used	Allocation	Delivery	First Month Used	Last Month Used	Allocation	Delivery	US + Mex Allocation
(2)	1979	Yes	414,448	343,811	Mar	Sep	315,548	240,471	Mar	Sep	60,000	60,055	789,996
	1980	Yes	414,448	414,452	Feb	Sep	315,548	302,339	Feb	Sep	60,000	60,033	789,996
(3)	1981	Yes	393,671	381,211	Mar	Sep	296,980	242,754	Mar	Sep	60,000	60,262	750,650
	1982	Yes	414,448	406,059	Feb	Sep	315,548	271,797	Feb	Sep	60,000	59,257	789,996
	1983	Yes	414,448	414,069	Mar	Aug	315,548	256,034	Mar	Sep	60,000	60,621	789,996
	1984	Yes	478,037	408,028	Mar	Oct	363,960	289,976	Mar	Oct	60,000	58,588	901,997
	1985	Yes	478,037	430,098	Feb	Oct	363,963	275,540	Feb	Oct	60,000	60,276	902,000
	1986	Yes	478,037	526,325	Jan	Oct	363,963	389,740	Jan	Oct	60,000	66,163	902,000
	1987	Yes	478,037	513,174	Feb	Oct	363,963	308,850	Feb	Oct	60,000	65,866	902,000
	1988	Yes	478,037	487,021	Feb	Oct	363,963	340,574	Feb	Oct	60,000	61,935	902,000
	1989	Yes	471,735	477,083	Feb	Sep	359,165	333,183	Feb	Oct	60,000	58,854	890,900
	1990	Yes	471,735	407,662	Feb	Oct	359,165	282,749	Feb	Oct	60,000	58,353	890,900
	1991	Yes	494,979	395,933	Feb	Oct	376,862	234,303	Mar	Oct	60,000	59,242	931,841
	1992	Yes	494,979	421,533	Feb	Oct	376,862	360,712	Jan	Oct	60,000	58,080	931,841
	1993	Yes	494,979	465,666	Feb	Oct	376,862	405,681	Jan	Oct	60,000	63,763	931,841
	1994	Yes	494,979	454,492	Feb	Oct	376,862	306,247	Jan	Oct	60,000	60,167	931,841
	1995	Yes	494,979	367,520	Feb	Oct	376,862	279,723	Jan	Oct	60,000	63,618	931,841
	1996	Yes	494,979	483,214	Jan	Sep	376,862	315,001	Jan	Sep	60,000	60,063	931,841
	1997	Yes	494,979	500,483	Feb	Oct	376,862	334,751	Jan	Oct	60,000	50,442	931,841
	1998	Yes	494,979	488,516	Feb	Oct	376,862	346,782	Jan	Oct	60,000	60,626	931,841
	1999	Yes	494,979	426,132	Feb	Oct	376,862	340,727	Jan	Oct	60,000	58,306	931,841
	2000	Yes	494,979	460,278	Feb	Oct	376,862	306,375	Jan	Oct	60,000	60,611	931,841
	2001	Yes	494,979	460,182	Feb	Oct	376,862	343,365	Feb	Oct	60,000	61,037	931,841
	2002	Yes	494,979	431,521	Feb	Oct	376,862	376,926	Feb	Oct	60,000	60,324	931,841
	2003	No	165,144	164,740	Mar	Sep	137,862	137,250	Mar	Sep	26,616	26,948	329,622
	2004	No	185,507	164,572	Mar	Oct	154,265	144,005	Mar	Sep	27,197	27,613	366,969
	2005	Yes	494,979	353,261	Mar	Oct	376,862	247,607	Mar	Oct	60,000	58,091	931,841
	2006	No	211,385	211,841	Mar	Oct	241,657	177,183	Mar	Oct	33,895	27,112	486,937
	2007	Yes	311,517	302,665	Mar	Oct	403,491	278,252	Mar	Oct	58,769	51,245	773,777
	2008	Yes	324,990	329,294	Mar	Oct	512,055	279,173	Feb	Oct	60,000	56,048	897,045
	2009	Yes	345,817	305,475	Feb	Sep	552,997	320,083	Feb	Oct	53,386	58,688	952,200
	2010	No	305,870	282,082	Mar	Sep	532,158	304,937	Mar	Sep	50,235	56,883	888,263
	2011	No	77,104	59,771	Jun	Jul	267,813	258,772	Mar	Sep	25,649	25,650	370,566
	2012	No	135,633	133,060	Apr	Aug	141,977	136,380	Apr	Sep	23,196	23,187	300,806
	2013	No	57,011	54,002	Jun	Jul	47,043	53,530	Jun	Jul	3,665	3,709	107,719
	2014	No	107,659	99,007	May	Aug	100,103	97,418	May	Aug	18,216	18,261	225,978
	2015	No	170,592	143,404	May	Sep	200,314	165,872	May	Sep	35,355	33,772	406,262
	2016	No	180,912	175,199	Apr	Sep	268,381	216,309	Mar	Sep	46,497	43,787	495,790
	2017	Yes	270,749	259,510	Apr	Oct	452,021	249,919	Mar	Oct	60,000	54,506	782,770
	2018	No	123,315	127,487	Apr	Aug	314,520	279,211	Jun	Oct	37,670	37,735	475,504
	Average		369,826	343,246			333,079	270,762			51,509	51,244	754,414
	1979-2007		437,703	405,570			342,545	292,031			56,775	56,467	837,023
	2008-2018		190,877	178,936			308,126	214,691			37,624	37,475	536,627

Note: (1) From 1979 - 2005 full supply years are years with Mexico allocations (rounded to nearest 1,000) equal to or greater than 60,000 acre-feet. From 2006 - 2018, full supply years are years with EPCWID current year allocation greater than 360,000 acre-feet.
(2) Annual total allotment for 1979 from USBR table (USBR handout in DC_11282012.pdf).
(3) Full supply year per reported allotment to EBID of 3.00 af/acre.

Table 5-1

Comparison of Historical Average Annual Flows to Rio Grande Joint Investigation for Various Periods (1,000 AF)

	(1)	(2)	(3)	(4)
Period	San Marcial	Reservoir Release	El Paso	Caballo to El Paso Depletion
(5,6) RGJI	1,031	773		
1922 - 2017	780	678	414	264
1936 - 1950	961	845	583	263
1936 - 2017	754	651	381	269
1922 - 1950	949	843	594	248
1930 - 1950	906	829	568	261
1951 - 2017	707	607	336	271
1951 - 1979	602	508	261	247
1980 - 2002	951	806	493	313
2003 - 2017	537	493	242	251
1951 - 1984	652	528	273	255
1985 - 2002	953	852	536	316
2003 - 2007	538	502	261	241
2008 - 2017	537	488	232	256

<u>Notes:</u>

(1) Rio Grande at San Marcial gage.
(2) Rio Grande above Percha Dam gage for 1922-1938 and Caballo Reservoir release for 1938-2017.
(3) Rio Grande at El Paso gage.
(4) Reservoir release minus El Paso gage.
(5) RGJI estimate of average San Marcial flow (1890-1935 adjusted for upstream development (Table 34).
(6) RGJI of annual reservoir release required to supply the Project (Table 95).

Table 6-1
Example of the Canal and Farm Budget Calculations

Single Input

Monthly Input

Annual Input

Rincon Unit

Heading	**Units**	**Col.**	**Equation**
Date		a	Date
Mo		b	Month
Year		c	Year
Days in Mo.		d	Days in month
Pump Seas		e	Pumping season (1 = yes, 0 = no)
Surface Water Irrigated Lands	(ac)	f	Irrigated Acreage with Surface Water Supplies
Primary Ground Water Irrigated Lands	(ac)	g	Irrigated Acreage with Only Ground Water Supplies
Surface Water Diversion	(af)	h	Total Surface Water Diversions
Crop Irrigation Req.	(af/ac)	I	Crop Irrigation Requirement of lands with Surface Water Supplies
Crop Irrigation Req. GW Only	(af/ac)	j	Crop Irrigation Requirement of lands with Only Ground Water Supplies
Excess Effective Precipitation	(af)	k	Excess Effective Precipitation
SW Lands Crop Irrigation Req.	(af)	l	Surface Water Irrigated Land * Crop Irrigation Req.
Total Crop Irrigation Req.	(af)	m	(Surface Water Irrigated Lands + Primary Ground Water Irrigated Lands) * Crop Irrigation Req.
Total Canal Loss	(af)	n	Surface Water Diversions * Total Canal Loss %
Incidental Canal Loss	(af)	o	Total Canal Loss * Incidental Loss %
Canal Seepage	(af)	p	Total Canal Loss - Incidental Conveyance Loss
Wasteway Flows	(af)	q	Surface Water Diversion * Wasteway Flows %
MFE	(%)	r	Maximum On-farm Irrigation Efficiency
El Paso Valley Carriage	(af)	s	Surface Water Diversions * El Paso Valley Carriage %
FHG Delivery	(af)	t	Surface Water Diversion - (Total Canal Loss + Wasteway Flows + El Paso Valley Carriage)
BOM Soil Moisture	(af)	u	EOM Soil Moisture + Excess Effective Precipitation
FHG Surface Water Available	(af)	v	FHG Delivery * Maximum On-farm Irrigation Efficiency %
CU of Surface Water	(af)	w	MIN(SW Lands Crop Irrigation Req., FHG Surface Water Available)
CU of Soil Moisture Carryover	(af)	x	MIN((SW Lands Crop Irrigation Req. - CU of Surface Water), BOM Soil Moisture)
Max Suppl Ground Water	(af)	y	((Supplemental Pumping Capacity / 226.29 * Days in Mo.) * Maximum On-farm Irrigation Efficiency % * Supplemental Pumping Development % * Pump Seas * Simulate Ground Water Pumping (1=y, 0=n)
CU of Suppl Ground Water Pumping	(af)	z	MIN(Max Suppl Ground Water, (SW Lands Crop Irrigation Req. - (CU of Surface Water + CU of Soil Moisture)) * Supplemental Pumping Development %) * % Unmet Demand met by Suppl Pumping
Suppl Ground Water Pumping	(af)	aa	CU of Suppl Ground Water Pumping / Maximum On-farm Irrigation Efficiency %
CU of Primary Ground Water Pumping	(af)	ab	MIN(Primary Pumping Capacity * Maximum On-farm Irrigation Efficiency %), Crop Irrigation Req. * Primary Ground Water Irrigated Lands)* % Unmet Demand met by Primary Pumping * Pump Seas * Simulate Ground Water Pumping (1=y, 0=n)
Primary Ground Water Pumping	(af)	ac	CU of Primary Ground Water Pumping / Maximum On-farm Irrigation Efficiency %
Total Ground Water Pumping	(af)	ad	Suppl Ground Water Pumping + Primary Ground Water Pumping
Available for Soil Moisture Carryover	(af)	ae	BOM Soil Moisture + FHG Surface Water Available - CU of Surface Water - CU of Soil Moisture Carryover+ Suppl Ground Water Pumping * Maximum On-farm Irrigation Efficiency % - CU of Suppl Ground Water Pumping
EOM Soil Moisture	(af)	af	MIN(Soil Moisture Reservoir Capacity / 12 * Surface Water Irrigated Lands, Available for Soil Moisture Carryover)

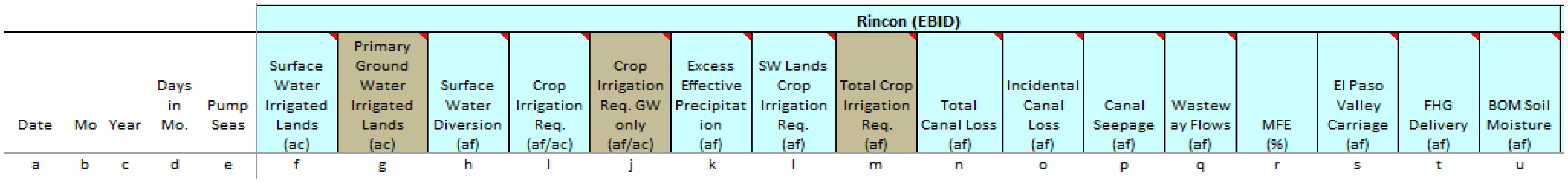
Table 6-1
Example of the Canal and Farm Budget Calculations

Single Input
Monthly Input
Annual Input

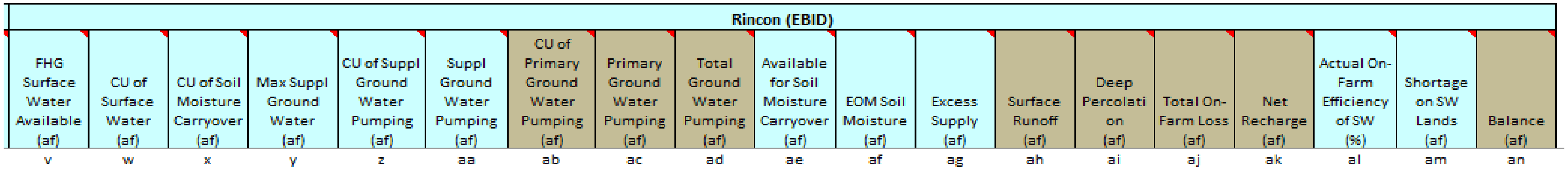
Rincon Unit

Heading	**Units**	**Col.**	**Equation**
Excess Supply	(af)	ag	Available for Soil Moisture Carryover - EOM Soil Moisture
Surface Runoff	(af)	ah	((FHG Delivery + Total Ground Water Pumping)*(1 - Maximum On-farm Irrigation Efficiency %) + Excess Supply) * Surface Runoff %
Deep Percolation	(af)	ai	((FHG Delivery + Total Ground Water Pumping)*(1 - Maximum On-farm Irrigation Efficiency %) + Excess Supply) * (1 - Surface Runoff %)
Total On-Farm Loss	(af)	aj	Surface Runoff + Deep Percolation
Net Recharge	(af)	ak	(Canal Seepage + Deep Percolation) - Total Ground Water Pumping
Actual On-Farm Efficiency of SW	(%)	al	IFERROR((CU of Surface Water + MAX((EOM Soil Moisture - BOM Soil Moisture),0)/(FHG Delivery), " ")
Shortage on SW Lands	(af)	am	SW Lands Crop Irrigation Req. - CU of Surface Water - CU of Soil Moisture Carryover- CU of Suppl Ground Water Pumping
Balance	(af)	an	(Surface Water Diversion - Total Canal Loss - Wasteway Flows - El Paso Valley Carriage) + Primary Ground Water Pumping + Suppl Ground Water Pumping - Total On-Farm Loss - CU of Surface Water - CU of Soil Moisture Carryover- CU of Suppl Ground Water Pumping - CU of Primary Ground Water Pumping - (EOM Soil Moisture - BOM Soil Moisture)

Example Column Headings:



					Rincon (EBID)															
Date	Mo	Year	Days in Mo.	Pump Seas	Surface Water Irrigated Lands (ac)	Primary Ground Water Irrigated Lands (ac)	Surface Water Diversion (af)	Crop Irrigation Req. (af/ac)	Crop Irrigation Req. GW only (af/ac)	Excess Effective Precipitation (af)	SW Lands Crop Irrigation Req. (af)	Total Crop Irrigation Req. (af)	Total Canal Loss (af)	Incidental Canal Loss (af)	Canal Seepage (af)	Wasteway Flows (af)	MFE (%)	El Paso Valley Carriage (af)	FHG Delivery (af)	BOM Soil Moisture (af)
a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u



Rincon (EBID)																		
FHG Surface Water Available (af)	CU of Surface Water (af)	CU of Soil Moisture Carryover (af)	Max Suppl Ground Water (af)	CU of Suppl Ground Water Pumping (af)	Suppl Ground Water Pumping (af)	CU of Primary Ground Water Pumping (af)	Primary Ground Water Pumping (af)	Total Ground Water Pumping (af)	Available for Soil Moisture Carryover (af)	EOM Soil Moisture (af)	Excess Supply (af)	Surface Runoff (af)	Deep Percolation (af)	Total On-Farm Loss (af)	Net Recharge (af)	Actual On-Farm Efficiency of SW (%)	Shortage on SW Lands (af)	Balance (af)
v	w	x	y	z	aa	ab	ac	ad	ae	af	ag	ah	ai	aj	ak	al	am	an

Table 6-2
Annual Farm Headgate Deliveries
Canal and Farm Budget Models
1938 - 2017 (acre-feet)

Year	Rincon (EBID)	Leasburg (EBID)	Mesilla (EBID + EPCWID)	Total Mesilla (EBID)	Mesilla East (EBID)	Mesilla West (EBID)	Total EBID	Mesilla East TX (EPCWID)	Mesilla West TX (EPCWID)	El Paso Valley (EPCWID)	Total EPCWID	HCCRD	Total JID
1938	33,707	79,893	133,086	192,852	38,172	74,786	226,559	2,206	17,921	122,842	142,969	68,782	42,082
1939	39,913	94,143	153,712	224,185	45,057	84,985	264,098	2,683	20,987	148,996	172,667	65,845	45,238
1940	41,123	89,823	151,043	217,728	44,807	83,098	258,851	2,662	20,475	154,284	177,422	59,794	49,406
1941	35,146	74,238	128,967	183,629	36,909	72,482	218,775	2,141	17,435	117,414	136,990	50,544	49,894
1942	41,593	79,425	136,299	195,449	40,489	75,535	237,042	2,321	17,954	126,240	146,515	56,993	61,999
1943	49,335	100,990	163,144	240,129	49,307	89,832	289,464	2,806	21,199	169,683	193,688	50,307	52,595
1944	47,873	98,394	163,346	237,623	49,069	90,160	285,496	2,798	21,319	162,200	186,317	55,941	50,741
1945	50,532	113,430	184,150	270,606	55,890	101,286	321,139	3,168	23,806	186,850	213,824	56,830	57,165
1946	46,929	99,630	170,810	245,169	49,472	96,068	292,098	2,792	22,479	180,950	206,221	58,580	53,548
1947	43,420	95,210	157,827	229,470	44,157	90,103	272,890	2,491	21,076	170,370	193,937	49,489	47,218
1948	40,890	93,728	157,439	227,720	46,050	87,942	268,610	2,629	20,818	159,580	183,027	59,240	41,959
1949	43,594	95,140	163,440	234,775	49,312	90,322	278,368	2,770	21,036	176,050	199,855	69,881	43,423
1950	48,038	100,290	158,691	235,769	47,140	88,339	283,807	2,647	20,566	181,004	204,216	74,588	46,417
1951	24,702	49,982	87,227	124,355	24,865	49,508	149,057	1,389	11,466	125,707	138,561	26,787	22,751
1952	28,181	54,825	95,340	136,442	28,402	53,215	164,623	1,565	12,158	153,497	167,220	30,449	33,624
1953	26,638	51,494	94,579	132,316	26,721	54,101	158,954	1,464	12,293	127,154	140,911	21,901	28,132
1954	8,021	18,383	33,932	47,675	9,358	19,934	55,696	472	4,168	41,064	45,704	3,819	9,625
1955	5,554	14,843	25,278	36,540	5,797	15,901	42,095	289	3,291	34,779	38,360	224	8,787
1956	5,610	12,386	22,300	31,747	5,559	13,803	37,357	260	2,679	24,382	27,321	2	8,237
1957	12,041	30,963	51,412	75,365	10,980	33,422	87,406	515	6,495	75,568	82,578	794	20,000
1958	38,245	73,232	135,383	189,478	35,857	80,388	227,723	1,859	17,279	153,927	173,064	16,846	45,578
1959	36,595	75,152	121,237	179,421	35,961	68,308	216,016	1,912	15,057	173,983	190,951	27,534	45,877
1960	41,068	75,015	127,321	184,693	37,312	72,366	225,761	1,951	15,692	158,979	176,622	36,882	46,219
1961	26,833	57,745	104,043	147,635	29,210	60,680	174,468	1,472	12,681	137,360	151,513	30,728	37,097
1962	38,424	77,027	137,436	195,421	41,315	77,078	233,845	2,180	16,863	158,533	177,575	47,586	45,245
1963	27,886	56,665	103,541	145,379	29,061	59,653	173,265	1,559	13,268	124,914	139,741	32,239	29,263
1964	5,304	10,864	19,117	27,130	3,829	12,437	32,434	197	2,654	29,682	32,533	2,865	8,155
1965	22,328	41,176	79,473	109,713	21,363	47,174	132,041	1,077	9,859	91,596	102,532	4,062	27,671
1966	32,192	58,937	100,412	145,653	29,147	57,569	177,845	1,490	12,206	109,927	123,623	25,143	39,903
1967	20,788	40,823	72,854	103,405	21,231	41,351	124,193	1,132	9,140	90,788	101,060	15,006	24,298
1968	29,334	46,800	86,440	121,202	23,822	50,581	150,536	1,228	10,810	92,912	104,950	22,558	33,421
1969	37,184	66,661	123,908	173,073	32,304	74,108	210,257	1,664	15,832	136,314	153,810	48,605	47,828
1970	40,581	76,274	132,824	190,655	35,084	79,297	231,236	1,778	16,665	138,870	157,313	59,685	47,120
1971	27,545	48,425	87,663	124,112	23,677	52,010	151,657	1,185	10,791	105,454	117,430	30,752	30,796
1972	11,354	20,258	38,342	53,076	9,385	23,433	64,430	487	5,038	52,698	58,222	15,390	20,808
1973	38,282	65,031	120,648	170,007	34,184	70,792	208,289	1,635	14,038	114,805	130,477	32,756	50,422
1974	38,463	66,013	125,076	175,231	35,518	73,700	213,694	1,651	14,207	122,339	138,197	55,013	53,429
1975	38,488	67,073	119,898	171,803	34,872	69,858	210,290	1,630	13,539	120,079	135,247	57,729	52,922
1976	44,460	71,518	130,553	180,418	37,038	71,861	224,878	3,208	18,445	127,261	148,914	63,878	53,749
1977	19,967	35,614	56,311	82,397	13,758	33,025	102,364	1,269	8,258	72,279	81,807	26,800	27,834
1978	11,782	18,006	28,763	42,085	7,385	16,694	53,867	657	4,027	48,165	52,849	14,846	25,466
1979	36,187	49,763	99,045	133,199	26,782	56,654	169,386	4,522	11,088	111,215	126,825	30,297	58,755
1980	46,320	68,226	126,731	177,436	34,764	74,446	223,756	4,972	12,548	122,183	139,704	27,199	61,168
1981	43,367	60,979	122,136	165,271	33,861	70,431	208,639	5,240	12,605	120,730	138,574	43,038	68,337
1982	47,372	66,010	136,616	179,344	35,776	77,559	226,717	6,625	16,656	144,054	167,336	53,392	65,205

Table 6-2
Annual Farm Headgate Deliveries
Canal and Farm Budget Models
1938 - 2017 (acre-feet)

Year	Rincon (EBID)	Leasburg (EBID)	Mesilla (EBID + EPCWID)	Total Mesilla (EBID)	Mesilla East (EBID)	Mesilla West (EBID)	Total EBID	Mesilla East TX (EPCWID)	Mesilla West TX (EPCWID)	El Paso Valley (EPCWID)	Total EPCWID	HCCRD	Total JID
1983	44,435	68,830	137,639	183,541	34,370	80,341	227,976	6,031	16,897	113,809	136,737	47,978	66,440
1984	45,039	67,408	127,604	177,387	36,360	73,619	222,425	5,227	12,398	111,766	129,391	62,832	69,855
1985	58,080	74,772	140,327	197,135	40,152	82,210	255,215	5,323	12,642	116,255	134,220	70,370	64,116
1986	60,847	80,676	137,723	202,736	42,886	79,174	263,583	4,982	10,681	117,344	133,007	33,868	69,641
1987	58,647	83,177	136,997	205,259	41,310	80,772	263,906	4,571	10,344	118,556	133,471	61,586	71,952
1988	53,563	78,939	132,481	197,111	38,314	79,859	250,674	4,190	10,118	118,483	132,791	46,714	71,493
1989	54,588	73,688	132,489	189,738	38,068	77,981	244,326	4,879	11,561	118,088	134,528	48,406	72,072
1990	38,003	68,009	125,966	179,007	33,960	77,038	217,010	4,148	10,820	108,658	123,626	62,458	72,725
1991	48,576	73,202	127,266	178,827	32,975	72,651	227,403	5,999	15,642	140,160	161,801	45,252	73,822
1992	39,796	75,940	135,125	197,131	34,346	86,845	236,927	3,455	10,479	94,696	108,630	69,902	74,692
1993	49,527	73,178	139,471	192,364	35,736	83,450	241,891	5,276	15,008	120,429	140,713	57,376	78,188
1994	60,037	81,338	158,292	213,988	42,142	90,509	274,025	7,184	18,457	146,048	171,690	65,058	79,490
1995	60,533	72,806	144,336	194,316	39,325	82,185	254,849	6,540	16,285	146,765	169,591	67,762	82,711
1996	51,325	67,736	160,207	196,048	41,532	86,780	247,373	9,237	22,659	178,169	210,064	66,866	79,802
1997	52,362	74,527	153,930	208,169	43,516	90,126	260,531	5,842	14,447	120,217	140,505	50,508	79,166
1998	61,914	73,877	149,291	201,811	41,652	86,282	263,725	6,095	15,263	129,957	151,315	61,917	81,643
1999	51,695	60,656	138,790	169,560	34,690	74,214	221,255	8,426	21,460	203,138	233,024	68,023	80,435
2000	55,585	69,008	140,709	189,698	40,198	80,492	245,283	5,926	14,093	135,916	155,935	64,940	82,505
2001	57,194	68,540	137,028	186,696	38,563	79,594	243,890	5,510	13,362	168,480	187,351	61,211	83,602
2002	55,628	63,490	139,418	178,990	36,951	78,549	234,618	6,834	17,085	221,097	245,015	65,712	82,489
2003	12,342	12,975	49,782	54,148	12,104	29,069	66,490	2,232	6,376	85,346	93,955	30,907	59,448
2004	12,967	12,283	39,340	42,678	8,473	21,922	55,645	2,206	6,739	87,262	96,206	29,632	58,295
2005	41,213	45,685	105,729	139,144	28,613	64,846	180,357	3,386	8,884	99,595	111,866	34,793	80,932
2006	19,206	19,345	56,370	65,277	13,967	31,966	84,483	2,894	7,544	101,333	111,771	35,633	60,394
2007	35,117	32,834	90,336	113,375	24,475	56,066	148,492	2,700	7,095	105,310	115,105	43,481	78,459
2008	43,081	45,045	109,874	144,820	30,578	69,197	187,901	2,822	7,277	105,006	115,105	60,443	81,392
2009	43,311	46,214	108,601	143,897	30,601	67,082	187,208	637	10,282	138,510	149,428	63,977	84,267
2010	33,647	36,415	107,088	121,770	25,743	59,611	155,417	5,879	15,854	142,018	163,751	60,352	83,883
2011	5,139	4,993	15,601	19,010	3,785	10,232	24,149	84	1,500	93,938	95,522	21,202	64,921
2012	12,570	11,208	36,269	44,444	10,096	23,140	57,014	232	2,801	55,380	58,413	10,423	62,567
2013	4,157	4,086	12,679	15,554	3,230	8,238	19,711	74	1,137	30,891	32,102	10,254	50,321
2014	9,271	11,050	30,701	38,864	8,274	19,540	48,135	190	2,697	48,303	51,190	12,579	62,100
2015	13,701	15,144	45,857	56,715	12,607	28,963	70,416	289	3,998	64,256	68,543	14,056	73,280
2016	15,670	17,479	55,204	67,433	14,298	35,656	83,103	328	4,922	78,579	83,829	16,972	80,821
2017	25,925	35,456	100,370	126,355	26,729	64,170	152,280	613	8,858	87,209	96,680	25,993	87,240
Avg	35,723	58,006	109,084	151,497	30,383	63,108	187,221	2,911	12,682	119,358	134,951	41,638	55,057
Max	61,914	113,430	184,150	270,606	55,890	101,286	321,139	9,237	23,806	221,097	245,015	74,588	87,240
Min	4,157	4,086	12,679	15,554	3,230	8,238	19,711	74	1,137	24,382	27,321	2	8,155
Avg 38-78	31,706	63,305	109,348	156,867	31,191	62,370	188,573	1,739	14,048	121,939	137,725	37,261	38,194
Avg 79-07	46,602	62,686	124,868	169,289	33,995	72,608	215,891	5,188	13,077	127,761	146,026	51,969	72,684
Avg 08-17	20,647	22,709	62,225	77,886	16,594	38,583	98,533	1,115	5,933	84,409	91,456	29,625	73,079
Avg 40-17	35,696	57,262	108,204	150,035	30,095	62,678	185,731	2,923	12,508	118,933	134,364	40,980	55,349

Notes:

Farm headgate deliveries from WDR data with estimated and adjusted data for input into Integrated LRG Model.

Table 7-1

Summary of Required Simulation Processes For LRG Simulation Models

Physical Process	Management Process
	Project water allocation and accounting
	Reservoir releases
Reservoir evaporation	
Reservoir storage	
Reservoir spills	
River evaporation	
River routing	
River seepage	
	Canal diversions
	Wasteway flows
Canal conveyance losses	
	Farm headgate deliveries
	On-farm losses
Soil moisture storage	
Crop ET	
	Irrigation pumping
Drain flows	
	EPW water use (1)
	Other non-irrigation pumping (2)
Riparian/bare ground ET	
Ground water flow and storage	

Notes

(1) EPW use of Project water and pumping.

(2) Non-irrigation pumping and returns are specified model inputs

Table 10-1

List of Model Runs
Integrated LRG Model

Run No.	Name	Compare To Run	Notes
0	Historical Calibration Run		
1	Historical Base Run (All Pumping On)	0	
2	All Pumping Off	1	(1)
3	NM Pumping Off	1	(1)
4	TX Pumping Off	1	(1,2)
5	MX Pumping Off	1	(1)
6	R-M Pumping Off	1	(1,3)
7	TX Mesilla Pumping Off	1	(1)
8	TX Non-Irrigation Pumping Off	1	(1)
9	NM Non-Irrigation Pumping Off	1	(1)
10	MX Non-Irrigation Pumping Off	1	(1)
11	D1/D2 Allocation (All Pumping On)	--	(4)
12	D3+Carryover Allocation (All Pumping On)	11	(4)
13	Reduced Waste	1	

Notes:

(1) Corresponding WWTP returns and urban deep percolation returns are also turned off (no UDP simulated in Mexico).

(2) Including Texas Mesilla (EPCWID Mesilla and EPW Canutillo Wellfield).

(3) Including Texas Mesilla and Mexico Conejos-Medanos.

(4) Project allocation procedure simulated for 1951-2017.

Appendix 1A
Professional Resume of
Gregory K. Sullivan, P.E.

Gregory K. Sullivan, P.E.

Principal Water Resources Engineer

Education:

M.S., Civil Engineering, 1990, University of Colorado - Denver.
B.S., Civil Engineering, 1985, Colorado State University.

Professional Registration:

Professional Engineer in Colorado #26802, Idaho #8387, Nevada #10868, and New Mexico #22620

Professional Experience:

1990 - Present: ***Spronk Water Engineers, Inc., Principal and Senior Water Resources Engineer***

Mr. Sullivan is responsible for the management and successful completion of water rights engineering and water resources planning projects. Projects include water supply planning, changes of water rights, plans for augmentation, historical consumptive use and stream depletion analyses, water rights evaluations and appraisals, water supply planning, reservoir operations studies, ground water modeling and water rights accounting. Mr. Sullivan has extensive experience in litigation support and has provided expert testimony before courts and state agencies on numerous occasions.

Summary of Experience:

Mr. Sullivan has over thirty years of experience completing a wide variety of water resources engineering projects. Mr. Sullivan has extensive experience performing historical consumptive use analyses, stream depletions analyses, and reservoir operations studies. Mr. Sullivan serves as the primary consultant to numerous water providers for water supply planning and water rights engineering. In that role, he has been responsible for technical analyses in supporting changes of water rights, exchanges, augmentation plans, and other water right matters. He has led the development of complex surface water operations models that simulate municipal water demands and how those demands maybe met by available water supplies and water rights. Mr. Sullivan has served on the Eastern Snake Hydrologic Modeling Committee that guides the development and use of a regional ground water model of the Eastern Snake River Plain Aquifer since 1996. Mr. Sullivan has provided expert testimony in the U.S. Supreme Court, Colorado Water Courts, Snake River Basin Adjudication Court (Idaho), and in administrative hearings before the Idaho Department of Water Resources.

Gregory K. Sullivan, P.E.

Principal Water Resources Engineer

Description of Representative Projects:

Change of Water Rights, City of Loveland

Mr. Sullivan was the principal investigator for ditch-wide historical use analyses of the major Big Thompson River irrigation ditches that serve lands in and around the City of Loveland. These analyses served as the basis for successful changes of water rights that were approved by the Division 1 Water Court to allow the City to divert its ditch shares at the City's municipal water intakes to help meet its water supply needs.

Water Supply Yield Modeling, City of Loveland

Mr. Sullivan led the development of a model to simulate the daily water supply and demand of the City of Loveland over a study period from 1950 - 2017. The water supplies that are simulated in the model include the ditch shares that have been changed to municipal use, Colorado-Big Thompson Project units, Windy Gap Project units, and the operation of the City's Green Ridge Glade Reservoir. The model is used by the City to evaluate the firm yield of its water supply, and how that yield can be increased through acquisition of additional supplies, development of additional storage, changes in water supply operations and other actions.

Water Supply Planning, ACWWA

Mr. Sullivan has provided water resources and water rights consulting for the Arapahoe County Water and Wastewater Authority ("ACWWA") for almost 30 years. ACWWA serves lands in the Cherry Creek basin south of Denver through a combination of shallow alluvial wells and deep nontributary Denver Basin wells. Water use from these sources is integrated and optimized through operation of a complex plan for augmentation that provides for replacement of out-of-priority depletions to Cherry Creek to protect downstream senior water users. Mr. Sullivan has performed numerous analyses to evaluate the yield of ACWWA's water supplies, including completion of a raw water master plan in 2018.

Plan for Augmentation, Upper Cherry Creek Water Association

Mr. Sullivan led the development of an umbrella plan for augmentation for five major water users in the Cherry Creek Basin upstream of Cherry Creek Reservoir. The members have pooled their augmentation sources to replace the combined out-of-priority depletions resulting from alluvial well pumping and out-of-priority storage in Cherry Creek Reservoir. The plan includes an innovative method of computing depletions that considers times when Cherry Creek is dry in the area of the member wells.

Cherry Creek Aquifer Modeling Project

Mr. Sullivan led the development of a basin-wide simulation model of the hydrology and water use in the Cherry Creek basin upstream of Cherry Creek Reservoir. The model simulates the water supplies and water rights of the all of the municipal water providers in the study area and optimizes the alluvial pumping of the water users and the use of Denver Basin ground water replacement supplies. The model also simulates the operation of Cherry Creek Reservoir and Rueter-Hess Reservoir. The model is used by the study participants to evaluate changes in water supply operations and acquisition of new water supplies.

Snake River Delivery Calls, City of Pocatello, Idaho

Mr. Sullivan has provided technical analysis and expert testimony to the City of Pocatello in their participation in complex litigation involving water right delivery calls by senior surface water users on the Snake River in Idaho. Pocatello's water supply is derived primarily from junior priority wells that are tributary to the Snake River, and its water supply is threatened by the delivery calls. Mr. Sullivan analyzed the historical operation of seven major irrigation districts that placed the delivery calls to assess the extent of their claimed irrigation water shortages. The irrigation districts serve a combined area of 560,000 acres with annual diversions averaging 3.2 million acre-feet per year.

ESPA Cities Mitigation Plan, Idaho

Mr. provided technical expertise and analysis to develop a mitigation plan for Pocatello, Idaho Falls, and more than a dozen other cities to mitigate the impacts of pumping ground water from the Eastern Snake Plain Aquifer in Idaho. The plan relies largely on aquifer recharge to mitigate the impacts of aquifer depletions from pumping that is projected to increase from about 60,000 acre-feet per year to over 120,000 acre-feet per year over the next 50 years.

Division 3 Rules Case, Rio Grande Basin, Colorado

Mr. Sullivan represented a group of surface water right owners that opposed the enactment of administrative rules governing the withdrawal and use of ground water in the Rio Grande Basin in Colorado (Water Division 3). The primary basis for their opposition was that the rules did not provide for mitigation of impacts to a large spring that was the source of their surface water rights and which dried up in conjunction with the large-scale development of ground water irrigation in the area. Mr. Sullivan's work included analysis of the historical irrigation water use by his clients, review of hydrologic data and records, and review of a ground water modeling of the San Luis Valley performed by the State of Colorado. Mr. Sullivan provided expert testimony on behalf of his clients in a trial before the Division 3 Water Court.

Administration of Rocky Hill Seepage and Overflow Ditch, Rio Grande Basin, Colorado

Mr. Sullivan represented a majority owner of the Rocky Hill Seepage and Overflow Ditch in the northwestern portion of the San Luis Valley in an action brought to overturn a change in administration by the Division 3 Engineer that curtailed use of the ditch on the basis that the source of water for the ditch that has been used for almost 100 years is not described in the decree for the ditch. Mr. Sullivan's work involved research of historical documents related to adjudication of the water right and historical disputes among water users in the vicinity, compilation and analysis of historical hydrologic data, and development of opinions on the decreed source of the water for the ditch. Mr. Sullivan provided expert testimony in a trial over the dispute in the Division 3 Water Court.

Surface and Ground Water Modeling, Kansas v. Colorado

Mr. Sullivan was involved in the refinement and use of the H-I Model of the Arkansas River system in Colorado that was developed to support claims by the State of Kansas that Colorado was violating the terms of the 1948 Arkansas River Compact. The model simulates daily operation of irrigation water uses under approximately two dozen canal systems along the Arkansas River in Colorado between the City of Pueblo and the Colorado-Kansas from 1950 to the present. In addition, the model simulates the operation of sole-source and supplemental irrigation wells, and the impact of those wells on the flow of the Arkansas River. Mr. Sullivan provided expert testimony before a Special Master appointed by the U.S. Supreme Court regarding the use of the H-I Model to evaluate the effects on state-line flows resulting from post-compact well development in Colorado.

Injury Analysis, Kansas v. Colorado

Mr. Sullivan developed a model that was used as part of an analysis to compute the economic impacts and monetary damages to Kansas resulting from the compact violations by Colorado that were determined in the Kansas v. Colorado lawsuit. The model was used to translate monthly depletions to usable stateline flows during 1950 - 1994 into impacts to (a) surface water users in Kansas, (b) to supplemental pumping demands in Kansas and (c) to recharge of the regional ground water system. Mr.

Sullivan testified before the Special Master regarding the model development, operation, and results.

Analysis of Replacement Plans, Kansas v. Colorado
In order to continue their use of post-compact Arkansas River alluvial wells, the well owners were required to develop Replacement Plans to offset the impacts of pumping on senior surface water rights in Colorado and on usable stateline flows to Kansas. Mr. Sullivan analyzed the adequacy of these replacement plans through preparation of historical use analyses, water budgets, and other analyses. In addition, Mr. Sullivan used the H-I Model to simulate the effectiveness of the replacement plans in meeting Colorado's delivery obligations under the Arkansas River Compact. Mr. Sullivan provided expert testimony before the Special Master concerning his analyses of the Colorado Replacement Plans.

1985 – 1990: ***J. W. Patterson & Associates, Inc., Water Resources Engineer***
Performed water supply, hydraulic and hydrologic analyses for agricultural, industrial, commercial and municipal developments. Managed yield and impact analyses of water rights adjudications, transfers, exchanges and plans for augmentation. Conducted ground water studies including aquifer testing, project dewatering and water well design and construction monitoring.

Continuing Education

Applied Ground-Water Flow Modeling. International Ground Water Modeling Center, Colorado School of Mines, Golden, CO. March 1993

Introduction to Simulation Training in RiverWare, Center for Advanced Decision Support for Water and Environmental Systems, University of Colorado, May 2016.

List of Expert Reports Authored by
Gregory K. Sullivan, P.E.
During the Last Five Years

Report Date	Name of Report	Applicant	Case No.	Client
11/10/14	Applicant Expert Report, Applcation for Conditional Water Rights, Change of Water Rights, Plan for Augmentation, and Exchange, Case No. 10CW318, Water Division 1	Cherry Creek Project Water Authority	10CW318	CCPWA
12/08/14	Objector Expert Report - Change of Water Rights and Plan for Augmentation - Mount Carbon Metropolitan District Water Rights - Case Nos. 04CW196 and 04CW197	Mount Carbon Metro politan District	04CW196 & 04CW197	Genesee Water and Sanitation District
01/06/15	Applicant Expert Report - Application for Finding of Diligence, Cherry Creek Project Water Authority, Case No. 11CW120	Cherry Creek Project Water Authority	11CW120	CCPWA
03/09/15	Supplemental Applicant Expert Report - Change of Loveland Gard Right, Case No. 07CW325	City of Loveland	07CW325	Ryley Carlock & Applewhite
03/31/15	Applicant Expert Report - Application for Conditional Water Rights, Appropriative Rights of Exchange, Approval of Plan for Augmentation - Case No. 12CW124	Climax Molybdenum Company	12CW124	Climax Molybdenum Company
04/27/15	Rebuttal Expert Report - Application for Conditional Water Rights, Change of Water Rights, Plan for Augmentation, and Exchange, Case No. 10CW318, Water Division 1	Cherry Creek Project Water Authority	10CW318	CCPWA
06/01/15	Rebuttal Expert Report - Change of Loveland Gard Right, Case No. 07CW325, Water Division 1	City of Loveland	07CW325	Ryley Carlock & Applewhite
06/02/15	Supplemental Expert Report - Application for Conditional Water Rights, Appropriative Rights of Exchange, and Approval of Plan for Augmentation, Case No. 12CW124, Water Division 2	Climax Molybdenum Company	12CW124	Climax Molybdenum Company
07/20/15	Objector Expert Report - Change of Water Rights - Colorado Sweet Gold and Al Water, LLC - Case No. 12CW262	Colorado Sweet Gold, LLC	12CW262	City of Loveland
08/31/15	Rebuttal Expert Report - Application for Water Rights, Appropriative Rights of Exchange, and Plan for Augmentation	Climax Molybdenum Company	12CW124	Climax Molybdenum Company
12/28/15	Applicant Revised Expert Report - Arapahoe County Water and Wastewater Authority Plan for Augmentation - Case No. 96CW1144	ACWWA	96CW1144	Arapahoe County Water and Wastewater Authority
02/24/16	Rebuttal Expert Report - Arapahoe County Water and Wastewater Authority Plan for Augmentation - Case No. 96CW1144	ACWWA	96CW1144	Arapahoe County Water and Wastewater Authority
03/16/16	Supplemental Expert Report - Arapahoe County Water and Wastewater Authority Plan for Augmentation - Case No. 96CW1144	ACWWA	96CW1144	Arapahoe County Water and Wastewater Authority
04/18/16	Objector Expert Report - Denver Southeast Suburban Water and Sanitation District Plan for Augmentation - Case No. 11CW198	ACWWA and CWSD	11CW198	Arapahoe County Water and Wastewater Authority

List of Expert Reports Authored by
Gregory K. Sullivan, P.E.
During the Last Five Years

Report Date	Name of Report	Applicant	Case No.	Client
01/30/17	Expert Report - Application for Change of Water Rights - Case No. 16CW3003	2J Ranches, et. al.	16CW3003	2J Ranches, et. al.
05/25/17	Opposers Expert Report - Rules Governing the Withdrawal of Groundwater in Water Division No. 3 - Case No. 15CW3024	Colorado State Engineer	15CW3024	2J Ranches, et. al.
06/29/17	Rebuttal Expert Report - Application for Change of Water Rights - Case No. 16CW3003	2J Ranches, et. al.	16CW3003	2J Ranches, et. al.
07/13/17	Expert Report - Loveland Eisenhower Investments, LLC v. City of Loveland and Greeley and Loveland Irrigation Company - Case No. 16CV30362	Loveland Eisenhower Investments, LLC	16CV30362	City of Loveland
08/04/17	Sur-rebuttal Expert Report - Rules Governing the Withdrawal of Groundwater in Water Division No. 3 - Case No. 15CW3024	Colorado State Engineer	15CW3024	2J Ranches, et. al.
09/25/17	Objector Expert Report - Application for Water Rights, Change of Water Rights, and Plan for Augmentation - Sylvan Dale Ranch - Case No. 14CW3016	Sylvan Dale Ranch, LLP	14CW3016	City of Loveland
08/07/18	Expert Report, Protest of Application for Permit 63-34348 by Elmore County, Idaho	Elmore County, Idaho	n/a	City of Boise
09/18/18	Rebuttal Expert Report, Protest of Application for Permit 63-34348 by Elmore County, Idaho	Elmore County, Idaho	n/a	City of Boise
12/17/18	Applicant Expert Report, Application of Interpretation of Decree, Rocky Hill Seepage and Overflow Ditch, Case No. 2017CW3003, Water Division 3	State of Colorado	2017CW3003	Mike and Jim Kruse Partnership
01/30/19	Applicant Rebuttal Expert Report, Application of Interpretation of Decree, Rocky Hill Seepage and Overflow Ditch, Case No. 2017CW3003, Water Division 3	State of Colorado	2017CW3003	Mike and Jim Kruse Partnership

List of Cases in Which
Gregory K. Sullivan, P.E.
Has Testified as an Expert Witness
During the Past Four Years

Case No.	Court	Description	Client
10CW318	District Court, Water Division 1, Colorado	Application for Water Rights of Cherry Creek Project Water Authority	Cherry Creek Project Water Authority (Applicant)
16CW3003	District Court, Water Division 3, Colorado	Application for Water Rights of 2J Ranches, et. al.	2J Ranches, et. al.
15CW3024	District Court, Water Division 3, Colorado	Rules Governing the Withdrawal of Ground Water in Water Division 3	2J Ranches, et. al.
n/a	Idaho Department of Water Resources	Application for Permit No. 63-34348 by Elmore County Board of County Commissioners	City of Boise
17CW3003	District Court, Water Division 3, Colorado	Application of Interpretation of Decree, Rocky Hill Seepage and Overflow Ditch	Mike and Jim Kruse Partnership

Appendix 1B

Professional Resume of Adelheid M Welsh

Heidi M. Welsh, P.H.

Senior Watershed Scientist

Education:	B.S. Watershed Science, 2007, Colorado State University
Professional Registration:	Professional Hydrologist, American Institute of Hydrology

Professional Experience:

2009 - Present: ***Spronk Water Engineers, Inc., Senior Watershed Scientist***

Responsible for compilation and analysis of water resources, water rights and hydrologic data including climatological data, streamflow data, diversion records, cropping patterns, call records, water rights tabulations and decrees. Analyses include quantification of historical consumptive use, crop evapotranspiration calculations, water availability analyses, stream depletion modeling, point flow modeling, and other surface water modeling. Assists with water rights protection, substitute water supply plans, augmentation plans, and water rights accounting. Responsible for GIS mapping and modeling related to water resources including georeferencing and digitizing, delineation and quantification of irrigated area, hydrologic analyses, and geospatial analysis.

Summary of Experience:

Ms. Welsh has over ten years of experience working in the water resources field in Colorado, Wyoming, New Mexico, Montana, and Idaho. She has provided engineering support and assistance with water rights protection, substitute water supply plans, and augmentation plans. She is experienced in the review, development and maintenance of water rights accounting. She has extensive experience in GIS applications and modeling related to water resources and has prepared numerous court exhibits.

Description of Representative Projects:

Town of La Salle, Water Supply Consulting.

Assisted the Town in developing a water supply for irrigation of parks, ballfield, and subdivision lawns. Assisted with a substitute supply plan and assisted in change of Godfrey Ditch and Union Reservoir water rights application to allow use of an irrigation well, replacing depletions with leased water supplies from the reservoir. Engineering analyses include calculation of water demands, water consumption and timing of stream depletions to the South Platte River. Responsible for daily augmentation plan accounting.

City of Pocatello, Water Rights Protection and Water Supply.
Assists in preparation of exhibits and water rights analyses for administrative hearings. Engineering analyses include analysis and review of water rights data and water measurements, summarizing and mapping depletions using Eastern Snake Plain Aquifer Model runs, and mapping water rights data.

State of New Mexico, Rio Grande Compact.
Responsible for review, compilation, and maintenance of surface water data. Assists in the review of surface water modeling efforts, including RiverWare modeling.

Cherry Creek Project Water Authority.
Assists with analysis and mapping of the Cherry Creek Basin in support of water rights applications and basin modeling. Analyses include water availability analyses, point flow modeling, consumptive use analyses, and stream depletion modeling.

Climax Molybdenum, Plan for Augmentation in Division 2.
Assists with analysis in support of a water rights application. Analyses include computation of current and historical depletions, point flow and exchange potential modeling, and probability analyses. Responsible for GIS analyses and mapping for the project.

Centennial Water & Sanitation District, Water Rights Protection.
Assists with review of water court applications and substitute water supply plans for water rights protection. Analyses include return flow and consumptive use calculations, delineation of irrigated area, compilation of diversion records, and stream depletion modeling.

Yellowstone River Compact.
Delineated current and historic irrigated fields along the Powder and Tongue Rivers in Montana. Compiled and analyzed historical agricultural data from the U.S. Agricultural Census.

2007 – 2009: ***AATA International, Inc., Environmental/GIS Specialist***

Compiled and interpreted social and environmental data for preparation of large-scale environmental impact assessments and other technical reports. Responsible for collection and maintenance of databases. Conducted impact analysis, assessed water supply sources, and developed mitigation and monitoring plans for natural resource development projects. Utilized GIS software in mapping and analyses of environmental data and prepared numerous figures for technical reports.

2006 – 2007: ***USDA Forest Service, Hydrologic Technician***

Completed soil, stream crossing, and stream health surveys for timber sale units. Managed grazing by the completion of soil inventories for NEPA compliance. Mapped streams and forest roads using GPS and GIS. Evaluated Best Management Practices for feasibility and effectiveness.

2006: ***Teton Science School, Hydrology Intern***

Measured stream discharge, monitored ground water well levels and collected water quality samples weekly at twelve sites. Entered and analyzed data for technical documentation. Taught watershed science and hydrology field methods to adults and children.

Professional Memberships:

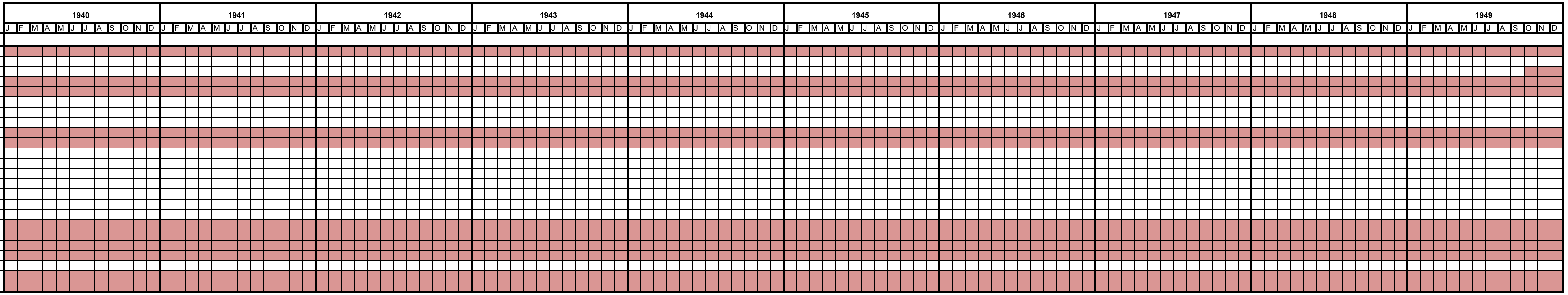
American Institute of Hydrology
American Water Resources Association
Colorado Ground Water Association

Appendix 3A
Monthly and Annual Data Availability Matrices

Summary of River Gage Data (red highlight = data available)

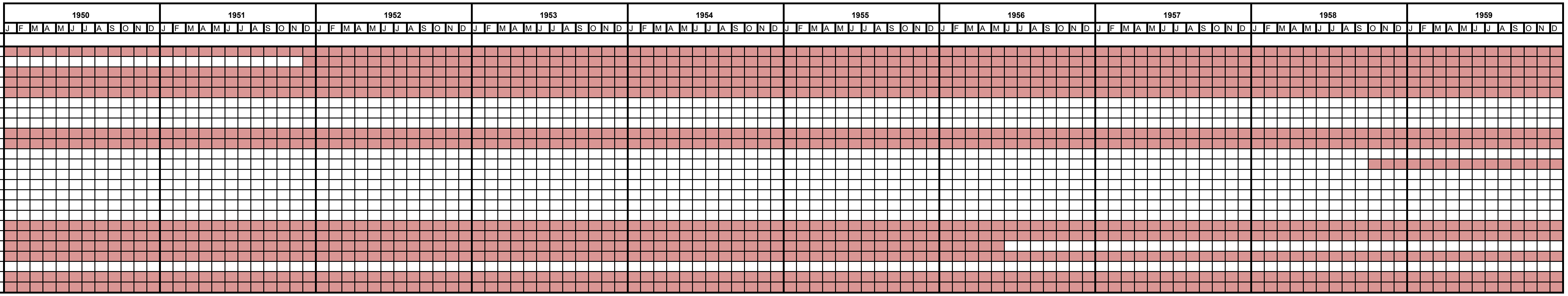
Monthly Data

1940 - 1949



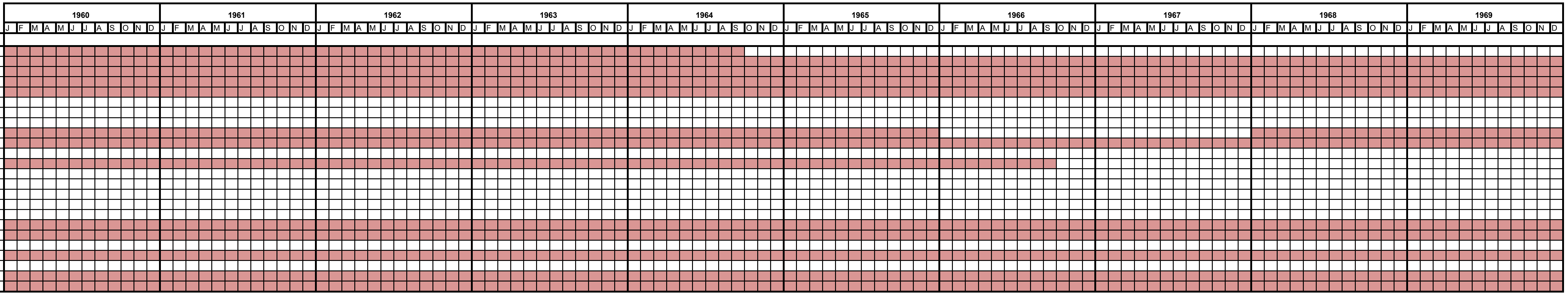
River Gages	POR
Rio Grande at San Marcial (old)	1899-1964
Rio Grande at San Marcial (conveyance)	1951-2017
Rio Grande at San Marcial (flood)	1949-2017
Rio Grande below Elephant Butte Dam	1913-2017
Rio Grande below Caballo Dam	1938-2017
Rio Grande below Percha Dam	1922-1937
Rio Grande at Haynor Bridge	2000-2005
Rio Grande at Tonuco	2000-2003
Rio Grande above Leasburg Dam	1924-1983
Rio Grande below Leasburg Dam	1919-2017
Rio Grande at Picacho Bridge	1991-2005
Las Cruces Arroyo near Las Cruces	1958-1966
Rio Grande below Mesilla Dam	1980-2017
Rio Grande at Vado Bridge	1985-1995
Rio Grande at Anthony	1986-2011
Rio Grande at Vinton Bridge	1970-1991
Rio Grande at Canutillo Bridge	1985-2017
Rio Grande at El Paso (Courchesne)	1889-2017
Rio Grande below American Dam	1938-2017
Rio Grande at Juarez Station	1938-1956
Rio Grande at Island Station	1938-1984
Rio Grande at Tornillo Bridge Station	1931-1938
Rio Grande at County Line Station	1938-1984
Rio Grande at Fort Quitman	1923-2017

1950 - 1959



River Gages	POR
Rio Grande at San Marcial (old)	1899-1964
Rio Grande at San Marcial (conveyance)	1951-2017
Rio Grande at San Marcial (flood)	1949-2017
Rio Grande below Elephant Butte Dam	1913-2017
Rio Grande below Caballo Dam	1938-2017
Rio Grande below Percha Dam	1922-1937
Rio Grande at Haynor Bridge	2000-2005
Rio Grande at Tonuco	2000-2003
Rio Grande above Leasburg Dam	1924-1983
Rio Grande below Leasburg Dam	1919-2017
Rio Grande at Picacho Bridge	1991-2005
Las Cruces Arroyo near Las Cruces	1958-1966
Rio Grande below Mesilla Dam	1980-2017
Rio Grande at Vado Bridge	1985-1995
Rio Grande at Anthony	1986-2011
Rio Grande at Vinton Bridge	1970-1991
Rio Grande at Canutillo Bridge	1985-2017
Rio Grande at El Paso (Courchesne)	1889-2017
Rio Grande below American Dam	1938-2017
Rio Grande at Juarez Station	1938-1956
Rio Grande at Island Station	1938-1984
Rio Grande at Tornillo Bridge Station	1931-1938
Rio Grande at County Line Station	1938-1984
Rio Grande at Fort Quitman	1923-2017

1960 - 1969



River Gages	POR
Rio Grande at San Marcial (old)	1899-1964
Rio Grande at San Marcial (conveyance)	1951-2017
Rio Grande at San Marcial (flood)	1949-2017
Rio Grande below Elephant Butte Dam	1913-2017
Rio Grande below Caballo Dam	1938-2017
Rio Grande below Percha Dam	1922-1937
Rio Grande at Haynor Bridge	2000-2005
Rio Grande at Tonuco	2000-2003
Rio Grande above Leasburg Dam	1924-1983
Rio Grande below Leasburg Dam	1919-2017
Rio Grande at Picacho Bridge	1991-2005
Las Cruces Arroyo near Las Cruces	1958-1966
Rio Grande below Mesilla Dam	1980-2017
Rio Grande at Vado Bridge	1985-1995
Rio Grande at Anthony	1986-2011
Rio Grande at Vinton Bridge	1970-1991
Rio Grande at Canutillo Bridge	1985-2017
Rio Grande at El Paso (Courchesne)	1889-2017
Rio Grande below American Dam	1938-2017
Rio Grande at Juarez Station	1938-1956
Rio Grande at Island Station	1938-1984
Rio Grande at Tornillo Bridge Station	1931-1938
Rio Grande at County Line Station	1938-1984
Rio Grande at Fort Quitman	1923-2017

Summary of River Gage Data (red highlight = data available)

Monthly Data

1970 - 1979

River Gages	POR	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
Rio Grande at San Marcial (old)	1899-1964										
Rio Grande at San Marcial (conveyance)	1951-2017	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
Rio Grande at San Marcial (flood)	1949-2017	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
Rio Grande below Elephant Butte Dam	1913-2017	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
Rio Grande below Caballo Dam	1938-2017	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
Rio Grande below Percha Dam	1922-1937										
Rio Grande at Haynor Bridge	2000-2005										
Rio Grande at Tonuco	2000-2003										
Rio Grande above Leasburg Dam	1924-1983	🟥	🟥	🟥		🟥	🟥	🟥	🟥	🟥	🟥
Rio Grande below Leasburg Dam	1919-2017	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
Rio Grande at Picacho Bridge	1991-2005										
Las Cruces Arroyo near Las Cruces	1958-1966										
Rio Grande below Mesilla Dam	1980-2017										
Rio Grande at Vado Bridge	1985-1995										
Rio Grande at Anthony	1986-2011										
Rio Grande at Vinton Bridge	1970-1991	🟥	🟥	🟥	🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥⬜⬜⬜					
Rio Grande at Canutillo Bridge	1985-2017										
Rio Grande at El Paso (Courchesne)	1889-2017	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
Rio Grande below American Dam	1938-2017	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
Rio Grande at Juarez Station	1938-1956										
Rio Grande at Island Station	1938-1984		🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
Rio Grande at Tornillo Bridge Station	1931-1938										
Rio Grande at County Line Station	1938-1984		🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
Rio Grande at Fort Quitman	1923-2017	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥

1980 - 1989

River Gages	POR	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Rio Grande at San Marcial (old)	1899-1964										
Rio Grande at San Marcial (conveyance)	1951-2017	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
Rio Grande at San Marcial (flood)	1949-2017	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
Rio Grande below Elephant Butte Dam	1913-2017	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
Rio Grande below Caballo Dam	1938-2017	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
Rio Grande below Percha Dam	1922-1937										
Rio Grande at Haynor Bridge	2000-2005										
Rio Grande at Tonuco	2000-2003										
Rio Grande above Leasburg Dam	1924-1983	🟥	🟥	🟥	🟥						
Rio Grande below Leasburg Dam	1919-2017	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
Rio Grande at Picacho Bridge	1991-2005										
Las Cruces Arroyo near Las Cruces	1958-1966										
Rio Grande below Mesilla Dam	1980-2017	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
Rio Grande at Vado Bridge	1985-1995						⬜🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥	🟥	🟥	🟥
Rio Grande at Anthony	1986-2011							🟥	🟥	🟥	🟥
Rio Grande at Vinton Bridge	1970-1991						🟥	🟥	🟥	🟥	🟥
Rio Grande at Canutillo Bridge	1985-2017						⬜⬜⬜⬜⬜⬜🟥🟥🟥🟥🟥🟥	🟥	🟥	🟥	🟥
Rio Grande at El Paso (Courchesne)	1889-2017	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
Rio Grande below American Dam	1938-2017	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
Rio Grande at Juarez Station	1938-1956										
Rio Grande at Island Station	1938-1984	🟥	🟥	🟥	🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥⬜⬜⬜					
Rio Grande at Tornillo Bridge Station	1931-1938										
Rio Grande at County Line Station	1938-1984	🟥	🟥	🟥	🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥⬜⬜⬜					
Rio Grande at Fort Quitman	1923-2017	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥

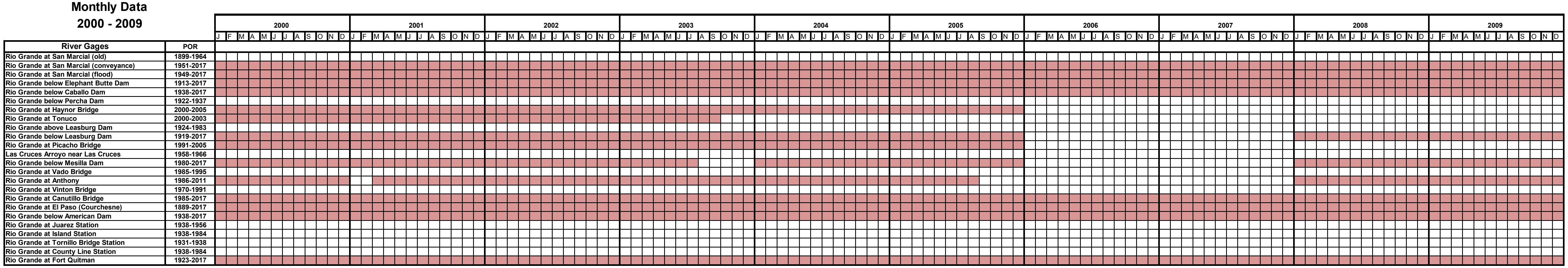
1990 - 1999

River Gages	POR	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Rio Grande at San Marcial (old)	1899-1964										
Rio Grande at San Marcial (conveyance)	1951-2017	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
Rio Grande at San Marcial (flood)	1949-2017	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
Rio Grande below Elephant Butte Dam	1913-2017	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
Rio Grande below Caballo Dam	1938-2017	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
Rio Grande below Percha Dam	1922-1937										
Rio Grande at Haynor Bridge	2000-2005										
Rio Grande at Tonuco	2000-2003										
Rio Grande above Leasburg Dam	1924-1983										
Rio Grande below Leasburg Dam	1919-2017	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
Rio Grande at Picacho Bridge	1991-2005		🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
Las Cruces Arroyo near Las Cruces	1958-1966										
Rio Grande below Mesilla Dam	1980-2017	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
Rio Grande at Vado Bridge	1985-1995	🟥	🟥	🟥	🟥	🟥	🟥				
Rio Grande at Anthony	1986-2011										
Rio Grande at Vinton Bridge	1970-1991	🟥	🟥⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜								
Rio Grande at Canutillo Bridge	1985-2017	🟥	🟥	🟥		🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥⬜⬜	🟥	🟥	🟥	🟥
Rio Grande at El Paso (Courchesne)	1889-2017	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
Rio Grande below American Dam	1938-2017	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
Rio Grande at Juarez Station	1938-1956										
Rio Grande at Island Station	1938-1984										
Rio Grande at Tornillo Bridge Station	1931-1938										
Rio Grande at County Line Station	1938-1984										
Rio Grande at Fort Quitman	1923-2017	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥

Summary of River Gage Data (red highlight = data available)

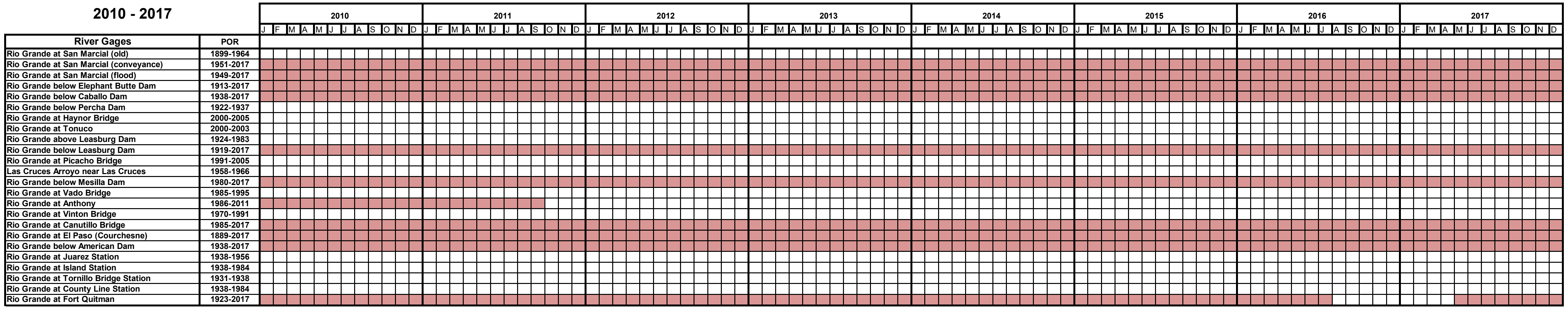
Monthly Data

2000 - 2009



River Gages	POR	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
		J F M A M J J A S O N D	J F M A M J J A S O N D	J F M A M J J A S O N D	J F M A M J J A S O N D	J F M A M J J A S O N D	J F M A M J J A S O N D	J F M A M J J A S O N D	J F M A M J J A S O N D	J F M A M J J A S O N D	J F M A M J J A S O N D
Rio Grande at San Marcial (old)	1899-1964	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜
Rio Grande at San Marcial (conveyance)	1951-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
Rio Grande at San Marcial (flood)	1949-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
Rio Grande below Elephant Butte Dam	1913-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
Rio Grande below Caballo Dam	1938-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
Rio Grande below Percha Dam	1922-1937	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜
Rio Grande at Haynor Bridge	2000-2005	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜
Rio Grande at Tonuco	2000-2003	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜
Rio Grande above Leasburg Dam	1924-1983	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜
Rio Grande below Leasburg Dam	1919-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
Rio Grande at Picacho Bridge	1991-2005	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜
Las Cruces Arroyo near Las Cruces	1958-1966	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜
Rio Grande below Mesilla Dam	1980-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥⬜⬜⬜⬜⬜	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
Rio Grande at Vado Bridge	1985-1995	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜
Rio Grande at Anthony	1986-2011	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	⬜⬜🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
Rio Grande at Vinton Bridge	1970-1991	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜
Rio Grande at Canutillo Bridge	1985-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
Rio Grande at El Paso (Courchesne)	1889-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
Rio Grande below American Dam	1938-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
Rio Grande at Juarez Station	1938-1956	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜
Rio Grande at Island Station	1938-1984	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜
Rio Grande at Tornillo Bridge Station	1931-1938	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜
Rio Grande at County Line Station	1938-1984	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜
Rio Grande at Fort Quitman	1923-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥

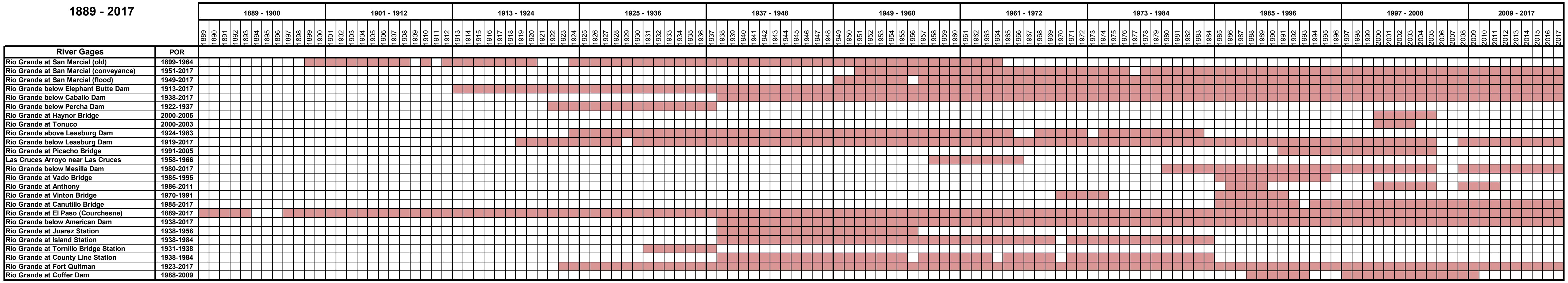
2010 - 2017



River Gages	POR	2010	2011	2012	2013	2014	2015	2016	2017
		J F M A M J J A S O N D	J F M A M J J A S O N D	J F M A M J J A S O N D	J F M A M J J A S O N D	J F M A M J J A S O N D	J F M A M J J A S O N D	J F M A M J J A S O N D	J F M A M J J A S O N D
Rio Grande at San Marcial (old)	1899-1964	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜
Rio Grande at San Marcial (conveyance)	1951-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
Rio Grande at San Marcial (flood)	1949-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
Rio Grande below Elephant Butte Dam	1913-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
Rio Grande below Caballo Dam	1938-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
Rio Grande below Percha Dam	1922-1937	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜
Rio Grande at Haynor Bridge	2000-2005	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜
Rio Grande at Tonuco	2000-2003	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜
Rio Grande above Leasburg Dam	1924-1983	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜
Rio Grande below Leasburg Dam	1919-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
Rio Grande at Picacho Bridge	1991-2005	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜
Las Cruces Arroyo near Las Cruces	1958-1966	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜
Rio Grande below Mesilla Dam	1980-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
Rio Grande at Vado Bridge	1985-1995	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜
Rio Grande at Anthony	1986-2011	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜
Rio Grande at Vinton Bridge	1970-1991	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜
Rio Grande at Canutillo Bridge	1985-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
Rio Grande at El Paso (Courchesne)	1889-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
Rio Grande below American Dam	1938-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
Rio Grande at Juarez Station	1938-1956	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜
Rio Grande at Island Station	1938-1984	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜
Rio Grande at Tornillo Bridge Station	1931-1938	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜
Rio Grande at County Line Station	1938-1984	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜
Rio Grande at Fort Quitman	1923-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥⬜⬜⬜⬜⬜	⬜⬜⬜⬜🟥🟥🟥🟥🟥🟥🟥🟥

Summary of River Gage Data (red highlight = data available)

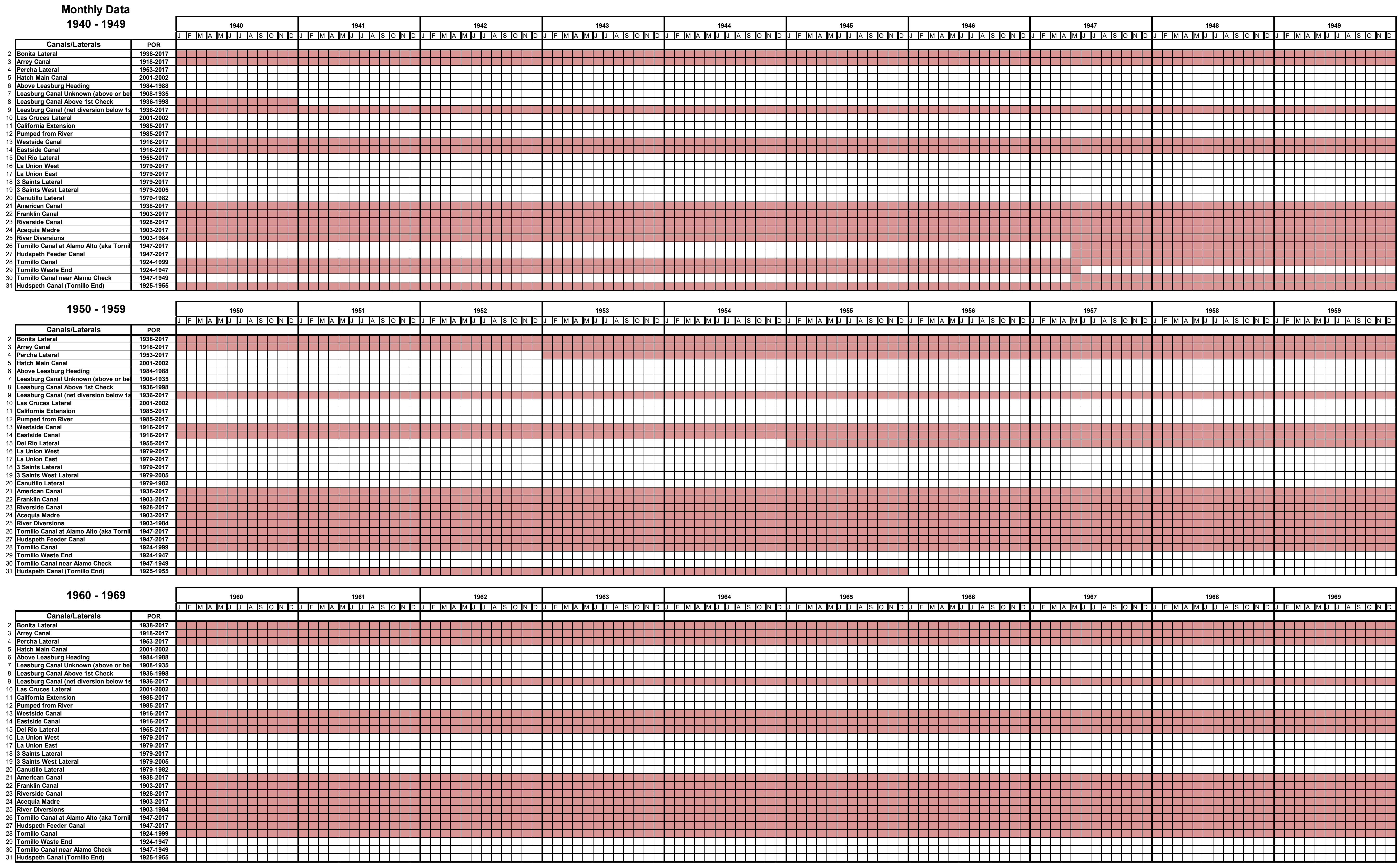
Annual Data
1889 - 2017



		1889 - 1900												1901 - 1912												1913 - 1924												1925 - 1936												1937 - 1948												1949 - 1960												1961 - 1972												1973 - 1984												1985 - 1996												1997 - 2008												2009 - 2017								
River Gages	**POR**	1889	1890	1891	1892	1893	1894	1895	1896	1897	1898	1899	1900	1901	1902	1903	1904	1905	1906	1907	1908	1909	1910	1911	1912	1913	1914	1915	1916	1917	1918	1919	1920	1921	1922	1923	1924	1925	1926	1927	1928	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938	1939	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Rio Grande at San Marcial (old)	**1899-1964**											🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥		🟥		🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥				🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥																																																		
Rio Grande at San Marcial (conveyance)	**1951-2017**																																																															🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥		🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
Rio Grande at San Marcial (flood)	**1949-2017**																																																													🟥	🟥	🟥	🟥	🟥	🟥	🟥		🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
Rio Grande below Elephant Butte Dam	**1913-2017**																									🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
Rio Grande below Caballo Dam	**1938-2017**																																																	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
Rio Grande below Percha Dam	**1922-1937**																																	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥																																																																																						
Rio Grande at Haynor Bridge	**2000-2005**																																																																																																																				🟥	🟥	🟥	🟥	🟥	🟥												
Rio Grande at Tonuco	**2000-2003**																																																																																																																				🟥	🟥	🟥	🟥														
Rio Grande above Leasburg Dam	**1924-1983**																																				🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥			🟥	🟥	🟥	🟥	🟥		🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥																																						
Rio Grande below Leasburg Dam	**1919-2017**																														🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥		🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥			🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
Rio Grande at Picacho Bridge	**1991-2005**																																																																																																					🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥												
Las Cruces Arroyo near Las Cruces	**1958-1966**																																																																						🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥																																																									
Rio Grande below Mesilla Dam	**1980-2017**																																																																																															🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥			🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
Rio Grande at Vado Bridge	**1985-1995**																																																																																																								🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥																						
Rio Grande at Anthony	**1986-2011**																																																																																																									🟥	🟥	🟥	🟥											🟥	🟥	🟥	🟥	🟥	🟥			🟥	🟥	🟥	🟥						
Rio Grande at Vinton Bridge	**1970-1991**																																																																																		🟥	🟥	🟥	🟥	🟥											🟥	🟥	🟥	🟥	🟥	🟥	🟥																										
Rio Grande at Canutillo Bridge	**1985-2017**																																																																																																							🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥		🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
Rio Grande at El Paso (Courchesne)	**1889-2017**	🟥	🟥	🟥	🟥	🟥				🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
Rio Grande below American Dam	**1938-2017**																																																	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
Rio Grande at Juarez Station	**1938-1956**																																																	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥																																																																							
Rio Grande at Island Station	**1938-1984**																																																|🟥|🟥|🟥|🟥|🟥|🟥|🟥|🟥|🟥|🟥|🟥|🟥|🟥|🟥|🟥|🟥|🟥|🟥|🟥|🟥|🟥|🟥|🟥|🟥|🟥|🟥|🟥|🟥|🟥|🟥|🟥|🟥| |🟥|🟥|🟥|🟥|🟥|🟥|🟥|🟥|🟥|🟥|🟥|🟥|🟥|🟥|																																																																																					
Rio Grande at Tornillo Bridge Station	**1931-1938**																																										|🟥|🟥|🟥|🟥|🟥|🟥|🟥|																																																																																															
Rio Grande at County Line Station	**1938-1984**																																																|🟥|🟥|🟥|🟥|🟥|🟥|🟥|🟥|🟥|🟥|🟥|🟥|🟥|🟥|🟥|🟥|🟥|🟥| |🟥|🟥|🟥|🟥|🟥|🟥|🟥| |🟥|🟥|🟥|🟥|🟥| |🟥|🟥|🟥|🟥|🟥|🟥|🟥|🟥|🟥|🟥|🟥|🟥|🟥|🟥|																																																																																			
Rio Grande at Fort Quitman	**1923-2017**																																			🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
Rio Grande at Coffer Dam	**1988-2009**																																																																																																											🟥	🟥	🟥	🟥	🟥	🟥				🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥								

Note: There may be missing months of data within the year.

Summary of Canal/Lateral Data (red highlight = data available)



Monthly Data 1940 - 1949

	Canals/Laterals	POR	1940 J F M A M J J A S O N D	1941 J F M A M J J A S O N D	1942 J F M A M J J A S O N D	1943 J F M A M J J A S O N D	1944 J F M A M J J A S O N D	1945 J F M A M J J A S O N D	1946 J F M A M J J A S O N D	1947 J F M A M J J A S O N D	1948 J F M A M J J A S O N D	1949 J F M A M J J A S O N D
2	Bonita Lateral	1938-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
3	Arrey Canal	1918-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
4	Percha Lateral	1953-2017										
5	Hatch Main Canal	2001-2002										
6	Above Leasburg Heading	1984-1988										
7	Leasburg Canal Unknown (above or bel	1908-1935										
8	Leasburg Canal Above 1st Check	1936-1998	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥									
9	Leasburg Canal (net diversion below 1s	1936-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
10	Las Cruces Lateral	2001-2002										
11	California Extension	1985-2017										
12	Pumped from River	1985-2017										
13	Westside Canal	1916-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
14	Eastside Canal	1916-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
15	Del Rio Lateral	1955-2017										
16	La Union West	1979-2017										
17	La Union East	1979-2017										
18	3 Saints Lateral	1979-2017										
19	3 Saints West Lateral	1979-2005										
20	Canutillo Lateral	1979-1982										
21	American Canal	1938-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
22	Franklin Canal	1903-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
23	Riverside Canal	1928-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
24	Acequia Madre	1903-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
25	River Diversions	1903-1984	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
26	Tornillo Canal at Alamo Alto (aka Tornil	1947-2017								⬜⬜⬜⬜🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
27	Hudspeth Feeder Canal	1947-2017								⬜⬜⬜⬜🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
28	Tornillo Canal	1924-1999	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
29	Tornillo Waste End	1924-1947	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥⬜⬜⬜⬜⬜⬜⬜		
30	Tornillo Canal near Alamo Check	1947-1949								⬜⬜⬜⬜🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
31	Hudspeth Canal (Tornillo End)	1925-1955	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥

1950 - 1959

	Canals/Laterals	POR	1950 J F M A M J J A S O N D	1951 J F M A M J J A S O N D	1952 J F M A M J J A S O N D	1953 J F M A M J J A S O N D	1954 J F M A M J J A S O N D	1955 J F M A M J J A S O N D	1956 J F M A M J J A S O N D	1957 J F M A M J J A S O N D	1958 J F M A M J J A S O N D	1959 J F M A M J J A S O N D
2	Bonita Lateral	1938-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
3	Arrey Canal	1918-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
4	Percha Lateral	1953-2017				🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
5	Hatch Main Canal	2001-2002										
6	Above Leasburg Heading	1984-1988										
7	Leasburg Canal Unknown (above or bel	1908-1935										
8	Leasburg Canal Above 1st Check	1936-1998										
9	Leasburg Canal (net diversion below 1s	1936-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
10	Las Cruces Lateral	2001-2002										
11	California Extension	1985-2017										
12	Pumped from River	1985-2017										
13	Westside Canal	1916-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
14	Eastside Canal	1916-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
15	Del Rio Lateral	1955-2017						🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
16	La Union West	1979-2017										
17	La Union East	1979-2017										
18	3 Saints Lateral	1979-2017										
19	3 Saints West Lateral	1979-2005										
20	Canutillo Lateral	1979-1982										
21	American Canal	1938-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
22	Franklin Canal	1903-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
23	Riverside Canal	1928-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
24	Acequia Madre	1903-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
25	River Diversions	1903-1984	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
26	Tornillo Canal at Alamo Alto (aka Tornil	1947-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
27	Hudspeth Feeder Canal	1947-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
28	Tornillo Canal	1924-1999	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
29	Tornillo Waste End	1924-1947										
30	Tornillo Canal near Alamo Check	1947-1949										
31	Hudspeth Canal (Tornillo End)	1925-1955	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥				

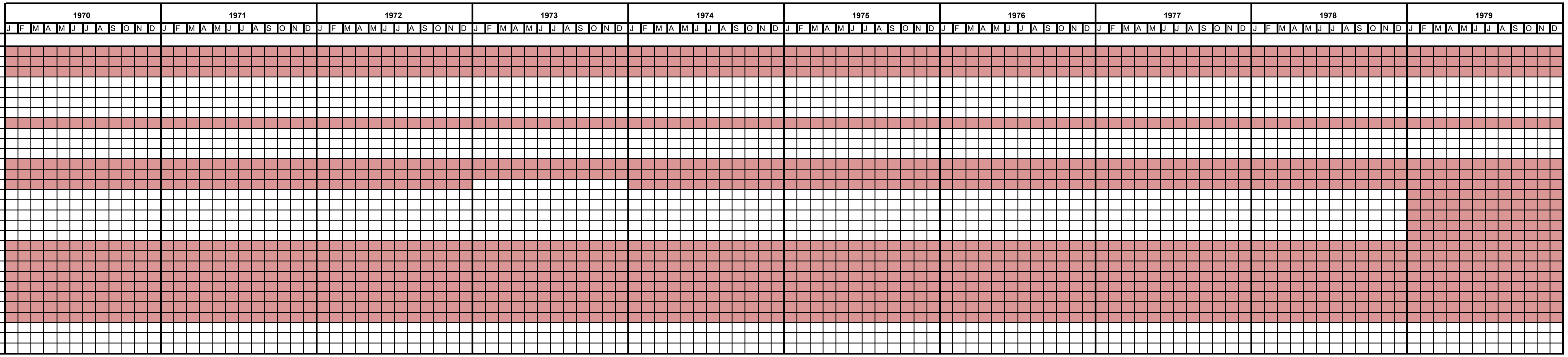
1960 - 1969

	Canals/Laterals	POR	1960 J F M A M J J A S O N D	1961 J F M A M J J A S O N D	1962 J F M A M J J A S O N D	1963 J F M A M J J A S O N D	1964 J F M A M J J A S O N D	1965 J F M A M J J A S O N D	1966 J F M A M J J A S O N D	1967 J F M A M J J A S O N D	1968 J F M A M J J A S O N D	1969 J F M A M J J A S O N D
2	Bonita Lateral	1938-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
3	Arrey Canal	1918-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
4	Percha Lateral	1953-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
5	Hatch Main Canal	2001-2002										
6	Above Leasburg Heading	1984-1988										
7	Leasburg Canal Unknown (above or bel	1908-1935										
8	Leasburg Canal Above 1st Check	1936-1998										
9	Leasburg Canal (net diversion below 1s	1936-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
10	Las Cruces Lateral	2001-2002										
11	California Extension	1985-2017										
12	Pumped from River	1985-2017										
13	Westside Canal	1916-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
14	Eastside Canal	1916-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
15	Del Rio Lateral	1955-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
16	La Union West	1979-2017										
17	La Union East	1979-2017										
18	3 Saints Lateral	1979-2017										
19	3 Saints West Lateral	1979-2005										
20	Canutillo Lateral	1979-1982										
21	American Canal	1938-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
22	Franklin Canal	1903-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
23	Riverside Canal	1928-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
24	Acequia Madre	1903-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
25	River Diversions	1903-1984	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
26	Tornillo Canal at Alamo Alto (aka Tornil	1947-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
27	Hudspeth Feeder Canal	1947-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
28	Tornillo Canal	1924-1999	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
29	Tornillo Waste End	1924-1947										
30	Tornillo Canal near Alamo Check	1947-1949										
31	Hudspeth Canal (Tornillo End)	1925-1955										

Summary of Canal/Lateral Data (red highlight = data available)

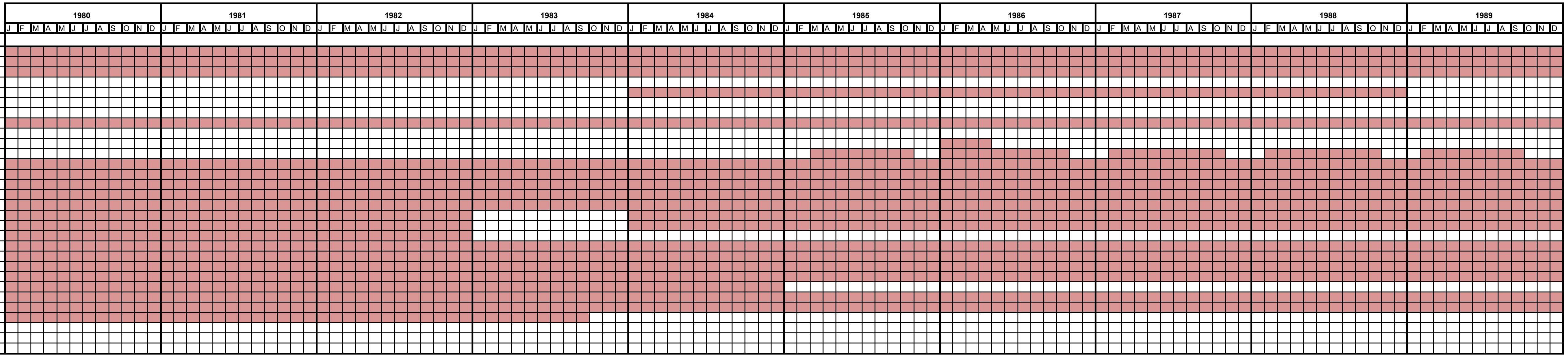
1970 - 1979

	Canals/Laterals	POR
2	Bonita Lateral	1938-2017
3	Arrey Canal	1918-2017
4	Percha Lateral	1953-2017
5	Hatch Main Canal	2001-2002
6	Above Leasburg Heading	1984-1988
7	Leasburg Canal Unknown (above or bel	1908-1935
8	Leasburg Canal Above 1st Check	1936-1998
9	Leasburg Canal (net diversion below 1s	1936-2017
10	Las Cruces Lateral	2001-2002
11	California Extension	1985-2017
12	Pumped from River	1985-2017
13	Westside Canal	1916-2017
14	Eastside Canal	1916-2017
15	Del Rio Lateral	1955-2017
16	La Union West	1979-2017
17	La Union East	1979-2017
18	3 Saints Lateral	1979-2017
19	3 Saints West Lateral	1979-2005
20	Canutillo Lateral	1979-1982
21	American Canal	1938-2017
22	Franklin Canal	1903-2017
23	Riverside Canal	1928-2017
24	Acequia Madre	1903-2017
25	River Diversions	1903-1984
26	Tornillo Canal at Alamo Alto (aka Tornil	1947-2017
27	Hudspeth Feeder Canal	1947-2017
28	Tornillo Canal	1924-1999
29	Tornillo Waste End	1924-1947
30	Tornillo Canal near Alamo Check	1947-1949
31	Hudspeth Canal (Tornillo End)	1925-1955



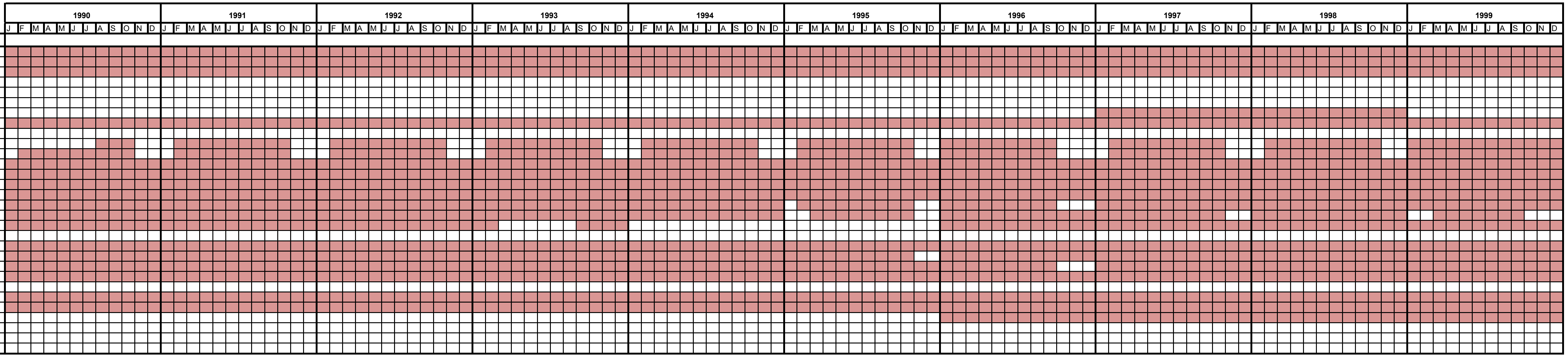
1980 - 1989

	Canals/Laterals	POR
2	Bonita Lateral	1938-2017
3	Arrey Canal	1918-2017
4	Percha Lateral	1953-2017
5	Hatch Main Canal	2001-2002
6	Above Leasburg Heading	1984-1988
7	Leasburg Canal Unknown (above or bel	1908-1935
8	Leasburg Canal Above 1st Check	1936-1998
9	Leasburg Canal (net diversion below 1s	1936-2017
10	Las Cruces Lateral	2001-2002
11	California Extension	1985-2017
12	Pumped from River	1985-2017
13	Westside Canal	1916-2017
14	Eastside Canal	1916-2017
15	Del Rio Lateral	1955-2017
16	La Union West	1979-2017
17	La Union East	1979-2017
18	3 Saints Lateral	1979-2017
19	3 Saints West Lateral	1979-2005
20	Canutillo Lateral	1979-1982
21	American Canal	1938-2017
22	Franklin Canal	1903-2017
23	Riverside Canal	1928-2017
24	Acequia Madre	1903-2017
25	River Diversions	1903-1984
26	Tornillo Canal at Alamo Alto (aka Tornil	1947-2017
27	Hudspeth Feeder Canal	1947-2017
28	Tornillo Canal	1924-1999
29	Tornillo Waste End	1924-1947
30	Tornillo Canal near Alamo Check	1947-1949
31	Hudspeth Canal (Tornillo End)	1925-1955



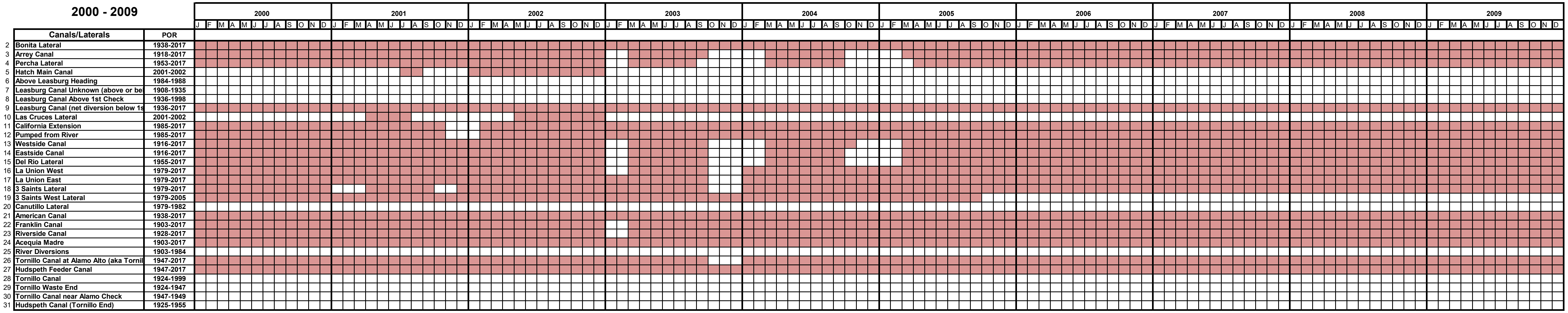
1990 - 1999

	Canals/Laterals	POR
2	Bonita Lateral	1938-2017
3	Arrey Canal	1918-2017
4	Percha Lateral	1953-2017
5	Hatch Main Canal	2001-2002
6	Above Leasburg Heading	1984-1988
7	Leasburg Canal Unknown (above or bel	1908-1935
8	Leasburg Canal Above 1st Check	1936-1998
9	Leasburg Canal (net diversion below 1s	1936-2017
10	Las Cruces Lateral	2001-2002
11	California Extension	1985-2017
12	Pumped from River	1985-2017
13	Westside Canal	1916-2017
14	Eastside Canal	1916-2017
15	Del Rio Lateral	1955-2017
16	La Union West	1979-2017
17	La Union East	1979-2017
18	3 Saints Lateral	1979-2017
19	3 Saints West Lateral	1979-2005
20	Canutillo Lateral	1979-1982
21	American Canal	1938-2017
22	Franklin Canal	1903-2017
23	Riverside Canal	1928-2017
24	Acequia Madre	1903-2017
25	River Diversions	1903-1984
26	Tornillo Canal at Alamo Alto (aka Tornil	1947-2017
27	Hudspeth Feeder Canal	1947-2017
28	Tornillo Canal	1924-1999
29	Tornillo Waste End	1924-1947
30	Tornillo Canal near Alamo Check	1947-1949
31	Hudspeth Canal (Tornillo End)	1925-1955



Summary of Canal/Lateral Data (red highlight = data available)

2000 - 2009



	Canals/Laterals	POR
2	Bonita Lateral	1938-2017
3	Arrey Canal	1918-2017
4	Percha Lateral	1953-2017
5	Hatch Main Canal	2001-2002
6	Above Leasburg Heading	1984-1988
7	Leasburg Canal Unknown (above or bel	1908-1935
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21	American Canal	1938-2017
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25	River Diversions	1903-1984
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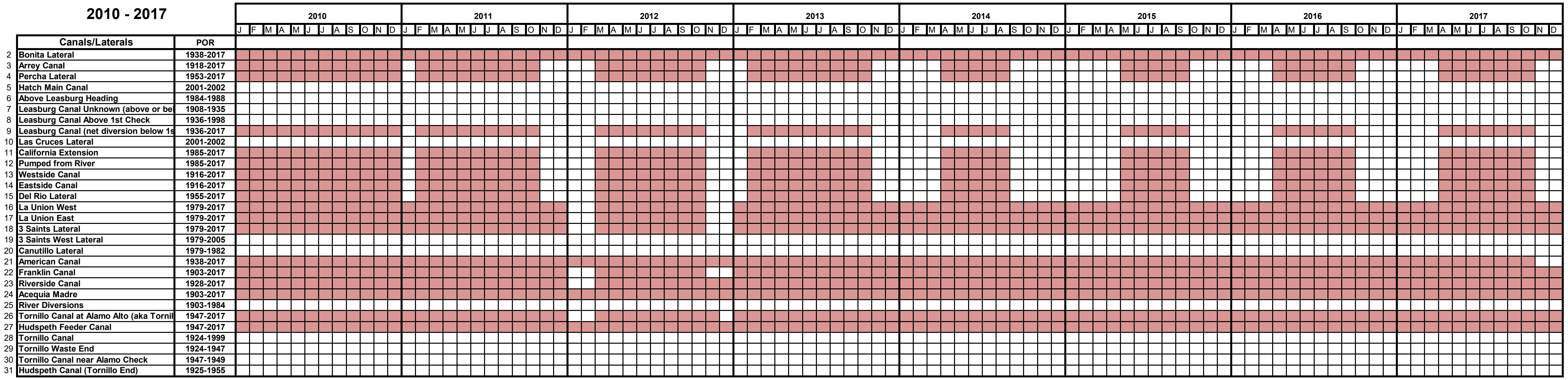
27	Hudspeth Feeder Canal	1947-2017
28	Tornillo Canal	1924-1999
29	Tornillo Waste End	1924-1947
30	Tornillo Canal near Alamo Check	1947-1949
31	Hudspeth Canal (Tornillo End)	1925-1955

2010 - 2017



	Canals/Laterals	POR
2	Bonita Lateral	1938-2017
3	Arrey Canal	1918-2017
4	Percha Lateral	1953-2017
5	Hatch Main Canal	2001-2002
6	Above Leasburg Heading	1984-1988
7	Leasburg Canal Unknown (above or bel	1908-1935
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20	Canutillo Lateral	1979-1982
21	American Canal	1938-2017
22	Franklin Canal	1903-2017
23	Riverside Canal	1928-2017
24	Acequia Madre	1903-2017
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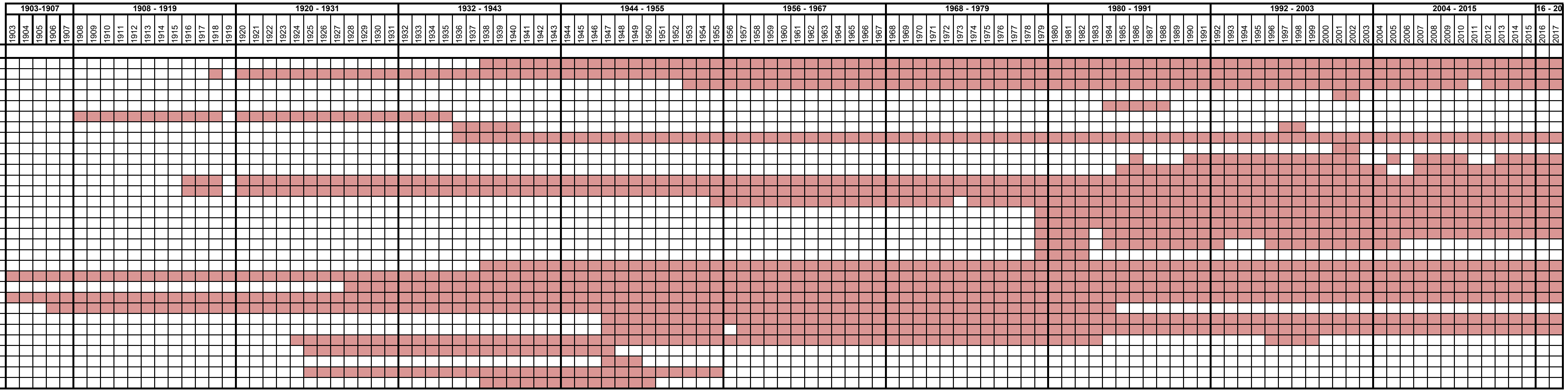
26	Tornillo Canal at Alamo Alto (aka Tornil	1947-2017
27	Hudspeth Feeder Canal	1947-2017
28	Tornillo Canal	1924-1999
29	Tornillo Waste End	1924-1947
30	Tornillo Canal near Alamo Check	1947-1949
31	Hudspeth Canal (Tornillo End)	1925-1955

Summary of Canal/Lateral Data (red highlight = data available)

Annual Data
1903 - 2017



	Canals/Laterals	POR
2	Bonita Lateral	1938-2017
3	Arrey Canal	1918-2017
4	Percha Lateral	1953-2017
5	Hatch Main Canal	2001-2002
6	Above Leasburg Heading	1984-1988
7	Leasburg Canal Unknown (above or be	1908-1935
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18	3 Saints Lateral	1979-2017
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21	American Canal	1938-2017
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26	Tornillo Canal at Alamo Alto (aka Tornil	1947-2017
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28	Tornillo Canal	1924-1999
29	Tornillo Waste End	1924-1947
30	Tornillo Canal near Alamo Check	1947-1949
31	Hudspeth Canal (Tornillo End)	1925-1955
32	Acequia Madre en el Sauzal	1938-1956

Note: There may be missing months of data within the year.

Summary of Drain Data (red highlight = data available)

Monthly Data
1940 - 1949

	Drains	POR	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949
			J F M A M J J A S O N D	J F M A M J J A S O N D	J F M A M J J A S O N D	J F M A M J J A S O N D	J F M A M J J A S O N D	J F M A M J J A S O N D	J F M A M J J A S O N D	J F M A M J J A S O N D	J F M A M J J A S O N D	J F M A M J J A S O N D
2	Garfield Drain	1923-2005	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
3	Hatch Drain	1923-2005	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
4	Angostura Drain	1926-1983	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
5	Rincon Drain	1925-2005	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
6	Selden Drain	1923-1983	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
7	Leasburg Drain	1923-1983	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
8	Picacho Drain	1923-2005	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
9	Mesilla Drain	1923-1983	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
10	Santo Tomas River Drain	1985-1990										
11	Santo Tomas Drain	1980-1985										
12	West Drain	1923-2013	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
13	La Mesa Drain	1923-2013	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
14	Chamberino Drain	1923-1983	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
15	Nemexas Drain	1923-2013	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
16	Del Rio Drain	1923-2013	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
17	Mesquite Drain	1997-2001										
18	East Drain	1930-2013	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
19	Anthony Drain	1923-2005	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
20	Montoya Drain	1923-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
21	East Drain (EPCWID)	1923-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
22	Montoya Intercepting Drain	1985-1990										
23	Franklin Drain	1921-1983	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
24	Playa Drain	1923-1983	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
25	Middle Drain	1921-1983	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
26	River Drain	1923-1983	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
27	Cuadrilla Drain	1931-1983	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
28	Mesa Drain	1921-1983	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
29	Fabens Intercepting Drain	1931-1971	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
30	Border Drain	1923-1983	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
31	Island Drain	1921-1983	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
32	Island Syphon Drain	1936-1983	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
33	Alamo Alto Drain	1925-1983	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
34	Drain Water Diverted at Fabens	1945-1982						🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
35	Fabens Waste Drain	1984-2017										
36	Fabens Drain	1923-1983	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
37	Tornillo Drain	1923-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥

1950 - 1959

	Drains	POR	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959
			J F M A M J J A S O N D	J F M A M J J A S O N D	J F M A M J J A S O N D	J F M A M J J A S O N D	J F M A M J J A S O N D	J F M A M J J A S O N D	J F M A M J J A S O N D	J F M A M J J A S O N D	J F M A M J J A S O N D	J F M A M J J A S O N D
2	Garfield Drain	1923-2005	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
3	Hatch Drain	1923-2005	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
4	Angostura Drain	1926-1983	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
5	Rincon Drain	1925-2005	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
6	Selden Drain	1923-1983	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
7	Leasburg Drain	1923-1983	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
8	Picacho Drain	1923-2005	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
9	Mesilla Drain	1923-1983	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
10	Santo Tomas River Drain	1985-1990										
11	Santo Tomas Drain	1980-1985										
12	West Drain	1923-2013	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
13	La Mesa Drain	1923-2013	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
14	Chamberino Drain	1923-1983	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
15	Nemexas Drain	1923-2013	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
16	Del Rio Drain	1923-2013	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
17	Mesquite Drain	1997-2001										
18	East Drain	1930-2013	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
19	Anthony Drain	1923-2005	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
20	Montoya Drain	1923-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
21	East Drain (EPCWID)	1923-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
22	Montoya Intercepting Drain	1985-1990										
23	Franklin Drain	1921-1983	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
24	Playa Drain	1923-1983	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
25	Middle Drain	1921-1983	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
26	River Drain	1923-1983	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
27	Cuadrilla Drain	1931-1983	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
28	Mesa Drain	1921-1983	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
29	Fabens Intercepting Drain	1931-1971	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
30	Border Drain	1923-1983	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
31	Island Drain	1921-1983	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
32	Island Syphon Drain	1936-1983	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
33	Alamo Alto Drain	1925-1983	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
34	Drain Water Diverted at Fabens	1945-1982	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
35	Fabens Waste Drain	1984-2017										
36	Fabens Drain	1923-1983	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
37	Tornillo Drain	1923-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥

Summary of Drain Data (red highlight = data available)

Monthly Data

1960 - 1969

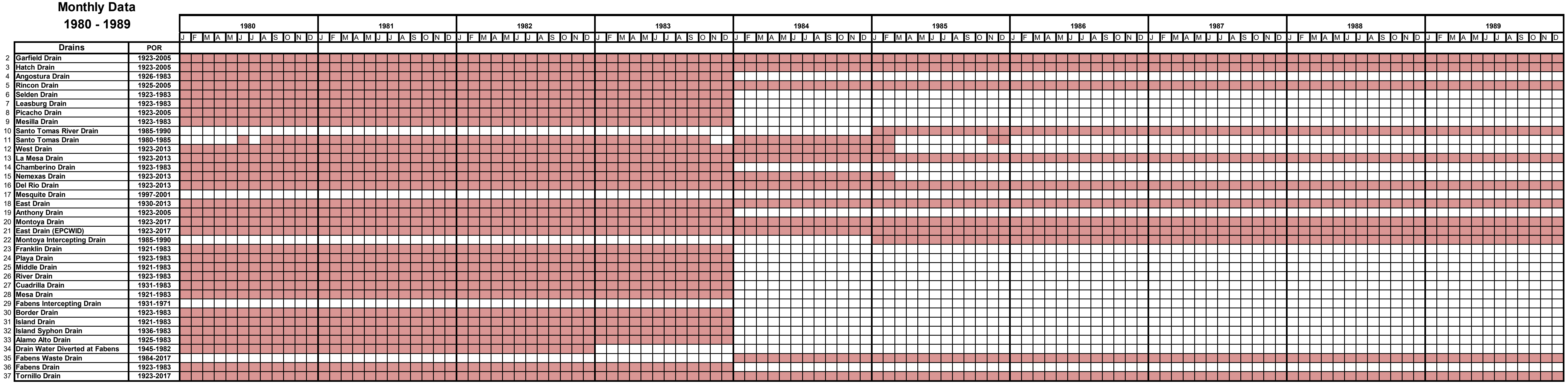
	Drains	POR	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
2	Garfield Drain	1923-2005	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
3	Hatch Drain	1923-2005	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
4	Angostura Drain	1926-1983	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
5	Rincon Drain	1925-2005	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
6	Selden Drain	1923-1983	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
7	Leasburg Drain	1923-1983	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
8	Picacho Drain	1923-2005	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
9	Mesilla Drain	1923-1983	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
10	Santo Tomas River Drain	1985-1990										
11	Santo Tomas Drain	1980-1985										
12	West Drain	1923-2013	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
13	La Mesa Drain	1923-2013	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
14	Chamberino Drain	1923-1983	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
15	Nemexas Drain	1923-2013	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
16	Del Rio Drain	1923-2013	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
17	Mesquite Drain	1997-2001										
18	East Drain	1930-2013	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
19	Anthony Drain	1923-2005	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
20	Montoya Drain	1923-2017	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
21	East Drain (EPCWID)	1923-2017	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
22	Montoya Intercepting Drain	1985-1990										
23	Franklin Drain	1921-1983	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
24	Playa Drain	1923-1983	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
25	Middle Drain	1921-1983	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
26	River Drain	1923-1983	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
27	Cuadrilla Drain	1931-1983	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
28	Mesa Drain	1921-1983	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
29	Fabens Intercepting Drain	1931-1971	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
30	Border Drain	1923-1983	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
31	Island Drain	1921-1983	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
32	Island Syphon Drain	1936-1983	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
33	Alamo Alto Drain	1925-1983	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
34	Drain Water Diverted at Fabens	1945-1982	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
35	Fabens Waste Drain	1984-2017										
36	Fabens Drain	1923-1983	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
37	Tornillo Drain	1923-2017	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥

1970 - 1979

	Drains	POR	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
2	Garfield Drain	1923-2005	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
3	Hatch Drain	1923-2005	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
4	Angostura Drain	1926-1983	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
5	Rincon Drain	1925-2005	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
6	Selden Drain	1923-1983	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
7	Leasburg Drain	1923-1983	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
8	Picacho Drain	1923-2005	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
9	Mesilla Drain	1923-1983	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
10	Santo Tomas River Drain	1985-1990										
11	Santo Tomas Drain	1980-1985										
12	West Drain	1923-2013	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
13	La Mesa Drain	1923-2013	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
14	Chamberino Drain	1923-1983	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
15	Nemexas Drain	1923-2013	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
16	Del Rio Drain	1923-2013	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
17	Mesquite Drain	1997-2001										
18	East Drain	1930-2013	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
19	Anthony Drain	1923-2005	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
20	Montoya Drain	1923-2017	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
21	East Drain (EPCWID)	1923-2017	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
22	Montoya Intercepting Drain	1985-1990										
23	Franklin Drain	1921-1983	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
24	Playa Drain	1923-1983	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
25	Middle Drain	1921-1983	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
26	River Drain	1923-1983	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
27	Cuadrilla Drain	1931-1983	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
28	Mesa Drain	1921-1983	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
29	Fabens Intercepting Drain	1931-1971	🟥	🟥								
30	Border Drain	1923-1983	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
31	Island Drain	1921-1983	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
32	Island Syphon Drain	1936-1983	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
33	Alamo Alto Drain	1925-1983	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
34	Drain Water Diverted at Fabens	1945-1982	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
35	Fabens Waste Drain	1984-2017										
36	Fabens Drain	1923-1983	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
37	Tornillo Drain	1923-2017	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥

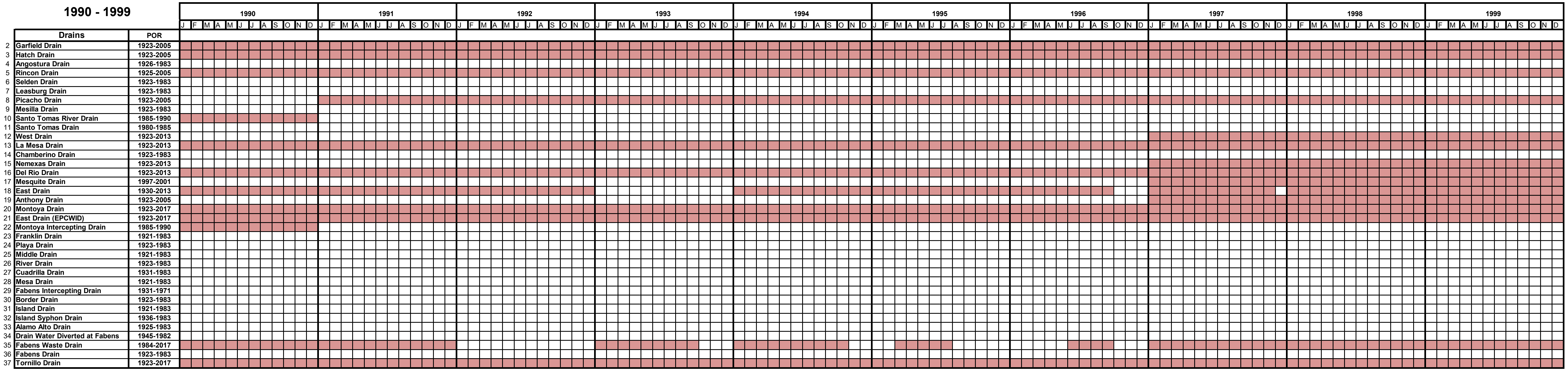
Summary of Drain Data (red highlight = data available)

Monthly Data
1980 - 1989



	Drains	POR	1980 J F M A M J J A S O N D	1981 J F M A M J J A S O N D	1982 J F M A M J J A S O N D	1983 J F M A M J J A S O N D	1984 J F M A M J J A S O N D	1985 J F M A M J J A S O N D	1986 J F M A M J J A S O N D	1987 J F M A M J J A S O N D	1988 J F M A M J J A S O N D	1989 J F M A M J J A S O N D
2	Garfield Drain	1923-2005	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
3	Hatch Drain	1923-2005	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
4	Angostura Drain	1926-1983	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥						
5	Rincon Drain	1925-2005	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
6	Selden Drain	1923-1983	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥						
7	Leasburg Drain	1923-1983	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥						
8	Picacho Drain	1923-2005	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥						
9	Mesilla Drain	1923-1983	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥						
10	Santo Tomas River Drain	1985-1990						🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
11	Santo Tomas Drain	1980-1985	⬜⬜⬜⬜🟥⬜🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥⬜⬜	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥⬜⬜⬜⬜⬜⬜⬜⬜🟥🟥				
12	West Drain	1923-2013	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜				
13	La Mesa Drain	1923-2013	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
14	Chamberino Drain	1923-1983	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥						
15	Nemexas Drain	1923-2013	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥⬜⬜⬜⬜⬜⬜⬜⬜⬜⬜				
16	Del Rio Drain	1923-2013	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
17	Mesquite Drain	1997-2001										
18	East Drain	1930-2013	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
19	Anthony Drain	1923-2005	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥						
20	Montoya Drain	1923-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
21	East Drain (EPCWID)	1923-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
22	Montoya Intercepting Drain	1985-1990						🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
23	Franklin Drain	1921-1983	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥						
24	Playa Drain	1923-1983	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥						
25	Middle Drain	1921-1983	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥						
26	River Drain	1923-1983	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥						
27	Cuadrilla Drain	1931-1983	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥						
28	Mesa Drain	1921-1983	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥						
29	Fabens Intercepting Drain	1931-1971										
30	Border Drain	1923-1983	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥						
31	Island Drain	1921-1983	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥						
32	Island Syphon Drain	1936-1983	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥						
33	Alamo Alto Drain	1925-1983	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥						
34	Drain Water Diverted at Fabens	1945-1982	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥							
35	Fabens Waste Drain	1984-2017					🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
36	Fabens Drain	1923-1983	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥						
37	Tornillo Drain	1923-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥

1990 - 1999

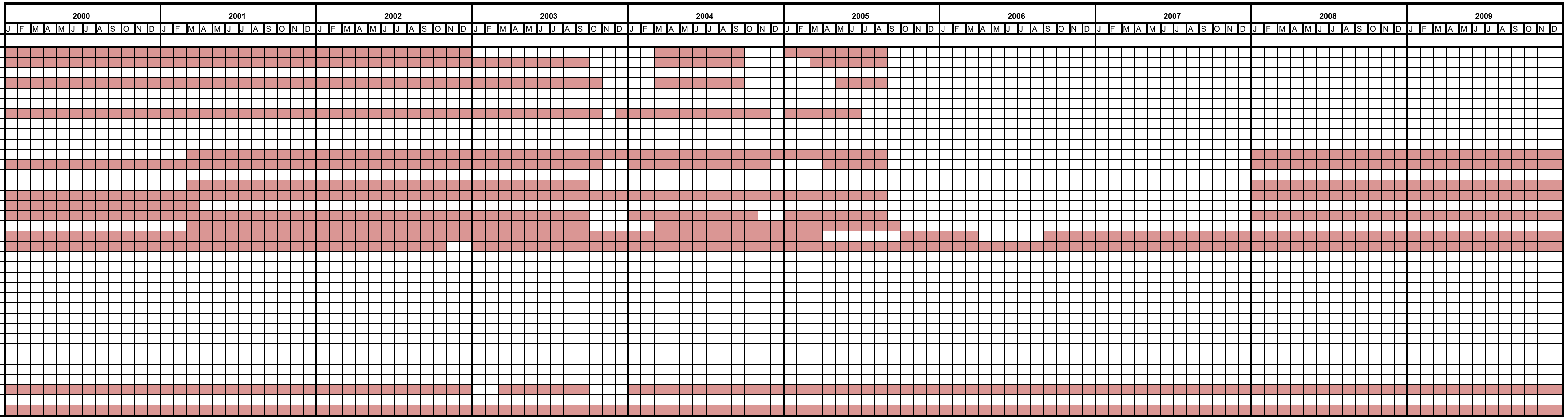


	Drains	POR	1990 J F M A M J J A S O N D	1991 J F M A M J J A S O N D	1992 J F M A M J J A S O N D	1993 J F M A M J J A S O N D	1994 J F M A M J J A S O N D	1995 J F M A M J J A S O N D	1996 J F M A M J J A S O N D	1997 J F M A M J J A S O N D	1998 J F M A M J J A S O N D	1999 J F M A M J J A S O N D
2	Garfield Drain	1923-2005	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
3	Hatch Drain	1923-2005	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
4	Angostura Drain	1926-1983										
5	Rincon Drain	1925-2005	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
6	Selden Drain	1923-1983										
7	Leasburg Drain	1923-1983										
8	Picacho Drain	1923-2005		🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
9	Mesilla Drain	1923-1983										
10	Santo Tomas River Drain	1985-1990	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥									
11	Santo Tomas Drain	1980-1985										
12	West Drain	1923-2013								🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
13	La Mesa Drain	1923-2013	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
14	Chamberino Drain	1923-1983										
15	Nemexas Drain	1923-2013								🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
16	Del Rio Drain	1923-2013	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
17	Mesquite Drain	1997-2001								🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
18	East Drain	1930-2013	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥		🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥⬜⬜⬜	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥⬜	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
19	Anthony Drain	1923-2005								🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
20	Montoya Drain	1923-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
21	East Drain (EPCWID)	1923-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
22	Montoya Intercepting Drain	1985-1990	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥									
23	Franklin Drain	1921-1983										
24	Playa Drain	1923-1983										
25	Middle Drain	1921-1983										
26	River Drain	1923-1983										
27	Cuadrilla Drain	1931-1983										
28	Mesa Drain	1921-1983										
29	Fabens Intercepting Drain	1931-1971										
30	Border Drain	1923-1983										
31	Island Drain	1921-1983										
32	Island Syphon Drain	1936-1983										
33	Alamo Alto Drain	1925-1983										
34	Drain Water Diverted at Fabens	1945-1982										
35	Fabens Waste Drain	1984-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥		🟥🟥🟥🟥🟥🟥🟥🟥🟥⬜⬜⬜	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥⬜⬜	⬜⬜🟥🟥🟥🟥🟥⬜⬜⬜⬜⬜	⬜⬜⬜⬜⬜🟥🟥🟥🟥⬜⬜⬜	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
36	Fabens Drain	1923-1983										
37	Tornillo Drain	1923-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥

Summary of Drain Data (red highlight = data available)

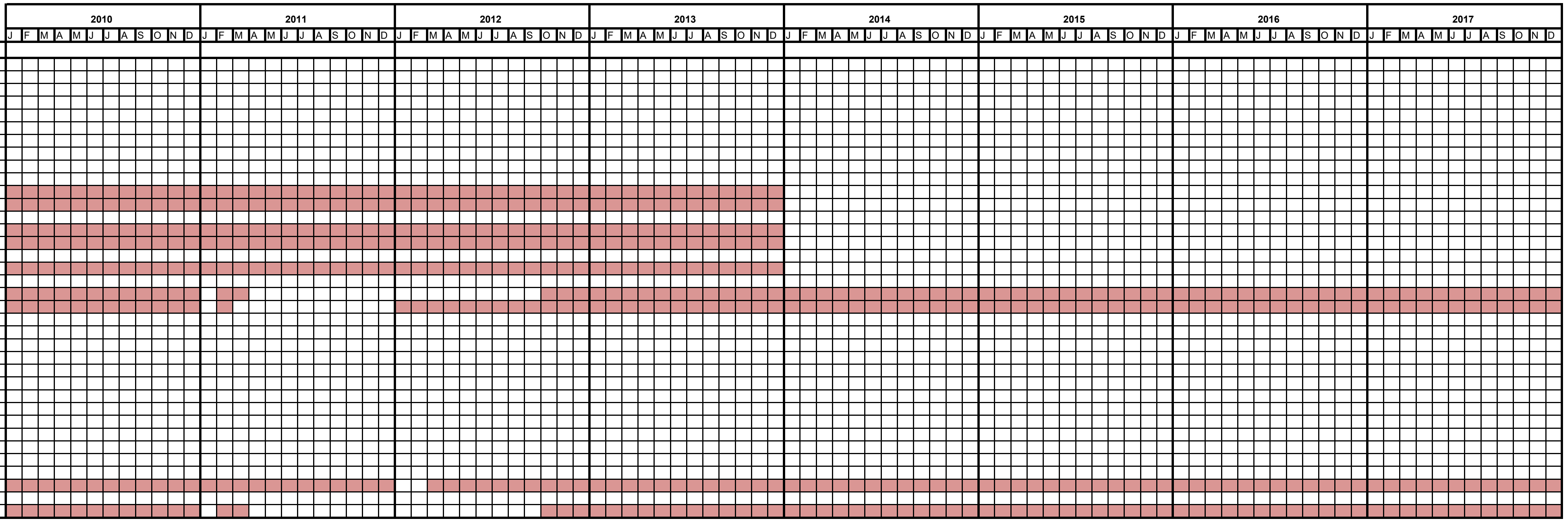
Monthly Data

2000 - 2009



	Drains	POR
2	Garfield Drain	1923-2005
3	Hatch Drain	1923-2005
4	Angostura Drain	1926-1983
5	Rincon Drain	1925-2005
6	Selden Drain	1923-1983
7	Leasburg Drain	1923-1983
8	Picacho Drain	1923-2005
9	Mesilla Drain	1923-1983
10	Santo Tomas River Drain	1985-1990
11	Santo Tomas Drain	1980-1985
12	West Drain	1923-2013
13	La Mesa Drain	1923-2013
14	Chamberino Drain	1923-1983
15	Nemexas Drain	1923-2013
16	Del Rio Drain	1923-2013
17	Mesquite Drain	1997-2001
18	East Drain	1930-2013
19	Anthony Drain	1923-2005
20	Montoya Drain	1923-2017
21	East Drain (EPCWID)	1923-2017
22	Montoya Intercepting Drain	1985-1990
23	Franklin Drain	1921-1983
24	Playa Drain	1923-1983
25	Middle Drain	1921-1983
26	River Drain	1923-1983
27	Cuadrilla Drain	1931-1983
28	Mesa Drain	1921-1983
29	Fabens Intercepting Drain	1931-1971
30	Border Drain	1923-1983
31	Island Drain	1921-1983
32	Island Syphon Drain	1936-1983
33	Alamo Alto Drain	1925-1983
34	Drain Water Diverted at Fabens	1945-1982
35	Fabens Waste Drain	1984-2017
36	Fabens Drain	1923-1983
37	Tornillo Drain	1923-2017

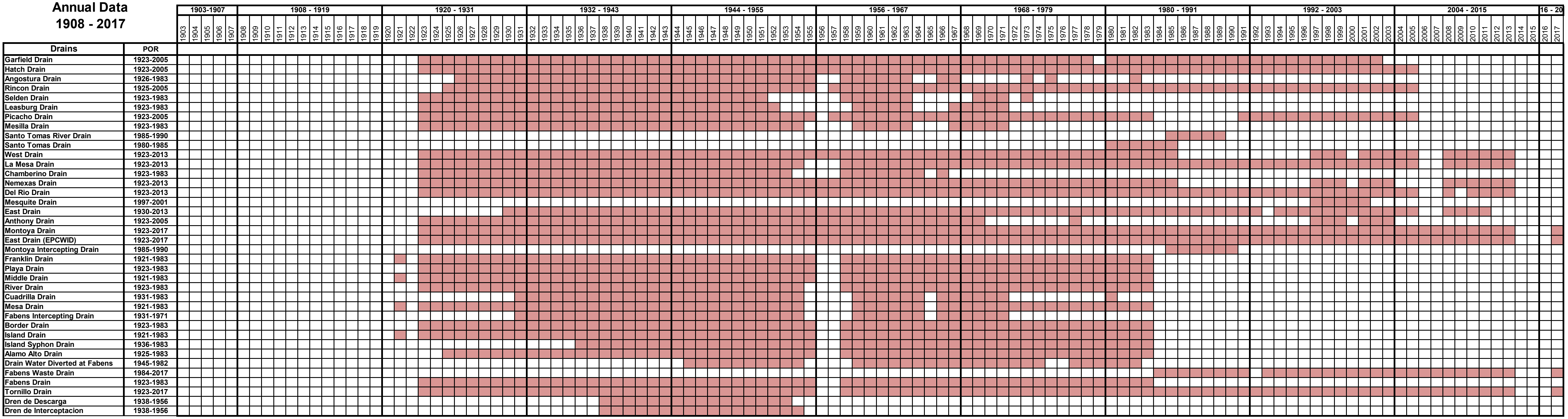
2010 - 2017



	Drains	POR
2	Garfield Drain	1923-2005
3	Hatch Drain	1923-2005
4	Angostura Drain	1926-1983
5	Rincon Drain	1925-2005
6	Selden Drain	1923-1983
7	Leasburg Drain	1923-1983
8	Picacho Drain	1923-2005
9	Mesilla Drain	1923-1983
10	Santo Tomas River Drain	1985-1990
11	Santo Tomas Drain	1980-1985
12	West Drain	1923-2013
13	La Mesa Drain	1923-2013
14	Chamberino Drain	1923-1983
15	Nemexas Drain	1923-2013
16	Del Rio Drain	1923-2013
17	Mesquite Drain	1997-2001
18	East Drain	1930-2013
19	Anthony Drain	1923-2005
20	Montoya Drain	1923-2017
21	East Drain (EPCWID)	1923-2017
22	Montoya Intercepting Drain	1985-1990
23	Franklin Drain	1921-1983
24	Playa Drain	1923-1983
25	Middle Drain	1921-1983
26	River Drain	1923-1983
27	Cuadrilla Drain	1931-1983
28	Mesa Drain	1921-1983
29	Fabens Intercepting Drain	1931-1971
30	Border Drain	1923-1983
31	Island Drain	1921-1983
32	Island Syphon Drain	1936-1983
33	Alamo Alto Drain	1925-1983
34	Drain Water Diverted at Fabens	1945-1982
35	Fabens Waste Drain	1984-2017
36	Fabens Drain	1923-1983
37	Tornillo Drain	1923-2017

Summary of Drain Data (red highlight = data available)

Annual Data
1908 - 2017



	Drains	POR
1	Garfield Drain	1923-2005
2	Hatch Drain	1923-2005
3	Angostura Drain	1926-1983
4	Rincon Drain	1925-2005
5	Selden Drain	1923-1983
6	Leasburg Drain	1923-1983
7	Picacho Drain	1923-2005
8	Mesilla Drain	1923-1983
9	Santo Tomas River Drain	1985-1990
10	Santo Tomas Drain	1980-1985
11	West Drain	1923-2013
12	La Mesa Drain	1923-2013
13	Chamberino Drain	1923-1983
14	Nemexas Drain	1923-2013
15	Del Rio Drain	1923-2013
16	Mesquite Drain	1997-2001
17	East Drain	1930-2013
18	Anthony Drain	1923-2005
19	Montoya Drain	1923-2017
20	East Drain (EPCWID)	1923-2017
21	Montoya Intercepting Drain	1985-1990
22	Franklin Drain	1921-1983
23	Playa Drain	1923-1983
24	Middle Drain	1921-1983
25	River Drain	1923-1983
26	Cuadrilla Drain	1931-1983
27	Mesa Drain	1921-1983
28	Fabens Intercepting Drain	1931-1971
29	Border Drain	1923-1983
30	Island Drain	1921-1983
31	Island Syphon Drain	1936-1983
32	Alamo Alto Drain	1925-1983
33	Drain Water Diverted at Fabens	1945-1982
34	Fabens Waste Drain	1984-2017
35	Fabens Drain	1923-1983
36	Tornillo Drain	1923-2017
37	Dren de Descarga	1938-1956
38	Dren de Interceptacion	1938-1956

Note: There may be missing months of data within the year. Blanks indicate drain flow data is either missing or annual drain flows equal zero.

Summary of Wasteway Data (red highlight = data available)

Monthly Data
1940 - 1949

			1940												1941												1942												1943												1944												1945												1946												1947												1948												1949											
			J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
	Wasteway	POR																																																																																																																																
2	WW No. 5 – Hatch Siphon	1979-2017																																																																																																																																	
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19	WW 32B – Vinton Cutoff Lateral	1985-2017																																																																																																																																	
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23	WW 35C – Schutz Lateral	1985-1988																																																																																																																																	
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30	WW 23A – Three Saints Lateral	1985-2017																																																																																																																																	
31	WW 36 – Montoya Lateral	1985-2017																																																																																																																																	
32	WW 38 – Montoya Lateral	1985-2017																																																																																																																																	
33	Leon Street WW	1938-1999	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
34	Franklin Settling Basin WW	1938-1999	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
35	Santa Fe WW (El Paso Electric)	1940-1960																																																																																																																																	
36	Ascarate WW	1916-2017	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
37	Riverside WW No. 1	1928-2017	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
38	Riverside WW No. 2	1930-2017	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
39	Fabens Waste Channel	1935-2017	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
40	Tornillo Canal WW No. 1	1981-2017																																																																																																																																	

1950 - 1959

			1950												1951												1952												1953												1954												1955												1956												1957												1958												1959											
			J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
	Wasteway	POR																																																																																																																																	
2|WW No. 5 – Hatch Siphon|1979-2017|																																																																																																																																	
3	WW No. 16 – Hatch Canal	1979-2017																																																																																																																																	
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31|WW 36 – Montoya Lateral|1985-2017|																																																																																																																																		
32|WW 38 – Montoya Lateral|1985-2017|																																																																																																																																	
33	Leon Street WW	1938-1999	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
34	Franklin Settling Basin WW	1938-1999	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
35|Santa Fe WW (El Paso Electric)|1940-1960|																																																																																																																																	
36	Ascarate WW	1916-2017	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
37	Riverside WW No. 1	1928-2017	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
38	Riverside WW No. 2	1930-2017	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
39	Fabens Waste Channel	1935-2017	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
40	Tornillo Canal WW No. 1	1981-2017																																																																																																																																	

Summary of Wasteway Data (red highlight = data available)

Monthly Data
1960 - 1969

			1960												1961												1962												1963												1964												1965												1966												1967												1968												1969											
	Wasteway	POR	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
2	WW No. 5 – Hatch Siphon	1979-2017																																																																																																																									
3	WW No. 16 – Hatch Canal	1979-2017																																																																																																																									
4	WW No. 18 – Rincon Lateral	1979-2017																																																																																																																									
5	WW No. 1A – Leasburg Canal	1989-2002																																																																																																																									
6	WW No. 1 – Leasburg Canal	1992-2002																																																																																																																									
7	WW No. 3 – Picacho Lateral	2001-2017																																																																																																																									
8	WW No. 5 – Leasburg Canal	1979-2017																																																																																																																										
9	WW No. 8 – Leasburg Canal	1979-2017																																																																																																																										
10	WW No. 40 – Picacho Lateral	1991-2017																																																																																																																										
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18	WW 32A – Rowley Lateral	1985-1988																																																																																																																										
19	WW 32B – Vinton Cutoff Lateral	1985-2017																																																																																																																										
20	WW 34 – Canutillo Lateral	1983-2017																																																																																																																										
21	WW 34A – Pence Lateral	1985-1988																																																																																																																										
22	WW 35 – Westside Canal	1980-2017																																																																																																																										
23	WW 35C – Schutz Lateral	1985-1988																																																																																																																										
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25	WW 16B – Brazito Lateral	1985-1990																																																																																																																										
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27	WW 19 – Three Saints Lateral	1982-2003																																																																																																																										
28	WW 20 – Three Saints West Lateral	1979-1988																																																																																																																										
29	WW 21 – Three Saints West Lateral	1985-2003																																																																																																																										
30	WW 23A – Three Saints Lateral	1985-2017																																																																																																																										
31	WW 36 – Montoya Lateral	1985-2017																																																																																																																										
32	WW 38 – Montoya Lateral	1985-2017																																																																																																																										
33	Leon Street WW	1938-1999	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
34	Franklin Settling Basin WW	1938-1999	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
35	Santa Fe WW (El Paso Electric)	1940-1960																																																																																																																										
36	Ascarate WW	1916-2017	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
37	Riverside WW No. 1	1928-2017	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
38	Riverside WW No. 2	1930-2017	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
39	Fabens Waste Channel	1935-2017	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
40	Tornillo Canal WW No. 1	1981-2017																																																																																																																										

1970 - 1979

			1970												1971												1972												1973												1974												1975												1976												1977												1978												1979											
	Wasteway	POR	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
2	WW No. 5 – Hatch Siphon	1979-2017																																																																																																														🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
3	WW No. 16 – Hatch Canal	1979-2017																																																																																																														🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
4	WW No. 18 – Rincon Lateral	1979-2017																																																																																																														🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
5	WW No. 1A – Leasburg Canal	1989-2002																																																																																																																											
6	WW No. 1 – Leasburg Canal	1992-2002																																																																																																																											
7	WW No. 3 – Picacho Lateral	2001-2017																																																																																																																											
8	WW No. 5 – Leasburg Canal	1979-2017																																																																																																													🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
9	WW No. 8 – Leasburg Canal	1979-2017																																																																																																													🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
10	WW No. 40 – Picacho Lateral	1991-2017																																																																																																																											
11	WW No. 13 – California Extension	1984-1991																																																																																																																											
12	WW 25 – Santo Tomas Lateral	1985-2001																																																																																																																											
13	WW 26 – Upper Chamberino Lateral	1979-2003																																																																																																													🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
14	WW 30 – Chamberino East Lateral	1985-2003																																																																																																																											
15	WW 31 – La Union Main Canal	1981-2003																																																																																																																											
16	WW 31B – Jimenez Lateral	1985-2003																																																																																																																											
17	WW 32 – La Union East Lateral	1979-2017																																																																																																												🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
18	WW 32A – Rowley Lateral	1985-1988																																																																																																																											
19	WW 32B – Vinton Cutoff Lateral	1985-2017																																																																																																																											
20	WW 34 – Canutillo Lateral	1983-2017																																																																																																																											
21	WW 34A – Pence Lateral	1985-1988																																																																																																																											
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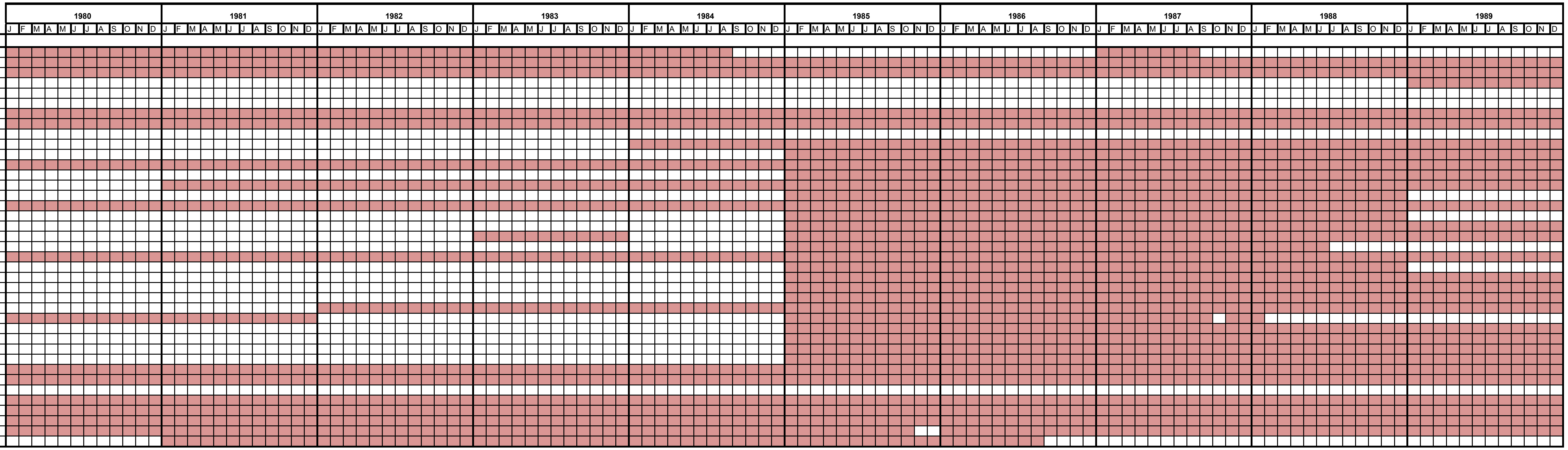
26	WW 18 – Eastside Canal	1985-2003																																																																																																																											
27	WW 19 – Three Saints Lateral	1982-2003																																																																																																																											
28	WW 20 – Three Saints West Lateral	1979-1988																																																																																																													🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
29	WW 21 – Three Saints West Lateral	1985-2003																																																																																																																												
30	WW 23A – Three Saints Lateral	1985-2017																																																																																																																											
31	WW 36 – Montoya Lateral	1985-2017																																																																																																																												
32	WW 38 – Montoya Lateral	1985-2017																																																																																																																											
33	Leon Street WW	1938-1999	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
34	Franklin Settling Basin WW	1938-1999	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
35	Santa Fe WW (El Paso Electric)	1940-1960																																																																																																																										
36	Ascarate WW	1916-2017	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
37	Riverside WW No. 1	1928-2017	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
38	Riverside WW No. 2	1930-2017	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
39	Fabens Waste Channel	1935-2017	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
40	Tornillo Canal WW No. 1	1981-2017																																																																																																																											

Summary of Wasteway Data (red highlight = data available)

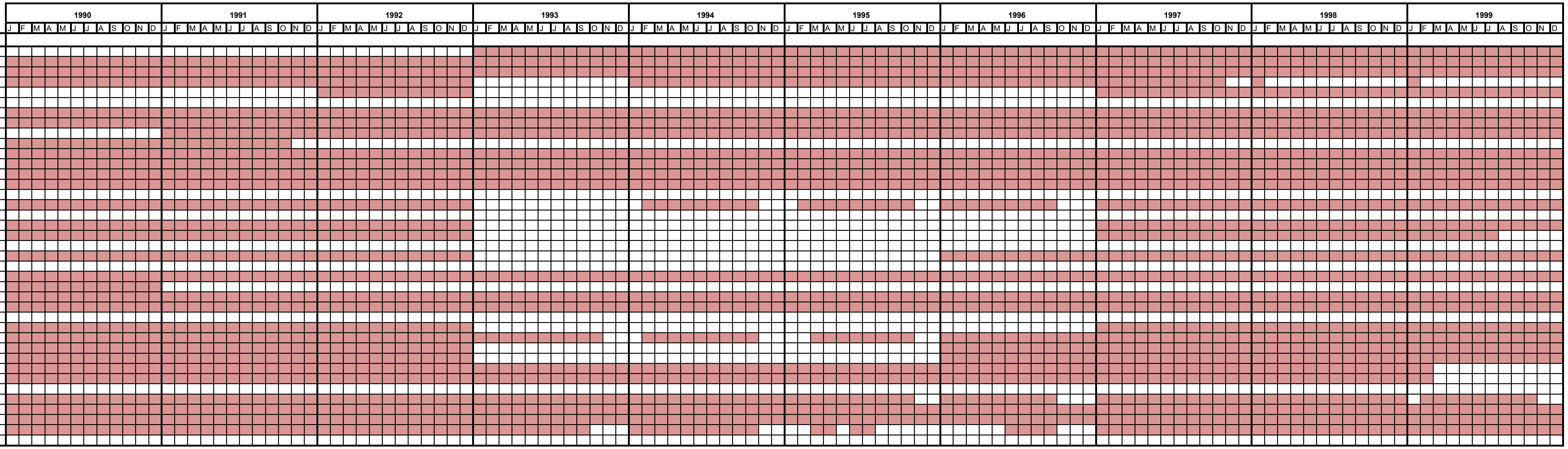
Monthly Data
1980 - 1989

	Wasteway	POR
2	WW No. 5 – Hatch Siphon	1979-2017
3	WW No. 16 – Hatch Canal	1979-2017
4	WW No. 18 – Rincon Lateral	1979-2017
5	WW No. 1A – Leasburg Canal	1989-2002
6	WW No. 1 – Leasburg Canal	1992-2002
7	WW No. 3 – Picacho Lateral	2001-2017
8	WW No. 5 – Leasburg Canal	1979-2017
9	WW No. 8 – Leasburg Canal	1979-2017
10	WW No. 40 – Picacho Lateral	1991-2017
11	WW No. 13 – California Extension	1984-1991
12	WW 25 – Santo Tomas Lateral	1985-2001
13	WW 26 – Upper Chamberino Lateral	1979-2003
14	WW 30 – Chamberino East Lateral	1985-2003
15	WW 31 – La Union Main Canal	1981-2003
16	WW 31B – Jimenez Lateral	1985-2003
17	WW 32 – La Union East Lateral	1979-2017
18	WW 32A – Rowley Lateral	1985-1988
19	WW 32B – Vinton Cutoff Lateral	1985-2017
20	WW 34 – Canutillo Lateral	1983-2017
21	WW 34A – Pence Lateral	1985-1988
22	WW 35 – Westside Canal	1980-2017
23	WW 35C – Schutz Lateral	1985-1988
24	WW 15 – Eastside Canal	1985-2003
25	WW 16B – Brazito Lateral	1985-1990
26	WW 18 – Eastside Canal	1985-2003
27	WW 19 – Three Saints Lateral	1982-2003
28	WW 20 – Three Saints West Lateral	1979-1988
29	WW 21 – Three Saints West Lateral	1985-2003
30	WW 23A – Three Saints Lateral	1985-2017
31	WW 36 – Montoya Lateral	1985-2017
32	WW 38 – Montoya Lateral	1985-2017
33	Leon Street WW	1938-1999
34	Franklin Settling Basin WW	1938-1999
35	Santa Fe WW (El Paso Electric)	1940-1960
36	Ascarate WW	1916-2017
37	Riverside WW No. 1	1928-2017
38	Riverside WW No. 2	1930-2017
39	Fabens Waste Channel	1935-2017
40	Tornillo Canal WW No. 1	1981-2017



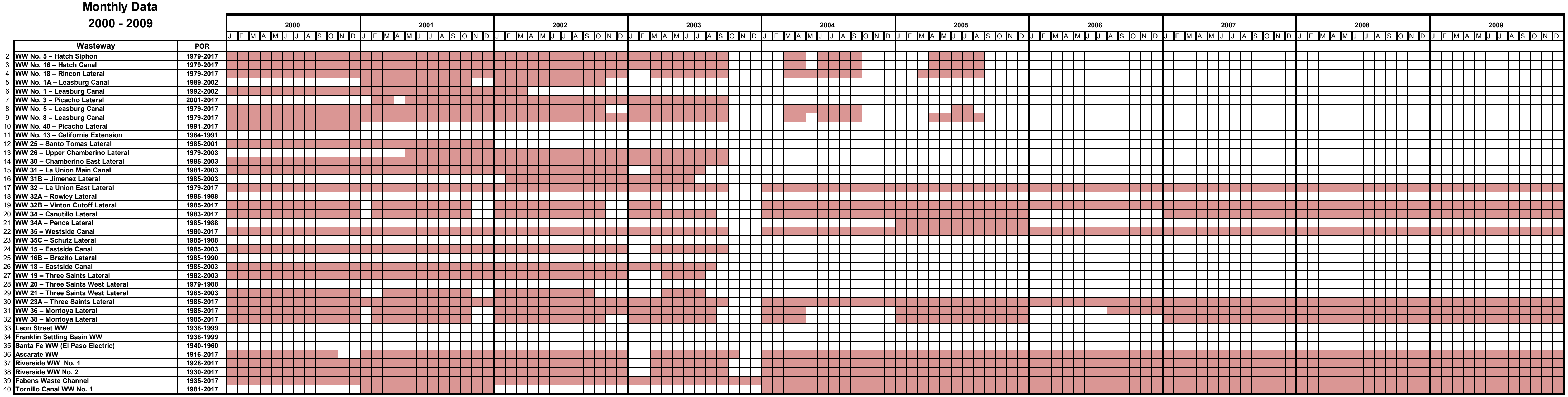
1990 - 1999

	Wasteway	POR
2	WW No. 5 – Hatch Siphon	1979-2017
3	WW No. 16 – Hatch Canal	1979-2017
4	WW No. 18 – Rincon Lateral	1979-2017
5	WW No. 1A – Leasburg Canal	1989-2002
6	WW No. 1 – Leasburg Canal	1992-2002
7	WW No. 3 – Picacho Lateral	2001-2017
8	WW No. 5 – Leasburg Canal	1979-2017
9	WW No. 8 – Leasburg Canal	1979-2017
10	WW No. 40 – Picacho Lateral	1991-2017
11	WW No. 13 – California Extension	1984-1991
12	WW 25 – Santo Tomas Lateral	1985-2001
13	WW 26 – Upper Chamberino Lateral	1979-2003
14	WW 30 – Chamberino East Lateral	1985-2003
15	WW 31 – La Union Main Canal	1981-2003
16	WW 31B – Jimenez Lateral	1985-2003
17	WW 32 – La Union East Lateral	1979-2017
18	WW 32A – Rowley Lateral	1985-1988
19	WW 32B – Vinton Cutoff Lateral	1985-2017
20	WW 34 – Canutillo Lateral	1983-2017
21	WW 34A – Pence Lateral	1985-1988
22	WW 35 – Westside Canal	1980-2017
23	WW 35C – Schutz Lateral	1985-1988
24	WW 15 – Eastside Canal	1985-2003
25	WW 16B – Brazito Lateral	1985-1990
26	WW 18 – Eastside Canal	1985-2003
27	WW 19 – Three Saints Lateral	1982-2003
28	WW 20 – Three Saints West Lateral	1979-1988
29	WW 21 – Three Saints West Lateral	1985-2003
30	WW 23A – Three Saints Lateral	1985-2017
31	WW 36 – Montoya Lateral	1985-2017
32	WW 38 – Montoya Lateral	1985-2017
33	Leon Street WW	1938-1999
34	Franklin Settling Basin WW	1938-1999
35	Santa Fe WW (El Paso Electric)	1940-1960
36	Ascarate WW	1916-2017
37	Riverside WW No. 1	1928-2017
38	Riverside WW No. 2	1930-2017
39	Fabens Waste Channel	1935-2017
40	Tornillo Canal WW No. 1	1981-2017



Summary of Wasteway Data (red highlight = data available)

Monthly Data 2000 - 2009



	Wasteway	POR
2	WW No. 5 – Hatch Siphon	1979-2017
3	WW No. 16 – Hatch Canal	1979-2017
4	WW No. 18 – Rincon Lateral	1979-2017
5	WW No. 1A – Leasburg Canal	1989-2002
6	WW No. 1 – Leasburg Canal	1992-2002
7	WW No. 3 – Picacho Lateral	2001-2017
8	WW No. 5 – Leasburg Canal	1979-2017
9	WW No. 8 – Leasburg Canal	1979-2017
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17	WW 32 – La Union East Lateral	1979-2017
18	WW 32A – Rowley Lateral	1985-1988
19	WW 32B – Vinton Cutoff Lateral	1985-2017
20	WW 34 – Canutillo Lateral	1983-2017
21	WW 34A – Pence Lateral	1985-1988
22	WW 35 – Westside Canal	1980-2017
23	WW 35C – Schutz Lateral	1985-1988
24	WW 15 – Eastside Canal	1985-2003
25	WW 16B – Brazito Lateral	1985-1990
26	WW 18 – Eastside Canal	1985-2003
27	WW 19 – Three Saints Lateral	1982-2003
28	WW 20 – Three Saints West Lateral	1979-1988
29	WW 21 – Three Saints West Lateral	1985-2003
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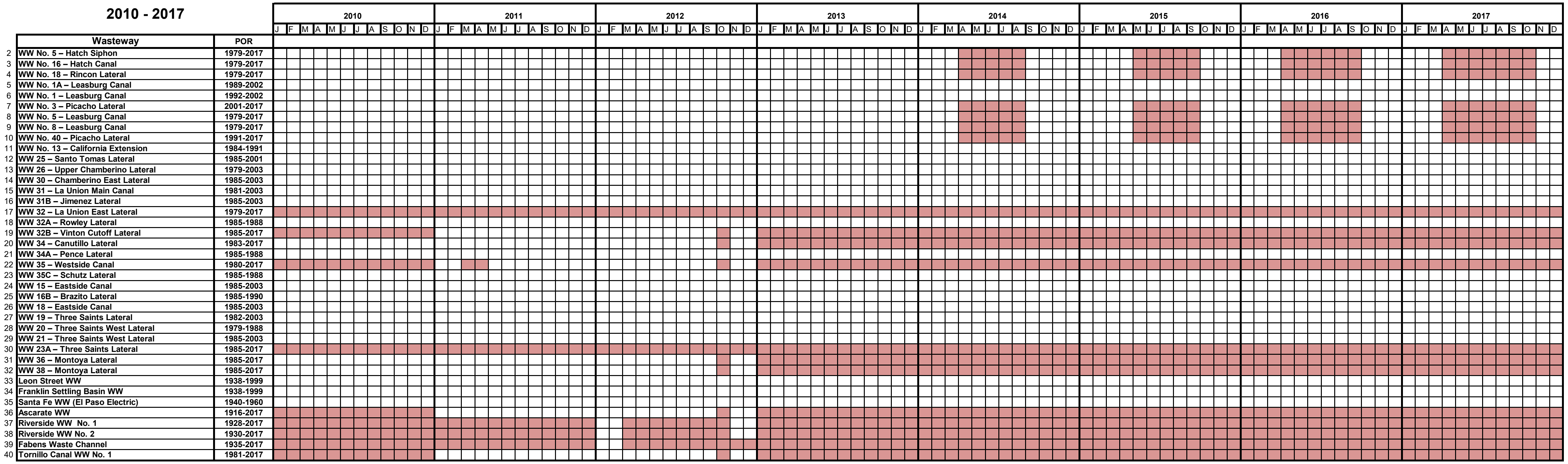
32	WW 38 – Montoya Lateral	1985-2017
33	Leon Street WW	1938-1999
34	Franklin Settling Basin WW	1938-1999
35	Santa Fe WW (El Paso Electric)	1940-1960
36	Ascarate WW	1916-2017
37	Riverside WW No. 1	1928-2017
38	Riverside WW No. 2	1930-2017
39	Fabens Waste Channel	1935-2017
40	Tornillo Canal WW No. 1	1981-2017

2010 - 2017



	Wasteway	POR
2	WW No. 5 – Hatch Siphon	1979-2017
3	WW No. 16 – Hatch Canal	1979-2017
4	WW No. 18 – Rincon Lateral	1979-2017
5	WW No. 1A – Leasburg Canal	1989-2002
6	WW No. 1 – Leasburg Canal	1992-2002
7	WW No. 3 – Picacho Lateral	2001-2017
8	WW No. 5 – Leasburg Canal	1979-2017
9	WW No. 8 – Leasburg Canal	1979-2017
10	WW No. 40 – Picacho Lateral	1991-2017
11	WW No. 13 – California Extension	1984-1991
12	WW 25 – Santo Tomas Lateral	1985-2001
13	WW 26 – Upper Chamberino Lateral	1979-2003
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18	WW 32A – Rowley Lateral	1985-1988
19	WW 32B – Vinton Cutoff Lateral	1985-2017
20	WW 34 – Canutillo Lateral	1983-2017
21	WW 34A – Pence Lateral	1985-1988
22	WW 35 – Westside Canal	1980-2017
23	WW 35C – Schutz Lateral	1985-1988
24	WW 15 – Eastside Canal	1985-2003
25	WW 16B – Brazito Lateral	1985-1990
26	WW 18 – Eastside Canal	1985-2003
27	WW 19 – Three Saints Lateral	1982-2003
28	WW 20 – Three Saints West Lateral	1979-1988
29	WW 21 – Three Saints West Lateral	1985-2003
30	WW 23A – Three Saints Lateral	1985-2017
31	WW 36 – Montoya Lateral	1985-2017
32	WW 38 – Montoya Lateral	1985-2017
33	Leon Street WW	1938-1999
34	Franklin Settling Basin WW	1938-1999
35	Santa Fe WW (El Paso Electric)	1940-1960
36	Ascarate WW	1916-2017
37	Riverside WW No. 1	1928-2017
38	Riverside WW No. 2	1930-2017
39	Fabens Waste Channel	1935-2017
40	Tornillo Canal WW No. 1	1981-2017

Summary of Wasteway Data (red highlight = data available)

Annual Data
1903 - 2017

	Wasteway	POR
2	WW No. 5 – Hatch Siphon	1979-2017
3	WW No. 16 – Hatch Canal	1979-2017
4	WW No. 18 – Rincon Lateral	1979-2017
5	WW No. 1A – Leasburg Canal	1989-2002
6	WW No. 1 – Leasburg Canal	1992-2002
7	WW No. 3 – Picacho Lateral	2001-2017
8	WW No. 5 – Leasburg Canal	1979-2017
9	WW No. 8 – Leasburg Canal	1979-2017
10	WW No. 40 – Picacho Lateral	1991-2017
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19	WW 32B – Vinton Cutoff Lateral	1985-2017
20	WW 34 – Canutillo Lateral	1983-2017
21	WW 34A – Pence Lateral	1985-1988
22	WW 35 – Westside Canal	1980-2017
23	WW 35C – Schutz Lateral	1985-1988
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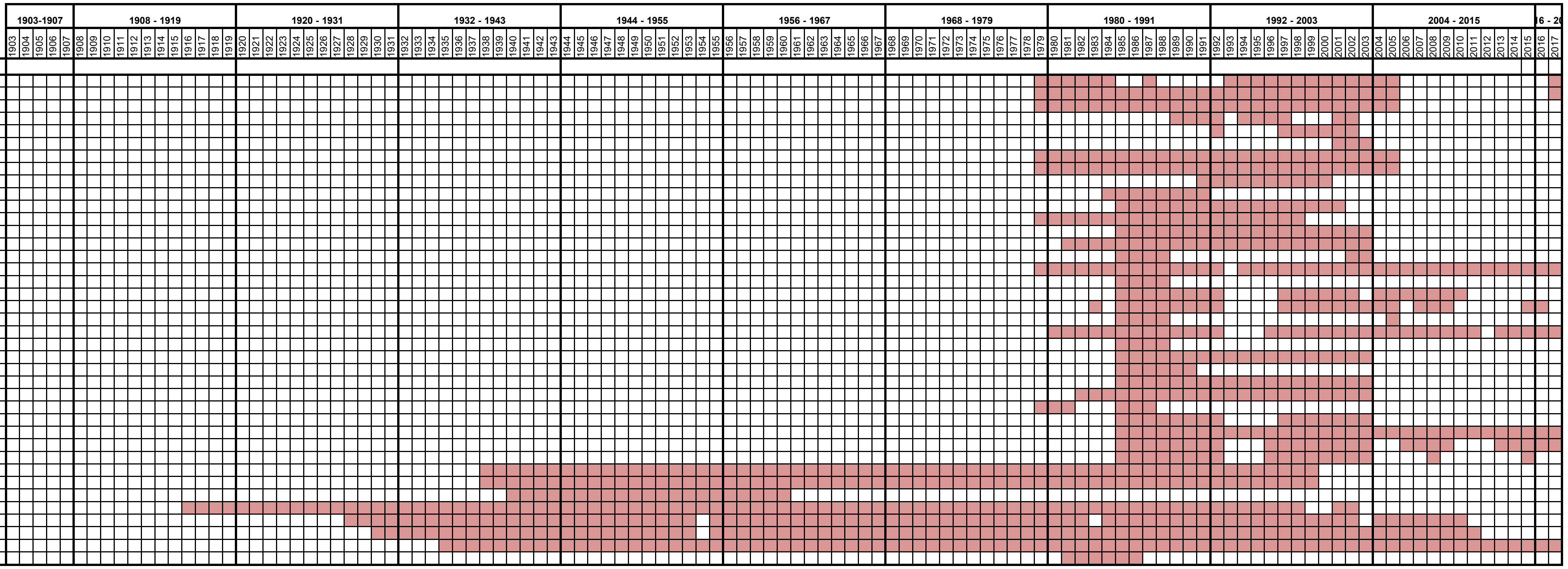
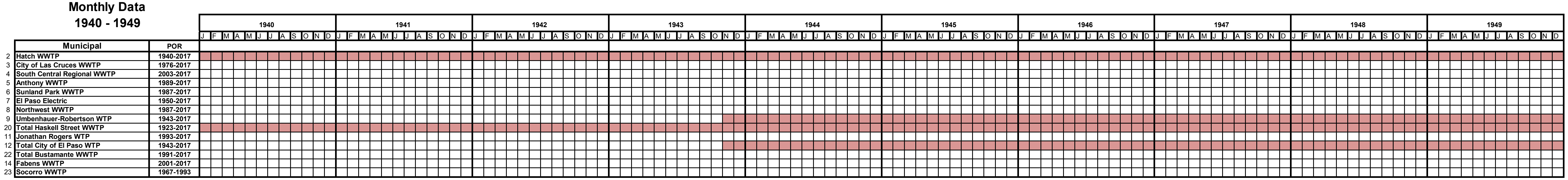
33	Leon Street WW	1938-1999
34	Franklin Settling Basin WW	1938-1999
35	Santa Fe WW (El Paso Electric)	1940-1960
36	Ascarate WW	1916-2017
37	Riverside WW No. 1	1928-2017
38	Riverside WW No. 2	1930-2017
39	Fabens Waste Channel	1935-2017
40	Tornillo Canal WW No. 1	1981-2017

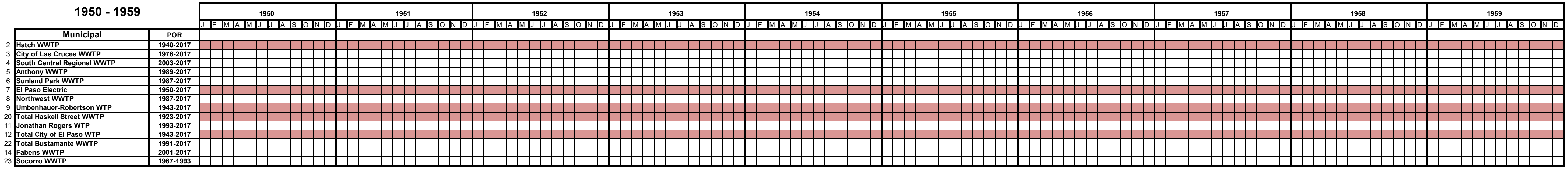


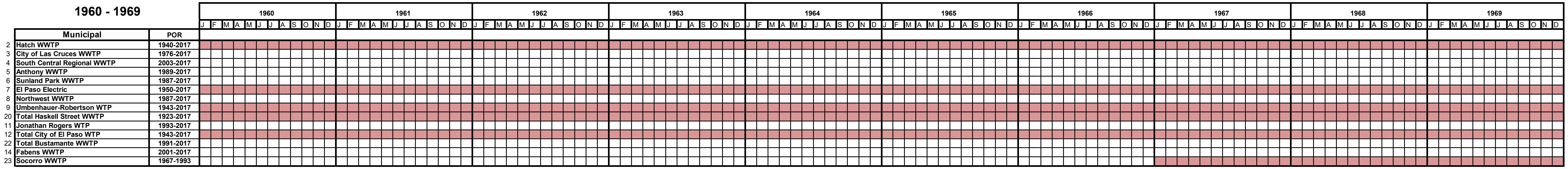
Note: There may be missing months of data within the year.

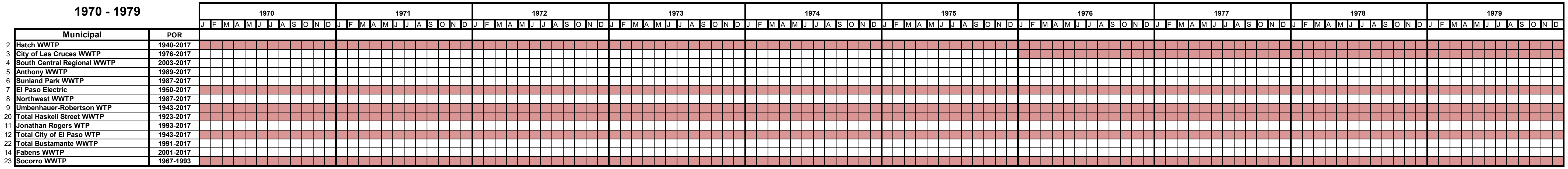
Summary of Municipal Data (red highlight = data available)

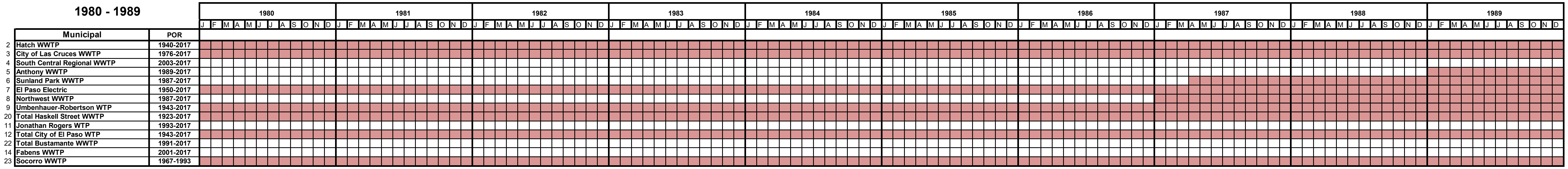
Monthly Data











Summary of Municipal Data (red highlight = data available)

1990 - 1999

	Municipal	POR	1990 J F M A M J J A S O N D	1991 J F M A M J J A S O N D	1992 J F M A M J J A S O N D	1993 J F M A M J J A S O N D	1994 J F M A M J J A S O N D	1995 J F M A M J J A S O N D	1996 J F M A M J J A S O N D	1997 J F M A M J J A S O N D	1998 J F M A M J J A S O N D	1999 J F M A M J J A S O N D
2	Hatch WWTP	1940-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
3	City of Las Cruces WWTP	1976-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
4	South Central Regional WWTP	2003-2017	☐☐☐☐☐☐☐☐☐☐☐☐	☐☐☐☐☐☐☐☐☐☐☐☐	☐☐☐☐☐☐☐☐☐☐☐☐	☐☐☐☐☐☐☐☐☐☐☐☐	☐☐☐☐☐☐☐☐☐☐☐☐	☐☐☐☐☐☐☐☐☐☐☐☐	☐☐☐☐☐☐☐☐☐☐☐☐	☐☐☐☐☐☐☐☐☐☐☐☐	☐☐☐☐☐☐☐☐☐☐☐☐	☐☐☐☐☐☐☐☐☐☐☐☐
5	Anthony WWTP	1989-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
6	Sunland Park WWTP	1987-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
7	El Paso Electric	1950-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
8	Northwest WWTP	1987-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
9	Umbenhauer-Robertson WTP	1943-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
20	Total Haskell Street WWTP	1923-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
11	Jonathan Rogers WTP	1993-2017	☐☐☐☐☐☐☐☐☐☐☐☐	☐☐☐☐☐☐☐☐☐☐☐☐	☐☐☐☐☐☐☐☐☐☐☐☐	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
12	Total City of El Paso WTP	1943-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
22	Total Bustamante WWTP	1991-2017	☐☐☐☐☐☐☐☐☐☐☐☐	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
14	Fabens WWTP	2001-2017	☐☐☐☐☐☐☐☐☐☐☐☐	☐☐☐☐☐☐☐☐☐☐☐☐	☐☐☐☐☐☐☐☐☐☐☐☐	☐☐☐☐☐☐☐☐☐☐☐☐	☐☐☐☐☐☐☐☐☐☐☐☐	☐☐☐☐☐☐☐☐☐☐☐☐	☐☐☐☐☐☐☐☐☐☐☐☐	☐☐☐☐☐☐☐☐☐☐☐☐	☐☐☐☐☐☐☐☐☐☐☐☐	☐☐☐☐☐☐☐☐☐☐☐☐
23	Socorro WWTP	1967-1993	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥☐☐☐☐☐☐☐☐☐☐	☐☐☐☐☐☐☐☐☐☐☐☐	☐☐☐☐☐☐☐☐☐☐☐☐	☐☐☐☐☐☐☐☐☐☐☐☐	☐☐☐☐☐☐☐☐☐☐☐☐	☐☐☐☐☐☐☐☐☐☐☐☐	☐☐☐☐☐☐☐☐☐☐☐☐

2000 - 2009

	Municipal	POR	2000 J F M A M J J A S O N D	2001 J F M A M J J A S O N D	2002 J F M A M J J A S O N D	2003 J F M A M J J A S O N D	2004 J F M A M J J A S O N D	2005 J F M A M J J A S O N D	2006 J F M A M J J A S O N D	2007 J F M A M J J A S O N D	2008 J F M A M J J A S O N D	2009 J F M A M J J A S O N D
2	Hatch WWTP	1940-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
3	City of Las Cruces WWTP	1976-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
4	South Central Regional WWTP	2003-2017	☐☐☐☐☐☐☐☐☐☐☐☐	☐☐☐☐☐☐☐☐☐☐☐☐	☐☐☐☐☐☐☐☐☐☐☐☐	☐☐☐☐🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
5	Anthony WWTP	1989-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
6	Sunland Park WWTP	1987-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
7	El Paso Electric	1950-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
8	Northwest WWTP	1987-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
9	Umbenhauer-Robertson WTP	1943-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
20	Total Haskell Street WWTP	1923-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
11	Jonathan Rogers WTP	1993-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
12	Total City of El Paso WTP	1943-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
22	Total Bustamante WWTP	1991-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
14	Fabens WWTP	2001-2017	☐☐☐☐☐☐☐☐☐☐☐☐	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
23	Socorro WWTP	1967-1993	☐☐☐☐☐☐☐☐☐☐☐☐	☐☐☐☐☐☐☐☐☐☐☐☐	☐☐☐☐☐☐☐☐☐☐☐☐	☐☐☐☐☐☐☐☐☐☐☐☐	☐☐☐☐☐☐☐☐☐☐☐☐	☐☐☐☐☐☐☐☐☐☐☐☐	☐☐☐☐☐☐☐☐☐☐☐☐	☐☐☐☐☐☐☐☐☐☐☐☐	☐☐☐☐☐☐☐☐☐☐☐☐	☐☐☐☐☐☐☐☐☐☐☐☐

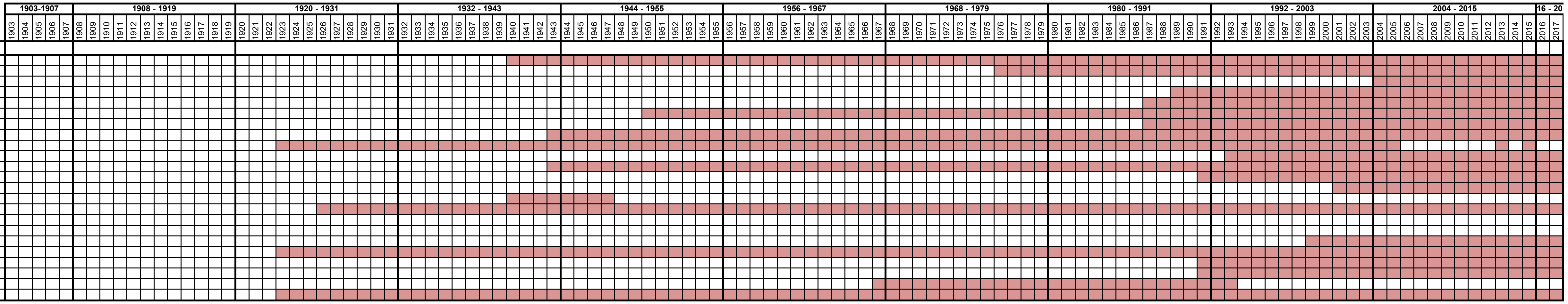
2010 - 2017

	Municipal	POR	2010 J F M A M J J A S O N D	2011 J F M A M J J A S O N D	2012 J F M A M J J A S O N D	2013 J F M A M J J A S O N D	2014 J F M A M J J A S O N D	2015 J F M A M J J A S O N D	2016 J F M A M J J A S O N D	2017 J F M A M J J A S O N D
2	Hatch WWTP	1940-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
3	City of Las Cruces WWTP	1976-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
4	South Central Regional WWTP	2003-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
5	Anthony WWTP	1989-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
6	Sunland Park WWTP	1987-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
7	El Paso Electric	1950-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
8	Northwest WWTP	1987-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
9	Umbenhauer-Robertson WTP	1943-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	☐☐🟥🟥🟥🟥🟥🟥🟥☐☐☐	☐☐☐☐☐🟥🟥☐☐☐☐☐	☐☐☐☐🟥🟥🟥🟥☐☐☐☐	☐☐☐☐🟥🟥🟥🟥🟥☐☐☐	☐☐🟥🟥🟥🟥🟥🟥🟥☐☐☐	☐☐🟥🟥🟥🟥🟥🟥🟥🟥☐☐
20	Total Haskell Street WWTP	1923-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
11	Jonathan Rogers WTP	1993-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	☐☐🟥🟥🟥🟥🟥🟥🟥☐☐☐	☐☐☐☐☐🟥🟥☐☐☐☐☐	☐☐☐☐🟥🟥🟥🟥☐☐☐☐	☐☐☐☐🟥🟥🟥🟥🟥☐☐☐	☐☐🟥🟥🟥🟥🟥🟥🟥☐☐☐	☐☐🟥🟥🟥🟥🟥🟥🟥🟥☐☐
12	Total City of El Paso WTP	1943-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	☐☐🟥🟥🟥🟥🟥🟥🟥☐☐☐	☐☐☐☐☐🟥🟥☐☐☐☐☐	☐☐☐☐🟥🟥🟥🟥☐☐☐☐	☐☐☐☐🟥🟥🟥🟥🟥☐☐☐	☐☐🟥🟥🟥🟥🟥🟥🟥☐☐☐	☐☐🟥🟥🟥🟥🟥🟥🟥🟥☐☐
22	Total Bustamante WWTP	1991-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
14	Fabens WWTP	2001-2017	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥	🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥🟥
23	Socorro WWTP	1967-1993	☐☐☐☐☐☐☐☐☐☐☐☐	☐☐☐☐☐☐☐☐☐☐☐☐	☐☐☐☐☐☐☐☐☐☐☐☐	☐☐☐☐☐☐☐☐☐☐☐☐	☐☐☐☐☐☐☐☐☐☐☐☐	☐☐☐☐☐☐☐☐☐☐☐☐	☐☐☐☐☐☐☐☐☐☐☐☐	☐☐☐☐☐☐☐☐☐☐☐☐

Summary of Municipal Data (red highlight = data available)

Annual Data
1903 - 2017

	Municipal	POR
2	Hatch WWTP	1940-2017
3	Las Cruces WWTP	1976-2017
4	South Central Regional WWTP	2003-2017
5	Anthony WWTP	1989-2017
6	Sunland Park WWTP	1987-2017
7	El Paso Electric	1950-2017
8	Northwest WWTP	1987-2017
9	Umbenhauer-Robertson WTP	1943-2017
10	Haskell WWTP to Rio Grande	1923-2017
11	Jonathan Rogers WTP	1993-2017
12	Total City of El Paso WTP	1943-2017
13	Bustamante WWTP to Rio Grande/Drain	1991-2017
14	Fabens WWTP	2001-2017
15	Juarez Sewage to Rio Grande	1940-1950
16	Juarez Sewage to Canals	1926-2017
17	Juarez North Plant	No Data
18	Juarez South Plant	No Data
19	Haskell WWTP to ACE	1998-2017
20	Total Haskell WWTP	1923-2017
21	Bustamante WWTP to Riverside Canal	1991-2017
22	Total Bustamante WWTP	1991-2017
23	Socorro WWTP	1967-1993
24	Total City of El Paso WWTP	1923-2017



Note: There may be missing months of data within the year.

Appendix 3B

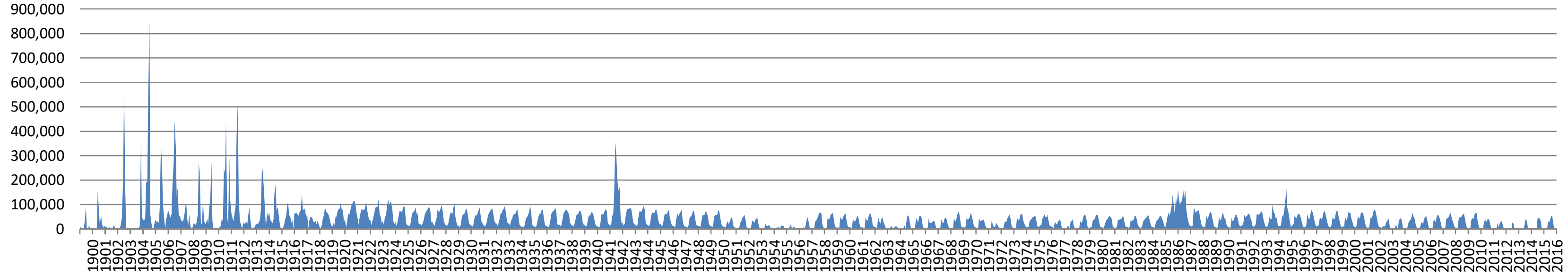
Example SWDataSet Data Summaries

River Flows

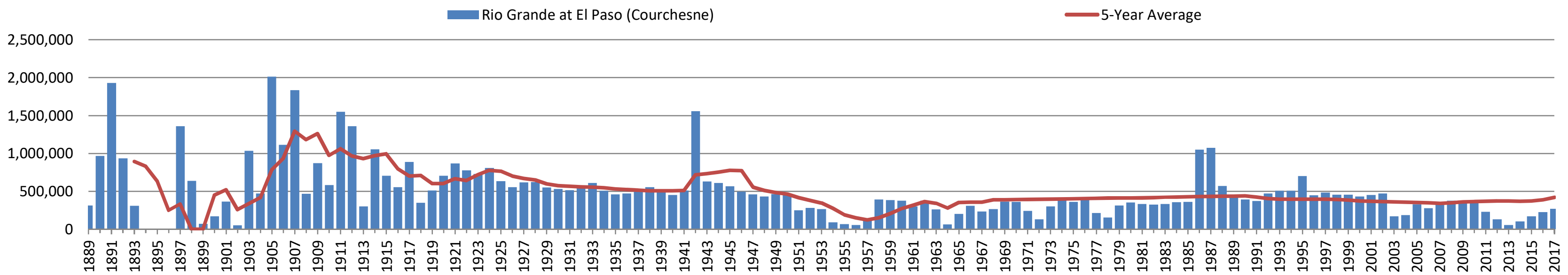
Rio Grande at El Paso (Courchesne)

1889 - 2017

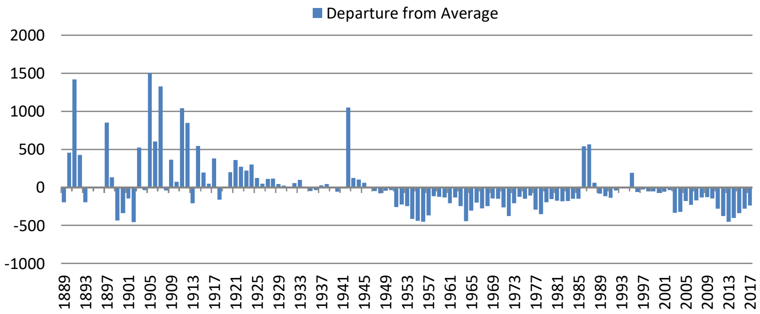
Total Monthly Flow (Acre-Feet)



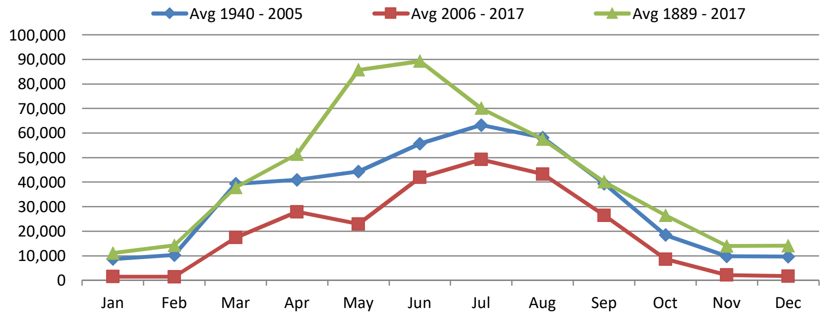
Total Annual Flow (Acre-Feet)



Annual Departure from Average (1,000 Acre-Feet)



Average Monthly Flow (Acre-Feet)



	Start	End
Period 1:	1940	2005
Period 2:	2006	2017

Rio Grande Project Flow Data

Total Monthly Flow (Acre-Feet)

1889 - 2017

Rio Grande at El Paso (Courchesne)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
1889	-	-	-	-	136,241	156,950	14,709	0	0	0	0	4,380	312,280
1890	12,099	16,141	26,047	130,259	353,742	265,876	52,532	45,156	10,471	3,997	16,959	32,953	966,232
1891	27,590	45,352	114,716	256,078	727,845	399,608	139,605	40,703	45,669	91,436	20,285	21,185	1,930,072
1892	20,093	27,378	46,231	187,293	436,243	174,988	41,264	700	0	0	0	0	934,190
1893	7,678	8,023	2,162	48,095	231,634	13,400	-	-	-	-	-	-	310,992
1894	-	-	-	-	-	-	-	-	-	-	-	-	-
1895	-	-	-	-	-	-	-	-	-	-	-	-	-
1896	-	-	-	-	-	-	-	-	-	-	-	-	-
1897	18,768	10,760	4,413	103,555	511,198	362,543	81,711	8,128	41,958	108,061	67,373	41,806	1,360,274
1898	0	33,872	20,023	97,918	140,221	111,576	196,383	31,206	2,233	161	119	5,734	639,446
1899	13,111	11,326	7,041	8,832	10,348	0	19,583	436	0	0	0	2,836	73,513
1900	8,112	5,683	466	298	44,826	93,158	69	0	16,487	0	0	732	169,831
1901	278	4,502	3,669	0	158,172	77,074	12,565	60,653	20,999	5,334	12,811	7,993	364,050
1902	8,291	5,772	635	7,904	526	307	0	14,491	9,322	1,428	298	1,775	50,749
1903	615	1,289	22,602	49,482	203,585	587,004	158,225	4,364	1,031	2,033	298	2,440	1,032,968
1904	972	0	0	0	0	0	0	7,394	10,967	366,460	48,399	38,237	472,429
1905	35,919	43,309	188,418	197,835	546,145	851,149	58,800	19,781	3,322	4,225	25,474	37,470	2,011,847
1906	27,003	31,686	25,313	88,046	348,978	270,589	96,559	49,160	2,817	38,186	59,320	76,253	1,113,910
1907	60,430	46,621	60,050	175,763	269,341	442,621	337,482	135,253	166,891	49,987	54,946	37,636	1,837,021
1908	32,979	31,164	47,750	80,138	116,882	40,167	16,320	58,627	14,255	0	5,078	23,391	466,751
1909	22,330	17,159	28,776	61,531	270,214	233,558	24,801	19,031	117,820	35,367	20,618	22,806	874,011
1910	43,480	20,908	92,932	117,021	273,695	33,118	69	0	129	0	0	595	581,947
1911	9,257	11,891	43,547	31,849	247,918	229,182	435,475	53,572	11,589	294,397	118,909	62,382	1,549,968
1912	48,607	32,303	60,373	95,958	382,334	514,483	125,988	30,815	20,273	1,230	18,391	26,999	1,357,754
1913	18,819	34,955	15,636	50,700	88,645	43,012	5,695	0	0	6,754	17,133	21,150	302,499
1914	21,884	23,147	38,735	73,037	259,541	227,474	146,930	70,096	8,212	68,075	50,975	67,482	1,055,588
1915	39,273	32,029	22,185	37,785	143,258	183,612	76,699	88,310	59,911	19,444	1,930	0	704,436
1916	3,441	16,312	36,553	53,800	93,800	111,669	53,760	55,345	25,878	39,915	595	64,645	555,713
1917	64,770	65,726	58,806	54,244	73,250	76,195	141,404	81,066	78,303	85,071	43,779	65,829	888,443
1918	2,337	31,956	48,827	48,543	46,594	28,661	26,961	33,935	19,496	33,896	20,315	6,397	347,918
1919	3,525	17,117	42,881	56,410	90,171	71,048	67,156	61,974	50,874	26,941	16,504	7,261	511,862
1920	24,196	13,103	49,478	50,368	72,496	82,600	84,103	106,703	74,763	79,755	28,203	41,060	706,828
1921	6,639	24,817	67,008	53,913	76,592	93,654	104,709	113,839	115,851	100,316	69,168	43,906	870,412
1922	17,806	47,927	67,511	85,549	74,860	78,984	83,238	112,417	82,294	54,093	36,662	37,831	779,172
1923	16,499	33,697	47,211	72,153	87,350	90,300	90,863	122,902	60,422	51,558	23,258	32,261	728,474
1924	17,520	48,583	56,868	91,174	122,263	98,180	110,624	107,248	77,207	32,019	21,064	27,699	810,449
1925	11,603	29,199	56,688	75,053	73,156	68,416	79,771	96,875	87,360	25,331	15,287	14,860	633,599
1926	12,151	15,423	41,254	65,441	69,459	75,235	88,931	63,102	64,957	21,049	21,013	18,797	556,812
1927	13,896	24,577	38,081	58,943	71,746	73,785	86,757	90,700	80,640	30,309	29,457	20,579	619,470
1928	12,734	26,584	43,503	80,053	68,668	72,895	86,233	97,652	67,279	31,740	22,336	14,273	623,950
1929	13,226	18,002	37,083	62,577	70,481	56,210	82,762	106,913	51,540	25,912	14,311	12,720	551,737
1930	8,208	16,298	42,819	62,263	58,780	67,972	82,336	83,300	51,892	25,761	16,685	16,114	532,428
1931	9,098	13,902	40,423	56,820	53,649	63,257	76,423	88,621	52,469	26,735	22,255	14,130	517,782
1932	9,134	16,879	34,524	57,227	62,454	73,634	78,462	85,763	65,810	34,863	24,369	22,473	565,592
1933	11,821	24,883	39,632	66,422	63,479	79,081	82,621	95,687	66,666	33,622	20,460	24,760	609,134
1934	11,226	33,112	43,446	56,648	60,674	61,997	73,827	80,227	48,024	18,313	11,355	9,590	508,439

Rio Grande Project Flow Data

Total Monthly Flow (Acre-Feet)

1889 - 2017

Rio Grande at El Paso (Courchesne)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
1935	8,509	8,797	18,375	44,894	47,605	56,686	69,868	95,889	65,766	20,186	11,472	11,457	459,504
1936	8,569	10,659	29,369	50,826	62,555	62,822	76,542	79,686	50,448	17,837	12,506	12,018	473,837
1937	8,545	10,163	26,200	60,387	69,467	73,287	76,296	88,512	68,200	19,825	17,088	18,155	536,125
1938	10,895	16,814	43,934	66,327	71,100	78,540	77,978	68,940	60,976	27,300	16,612	15,523	554,939
1939	10,328	15,673	36,708	56,015	59,566	64,088	73,480	72,240	61,166	27,540	18,220	16,475	511,499
1940	10,748	12,732	38,672	57,753	52,163	68,253	68,858	61,000	41,667	19,039	11,889	11,000	453,774
1941	8,495	7,234	26,465	61,386	58,598	61,638	74,178	82,463	71,611	25,795	16,655	16,812	511,330
1942	13,014	52,199	62,543	139,061	356,533	304,421	197,881	157,620	171,453	57,923	21,021	25,605	1,559,274
1943	15,138	21,836	52,368	78,555	82,500	82,124	85,613	84,908	63,459	27,128	21,281	16,865	631,775
1944	11,939	15,519	46,143	74,519	71,685	71,738	83,919	94,007	79,254	29,510	16,695	16,969	611,897
1945	11,387	16,655	49,016	68,275	66,718	63,047	76,215	81,568	60,540	35,375	18,377	21,604	568,777
1946	12,038	15,243	38,446	61,390	63,461	59,117	71,100	77,667	45,078	25,214	15,217	14,013	497,984
1947	9,864	9,136	37,252	64,979	51,816	63,215	69,693	77,784	40,552	14,573	10,395	9,457	458,716
1948	7,775	6,508	22,278	51,616	49,724	59,841	74,741	71,772	41,841	18,869	13,377	13,258	431,600
1949	10,800	8,140	34,455	57,219	56,188	59,044	73,456	65,474	51,548	20,077	14,896	12,248	463,545
1950	9,830	10,175	48,054	57,669	56,676	59,548	78,395	68,795	44,521	18,315	10,939	9,703	472,620
1951	8,456	6,571	24,633	32,295	17,903	33,919	45,485	47,736	17,125	6,934	5,641	5,304	252,002
1952	4,290	3,197	8,959	26,099	34,383	47,076	51,427	57,975	32,686	7,416	5,119	5,000	283,627
1953	4,324	2,876	34,941	33,005	24,664	35,234	42,403	46,802	26,850	5,530	4,284	3,699	264,612
1954	3,257	2,003	5,468	22,679	12,748	12,484	16,171	11,691	2,428	3,790	541	444	93,704
1955	540	282	4,588	10,538	2,126	6,018	14,973	12,067	13,803	1,484	391	278	67,088
1956	236	210	10,992	17,780	1,218	7,335	9,917	4,871	4,304	149	228	204	57,444
1957	224	133	1,779	6,821	538	14,537	36,992	47,494	27,697	2,370	551	432	139,568
1958	399	359	29,653	34,986	42,944	55,006	68,104	65,931	64,425	19,410	6,557	5,048	392,822
1959	4,009	3,342	50,696	38,662	44,751	60,897	62,178	66,395	33,737	8,471	6,121	6,569	385,828
1960	5,710	3,832	50,715	38,664	41,583	52,782	60,863	61,757	36,613	10,994	7,402	7,216	378,131
1961	5,814	3,963	37,807	33,140	29,808	40,618	53,978	48,226	26,947	7,484	5,825	7,196	300,806
1962	5,014	3,693	46,487	35,867	34,707	52,128	63,852	62,993	41,183	13,307	8,832	8,100	376,163
1963	6,065	4,266	48,434	32,731	22,173	41,191	48,056	29,429	16,520	6,089	4,566	4,197	263,717
1964	3,517	2,325	7,878	12,056	1,210	6,317	9,652	10,419	9,429	536	480	502	64,321
1965	488	448	3,598	15,245	530	39,546	57,130	51,215	29,820	2,087	1,194	1,079	202,380
1966	992	746	44,759	36,712	28,786	51,509	54,387	54,714	20,269	6,583	4,748	4,576	308,781
1967	3,723	2,406	46,064	25,351	24,210	25,299	31,670	36,111	27,485	5,086	2,513	2,809	232,727
1968	2,781	1,874	39,556	27,261	23,466	41,403	46,592	40,703	23,889	6,629	5,004	5,228	264,386
1969	4,683	2,573	42,307	33,705	30,952	52,810	67,708	69,237	36,601	10,842	6,793	7,180	365,391
1970	5,601	5,578	46,374	38,239	40,808	46,774	67,252	54,204	31,743	11,837	6,740	5,548	360,698
1971	5,012	3,189	43,170	30,849	33,572	37,087	39,602	28,078	13,144	4,824	2,844	2,769	244,140
1972	2,495	1,743	33,840	16,312	8,894	7,160	24,670	21,144	10,441	5,131	916	805	133,551
1973	470	359	24,912	30,405	31,242	44,293	53,274	58,602	38,160	10,009	5,514	4,542	301,782
1974	4,272	3,735	49,182	35,833	36,460	55,025	61,273	59,778	35,825	22,138	12,143	7,230	382,894
1975	9,070	6,706	32,154	38,418	41,472	49,821	49,123	55,575	47,048	13,450	9,047	9,078	360,962
1976	15,580	14,168	40,108	50,005	59,972	50,608	48,585	57,384	31,561	14,340	10,475	9,999	402,785
1977	7,630	4,473	30,867	22,661	18,710	31,269	34,493	41,383	14,961	3,271	2,265	2,600	214,583
1978	2,097	1,382	13,942	10,754	2,604	30,781	32,069	41,187	13,113	2,924	3,537	1,603	155,993
1979	1,458	1,039	31,537	26,327	28,013	50,664	59,591	55,696	40,832	8,688	5,066	3,652	312,563
1980	8,805	7,458	33,128	38,289	40,854	55,260	59,784	54,242	30,163	11,074	7,674	7,277	354,008
1981	3,540	10,990	27,342	36,492	41,060	48,914	54,111	48,165	40,257	11,197	6,464	4,812	333,344

Rio Grande Project Flow Data

Total Monthly Flow (Acre-Feet)

1889 - 2017

Rio Grande at El Paso (Courchesne)

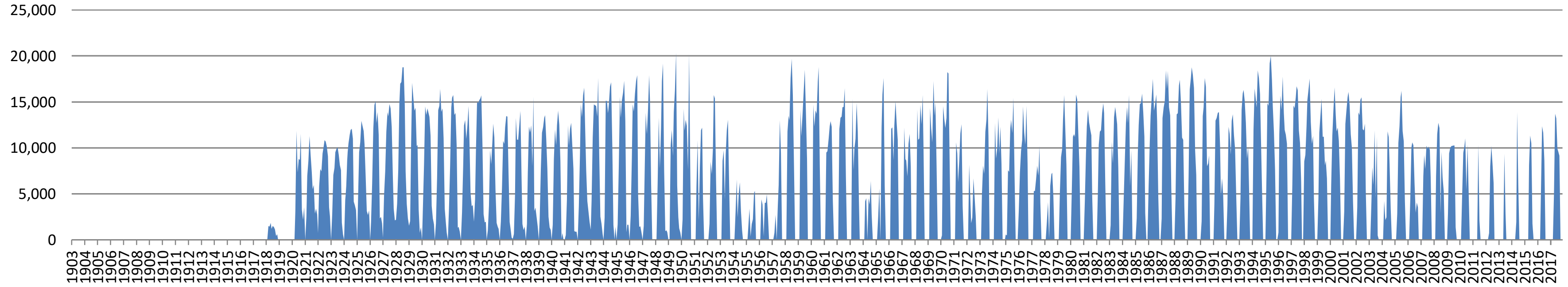
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
1982	4,257	8,309	36,768	36,920	40,072	38,822	47,484	53,520	33,162	11,825	7,392	8,067	326,598
1983	5,304	9,189	34,181	30,744	37,260	39,152	54,087	53,915	37,133	17,589	8,422	4,969	331,945
1984	4,199	10,768	33,640	35,369	44,136	45,539	55,142	54,831	36,666	21,178	8,801	9,064	359,333
1985	6,776	4,739	31,260	33,802	39,741	45,521	54,409	53,246	40,183	31,277	11,016	7,940	359,910
1986	23,242	51,148	67,422	54,555	69,275	94,562	139,299	94,221	61,577	132,714	100,911	160,007	1,048,933
1987	121,644	99,178	113,835	112,030	159,386	125,415	159,047	81,457	47,994	29,324	15,642	11,266	1,076,218
1988	10,766	13,716	86,644	80,124	64,024	72,706	76,280	75,352	44,807	25,031	11,201	9,293	569,944
1989	7,448	10,161	54,474	40,903	49,127	64,516	72,113	60,575	37,557	16,167	8,333	6,778	428,152
1990	5,240	7,412	50,606	36,184	38,370	61,281	67,164	42,783	43,819	20,694	10,596	7,738	391,887
1991	5,595	5,361	45,356	32,826	36,238	49,922	61,640	53,901	40,167	19,327	10,770	10,975	372,078
1992	17,248	17,496	58,058	46,231	51,304	56,069	63,380	59,492	46,340	32,342	12,762	9,660	470,382
1993	11,042	20,898	59,843	60,381	58,306	62,386	72,639	69,709	46,889	26,271	11,685	7,968	508,017
1994	11,094	16,967	50,894	42,323	42,188	100,011	67,613	63,675	44,707	43,922	13,303	11,889	508,586
1995	12,371	15,219	57,039	47,716	74,995	111,092	163,668	87,630	66,155	42,403	13,926	10,215	702,429
1996	15,437	20,323	55,978	45,588	44,535	61,581	62,160	58,173	44,547	23,332	9,318	5,871	446,843
1997	8,277	14,469	60,046	43,404	39,540	65,391	77,334	68,198	52,215	31,472	13,331	9,445	483,122
1998	12,347	16,871	49,000	41,268	39,176	59,897	75,630	68,493	45,427	27,733	12,254	8,483	456,579
1999	6,849	16,106	50,487	40,804	41,149	63,358	73,519	72,099	47,002	27,729	10,284	7,987	457,373
2000	11,320	9,882	48,087	35,889	40,816	70,863	65,042	64,481	41,405	25,599	11,925	7,942	433,251
2001	6,246	17,417	53,320	46,631	42,434	65,248	69,709	65,381	47,746	24,230	8,626	6,508	453,496
2002	4,844	8,412	47,014	43,928	55,599	73,640	81,519	70,631	46,969	24,601	9,076	7,261	473,494
2003	5,782	4,191	9,495	11,671	8,842	31,125	29,109	47,149	22,677	950	758	591	172,340
2004	1,160	381	15,894	10,740	1,803	33,320	41,738	44,216	30,972	5,101	768	801	186,894
2005	942	899	23,278	32,491	37,109	46,992	66,094	51,567	41,453	20,673	5,155	3,142	329,795
2006	2,122	1,328	24,360	27,161	20,914	40,556	46,685	53,753	40,641	14,124	4,071	2,793	278,508
2007	2,587	1,799	33,058	37,425	27,832	50,313	59,643	53,059	42,678	21,706	4,474	3,272	337,846
2008	2,132	2,964	38,245	44,016	45,123	55,048	67,096	52,674	34,255	22,948	8,139	5,207	377,847
2009	3,541	4,828	45,523	47,785	46,636	53,661	60,484	62,158	38,178	14,107	2,468	2,666	382,035
2010	2,293	2,057	37,154	44,268	40,668	59,475	67,096	63,853	32,991	10,704	1,807	1,453	363,819
2011	1,301	1,247	25,693	41,509	25,516	37,635	41,165	36,052	18,336	699	560	681	230,394
2012	696	572	544	24,694	6,581	23,396	29,509	33,313	12,218	497	440	483	132,943
2013	495	460	531	382	165	26,862	22,489	731	3,220	755	680	680	57,450
2014	626	581	527	301	796	31,964	43,421	23,286	1,371	951	774	671	105,270
2015	636	591	631	285	376	41,950	47,091	43,582	32,351	1,547	635	831	170,506
2016	749	600	1,899	32,207	26,892	39,008	55,546	50,923	17,591	1,595	675	690	228,375
2017	729	599	572	35,207	34,105	42,888	50,306	45,935	44,002	13,982	1,240	930	270,497
Avg	11,065	14,191	37,775	51,390	85,724	89,266	70,099	57,486	40,069	26,460	13,958	14,094	511,577

Canal Flows

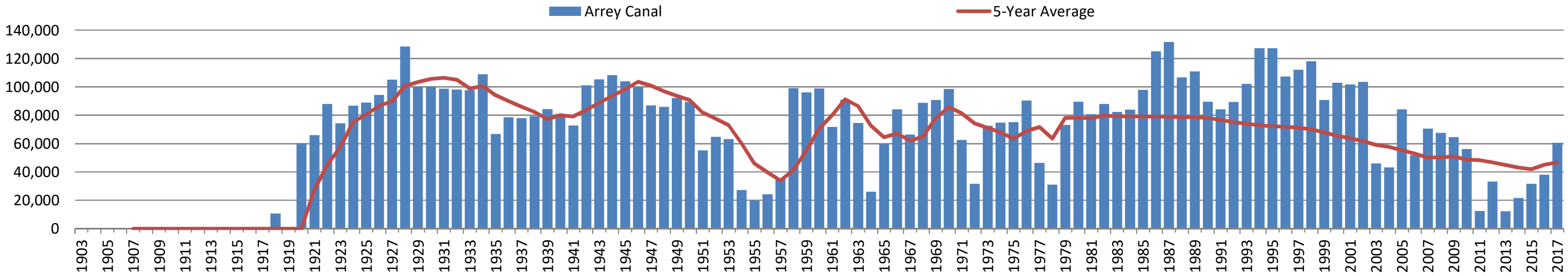
Arrey Canal

1903 - 2017

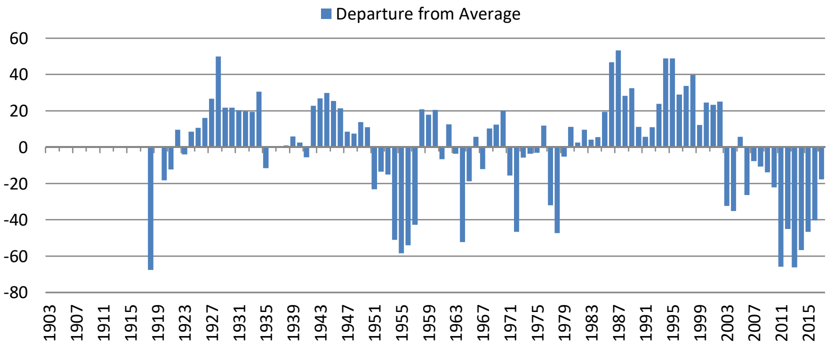
Total Monthly Flow (Acre-Feet)



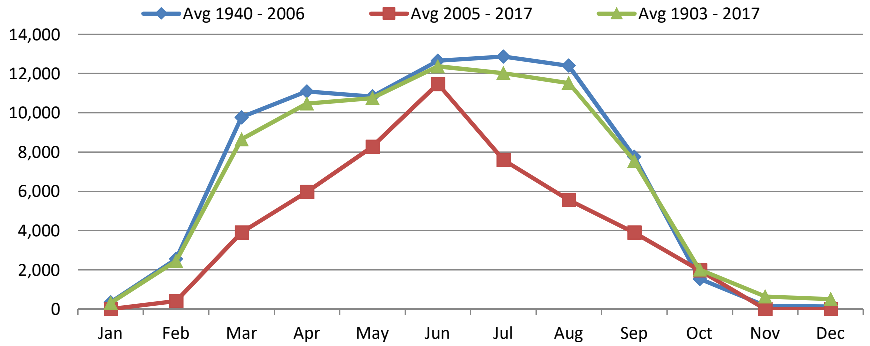
Total Annual Flow (Acre-Feet)



Annual Departure from Average (1,000 Acre-Feet)



Average Monthly Flow (Acre-Feet)



	Start	End
Period 1:	1940	2005
Period 2:	2006	2017

Rio Grande Project Flow Data
Total Monthly Flow (Acre-Feet)
1903 - 2017
Arrey Canal

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
1903	-	-	-	-	-	-	-	-	-	-	-	-	-
1904	-	-	-	-	-	-	-	-	-	-	-	-	-
1905	-	-	-	-	-	-	-	-	-	-	-	-	-
1906	-	-	-	-	-	-	-	-	-	-	-	-	-
1907	-	-	-	-	-	-	-	-	-	-	-	-	-
1908	-	-	-	-	-	-	-	-	-	-	-	-	-
1909	-	-	-	-	-	-	-	-	-	-	-	-	-
1910	-	-	-	-	-	-	-	-	-	-	-	-	-
1911	-	-	-	-	-	-	-	-	-	-	-	-	-
1912	-	-	-	-	-	-	-	-	-	-	-	-	-
1913	-	-	-	-	-	-	-	-	-	-	-	-	-
1914	-	-	-	-	-	-	-	-	-	-	-	-	-
1915	-	-	-	-	-	-	-	-	-	-	-	-	-
1916	-	-	-	-	-	-	-	-	-	-	-	-	-
1917	-	-	-	-	-	-	-	-	-	-	-	-	-
1918	0	0	1,458	1,398	1,825	1,170	1,468	1,369	1,111	377	563	0	10,739
1919	-	-	-	-	-	-	-	-	-	-	-	-	-
1920	0	0	0	3,074	11,851	7,317	8,779	8,648	11,488	3,273	2,156	3,499	60,085
1921	0	2,460	6,922	8,549	11,238	9,152	7,301	5,480	5,948	2,817	3,356	2,729	65,952
1922	714	5,802	7,686	7,440	9,364	10,155	10,832	10,677	10,104	9,047	3,507	2,539	87,867
1923	0	2,700	7,025	7,807	9,489	9,864	10,044	9,251	8,104	7,537	1,855	567	74,243
1924	0	4,356	5,998	8,900	10,264	11,197	11,927	12,069	10,984	4,126	3,725	3,197	86,743
1925	0	5,480	9,501	10,600	12,908	12,377	11,823	10,387	6,912	3,108	2,660	3,174	88,930
1926	0	1,918	6,135	12,040	14,654	15,084	12,666	13,876	11,405	2,311	2,461	1,763	94,313
1927	198	4,848	7,440	11,742	13,870	13,408	14,737	14,289	12,238	6,783	3,360	2,099	105,012
1928	2,148	3,870	7,537	14,870	16,969	17,137	18,754	18,754	14,658	7,388	3,882	2,313	128,280
1929	1,501	2,025	9,733	17,046	15,539	14,033	14,340	10,183	10,286	3,253	720	1,357	100,016
1930	0	3,513	8,200	14,503	13,571	14,277	13,757	13,337	11,276	3,648	2,299	1,648	100,029
1931	0	1,763	6,700	14,095	14,555	16,407	13,900	14,273	11,000	3,360	1,801	722	98,576
1932	0	3,414	8,001	14,311	15,451	15,715	13,565	13,777	10,233	1,289	1,371	855	97,982
1933	0	2,941	7,916	12,413	13,006	10,953	12,417	14,535	11,030	5,084	3,634	3,747	97,676
1934	1,932	4,393	9,580	14,947	14,858	15,160	15,376	15,681	10,381	2,755	1,874	1,932	108,869
1935	0	996	3,663	9,723	8,204	10,616	12,607	11,094	5,427	1,797	1,394	1,168	66,689
1936	0	1,952	5,657	10,739	10,429	12,212	13,446	13,394	7,269	1,894	1,214	206	78,412
1937	95	621	4,943	13,212	10,883	10,856	12,430	13,987	6,730	1,692	1,051	1,416	77,916
1938	0	1,698	7,234	12,294	11,647	12,415	7,989	15,542	3,092	3,475	2,444	1,420	79,250
1939	0	2,321	7,632	11,633	12,252	13,271	13,543	10,979	7,712	2,505	1,321	1,045	84,214
1940	0	1,583	8,751	12,008	10,268	12,448	14,015	12,518	8,533	69	688	0	80,881
1941	0	498	4,338	12,419	10,241	12,054	12,702	10,243	7,674	904	841	865	72,779
1942	0	3,626	9,156	14,739	13,315	15,709	16,526	11,248	7,509	4,187	3,059	1,904	100,978
1943	1,061	4,221	11,086	14,711	14,624	14,549	13,384	17,587	9,156	2,505	1,714	581	105,179
1944	0	2,390	15,118	15,088	13,749	14,735	16,649	17,101	10,387	1,595	0	1,380	108,192
1945	0	1,666	8,003	15,552	13,263	15,170	15,983	17,276	12,883	793	1,622	1,585	103,796

Rio Grande Project Flow Data

Total Monthly Flow (Acre-Feet)

1903 - 2017

Arrey Canal

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
1946	0	2,624	8,733	14,717	13,948	15,878	17,258	17,901	5,028	1,375	1,442	752	99,656
1947	0	1,474	6,887	13,793	11,459	14,055	17,885	15,108	6,129	0	0	0	86,790
1948	0	0	6,026	13,267	7,763	12,147	17,246	19,142	7,480	906	998	787	85,762
1949	0	0	10,251	11,923	9,082	13,872	16,229	20,337	5,893	2,422	1,228	766	92,003
1950	0	2,188	14,221	11,873	13,045	12,377	7,569	20,176	7,878	0	0	0	89,327
1951	0	0	5,794	10,804	2,045	7,864	11,905	12,177	4,544	0	0	0	55,133
1952	0	0	1,730	8,477	7,125	9,820	15,727	15,368	6,551	0	0	0	64,798
1953	0	0	8,577	9,697	4,374	9,197	11,897	13,055	6,387	0	0	0	63,184
1954	0	0	3,088	6,536	2,436	4,881	6,210	3,059	992	0	0	0	27,202
1955	0	0	1,920	3,362	341	1,678	2,210	5,060	5,294	0	0	0	19,865
1956	0	0	4,372	3,812	327	3,993	3,993	4,917	2,743	0	0	0	24,157
1957	0	0	734	2,678	0	3,717	5,952	12,974	9,420	0	0	0	35,475
1958	0	0	11,754	13,462	12,966	17,562	19,666	15,665	8,025	0	0	0	99,100
1959	0	0	14,150	11,242	13,498	15,985	18,478	13,958	8,795	0	0	0	96,106
1960	0	0	14,688	12,309	14,053	13,678	17,197	18,768	8,039	0	0	0	98,732
1961	0	0	9,475	9,614	10,885	12,323	12,881	12,272	4,259	0	0	0	71,709
1962	0	0	12,032	13,263	13,371	14,410	14,428	16,457	6,936	0	0	0	90,897
1963	0	0	15,316	7,559	9,874	10,959	14,860	11,742	4,245	0	0	0	74,555
1964	0	0	4,149	4,497	0	4,506	3,810	6,377	2,733	0	0	0	26,072
1965	0	0	2,448	5,572	0	12,222	15,780	17,587	5,921	0	0	0	59,530
1966	0	0	12,054	12,206	8,626	12,422	15,090	12,766	10,863	0	0	0	84,027
1967	0	0	12,190	8,765	8,606	6,859	10,405	11,504	7,930	0	0	0	66,259
1968	0	0	14,138	10,861	11,006	14,640	12,561	15,723	9,699	0	0	0	88,628
1969	0	0	14,297	12,093	10,580	17,230	13,466	14,938	8,011	0	0	0	90,615
1970	0	446	14,509	13,146	12,141	13,256	18,240	18,065	8,632	0	0	0	98,435
1971	0	0	10,586	9,376	6,264	8,594	11,576	12,561	3,624	0	0	0	62,581
1972	0	0	8,140	5,345	1,795	2,404	6,653	4,677	2,598	0	0	0	31,612
1973	0	0	4,939	8,045	7,152	11,704	13,061	16,383	11,266	0	0	0	72,550
1974	0	0	12,670	8,801	10,003	13,303	9,354	12,258	8,231	0	0	0	74,620
1975	545	446	7,549	7,359	12,085	13,049	11,607	15,410	7,097	0	0	0	75,147
1976	3,136	7,317	9,660	10,818	14,481	11,675	10,316	14,511	8,239	0	0	0	90,153
1977	0	0	5,266	5,298	6,561	8,045	6,974	10,171	4,020	0	0	0	46,335
1978	0	0	1,916	4,076	107	5,859	7,117	7,263	4,675	0	0	0	31,013
1979	0	0	5,131	8,975	9,896	13,027	15,727	12,077	8,150	0	0	0	72,983
1980	0	5,286	11,193	11,460	11,171	15,777	15,223	11,506	7,870	0	0	0	89,486
1981	0	4,189	9,382	12,288	14,116	12,764	12,004	11,338	4,643	0	0	0	80,724
1982	0	5,179	10,310	11,752	11,907	13,821	14,842	13,757	6,240	0	0	0	87,808
1983	0	1,575	10,645	8,301	13,311	14,430	13,730	12,545	7,799	0	0	0	82,336
1984	0	4,237	8,577	12,657	14,416	12,670	15,739	5,837	9,719	0	0	0	83,852
1985	0	2,344	9,461	12,500	14,747	14,852	15,880	13,880	11,224	2,900	0	0	97,788
1986	5,794	10,453	13,468	15,503	17,488	14,039	14,769	15,802	12,887	4,766	0	0	124,969
1987	2,261	13,242	14,378	15,070	18,424	16,415	18,351	14,414	13,498	5,534	0	0	131,587
1988	0	4,629	13,634	13,755	16,778	17,379	14,916	11,103	10,861	3,550	0	0	106,605

Rio Grande Project Flow Data
Total Monthly Flow (Acre-Feet)
1903 - 2017
Arrey Canal

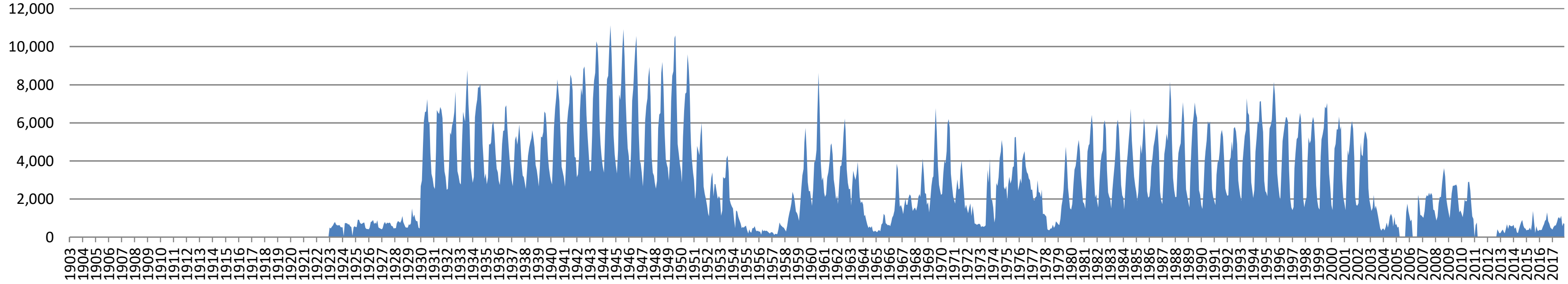
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
1989	0	6,847	16,348	17,574	18,744	17,923	16,497	9,721	7,031	0	0	0	110,685
1990	0	1,999	13,454	14,392	17,589	16,620	7,970	8,289	9,144	0	0	0	89,457
1991	0	3,870	12,940	13,212	13,785	13,860	10,193	4,727	6,690	4,766	0	0	84,043
1992	0	3,769	12,268	11,482	9,255	12,932	13,615	11,387	9,818	4,721	0	0	89,247
1993	0	4,502	14,136	15,905	16,284	15,078	12,728	8,819	10,080	4,526	0	0	102,058
1994	0	11,974	16,421	15,552	14,382	18,413	17,572	15,830	11,451	5,482	0	0	127,077
1995	0	7,464	14,872	14,549	19,178	19,970	17,399	14,499	11,702	7,581	0	0	127,214
1996	776	11,478	15,652	14,134	17,718	13,738	11,940	11,397	10,429	0	0	0	107,262
1997	0	6,044	14,586	14,315	15,437	16,693	16,260	11,867	10,510	6,355	0	0	112,067
1998	8,499	9,211	12,272	15,160	16,314	17,506	12,801	10,417	11,280	4,556	0	0	118,016
1999	0	4,502	11,623	13,438	15,308	11,183	11,183	8,085	8,588	6,664	0	0	90,574
2000	0	5,917	11,292	14,152	16,556	13,609	11,778	12,175	10,742	6,621	0	0	102,842
2001	0	3,057	12,587	14,130	15,501	16,078	14,644	11,457	9,993	4,112	0	0	101,559
2002	0	3,493	13,843	13,523	15,203	15,465	12,016	11,863	12,623	5,320	0	0	103,349
2003	-	-	4,112	7,876	5,935	11,869	4,497	11,187	442	-	-	-	45,918
2004	-	-	4,175	2,106	2,428	11,792	11,141	8,200	3,326	-	-	-	43,168
2005	-	-	2,789	10,508	12,325	15,495	16,183	11,814	10,699	4,201	0	0	84,014
2006	0	0	4,350	10,015	10,586	10,261	6,147	2,916	4,034	3,517	0	0	51,824
2007	0	0	6,901	9,181	7,668	10,213	9,884	10,104	9,775	6,791	0	0	70,516
2008	0	0	6,901	11,462	12,700	12,133	2,854	9,546	6,736	5,258	0	0	67,591
2009	0	2,878	9,366	9,975	10,165	10,203	10,249	10,233	1,351	0	0	0	64,420
2010	0	0	4,840	9,447	10,159	11,002	5,379	10,316	5,012	0	0	0	56,155
2011	-	0	0	0	0	10,294	2,065	0	0	0	-	-	12,359
2012	-	-	0	698	7,972	10,171	8,287	6,121	0	0	-	-	33,249
2013	-	0	0	0	0	9,354	2,817	0	0	0	-	-	12,171
2014	-	-	-	0	1,900	13,877	5,908	0	-	-	-	-	21,685
2015	-	-	-	-	8,108	11,308	10,493	1,726	0	-	-	-	31,634
2016	-	-	-	5,373	12,329	11,623	8,608	0	0	-	-	-	37,934
2017	-	-	-	5,076	13,678	13,206	9,906	9,593	9,128	0	-	-	60,588
Avg	322	2,458	8,648	10,469	10,745	12,370	12,028	11,520	7,543	2,016	647	511	79,277

Drain Flows

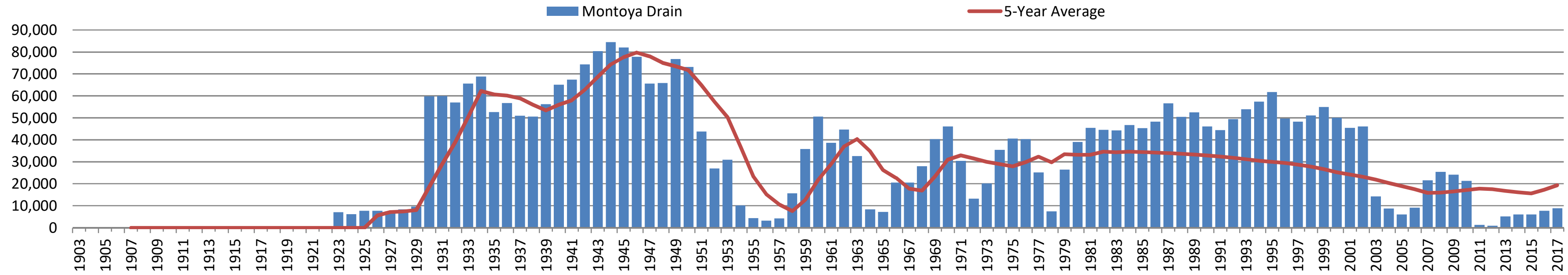
Montoya Drain

1903 - 2017

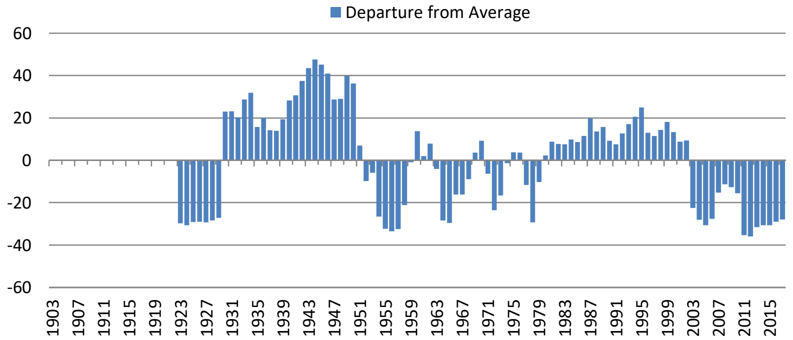
Total Monthly Flow (Acre-Feet)



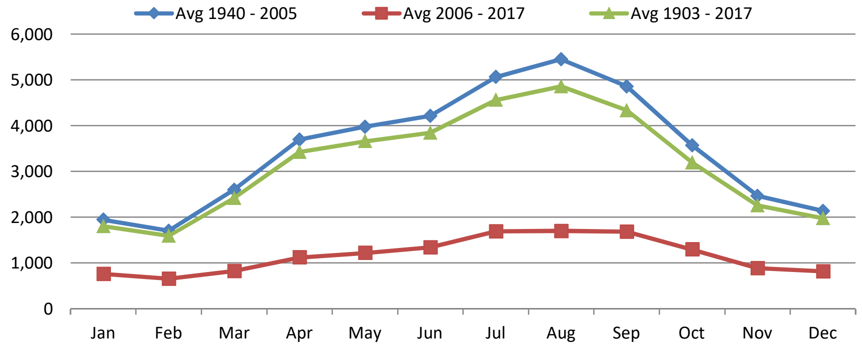
Total Annual Flow (Acre-Feet)



Annual Departure from Average (1,000 Acre-Feet)



Average Monthly Flow (Acre-Feet)



	Start	End
Period 1:	1940	2005
Period 2:	2006	2017

Rio Grande Project Flow Data
Total Monthly Flow (Acre-Feet)
1903 - 2017
Montoya Drain

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
1903	-	-	-	-	-	-	-	-	-	-	-	-	-
1904	-	-	-	-	-	-	-	-	-	-	-	-	-
1905	-	-	-	-	-	-	-	-	-	-	-	-	-
1906	-	-	-	-	-	-	-	-	-	-	-	-	-
1907	-	-	-	-	-	-	-	-	-	-	-	-	-
1908	-	-	-	-	-	-	-	-	-	-	-	-	-
1909	-	-	-	-	-	-	-	-	-	-	-	-	-
1910	-	-	-	-	-	-	-	-	-	-	-	-	-
1911	-	-	-	-	-	-	-	-	-	-	-	-	-
1912	-	-	-	-	-	-	-	-	-	-	-	-	-
1913	-	-	-	-	-	-	-	-	-	-	-	-	-
1914	-	-	-	-	-	-	-	-	-	-	-	-	-
1915	-	-	-	-	-	-	-	-	-	-	-	-	-
1916	-	-	-	-	-	-	-	-	-	-	-	-	-
1917	-	-	-	-	-	-	-	-	-	-	-	-	-
1918	-	-	-	-	-	-	-	-	-	-	-	-	-
1919	-	-	-	-	-	-	-	-	-	-	-	-	-
1920	-	-	-	-	-	-	-	-	-	-	-	-	-
1921	-	-	-	-	-	-	-	-	-	-	-	-	-
1922	-	-	-	-	-	-	-	-	-	-	-	-	-
1923	479	444	523	607	726	786	652	602	601	621	512	504	7,057
1924	504	47	726	714	707	649	658	565	518	48	494	559	6,189
1925	516	516	896	892	738	684	688	738	756	468	410	405	7,707
1926	398	484	781	809	890	678	744	682	875	498	458	424	7,721
1927	400	461	676	779	664	750	707	750	726	578	553	437	7,481
1928	461	449	707	827	793	732	861	1,088	785	639	500	486	8,328
1929	486	661	621	708	1,488	1,023	1,162	916	821	824	482	436	9,628
1930	2,656	2,955	4,821	6,069	6,561	6,593	7,243	6,057	5,986	4,433	3,314	3,062	59,750
1931	2,650	2,516	4,470	6,653	6,542	6,456	6,825	6,671	6,236	4,292	3,439	3,136	59,886
1932	2,466	2,525	3,702	5,486	5,362	5,843	6,093	6,567	7,640	4,728	3,439	3,191	57,042
1933	2,835	2,744	4,901	6,575	6,333	6,046	7,588	8,756	6,974	5,829	3,660	3,296	65,537
1934	2,835	3,149	6,284	6,849	7,219	7,855	7,852	8,043	6,831	4,876	3,892	3,044	68,729
1935	3,339	2,760	3,117	4,861	4,851	4,957	5,860	6,069	5,427	4,359	3,582	3,388	52,570
1936	2,964	2,715	3,462	4,861	5,558	5,593	6,788	6,917	5,683	4,802	4,017	3,394	56,754
1937	2,976	2,666	3,714	5,088	5,294	4,838	5,202	5,909	5,022	3,855	3,225	3,142	50,931
1938	2,798	2,516	3,394	4,266	4,679	4,969	5,190	5,608	5,219	4,710	3,779	3,499	50,627
1939	3,056	2,644	3,652	5,266	5,220	5,498	6,585	6,487	5,855	4,882	3,689	3,345	56,179
1940	2,951	2,755	4,058	5,772	6,727	7,349	8,270	7,588	7,140	5,392	3,677	3,406	65,085
1941	3,117	2,627	3,640	5,903	6,598	7,039	8,522	8,313	7,700	5,583	4,207	4,150	67,399
1942	3,136	3,282	4,255	6,635	7,827	7,426	8,811	8,953	7,872	6,413	5,296	4,359	74,265
1943	3,437	3,493	5,300	7,254	8,221	8,622	10,275	10,066	8,670	6,081	4,737	4,107	80,263
1944	3,671	3,371	5,436	7,176	8,289	8,461	10,022	11,117	9,628	7,532	5,355	4,329	84,387
1945	3,769	3,332	4,569	7,486	7,194	8,039	9,807	10,908	9,449	7,133	5,599	4,673	81,958

Rio Grande Project Flow Data

Total Monthly Flow (Acre-Feet)

1903 - 2017

Montoya Drain

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
1946	4,236	3,027	4,482	7,164	7,852	8,836	9,900	10,551	8,271	5,534	3,993	3,868	77,714
1947	3,351	2,644	3,861	6,111	6,862	7,289	8,381	8,922	7,390	4,169	3,368	3,204	65,552
1948	2,853	2,531	2,945	5,712	6,425	6,510	8,608	9,186	7,765	5,442	4,082	3,794	65,853
1949	3,622	2,955	4,126	7,135	8,467	8,700	10,453	10,588	7,569	4,876	4,385	3,837	76,713
1950	3,425	2,860	5,251	6,635	7,514	7,587	9,586	9,106	7,997	5,546	4,094	3,499	73,100
1951	2,988	1,927	2,460	4,778	4,538	4,284	5,337	5,977	4,570	2,644	2,261	1,992	43,756
1952	1,660	1,225	1,082	2,327	3,093	3,386	2,134	2,773	2,761	2,373	1,987	2,146	26,947
1953	2,017	1,111	1,377	3,154	3,068	3,118	4,114	4,273	3,368	1,986	1,738	1,593	30,917
1954	1,494	889	461	1,392	1,334	1,047	873	713	452	516	488	547	10,206
1955	584	344	178	399	264	214	455	449	559	357	298	320	4,421
1956	283	270	120	399	295	333	307	320	274	215	173	228	3,217
1957	246	205	106	158	146	143	397	753	613	553	500	480	4,300
1958	387	278	578	970	1,267	1,440	1,777	2,361	2,178	1,838	1,333	1,242	15,649
1959	1,107	844	1,648	2,511	3,240	3,570	4,962	5,731	4,528	2,865	2,392	2,416	35,814
1960	2,060	1,628	2,484	3,903	4,009	4,558	6,481	8,614	6,783	3,923	2,951	3,130	50,524
1961	2,324	2,099	2,232	3,118	3,406	3,915	4,802	4,907	4,338	3,013	2,582	1,955	38,691
1962	2,177	1,733	2,748	3,695	3,763	4,368	5,479	6,210	5,611	3,554	2,844	2,496	44,678
1963	2,527	1,644	2,601	3,475	3,197	2,987	3,320	3,935	3,225	2,091	1,779	1,869	32,650
1964	1,703	1,087	1,156	863	639	464	541	473	553	332	262	320	8,393
1965	283	250	332	357	295	649	719	1,205	1,119	726	655	609	7,199
1966	627	561	781	1,000	1,125	1,380	2,127	3,849	3,558	2,361	1,583	1,672	20,624
1967	1,494	1,200	1,648	2,011	1,679	1,678	2,054	2,238	2,148	1,605	1,351	1,482	20,588
1968	1,537	1,380	1,629	2,095	2,244	2,095	3,234	4,107	3,374	2,312	2,243	1,691	27,941
1969	1,814	1,283	1,918	2,654	3,111	3,178	5,140	6,770	5,522	3,738	2,731	2,496	40,355
1970	2,201	2,255	3,296	4,011	3,861	4,493	5,915	6,180	5,724	3,308	2,672	2,121	46,037
1971	1,949	1,738	2,423	3,023	2,484	2,541	3,511	4,009	3,189	2,373	1,482	1,679	30,401
1972	1,482	1,242	1,537	1,761	1,094	1,630	1,174	701	672	639	655	689	13,276
1973	652	516	553	530	541	601	2,460	3,517	2,844	4,107	1,952	1,943	20,216
1974	1,543	744	996	2,826	2,675	3,142	4,144	4,476	5,088	4,642	2,618	2,490	35,384
1975	2,675	1,899	2,718	3,154	2,798	3,005	3,659	3,720	5,224	5,257	4,034	2,423	40,566
1976	2,705	3,077	2,798	4,046	4,323	4,493	3,720	3,400	3,291	3,074	2,975	2,472	40,374
1977	2,490	1,972	1,906	2,071	2,121	2,975	2,349	2,324	2,089	2,490	1,190	1,217	25,194
1978	1,138	1,061	400	357	357	446	443	627	476	566	803	750	7,424
1979	664	622	922	1,619	1,894	2,452	3,671	4,735	3,898	2,570	1,970	1,500	26,517
1980	1,427	1,731	2,718	3,529	3,732	4,082	4,728	5,097	4,504	3,160	2,458	1,832	38,998
1981	1,738	1,482	2,763	4,483	4,806	4,881	5,772	6,407	5,687	3,197	2,049	2,235	45,500
1982	1,859	1,537	2,785	3,892	4,332	4,556	5,881	6,129	5,661	3,469	2,339	2,108	44,548
1983	2,005	1,492	2,430	3,136	3,784	4,620	5,778	6,157	5,693	4,284	2,739	2,192	44,310
1984	2,033	1,436	2,537	3,638	4,300	5,094	5,821	6,734	5,070	4,140	3,170	2,690	46,663
1985	2,315	1,888	2,364	3,612	4,867	4,350	5,163	6,236	5,760	4,348	2,396	2,051	45,350
1986	2,128	2,696	3,689	4,130	4,766	5,088	5,526	5,927	5,570	4,457	2,360	1,904	48,241
1987	1,718	3,043	4,332	4,770	5,419	5,042	6,309	8,154	7,200	5,107	3,090	2,448	56,632
1988	2,079	2,097	3,683	4,391	4,711	4,913	6,161	7,073	6,184	4,491	2,505	2,166	50,454

Rio Grande Project Flow Data
Total Monthly Flow (Acre-Feet)
1903 - 2017
Montoya Drain

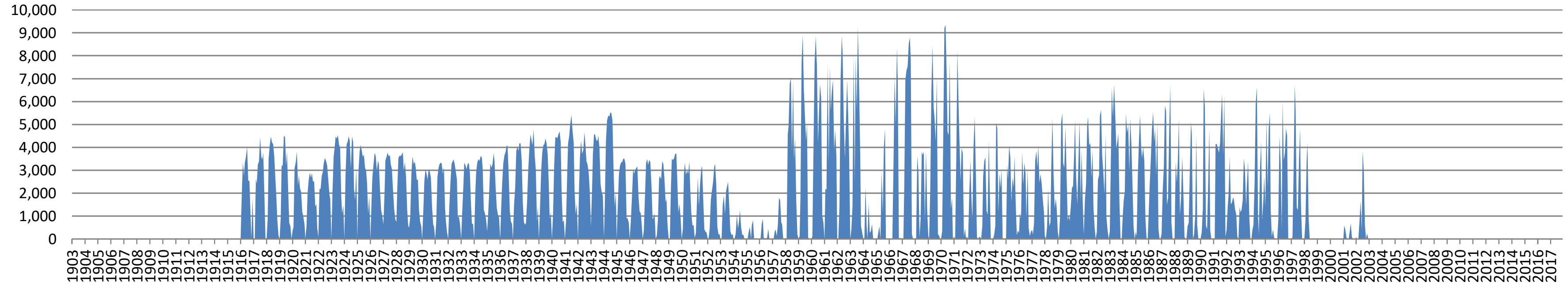
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
1989	1,841	1,557	3,596	4,639	5,847	6,341	7,065	6,516	6,262	4,145	2,450	2,206	52,465
1990	1,670	1,462	2,491	3,959	4,502	5,048	6,069	5,919	6,050	4,276	2,513	2,106	46,065
1991	1,894	1,664	3,273	3,901	4,007	4,457	5,377	5,617	5,246	4,054	2,543	2,346	44,379
1992	2,152	2,184	3,995	4,171	5,018	4,479	5,699	5,776	5,532	4,865	2,961	2,573	49,405
1993	2,152	1,885	3,859	4,594	5,299	5,602	7,278	6,532	6,388	5,004	2,869	2,396	53,858
1994	2,034	2,463	4,463	5,173	6,061	5,991	7,107	7,128	6,110	5,512	2,947	2,399	57,388
1995	2,335	2,130	4,385	5,702	5,854	6,155	7,410	8,142	7,496	6,067	3,348	2,662	61,686
1996	2,138	1,940	3,473	5,036	5,494	5,940	6,296	6,282	6,050	3,499	2,023	1,549	49,720
1997	1,400	1,565	3,588	4,419	5,141	5,222	6,063	6,510	6,210	4,614	2,023	1,549	48,304
1998	1,892	2,089	3,854	5,226	4,919	5,060	5,984	6,307	6,101	5,038	2,703	1,894	51,067
1999	1,531	1,432	4,217	5,117	5,385	5,730	6,831	6,756	7,033	4,984	3,320	2,580	54,916
2000	1,670	1,400	3,227	4,651	4,885	5,653	5,645	6,325	5,629	5,823	3,076	2,091	50,075
2001	1,779	1,400	3,130	4,564	4,276	4,889	5,760	6,087	5,665	4,157	2,118	1,670	45,495
2002	1,642	1,771	3,439	4,961	4,324	4,229	5,127	5,542	5,421	5,088	2,545	1,997	46,086
2003	1,666	1,365	1,515	2,204	1,466	1,646	1,412	1,111	762	444	325	403	14,319
2004	442	335	504	752	480	676	1,055	1,208	1,065	541	1,049	625	8,732
2005	672	480	522	-	-	-	-	-	-	1,305	1,743	1,327	6,049
2006	1,115	815	908	-	-	-	-	-	2,202	1,880	1,156	1,119	9,195
2007	1,041	1,006	1,347	2,033	2,194	2,124	2,323	2,170	2,299	2,184	1,432	1,384	21,537
2008	1,069	859	1,067	1,767	2,104	2,089	2,799	3,328	3,612	3,160	2,003	1,611	25,468
2009	1,291	986	1,543	2,273	2,674	2,692	2,701	2,743	2,650	1,890	1,281	1,392	24,116
2010	1,228	1,025	1,307	1,950	1,864	1,886	2,866	2,904	2,444	1,799	1,081	942	21,296
2011	-	621	756	-	-	-	-	-	-	-	-	-	1,377
2012	-	-	-	-	-	-	-	-	-	399	300	194	893
2013	208	309	377	248	188	417	662	415	637	571	553	565	5,150
2014	633	428	492	236	202	375	589	770	891	587	460	434	6,097
2015	331	361	365	482	341	653	1,363	766	208	561	337	303	6,071
2016	373	349	369	530	664	853	889	1,291	819	692	486	430	7,745
2017	383	508	581	601	770	990	1,039	940	1,111	563	728	682	8,896
Avg	1,807	1,596	2,419	3,425	3,661	3,849	4,562	4,858	4,333	3,197	2,258	1,979	37,944

Wasteway Flows

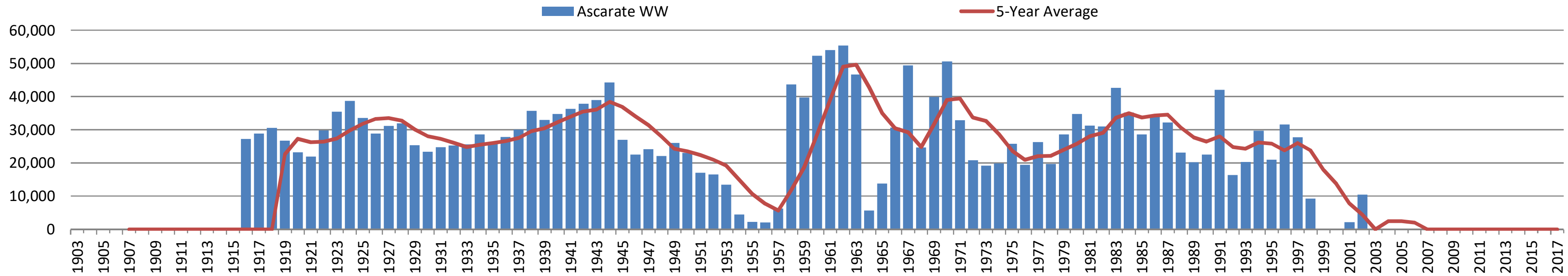
Ascarate WW

1903 - 2017

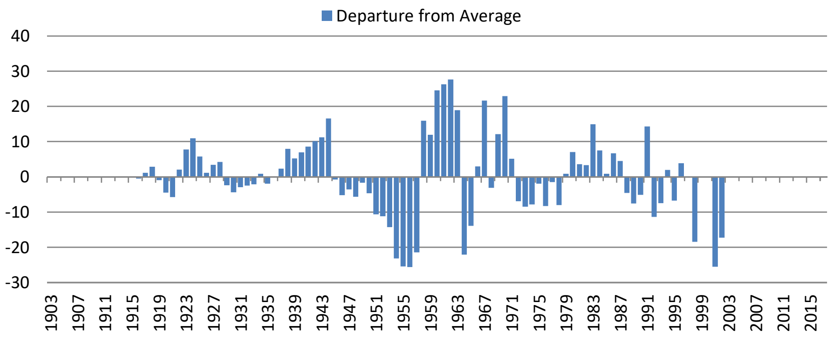
Total Monthly Flow (Acre-Feet)



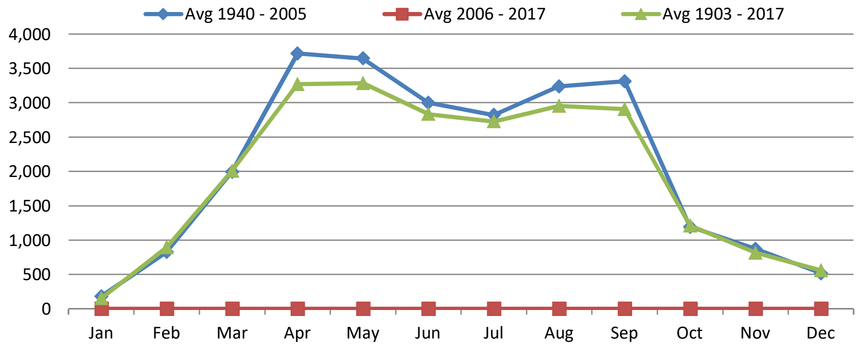
Total Annual Flow (Acre-Feet)



Annual Departure from Average (1,000 Acre-Feet)



Average Monthly Flow (Acre-Feet)



	Start	End
Period 1:	1940	2005
Period 2:	2006	2017

Rio Grande Project Flow Data
Total Monthly Flow (Acre-Feet)
1903 - 2017
Ascarate WW

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
1903	-	-	-	-	-	-	-	-	-	-	-	-	-
1904	-	-	-	-	-	-	-	-	-	-	-	-	-
1905	-	-	-	-	-	-	-	-	-	-	-	-	-
1906	-	-	-	-	-	-	-	-	-	-	-	-	-
1907	-	-	-	-	-	-	-	-	-	-	-	-	-
1908	-	-	-	-	-	-	-	-	-	-	-	-	-
1909	-	-	-	-	-	-	-	-	-	-	-	-	-
1910	-	-	-	-	-	-	-	-	-	-	-	-	-
1911	-	-	-	-	-	-	-	-	-	-	-	-	-
1912	-	-	-	-	-	-	-	-	-	-	-	-	-
1913	-	-	-	-	-	-	-	-	-	-	-	-	-
1914	-	-	-	-	-	-	-	-	-	-	-	-	-
1915	-	-	-	-	-	-	-	-	-	-	-	-	-
1916	0	1,872	3,344	2,758	3,323	3,588	4,011	2,526	2,542	1,462	0	1,779	27,205
1917	0	0	2,605	2,403	3,245	3,376	4,432	3,592	3,469	3,769	1,940	0	28,831
1918	0	943	3,502	4,075	4,460	4,199	4,133	3,590	2,862	1,912	785	131	30,592
1919	0	959	3,172	3,222	4,489	4,448	3,194	3,809	2,186	690	555	0	26,724
1920	372	505	3,093	3,325	3,812	2,332	2,758	2,202	2,041	1,180	951	621	23,192
1921	0	537	2,017	2,594	2,880	2,658	2,867	2,488	2,510	1,405	1,512	462	21,930
1922	69	2,171	2,186	2,753	2,930	3,291	3,526	3,405	3,208	2,571	1,935	1,732	29,777
1923	0	2,053	3,572	4,036	4,459	4,375	4,528	4,119	3,947	1,808	1,108	1,447	35,452
1924	0	2,745	4,132	4,255	4,474	4,289	3,086	4,469	4,228	2,196	1,690	3,083	38,647
1925	0	2,984	3,819	4,097	3,884	3,576	3,672	3,106	2,949	2,468	1,106	1,848	33,509
1926	0	1,606	2,681	3,240	3,743	3,594	2,969	3,418	3,259	2,090	1,245	999	28,844
1927	630	1,972	3,411	3,577	3,766	3,595	3,644	3,253	3,050	2,117	1,291	846	31,152
1928	740	2,139	3,527	3,620	3,608	3,671	3,782	2,957	3,341	2,710	1,257	554	31,906
1929	486	974	2,840	3,596	3,269	3,361	3,130	2,561	2,590	1,236	737	545	25,325
1930	0	1,155	2,549	3,035	2,828	2,572	3,046	2,917	2,665	1,408	630	528	23,333
1931	0	763	2,682	3,091	3,245	3,317	3,309	2,842	3,108	1,346	760	279	24,742
1932	0	1,396	2,423	3,265	3,359	3,467	3,264	2,931	2,586	921	970	631	25,213
1933	0	1,256	2,349	3,319	3,221	3,027	3,268	3,302	2,854	1,712	657	641	25,606
1934	0	1,981	2,900	3,328	3,479	3,406	3,612	3,554	3,100	1,273	1,106	844	28,583
1935	328	1,208	1,984	3,292	3,103	3,271	3,733	3,374	2,198	1,340	1,043	920	25,794
1936	0	1,155	2,417	3,288	3,637	3,786	4,070	4,041	2,833	1,219	749	635	27,830
1937	0	1,450	2,245	3,836	4,016	3,833	4,163	4,167	3,438	1,576	710	617	30,051
1938	673	1,559	2,948	3,866	4,554	4,364	4,083	4,777	3,649	3,004	762	1,406	35,645
1939	0	1,395	2,966	3,802	4,092	4,117	4,377	4,170	3,686	2,311	872	1,143	32,931
1940	0	1,085	3,199	4,425	4,438	4,388	4,561	4,686	4,224	2,155	724	815	34,700
1941	0	800	2,802	4,156	4,475	5,046	5,402	4,704	4,181	2,103	1,076	1,542	36,287
1942	0	2,244	3,533	4,292	3,710	3,876	4,645	4,008	3,386	3,236	2,879	2,010	37,819
1943	553	2,187	3,703	4,582	4,530	4,308	4,279	4,497	3,984	2,393	2,037	1,872	38,925
1944	62	1,482	4,252	5,169	5,381	5,339	5,524	5,491	5,174	2,975	1,410	2,003	44,262
1945	13	1,460	2,835	3,206	3,335	3,350	3,490	3,498	3,268	914	871	690	26,930

Rio Grande Project Flow Data
Total Monthly Flow (Acre-Feet)
1903 - 2017
Ascarate WW

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
1946	0	749	1,813	3,002	2,846	2,989	3,079	3,157	1,869	1,199	1,120	698	22,521
1947	0	341	1,846	3,311	3,482	3,224	3,438	3,338	2,329	850	922	1,097	24,178
1948	0	149	867	2,620	2,750	2,589	3,375	3,266	2,595	1,595	1,739	542	22,087
1949	0	0	2,283	3,487	3,445	3,513	3,711	3,711	2,286	1,151	1,525	908	26,020
1950	0	431	2,838	3,318	2,799	2,982	2,831	3,378	2,189	1,095	572	607	23,040
1951	42	226	1,294	2,664	1,441	2,404	3,035	3,185	1,748	419	307	265	17,030
1952	0	0	471	1,696	2,111	2,493	3,139	3,266	2,408	528	196	191	16,499
1953	0	0	1,470	1,890	1,069	2,099	2,260	2,488	1,435	328	160	212	13,411
1954	0	0	225	1,044	452	694	1,248	507	165	174	0	0	4,509
1955	0	0	307	520	0	593	809	4	0	0	0	0	2,233
1956	0	0	637	877	22	38	6	44	426	0	0	0	2,050
1957	0	0	315	409	119	587	1,773	1,692	716	627	0	0	6,238
1958	0	0	4,552	4,917	6,760	7,045	3,779	6,871	3,461	4,391	1,644	200	43,620
1959	0	113	1,880	7,708	8,894	6,460	5,278	4,288	5,028	42	0	0	39,691
1960	0	111	3,866	7,680	8,848	7,591	4,207	5,338	6,744	6,175	1,014	714	52,288
1961	0	2,176	2,142	7,648	3,330	7,490	5,605	6,450	6,928	3,856	4,740	3,592	53,957
1962	0	0	1,482	7,049	8,854	8,110	5,270	3,525	5,207	6,938	5,264	3,677	55,376
1963	0	407	1,430	8,023	2,430	7,926	5,595	9,263	6,885	3,862	555	288	46,664
1964	8	36	2,267	557	0	1,553	258	327	635	0	0	0	5,641
1965	0	0	345	543	0	2,959	1,109	4,034	4,800	0	0	0	13,790
1966	0	0	0	0	3,251	7,121	4,959	8,337	6,962	0	46	0	30,676
1967	30	0	2,227	6,958	7,361	7,523	8,521	8,779	7,767	196	0	0	49,362
1968	0	0	3,618	2,951	56	889	3,806	3,660	3,786	746	3,846	1,267	24,625
1969	145	0	2,208	6,440	8,428	5,722	5,306	4,259	7,018	210	131	0	39,867
1970	0	311	4,516	9,209	9,348	7,172	4,671	4,524	7,767	1,305	1,769	0	50,592
1971	77	0	3,445	8,255	5,861	4,397	2,529	3,953	3,735	97	440	50	32,839
1972	65	0	1,989	3,433	1,932	861	3,981	5,345	3,011	87	0	61	20,765
1973	79	0	545	2,713	3,394	3,560	1,220	1,061	4,284	2,352	0	0	19,208
1974	0	173	555	5,070	4,828	1,142	2,832	2,220	3,055	0	0	0	19,875
1975	0	3,215	2,614	4,070	3,578	1,630	2,674	2,257	3,612	1,585	159	353	25,747
1976	256	1,117	891	3,773	2,366	3,330	2,836	873	3,068	468	123	311	19,412
1977	393	179	678	3,402	3,840	3,114	4,112	2,444	2,824	2,398	1,696	1,166	26,246
1978	127	0	502	2,154	555	712	3,148	5,252	2,805	1,327	1,751	1,353	19,686
1979	290	0	964	5,094	5,492	3,318	3,094	4,867	2,836	801	1,057	768	28,581
1980	1,404	2,218	2,299	3,747	5,179	2,686	1,498	3,376	5,137	1,646	3,886	1,702	34,778
1981	177	1,720	2,384	4,917	5,328	4,078	4,181	2,676	3,872	1,398	540	0	31,271
1982	298	2,577	2,791	5,379	5,641	3,614	2,910	1,932	4,554	930	381	0	31,007
1983	317	3,721	6,597	5,310	6,740	5,486	3,949	4,262	4,618	1,597	0	0	42,597
1984	1,043	1,652	2,067	5,466	4,620	4,957	2,938	5,254	4,213	2,460	512	0	35,182
1985	303	117	2,753	4,266	5,407	3,959	3,535	4,009	3,386	877	0	0	28,612
1986	942	2,333	3,461	4,764	5,556	4,237	4,822	2,777	5,048	424	0	0	34,364
1987	190	2,075	3,124	5,810	5,576	1,480	1,803	4,703	6,710	702	0	0	32,173
1988	0	3,382	2,460	3,523	5,252	1,053	1,773	3,604	2,017	83	0	0	23,147

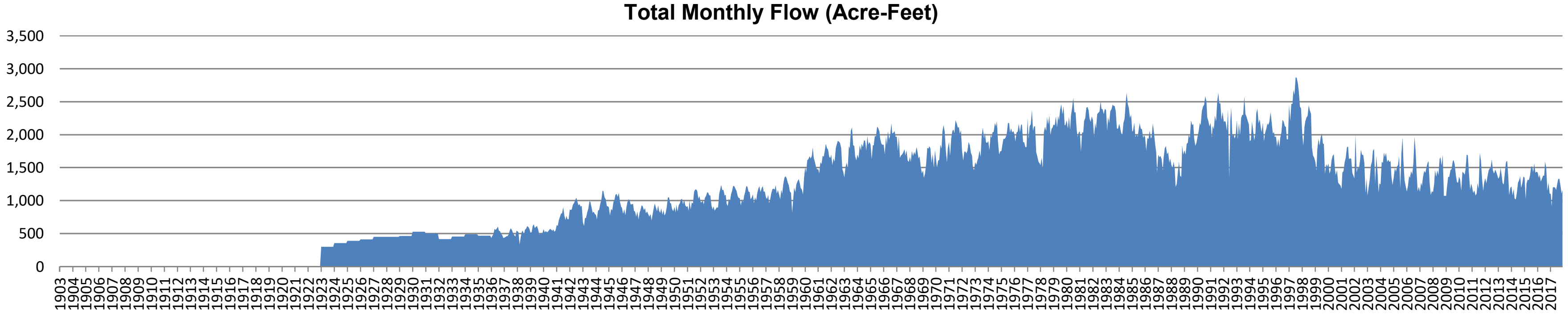
Rio Grande Project Flow Data
Total Monthly Flow (Acre-Feet)
1903 - 2017
Ascarate WW

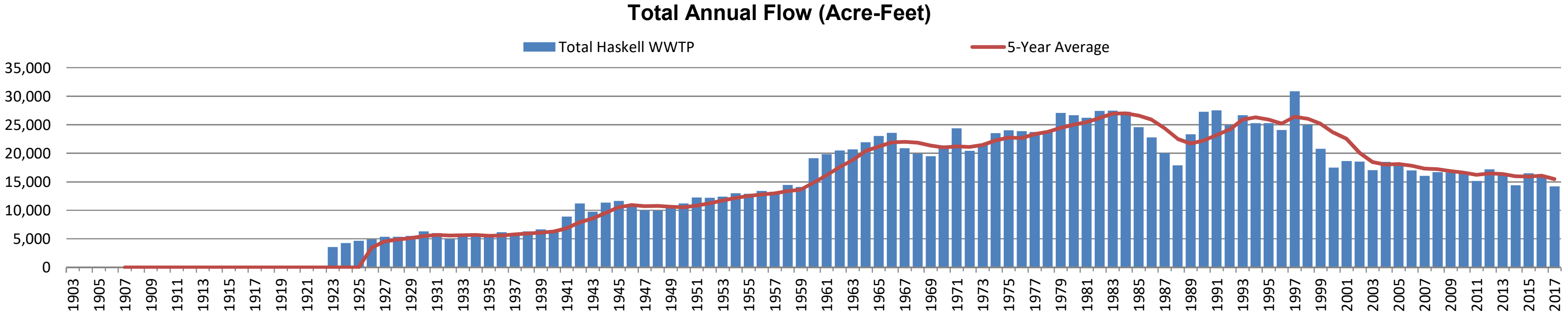
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
1989	549	704	2,969	5,088	4,528	0	194	1,023	4,512	609	0	0	20,176
1990	0	280	1,329	6,549	5,754	579	422	2,458	4,818	367	0	0	22,556
1991	0	0	4,132	4,138	3,959	3,759	4,183	5,540	6,319	3,660	6,252	85	42,027
1992	375	1,416	1,910	3,596	1,505	1,591	1,809	1,684	1,283	1,073	79	0	16,321
1993	1,390	1,160	1,267	1,680	3,509	2,987	1,452	2,414	3,358	1,049	0	0	20,266
1994	369	619	2,434	5,913	6,625	1,099	190	2,973	4,221	793	1,700	2,727	29,663
1995	1,400	5,197	2,265	4,840	5,502	1,250	79	409	40	0	-	-	20,982
1996	857	4,481	3,324	381	6,034	3,433	3,723	4,822	4,485	-	-	-	31,540
1997	0	63	2,999	6,708	5,621	1,369	1,256	3,427	4,804	1,454	0	0	27,701
1998	0	819	3,378	4,193	899	0	0	0	0	0	0	0	9,289
1999	-	0	0	0	0	0	0	0	0	0	-	-	-
2000	0	0	0	0	0	0	0	0	0	0	-	-	-
2001	0	575	391	38	24	8	365	674	73	0	0	0	2,148
2002	52	0	0	756	1,650	359	3,828	2,967	629	0	232	0	10,473
2003	-	-	0	0	0	0	0	0	0	0	-	-	-
2004	0	0	0	0	0	0	0	0	0	0	0	0	-
2005	0	0	0	0	0	0	0	0	0	0	0	0	-
2006	0	0	0	0	0	0	0	0	0	0	0	0	-
2007	0	0	0	0	0	0	0	0	0	0	0	0	-
2008	0	0	0	0	0	0	0	0	0	0	0	0	-
2009	0	0	0	0	0	0	0	0	0	0	0	0	-
2010	0	0	0	0	0	0	0	0	0	0	0	0	-
2011	-	-	-	-	-	-	-	-	-	-	-	-	-
2012	-	-	-	-	-	-	-	-	-	0	-	-	-
2013	0	0	0	0	0	0	0	0	0	0	0	0	-
2014	0	0	0	0	0	0	0	0	0	0	0	0	-
2015	0	0	0	0	0	0	0	0	0	0	0	0	-
2016	0	0	0	0	0	0	0	0	0	0	0	0	-
2017	0	0	0	0	0	0	0	0	0	0	0	0	-
Avg	154	898	2,011	3,271	3,286	2,836	2,730	2,954	2,910	1,214	818	563	23,644

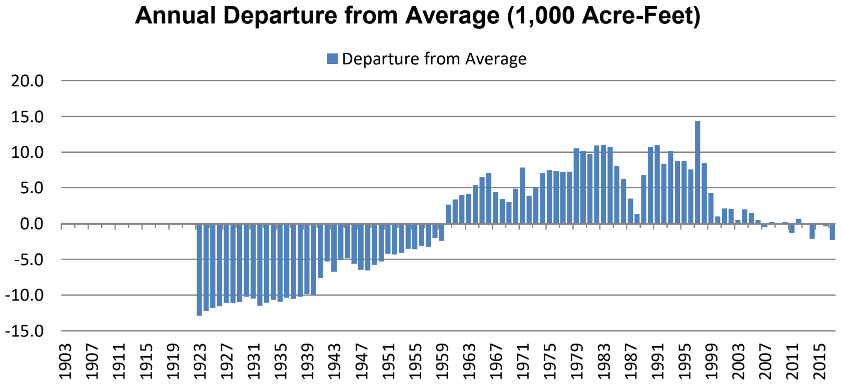
Municipal Flows

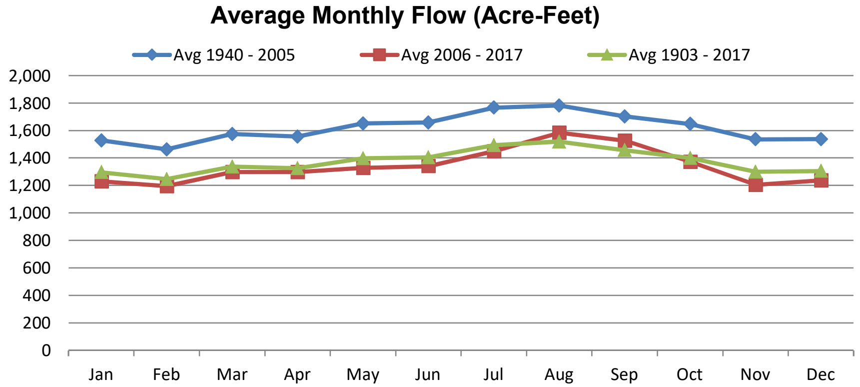
Total Haskell WWTP

1903 - 2017


Total Monthly Flow (Acre-Feet)


Total Annual Flow (Acre-Feet)


Annual Departure from Average (1,000 Acre-Feet)


Average Monthly Flow (Acre-Feet)

	Start	End
Period 1:	1940	2005
Period 2:	2006	2017

Rio Grande Project Flow Data
Total Monthly Flow (Acre-Feet)
1903 - 2017
Total Haskell WWTP

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
1903	-	-	-	-	-	-	-	-	-	-	-	-	-
1904	-	-	-	-	-	-	-	-	-	-	-	-	-
1905	-	-	-	-	-	-	-	-	-	-	-	-	-
1906	-	-	-	-	-	-	-	-	-	-	-	-	-
1907	-	-	-	-	-	-	-	-	-	-	-	-	-
1908	-	-	-	-	-	-	-	-	-	-	-	-	-
1909	-	-	-	-	-	-	-	-	-	-	-	-	-
1910	-	-	-	-	-	-	-	-	-	-	-	-	-
1911	-	-	-	-	-	-	-	-	-	-	-	-	-
1912	-	-	-	-	-	-	-	-	-	-	-	-	-
1913	-	-	-	-	-	-	-	-	-	-	-	-	-
1914	-	-	-	-	-	-	-	-	-	-	-	-	-
1915	-	-	-	-	-	-	-	-	-	-	-	-	-
1916	-	-	-	-	-	-	-	-	-	-	-	-	-
1917	-	-	-	-	-	-	-	-	-	-	-	-	-
1918	-	-	-	-	-	-	-	-	-	-	-	-	-
1919	-	-	-	-	-	-	-	-	-	-	-	-	-
1920	-	-	-	-	-	-	-	-	-	-	-	-	-
1921	-	-	-	-	-	-	-	-	-	-	-	-	-
1922	-	-	-	-	-	-	-	-	-	-	-	-	-
1923	298	298	298	298	298	298	298	298	298	298	298	298	3,581
1924	355	355	355	355	355	355	355	355	355	355	355	355	4,255
1925	387	387	387	387	387	387	387	387	387	387	387	387	4,643
1926	410	410	410	410	410	410	410	410	410	410	410	410	4,918
1927	447	447	447	447	447	447	447	447	447	447	447	447	5,370
1928	446	446	446	446	446	446	446	446	446	446	446	446	5,355
1929	460	460	460	460	460	460	460	460	460	460	460	460	5,520
1930	524	524	524	524	524	524	524	524	524	524	524	524	6,284
1931	501	501	501	501	501	501	501	501	501	501	501	501	6,013
1932	413	413	413	413	413	413	413	413	413	413	413	413	4,953
1933	450	450	450	450	450	450	450	450	450	450	450	450	5,402
1934	487	487	487	487	487	487	487	487	487	487	487	487	5,846
1935	464	464	464	464	464	464	464	464	464	464	464	464	5,565
1936	430	460	488	567	551	575	605	544	535	495	473	430	6,153
1937	436	445	455	460	491	552	576	550	505	474	454	538	5,936
1938	534	516	332	448	525	543	482	555	575	611	596	574	6,291
1939	513	517	613	636	583	601	614	562	483	495	504	506	6,627
1940	565	515	534	515	525	547	567	558	537	560	524	545	6,492
1941	627	618	708	748	798	808	899	766	704	766	714	715	8,871
1942	862	852	869	936	964	1,005	1,039	981	926	944	906	917	11,201
1943	669	611	727	737	816	875	988	979	902	816	829	795	9,744
1944	780	712	847	859	951	1,019	1,151	1,139	1,050	1,019	914	908	11,349
1945	898	774	872	848	973	1,019	1,083	1,101	1,055	1,114	979	905	11,621

Rio Grande Project Flow Data
Total Monthly Flow (Acre-Feet)
1903 - 2017
Total Haskell WWTP

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
1946	887	795	869	777	904	969	1,020	996	937	945	945	847	10,891
1947	830	755	832	712	821	855	928	908	852	884	807	832	10,016
1948	795	755	792	697	776	872	955	893	835	921	847	810	9,948
1949	875	783	856	773	804	899	1,044	1,047	960	954	865	838	10,698
1950	900	818	934	834	926	958	1,019	1,025	942	1,013	927	901	11,193
1951	913	848	1,005	863	972	954	1,130	1,163	1,169	1,142	1,026	1,066	12,247
1952	975	970	998	940	1,040	1,070	1,120	1,120	1,080	1,073	922	863	12,171
1953	908	845	871	896	887	1,097	1,157	1,234	1,157	1,160	1,075	1,088	12,376
1954	955	913	1,028	993	1,100	1,141	1,222	1,216	1,180	1,142	1,066	1,038	12,994
1955	1,034	925	1,018	975	1,078	1,125	1,216	1,210	1,135	1,126	1,019	1,041	12,902
1956	1,093	959	1,049	996	1,099	1,174	1,217	1,127	1,185	1,217	1,137	1,134	13,387
1957	1,049	1,023	1,085	956	1,019	1,114	1,174	1,178	1,166	1,234	1,104	1,156	13,258
1958	1,091	1,019	1,163	1,102	1,251	1,348	1,368	1,333	1,277	1,234	1,134	1,117	14,437
1959	816	1,033	1,196	1,124	1,248	1,291	1,323	1,254	1,191	1,165	1,093	1,354	14,088
1960	1,513	1,418	1,609	1,629	1,669	1,636	1,673	1,805	1,640	1,578	1,504	1,468	19,142
1961	1,480	1,411	1,579	1,553	1,673	1,667	1,745	1,859	1,796	1,771	1,661	1,644	19,839
1962	1,697	1,535	1,638	1,587	1,792	1,844	1,902	1,896	1,870	1,794	1,476	1,437	20,468
1963	1,351	1,497	1,574	1,489	1,825	1,790	2,060	2,108	1,840	1,828	1,672	1,612	20,646
1964	1,696	1,639	1,839	1,762	1,862	1,810	1,914	1,906	1,755	1,982	1,848	1,887	21,900
1965	1,848	1,625	1,838	1,833	1,979	1,971	2,119	2,098	2,045	1,932	1,859	1,844	22,991
1966	1,847	1,701	1,971	1,841	2,049	1,927	1,994	2,171	2,018	2,024	2,053	1,966	23,562
1967	1,967	1,752	1,973	1,650	1,685	1,701	1,732	1,779	1,683	1,760	1,612	1,584	20,878
1968	1,661	1,582	1,748	1,676	1,734	1,698	1,809	1,758	1,639	1,668	1,509	1,413	19,895
1969	1,456	1,344	1,406	1,552	1,802	1,786	1,820	1,791	1,569	1,704	1,493	1,763	19,486
1970	1,646	1,499	1,606	1,616	1,846	1,786	2,042	2,145	2,045	1,756	1,580	1,793	21,360
1971	1,885	1,680	1,944	2,056	2,077	2,020	2,221	2,171	2,106	2,111	2,011	2,067	24,349
1972	1,747	1,606	1,743	1,738	1,713	1,756	1,885	1,839	1,724	1,680	1,498	1,462	20,391
1973	1,581	1,539	1,612	1,649	1,763	1,662	1,988	2,102	1,936	2,027	1,883	1,875	21,617
1974	1,899	1,762	1,996	1,951	2,033	2,041	2,174	2,125	2,202	1,889	1,698	1,748	23,518
1975	1,747	1,861	1,932	1,935	1,954	2,021	2,176	2,177	2,032	2,092	2,028	2,054	24,009
1976	1,998	1,895	2,029	2,048	2,163	2,039	2,148	2,152	1,885	1,880	1,808	1,809	23,852
1977	2,249	1,928	2,126	2,160	2,371	2,056	2,120	2,127	1,737	1,668	1,588	1,564	23,694
1978	1,535	1,649	1,480	2,038	2,121	2,055	2,259	2,149	2,289	1,989	2,089	2,102	23,755
1979	2,154	2,136	2,273	2,111	2,282	2,210	2,378	2,456	2,306	2,430	2,137	2,150	27,023
1980	2,221	2,091	2,271	2,074	2,289	2,404	2,556	2,335	2,342	2,076	1,963	2,031	26,653
1981	2,050	1,739	2,033	2,030	2,206	2,247	2,409	2,416	2,366	2,243	2,195	2,275	26,209
1982	2,217	1,964	2,176	2,089	2,311	2,331	2,348	2,508	2,392	2,385	2,308	2,390	27,419
1983	2,369	2,059	2,261	2,174	2,355	2,382	2,453	2,435	2,437	2,359	2,090	2,090	27,464
1984	2,163	2,117	2,024	1,996	2,175	2,239	2,478	2,632	2,468	2,401	2,253	2,303	27,249
1985	2,041	2,063	2,178	1,960	2,013	1,966	2,060	2,173	2,090	2,079	1,953	1,992	24,568
1986	1,955	1,758	1,947	1,935	2,057	1,941	1,959	2,166	2,038	1,859	1,725	1,429	22,769
1987	1,690	1,657	1,675	1,628	1,456	1,647	1,793	1,824	1,702	1,729	1,571	1,635	20,007
1988	1,542	1,489	1,590	1,481	1,204	1,253	1,434	1,590	1,374	1,360	1,836	1,695	17,848

Rio Grande Project Flow Data

Total Monthly Flow (Acre-Feet)

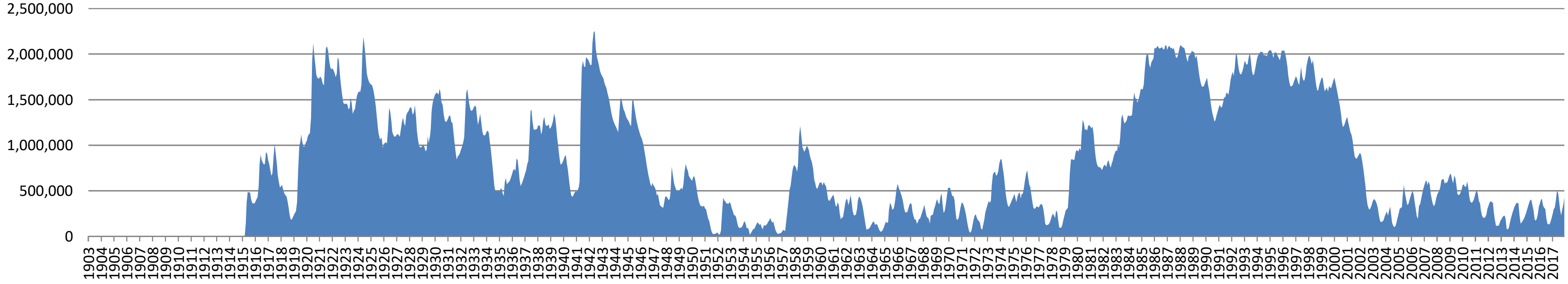
1903 - 2017

Total Haskell WWTP

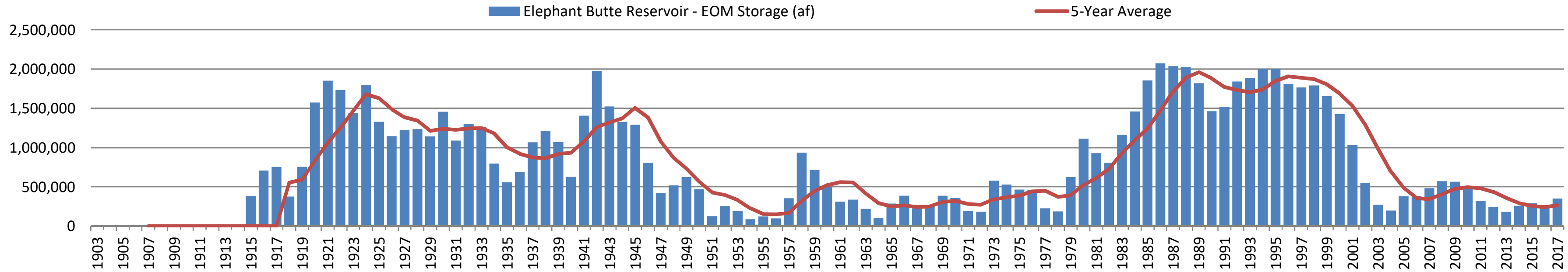
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
1989	1,759	1,698	1,862	1,876	2,003	1,945	2,216	2,145	2,159	1,941	1,832	1,868	23,304
1990	1,967	2,057	2,174	2,143	2,354	2,423	2,452	2,580	2,508	2,263	2,200	2,124	27,245
1991	2,174	1,951	2,131	2,082	2,286	2,196	2,508	2,633	2,472	2,474	2,224	2,342	27,474
1992	2,193	2,207	2,184	2,056	2,374	1,335	2,210	2,407	1,976	2,007	1,940	1,994	24,883
1993	2,220	1,921	2,170	1,989	2,252	2,302	2,298	2,578	2,309	2,267	2,206	2,153	26,666
1994	1,899	1,915	2,191	2,049	1,914	2,026	2,326	2,392	2,171	2,233	2,096	2,039	25,252
1995	2,182	1,901	2,026	2,086	2,167	2,144	2,199	2,340	2,189	2,018	2,037	1,959	25,248
1996	1,974	1,818	1,935	1,813	1,951	2,028	2,225	2,197	2,126	2,117	1,929	1,927	24,040
1997	2,451	2,205	2,465	2,464	2,677	2,601	2,872	2,858	2,773	2,660	2,425	2,397	30,848
1998	2,020	1,830	2,117	2,200	2,256	2,282	2,444	2,360	2,316	1,810	1,685	1,650	24,970
1999	1,589	1,455	1,768	1,935	1,835	1,962	2,015	1,862	1,859	1,408	1,550	1,509	20,747
2000	1,562	1,408	1,449	1,608	1,680	1,699	1,468	1,387	1,463	1,275	1,249	1,230	17,478
2001	1,173	1,426	1,447	1,580	1,654	1,810	1,818	1,625	1,642	1,633	1,417	1,371	18,596
2002	1,332	2,005	1,424	1,509	1,479	1,604	1,768	1,690	1,691	1,571	1,115	1,336	18,523
2003	1,075	1,196	1,319	1,531	1,593	1,755	1,782	1,263	1,677	1,449	1,118	1,261	17,017
2004	1,242	1,586	1,573	1,730	1,656	1,722	1,585	1,620	1,584	1,598	1,364	1,234	18,493
2005	1,347	1,489	1,439	1,520	1,532	1,670	1,186	1,710	1,954	1,612	1,309	1,218	17,986
2006	1,133	1,222	1,373	1,343	1,447	1,396	1,561	1,968	1,740	1,457	1,139	1,210	16,989
2007	1,130	1,267	1,220	1,360	1,450	1,420	1,501	1,571	1,595	1,270	1,085	1,139	16,008
2008	1,126	1,250	1,461	1,358	1,460	1,384	1,626	1,659	1,528	1,692	1,069	1,070	16,683
2009	1,072	1,208	1,354	1,358	1,460	1,476	1,592	1,616	1,547	1,384	1,278	1,269	16,614
2010	1,359	1,316	1,146	1,431	1,420	1,391	1,473	1,695	1,683	1,407	1,166	1,257	16,744
2011	1,200	1,114	1,154	1,075	1,104	1,265	1,176	1,724	1,607	1,322	1,145	1,266	15,152
2012	1,336	1,259	1,364	1,453	1,489	1,493	1,624	1,453	1,407	1,467	1,443	1,391	17,179
2013	1,331	1,363	1,492	1,371	1,265	1,242	1,428	1,583	1,603	1,353	1,083	1,190	16,304
2014	1,214	1,079	1,172	1,029	1,014	1,115	1,267	1,309	1,365	1,192	1,261	1,365	14,382
2015	1,345	1,016	1,258	1,317	1,307	1,377	1,515	1,513	1,428	1,559	1,420	1,438	16,494
2016	1,426	1,343	1,390	1,285	1,331	1,375	1,377	1,587	1,492	1,146	1,269	1,105	16,125
2017	1,101	908	1,194	1,202	1,194	1,160	1,261	1,323	1,329	1,224	1,103	1,160	14,159
Avg	1,297	1,247	1,338	1,327	1,398	1,406	1,494	1,520	1,458	1,400	1,301	1,306	16,492

Reservoir Data
Elephant Butte Reservoir - EOM Storage (af)
1903 - 2017

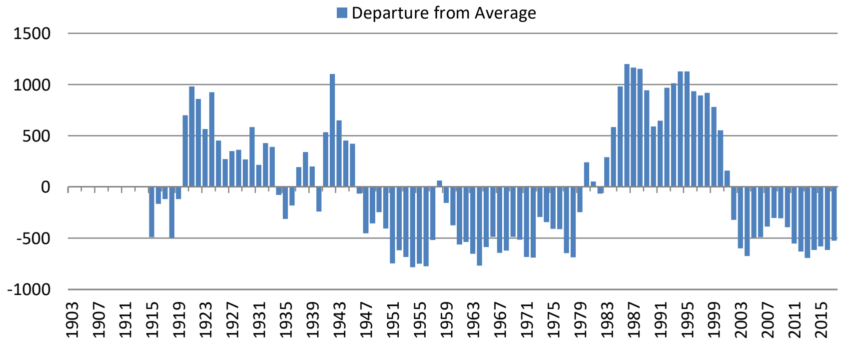
Total Monthly (Acre-Feet)



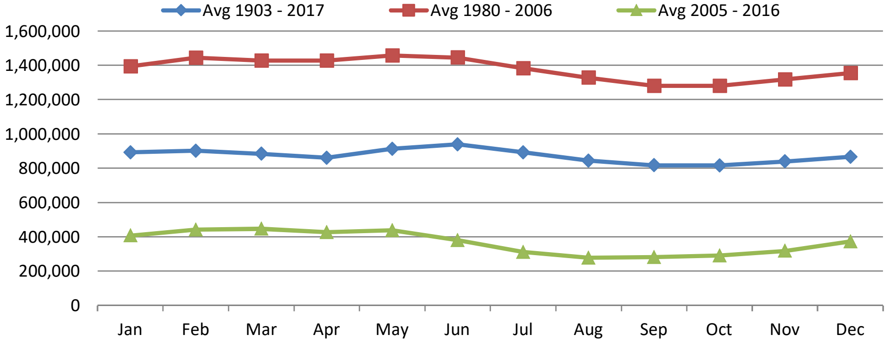
Average Annual (Acre-Feet)



Annual Departure from Average (1,000 Acre-Feet)



Average Monthly (Acre-Feet)



	Start	End
Period 1:	1980	2005
Period 2:	2006	2016

Rio Grande Project Data
Total Monthly
1903 - 2017
Elephant Butte Reservoir - EOM Storage (af)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
1903	-	-	-	-	-	-	-	-	-	-	-	-	-
1904	-	-	-	-	-	-	-	-	-	-	-	-	-
1905	-	-	-	-	-	-	-	-	-	-	-	-	-
1906	-	-	-	-	-	-	-	-	-	-	-	-	-
1907	-	-	-	-	-	-	-	-	-	-	-	-	-
1908	-	-	-	-	-	-	-	-	-	-	-	-	-
1909	-	-	-	-	-	-	-	-	-	-	-	-	-
1910	-	-	-	-	-	-	-	-	-	-	-	-	-
1911	-	-	-	-	-	-	-	-	-	-	-	-	-
1912	-	-	-	-	-	-	-	-	-	-	-	-	-
1913	-	-	-	-	-	-	-	-	-	-	-	-	-
1914	-	-	-	-	-	-	-	-	-	-	-	-	-
1915	-	-	-	136,550	367,890	486,632	478,407	484,491	402,777	361,676	361,464	357,898	381,976
1916	376,729	404,182	428,720	548,812	782,142	892,476	830,592	804,299	784,972	791,536	922,836	907,032	706,194
1917	832,560	785,123	717,299	661,835	689,303	863,176	1,013,198	903,895	788,495	670,712	594,981	532,227	754,400
1918	547,635	559,781	511,797	474,957	450,386	439,873	384,231	311,714	241,473	184,845	181,063	204,340	374,341
1919	234,066	257,891	269,268	371,751	725,470	983,097	1,041,994	1,116,269	1,028,519	984,427	984,493	1,023,037	751,690
1920	1,048,041	1,092,057	1,118,203	1,129,648	1,301,624	1,927,910	2,117,216	2,002,281	1,889,982	1,765,478	1,739,264	1,726,000	1,571,475
1921	1,738,607	1,750,936	1,723,680	1,672,054	1,655,749	1,894,727	2,060,096	2,085,702	2,032,153	1,921,170	1,848,733	1,831,531	1,851,262
1922	1,843,129	1,823,533	1,790,172	1,746,224	1,785,227	1,961,690	1,937,144	1,775,978	1,652,981	1,549,459	1,467,714	1,452,932	1,732,182
1923	1,451,652	1,454,118	1,442,567	1,391,094	1,408,875	1,520,111	1,460,812	1,341,193	1,378,675	1,396,309	1,466,659	1,540,922	1,437,749
1924	1,576,982	1,588,634	1,584,584	1,666,323	1,987,807	2,190,542	2,089,009	1,956,357	1,791,118	1,743,460	1,701,393	1,677,284	1,796,124
1925	1,666,623	1,657,224	1,612,866	1,551,147	1,491,419	1,369,347	1,238,646	1,131,092	1,075,066	1,059,267	1,085,923	970,843	1,325,789
1926	1,006,087	1,026,937	1,028,559	1,016,256	1,173,079	1,408,994	1,363,977	1,259,034	1,147,670	1,110,180	1,090,672	1,093,233	1,143,723
1927	1,112,308	1,121,760	1,110,798	1,089,960	1,176,658	1,256,479	1,299,866	1,238,411	1,210,055	1,325,327	1,355,888	1,372,016	1,222,461
1928	1,401,859	1,418,723	1,403,741	1,332,825	1,356,110	1,435,850	1,301,433	1,160,474	1,057,731	990,567	974,731	974,988	1,234,086
1929	991,545	997,297	978,654	930,541	948,104	1,101,871	1,020,404	1,084,753	1,195,256	1,419,646	1,481,165	1,525,893	1,139,594
1930	1,553,960	1,573,137	1,572,366	1,551,150	1,616,811	1,581,901	1,467,992	1,443,418	1,332,472	1,267,177	1,251,443	1,263,329	1,456,263
1931	1,288,813	1,322,164	1,322,159	1,251,973	1,246,585	1,160,657	1,038,244	930,756	842,745	874,129	883,451	905,895	1,088,964
1932	945,357	980,399	1,023,182	1,086,211	1,293,752	1,566,525	1,615,050	1,515,739	1,434,354	1,382,277	1,376,389	1,384,520	1,300,313
1933	1,413,233	1,429,905	1,422,982	1,332,649	1,222,132	1,274,378	1,345,164	1,248,040	1,145,973	1,112,170	1,104,566	1,113,337	1,263,711
1934	1,147,508	1,157,996	1,131,726	1,044,865	951,711	832,774	704,608	568,294	504,807	493,580	493,216	497,139	794,019
1935	488,897	518,907	528,116	470,143	440,503	595,737	638,584	570,410	582,520	595,119	615,487	653,174	558,133
1936	692,874	723,693	736,932	714,330	853,555	831,987	718,219	609,816	547,620	578,884	614,470	649,171	689,296
1937	683,994	721,750	789,228	826,237	1,071,800	1,373,973	1,385,984	1,258,635	1,172,520	1,167,823	1,170,273	1,176,529	1,066,562
1938	1,206,184	1,222,171	1,204,239	1,113,487	1,172,397	1,262,783	1,310,135	1,225,397	1,209,440	1,215,139	1,226,823	1,177,123	1,212,110
1939	1,190,635	1,217,725	1,265,139	1,344,500	1,299,300	1,218,067	1,082,900	977,986	866,723	786,619	787,757	806,768	1,070,343
1940	839,200	874,700	886,700	789,700	732,700	625,400	522,300	451,000	429,900	447,500	470,100	488,500	629,808
1941	485,500	501,600	534,000	595,700	1,390,600	1,850,200	1,924,000	1,863,800	1,855,100	1,968,600	1,949,700	1,937,700	1,404,708
1942	1,906,900	1,875,000	1,885,000	2,116,700	2,235,900	2,252,900	2,055,300	1,968,600	1,930,900	1,878,300	1,814,200	1,780,500	1,975,017
1943	1,755,100	1,731,900	1,693,500	1,653,100	1,623,900	1,565,400	1,523,700	1,454,400	1,394,300	1,329,300	1,276,700	1,250,600	1,520,992
1944	1,219,500	1,199,800	1,173,000	1,141,400	1,339,000	1,511,600	1,503,800	1,450,500	1,393,000	1,364,500	1,323,400	1,290,600	1,325,842
1945	1,272,100	1,257,400	1,223,900	1,209,600	1,484,600	1,496,700	1,423,200	1,351,200	1,272,100	1,221,700	1,167,700	1,130,100	1,292,525

Rio Grande Project Data
Total Monthly
1903 - 2017
Elephant Butte Reservoir - EOM Storage (af)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
1946	1,100,600	1,071,700	1,030,900	968,400	898,100	830,000	760,100	680,700	625,400	570,700	544,300	584,300	805,433
1947	557,300	537,600	507,400	446,100	461,300	405,600	341,100	324,900	316,900	309,900	366,400	435,500	417,500
1948	435,600	417,300	395,200	409,300	484,300	761,800	673,500	588,600	542,900	506,800	493,300	492,000	516,717
1949	496,100	517,300	530,500	508,300	570,700	709,900	793,300	746,800	714,000	663,900	639,800	621,000	625,967
1950	607,500	650,600	655,900	616,600	541,500	457,500	397,900	354,500	333,400	329,500	323,200	335,400	466,958
1951	303,900	293,200	248,800	192,200	166,400	106,600	53,200	27,700	19,400	22,900	26,700	36,500	124,792
1952	36,500	17,300	18,900	59,300	259,000	421,200	390,700	385,700	360,900	357,200	355,300	376,900	253,242
1953	351,600	311,800	277,400	232,300	228,700	209,200	162,800	109,600	88,500	90,600	93,900	110,600	188,917
1954	137,200	166,800	138,500	87,000	90,600	59,600	13,800	32,900	55,600	76,100	80,800	97,600	86,375
1955	125,100	150,300	141,100	121,100	131,900	97,600	73,000	120,800	112,300	122,800	130,400	155,000	123,450
1956	169,900	200,600	166,600	146,400	160,200	108,900	63,300	38,400	24,200	26,100	28,700	32,900	97,183
1957	47,300	68,400	64,300	50,200	160,600	267,400	381,000	509,300	556,100	635,900	731,500	776,100	354,008
1958	773,100	753,300	705,900	776,300	1,097,900	1,209,300	1,093,300	977,600	951,200	925,000	954,300	988,800	933,833
1959	977,100	943,700	890,900	844,500	808,500	741,300	621,800	576,400	532,800	517,500	549,300	586,400	715,850
1960	587,800	587,800	554,300	594,500	565,700	547,100	476,400	410,100	385,100	396,200	419,200	439,600	496,983
1961	452,200	409,500	335,700	321,900	371,800	334,700	249,700	185,600	201,600	208,000	285,800	360,900	309,783
1962	403,200	405,000	339,700	385,600	451,200	363,500	283,900	229,400	226,800	237,700	298,600	390,300	334,575
1963	432,800	420,500	392,400	338,600	268,400	217,200	130,200	66,500	78,800	80,200	93,500	112,000	219,258
1964	134,500	160,600	153,300	119,700	135,400	126,900	94,500	63,300	48,600	50,100	64,700	87,300	103,242
1965	125,800	159,000	144,800	154,600	288,700	366,900	337,800	287,800	298,300	327,600	412,900	517,200	285,117
1966	572,900	529,500	492,500	472,400	440,500	376,400	304,800	261,300	262,300	262,200	302,800	344,000	385,133
1967	363,400	347,800	268,200	215,200	180,700	179,800	134,100	160,200	188,500	190,200	227,500	267,100	226,892
1968	304,600	343,500	283,800	216,800	201,200	190,900	136,800	224,000	229,900	236,000	295,400	333,600	249,708
1969	382,100	406,200	364,000	352,200	435,100	467,400	363,000	253,800	274,000	346,800	443,800	528,200	384,717
1970	531,700	531,100	487,300	436,000	442,800	396,900	290,400	188,700	179,100	199,400	271,000	324,500	356,575
1971	367,800	361,100	316,500	289,000	221,200	154,000	98,400	47,300	35,400	64,500	128,000	177,000	188,350
1972	223,400	239,100	200,900	171,600	167,600	145,000	82,800	71,300	128,400	191,700	256,900	301,600	181,692
1973	343,400	384,400	366,100	386,700	551,900	675,900	699,100	705,300	663,800	671,800	706,600	794,200	579,100
1974	839,100	846,600	755,300	687,300	595,000	473,900	375,000	333,500	320,900	343,600	370,500	402,500	528,600
1975	427,800	463,700	425,800	371,300	434,800	468,800	479,700	411,900	462,100	463,700	528,500	617,200	462,942
1976	688,700	722,200	644,000	565,500	534,000	444,000	361,200	312,200	299,500	309,800	330,400	315,800	460,608
1977	317,100	342,000	350,900	347,800	304,500	219,500	136,100	120,900	123,600	127,800	148,300	181,400	226,658
1978	215,400	245,000	230,900	196,900	282,600	262,100	185,700	95,800	92,200	94,400	136,300	182,600	184,992
1979	228,600	280,000	295,800	310,600	494,700	691,600	840,400	844,400	839,400	834,300	907,900	943,500	625,933
1980	935,800	932,300	969,100	937,800	1,118,700	1,277,400	1,244,000	1,164,000	1,174,100	1,158,200	1,207,700	1,222,200	1,111,775
1981	1,205,200	1,183,900	1,201,300	1,115,800	990,700	872,800	799,500	765,900	754,000	758,000	745,700	725,300	926,508
1982	758,300	783,800	776,700	758,700	809,300	834,600	782,400	751,700	799,800	826,800	882,300	916,700	806,758
1983	942,200	932,600	1,015,700	968,400	1,092,300	1,293,700	1,337,300	1,271,700	1,236,400	1,251,800	1,269,900	1,322,700	1,161,225
1984	1,324,200	1,315,000	1,321,600	1,329,000	1,472,900	1,577,900	1,510,600	1,510,600	1,467,700	1,492,300	1,548,400	1,610,500	1,456,725
1985	1,619,500	1,607,100	1,665,400	1,838,000	1,965,600	2,010,900	1,983,400	1,892,000	1,846,900	1,909,400	1,930,300	1,955,700	1,852,017
1986	2,066,300	2,061,200	2,071,800	2,089,700	2,058,600	2,063,400	2,064,800	2,076,100	2,054,300	2,046,600	2,097,800	2,090,100	2,070,058
1987	2,045,900	2,082,400	2,087,100	2,063,000	2,069,200	2,052,100	2,065,600	2,017,800	1,961,000	1,957,500	1,995,200	2,043,400	2,036,683
1988	2,092,600	2,091,200	2,075,400	2,069,200	2,066,600	2,011,600	1,951,100	1,912,900	1,983,000	1,985,200	2,009,100	2,034,700	2,023,550

Rio Grande Project Data

Total Monthly

1903 - 2017

Elephant Butte Reservoir - EOM Storage (af)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
1989	2,023,900	2,020,300	1,953,300	1,983,700	1,934,300	1,837,900	1,751,500	1,688,200	1,642,700	1,639,600	1,643,900	1,675,300	1,816,217
1990	1,709,400	1,738,600	1,653,200	1,592,500	1,534,800	1,428,900	1,342,700	1,303,500	1,254,400	1,274,900	1,327,200	1,369,600	1,460,808
1991	1,416,200	1,443,000	1,414,300	1,416,700	1,462,500	1,524,400	1,522,600	1,574,000	1,573,400	1,551,500	1,618,200	1,713,900	1,519,225
1992	1,770,100	1,803,100	1,758,400	1,850,700	2,004,800	1,984,400	1,881,400	1,821,800	1,776,000	1,778,000	1,807,100	1,855,100	1,840,908
1993	1,921,400	1,913,100	1,881,400	1,890,600	1,967,000	2,011,300	1,915,200	1,818,100	1,767,800	1,777,000	1,836,900	1,907,500	1,883,942
1994	1,954,700	1,990,500	2,003,000	2,026,800	2,019,200	2,019,600	1,985,900	1,984,800	1,986,200	1,974,500	2,019,900	2,038,700	2,000,317
1995	2,040,200	2,038,000	2,005,200	1,955,000	2,016,700	2,017,400	2,014,200	1,981,200	1,957,100	1,931,900	1,987,600	2,040,200	1,998,725
1996	2,033,300	2,042,000	2,004,500	1,946,200	1,858,200	1,763,900	1,686,600	1,642,700	1,646,100	1,655,100	1,687,000	1,718,100	1,806,975
1997	1,753,200	1,734,100	1,687,600	1,660,100	1,744,100	1,860,500	1,747,000	1,709,400	1,710,400	1,777,700	1,861,200	1,926,600	1,764,325
1998	1,974,500	1,976,300	1,925,900	1,886,800	1,933,300	1,847,000	1,744,100	1,650,700	1,598,800	1,599,700	1,658,800	1,698,000	1,791,158
1999	1,739,300	1,737,300	1,667,500	1,592,200	1,609,100	1,629,800	1,585,000	1,650,400	1,635,600	1,622,200	1,666,300	1,708,200	1,653,575
2000	1,738,300	1,678,500	1,623,400	1,565,700	1,516,000	1,429,700	1,351,700	1,264,200	1,198,900	1,207,700	1,246,600	1,285,000	1,425,475
2001	1,306,100	1,251,000	1,199,400	1,142,000	1,111,800	1,047,600	946,000	877,400	853,700	849,300	874,300	897,600	1,029,683
2002	915,100	893,800	824,800	742,500	647,900	541,800	436,900	344,600	305,300	289,500	315,700	350,100	550,667
2003	384,200	405,100	395,700	369,400	340,800	268,900	217,700	158,600	154,300	163,100	179,000	210,500	270,608
2004	244,000	272,100	223,800	279,500	322,900	246,500	144,300	111,800	96,400	109,000	139,700	193,200	198,600
2005	241,700	297,700	310,300	318,400	452,900	558,700	466,800	403,000	342,500	349,500	386,000	428,700	379,683
2006	468,800	498,900	452,900	385,800	305,100	218,000	189,000	331,600	351,800	397,500	460,300	514,000	381,142
2007	558,400	598,500	609,100	556,000	601,300	571,400	461,300	396,600	357,600	325,600	352,000	408,800	483,050
2008	454,700	481,900	495,300	535,900	614,500	625,500	626,100	573,100	590,200	582,300	606,900	648,800	569,600
2009	682,100	681,000	622,000	580,400	665,900	634,400	548,400	466,300	448,200	454,500	483,800	519,700	565,558
2010	561,500	567,100	540,600	542,500	600,100	530,400	444,300	383,100	365,900	372,500	392,900	437,200	478,175
2011	474,200	504,300	466,400	383,700	359,300	283,100	223,000	202,200	201,000	208,100	241,000	294,500	320,067
2012	331,900	367,000	385,800	372,200	366,100	266,400	177,400	111,800	113,100	114,200	123,000	161,100	240,833
2013	183,100	207,100	220,200	223,100	193,800	80,600	74,500	90,900	163,600	192,500	236,200	279,100	178,725
2014	312,279	340,567	361,672	363,603	363,174	225,985	133,865	154,007	172,132	183,553	212,607	256,371	256,651
2015	291,047	328,717	368,452	393,277	399,509	342,023	283,123	185,445	168,427	183,134	232,406	322,516	291,506
2016	361,137	401,906	407,188	334,873	310,490	298,204	189,470	132,194	132,016	128,708	160,745	202,454	254,949
2017	250,968	295,292	312,777	395,649	501,124	469,917	366,940	285,213	227,210	297,912	354,744	425,083	348,569
Avg	892,788	902,228	884,762	862,226	913,623	939,619	892,919	844,181	817,779	816,741	840,073	867,494	10,474,436

Appendix 4A
Example Water Distribution Reports
1950 and 1993

Form 7-322 (May 1937)

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

MONTHLY WATER DISTRIBUTION

Project Rincon Unit

Area Irrigated 17651

Year 1950

QUANTITIES IN ACRE-FEET

MONTH	Diverted from Stream[1]	INFLOW FROM—		Delivered to Reservoirs[2]	Net Supply[3]	Total Waste	Total Losses	Delivered to Laterals[4]	Lateral Waste	Lateral Losses	DELIVERED TO FARMS[5]	
		Reservoirs[2]	Other Sources								Total	Per Acre
January,	0					0	0					
February,	(2,190)					(560)	--					
March,	(14,220)					(2,960)	7,011				5,879	.33
April,	11,870					2,270	2,202				7,398	.42
May,	13,050					2,280	4,258				6,512	.37
June,	12,380					1,940	3,937				6,503	.37
July,	7,570					1,440	993				5,137	.29
August,	20,180					2,150	8,168				9,862	.56
September,	7,880					950	183				6,747	.38
October,	0					0	0				0	
November,	0					0	0				0	
December,	0					0	0				0	
Total,	89,340					14,550	26,752				48,038	2.72
Acre ft. per acre,	5.06					0.82	1.52				2.72	
Per cent Net Supply,	100					16	30				54	

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[1] Diversion amount exclusive of waste at head gates for sand sluicing, etc.

[2] Reservoirs connected with distributing system only.

[3] Diversions plus inflow from reservoirs and other sources less delivery to reservoirs.

[4] Measured at

[5] Measured at

Form 7-322 (May 1937)

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

MONTHLY WATER DISTRIBUTION

Revised 11-21-51

Project Leasburg Unit Area Irrigated 30,548 Year 1950

QUANTITIES IN ACRE-FEET

MONTH	Diverted from Stream[1]	INFLOW FROM—		Delivered to Reservoirs[2]	Net Supply[3]	Main Canal Waste	Total ~~Main Canal~~ Losses	Delivered to ~~Laterals~~[4] E. Side Canal	Total ~~Lateral Waste~~ Waste	Lateral Losses	DELIVERED TO FARMS[5]	
		Reservoirs[2]	Other Sources								Total	Per Acre
January,	0					0	0	0	0			
February,	(3,250)					2,110	0	70	(2,180)			
March,	(28,150)					2,200	15,530	870	(3,070)		10,620	.35
April,	21,220					1,980	3,289	680	2,660		14,571	.48
May,	25,290					1,990	9,173	650	2,640		13,477	.44
June,	22,350					1,810	10,522	600	2,410		9,418	.31
July,	26,560					2,560	6,681	1,010	3,570		16,309	.53
August,	35,030					1,550	12,599	570	2,120		20,311	.66
September,	20,275					1,780	3,382	610	2,390		14,503	.48
October,	4,020					470	3,122	30	500		398	.01
November,	2,270					290	1,563	--	290		417	.01
December,	1,040					140	494	140	280		266	.01
Total,	189,455					16,880	67,055	5,230	22,110		100,290	3.28
Acre ft. per acre,	6.20					0.55	2.20	0.17	0.72		3.28	
Per cent Net Supply,	100					9	35	3	12		53	

[1] Diversion amount exclusive of waste at head gates for sand sluicing, etc.

[2] Reservoirs connected with distributing system only.

[3] Diversions plus inflow from reservoirs and other sources less delivery to reservoirs.

[4] Measured at

[5] Measured at

Form 7-322 (May 1937)

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

MONTHLY WATER DISTRIBUTION

Project Mesilla Unit
Eastside and Westside Canals

Area Irrigated 54,019

Year 1950

QUANTITIES IN ACRE-FEET

MONTH	Diverted from Stream[1]	INFLOW FROM—		From ~~Delivered to Reservoirs~~ Leasburg Canal	Total ~~Net Supply~~ Supply	Total ~~Canal~~ Waste	Total ~~Canal~~ Losses	Delivered to Laterals[4]	Lateral Waste	Lateral Losses	DELIVERED TO FARMS[5]	
		Reservoirs[2]	Other Sources								Total	Per Acre
January,	0			0	0	0						
February,	1,320			70	(1,390)	(330)						
March,	42,910			870	(43,780)	(4,920)	20,614				19,306	.36
April,	33,450			680	34,130	3,870	5,360				24,900	.46
May,	36,060			650	36,710	3,700	10,971				22,039	.41
June,	35,200			600	35,800	3,650	17,032				15,118	.28
July,	42,250			1010	43,260	8,030	8,692				26,538	.49
August,	51,020			570	51,590	3,850	19,683				28,057	.52
September,	26,830			610	27,440	2,690	2,476				22,274	.41
October,	3,940			30	3,970	1,710	1,864				396	.01
November,	204			—	204	—	161				43	
December,	0			140	140	0	120				20	
Total,	273,184			5230	278,414	32,750	86,973				158,691	2.94
Acre ft. per acre,	5.06			0.10	5.15	0.61	1.61				2.94	
Per cent Net Supply,	98			2	100	12	31				57	

---

[1] Diversion amount exclusive of waste at head gates for sand sluicing, etc.

[2] Reservoirs connected with distributing system only.

[3] Diversions plus inflow from reservoirs and other sources less delivery to reservoirs.

[4] Measured at

[5] Measured at

Form 7-322 (May 1937)

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

MONTHLY WATER DISTRIBUTION

✓

Project Total Mesilla Valley Leasburg, Eastside and Westside Canals

Area Irrigated 84,567

Year 1950

QUANTITIES IN ACRE-FEET

MONTH	Diverted from Stream [1]	INFLOW FROM—		Delivered to Reservoirs [2]	Net Supply [3]	Total ~~Canal~~ Waste to River	Total ~~Canal~~ Losses	Delivered to Laterals [4]	Lateral Waste	Lateral Losses	DELIVERED TO FARMS [5]	
		Reservoirs [2]	Other Sources								Total	Per Acre
January,	(0)					(0)	0				-	-
February,	(4,570)					(2,440)	0				-	-
March,	71,060					7,120	36,144				29,926	.35
April,	54,670					5,850	9,349				39,471	.47
May,	61,350					5,690	20,144				35,516	.42
June,	57,550					5,460	27,554				24,536	.29
July,	68,810					10,590	15,373				42,847	.51
August,	86,050					5,400	32,282				48,368	.57
September,	47,105					4,470	5,858				36,777	.43
October,	7,960					2,180	4,986				794	.01
November,	2,474					290	1,724				460	.01
December,	1,040					140	614				286	
Total,	462,639					49,630	154,028				258,981	3.06
Acre ft. per acre,	5.47					0.59	1.82				3.06	
Per cent Net Supply,	100					11	33				56	

[1] Diversion amount exclusive of waste at head gates for sand sluicing, etc.

[2] Reservoirs connected with distributing system only.

[3] Diversions plus inflow from reservoirs and other sources less delivery to reservoirs.

[4] Measured at

[5] Measured at

Form 7-32[illegible] (ay 1937)

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

MONTHLY WATER DISTRIBUTION

Project El Paso Valley Unit (Ysleta Division) Area Irrigated 56,486)
64) 56,550 Year 1950

QUANTITIES IN ACRE-FEET

MONTH	Diverted from Stream[1]	INFLOW FROM—		Delivered to Reservoirs[2]	Net Supply[3]	Total Waste	Total Losses	Delivered to Laterals[4]	Lateral Waste	Lateral Losses	DELIVERED TO FARMS[5]	
		Reservoirs[2]	Other Sources								Total	Per Acre
January,	0					0						
February,	(5,518)					(1,543)	--					
March,	(44,976)					(5,240)	26,506				17,205	.30
April,	50,600					6,315	8,661				35,624	.62
May,	39,116					5,382	9,922				23,812	.42
June,	43,662					4,475	14,880				24,307	.43
July,	43,578					8,885	11,641				23,052	.41
August,	51,564					3,674	15,614				32,276	.57
September,	27,919					7,458	1,962				18,499	.33
October,	12,789					5,055	4,515				3,219	.06
November,	9,177					4,952	2,614				1,611	.03
December,	6,530					3,062	2,069				1,399	.03
Total,	335,429					56,041	98,384				181,004	3.20
Acre ft. per acre,	5.93					0.99	1.74				3.20	
Per cent Net Supply,	100					17	29				54	

[1] Diversion amount exclusive of waste at head gates for sand sluicing, etc.
[2] Reservoirs connected with distributing system only.
[3] Diversions plus inflow from reservoirs and other sources less delivery to reservoirs.

[4] Measured at
[5] Measured at

Note: Tabulation does not include water delivered to City of El Paso Water Plant.

(Over)

Form 7-322 (May 1937)

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

Revised Jan. 2, 1952

MONTHLY WATER DISTRIBUTION

Project Rio Grande, New Mexico-Texas

Area Irrigated 158,704)
64) 158,783
15)

Year 1950

QUANTITIES IN ACRE-FEET

MONTH	Diverted from Stream [1]	INFLOW FROM— Reservoirs [2]	INFLOW FROM— Other Sources	Delivered to Reservoirs [2]	Net Supply [3]	Total ~~Main Canal~~ Waste	Total ~~Main Canal~~ Losses	Delivered to ~~Laterals~~ El Paso Water Plant	Lateral Waste	*Total ~~Lateral Losses~~ Delivered	DELIVERED TO FARMS [4] Total	DELIVERED TO FARMS [4] ~~Per Acre~~ Irrigated
January,	0					0	-	0		0	-	-
February,	(12,278)					(4,543)	-	0		0	-	-
March,	(130,256)					(15,320)	69,661	117		53,127	53,010	.33
April,	117,140					14,435	20,212	855		83,348	82,493	.52
May,	113,516					13,352	34,324	961		66,801	65,840	.41
June,	113,592					11,875	46,371	1,094		56,440	55,346	.35
July,	119,958					20,915	28,007	871		71,907	71,034	.45
August,	157,794					11,224	56,064	1,129		91,635	90,506	.57
September,	82,904					12,878	8,003	939		62,962	62,023	.39
October,	20,749					7,235	9,501	915		4,928	4,013	.03
November,	11,651					5,242	4,338	790		2,861	2,071	.01
December,	7,570					3,202	2,683	953		2,638	1,685	.01
Total,	887,408					120,221	279,164	8,624		496,647	488,023	3.07
Acre ft. per acre,	5.59					0.76	1.70	0.05		3.13	3.07	
Per cent Net Supply,	100					14	30	1		56	55	

[1] Diversion amount exclusive of waste at head gates for sand sluicing, etc.

[2] Reservoirs connected with distributing system only.

[3] Diversions plus inflow from reservoirs and other sources less delivery to reservoirs.

[4] Measured at ____

[5] Measured at ____

*Total delivered - charged to farms plus delivered to City of El Paso Water Treatment Plant (Over)

Revised May 13, 1954

Total losses computed on basis of farm deliveries instead of total deliveries.

ID CODE 406000
FULL CROP PRODUCTION AND WATER UTILIZATION EBID 1994 RVMV94C

	MONTH	NET SUPPLY	OPERATIONAL SPILLS	TRANSPORTATION LOSSES	NONAGRICULTURAL DELIVERIES MUNICIPAL	MISCELLANEOUS	DELIVERED TO FARMS	ACRE FEET PER ACRE
	PART E	PROJECT WATER (Acre Feet)						
201	January							
202	February	27,765	8,428	9,889			9,448	0.32
203	March	65,770	11,283	18,852			35,635	0.92
204	April	56,233	13,614	14,318			28,301	0.81
205	May	56,454	15,031	12,144			29,279	0.86
206	June	84,403	15,810	23,659			44,934	1.18
207	July	91,864	20,017	21,955			49,892	1.22
208	August	79,692	18,629	22,288			38,775	0.99
209	September	55,663	15,066	16,307			24,290	0.61
210	October	31,450	12,586	5,393			13,471	0.34
211	Novermber							
212	December							
213	TOTAL PART	549,294	130,464	144,805			274,025	3.56
214	M & I POPULATION							
	PART F	NONPROJECT WATER (Acre Feet)						
216	Annual Data							
217	TOTAL E & F							

PART G ANNUAL OPERATION, MAINTENANCE AND REPLACEMENT COSTS (Whole Dollars)

	WORKS OPERATED BY	AGRICULTURAL (13-21)	MUNICIPAL & INDUSTRIAL (22-30)	OTHER (31-39)	TOTAL ALL FUNCTIONS
221	Bureau	155,626			155,626
222	Water Users	4,013,906			4,013,906
223	TOTAL COSTS	4,169,532			4,169,532

ID CODE 406020
FULL CROP PRODUCTION AND WATER UTILIZATION EPCWID#1 1994 EP94C

	MONTH	NET SUPPLY	OPERATIONAL SPILLS	TRANSPORTATION LOSSES	NONAGRICULTURAL DELIVERIES MUNICIPAL	MISCELLANEOUS	DELIVERED TO FARMS	ACRE FEET PER ACRE
	PART E			PROJECT WATER (Acre Feet)				
201	January	6,837	329	4,492			2,016	0.04
202	February	17,098	2,045	11,789	892		3,264	0.06
203	March	46,374	6,246	14,568	4,499		25,560	0.47
204	April	29,952	8,864	7,163	6,483		13,925	0.26
205	May	30,119	3,271	12,622	7,883		14,226	0.26
206	June	49,421	14,259	6,224	8,157		28,938	0.54
207	July	60,204	9,414	17,827	7,303		32,963	0.61
208	August	53,764	4,169	18,789	7,505		30,806	0.57
209	September	37,989	7,842	13,105	6,350		17,042	0.32
210	October	33,061	20,650	9,461	6,647		2,950	0.05
211	November							
212	December							
213	TOTAL PART	364,819	77,089	116,040	55,719		171,690	3.18
214	M & I POPULATION SERVED				520,000			
	PART F			NONPROJECT WATER (Acre Feet)				
216	Annual Data							
217	TOTAL E & F							

PART G ANNUAL OPERATION, MAINTENANCE AND REPLACEMENT COSTS (Whole Dollars)

	WORKS OPERATED BY	AGRICULTURAL (13-21)	MUNICIPLE & INDUSTRIAL (22-30)	OTHER (31-39)	TOTAL ALL FUNCTIONS
221	Bureau	125,036			125,036
222	Water Users	166,610			166,610
223	TOTAL COSTS	291,646			291,646

D CODE 406030
UPP CROP PRODUCTION & WATER UTILIZATION HUDSPETH COUNTY HC94C

	MONTH	NET SUPPLY +	OPERATIONAL SPILLS	TRANSPORTATION LOSSES *	NONAGRICULTURAL DELIVERIES MUNICIPAL	MISCELLANEOUS	DELIVERED TO FARMS	ACRE FEET PER ACRE
	PART E			PROJECT WATER (Acre Feet)				
201	January	5,312		5,312				
202	February	9,788		7,628			2,160	0.13
203	March	16,155		7,184			8,971	0.53
204	April	15,620		11,822			3,738	0.22
205	May	11,282		8,390			2,892	0.17
206	June	16,455		6,547			9,908	0.58
207	July	18,978		5,818			13,160	0.77
208	August	15,374		1,694			13,680	0.80
209	September	16,790		11,640			5,150	0.30
210	October	12,928		12,928				
211	Novermber							
212	December							
213	TOTAL PART	138,682		78,963			59,659	3.49
214	M & I POPULATION							
	PART F			NONPROJECT WATER (Acre Feet)				
216	Annual Data							
217	TOTAL E & F							

PART G ANNUAL OPERATION, MAINTENANCE AND REPLACEMENT COSTS (Whole Dollars)

	WORKS OPERATED BY	AGRICULTURAL (13-21)	MUNICIPAL & INDUSTRIAL (22-30)	OTHER (31-39)	TOTAL ALL FUNCTIONS
221	Bureau				
222	Water Users	662,000			662,000
223	TOTAL COSTS	662,000			662,000

* THIS COLUMN INCLUDES OPERATIONAL SPILLS FOR WHICH NO DATA IS AVAILABLE
\+ THIS COLUMN INCLUDES FLOWS THRU RECORDER STATIONS AND ESTIMATED DIVERSIONS FROM RIVER

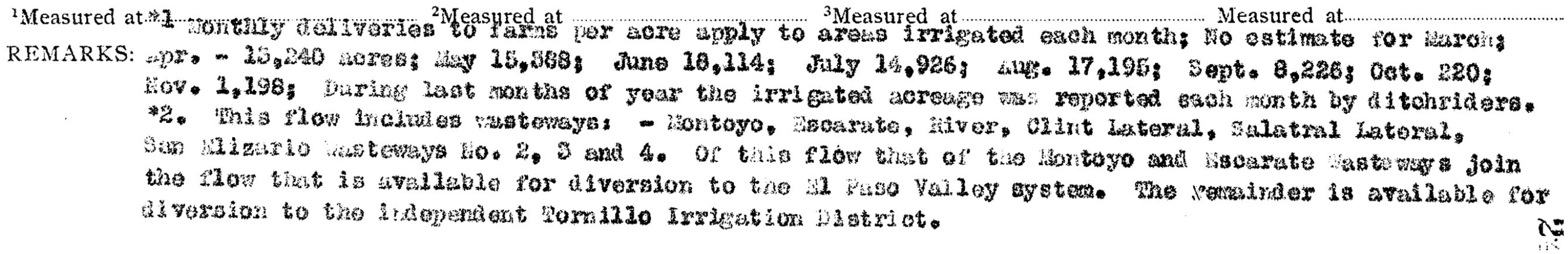
Appendix 4B

El Paso Valley Unit

Diversions and Waste Notes from Water Distribution Reports

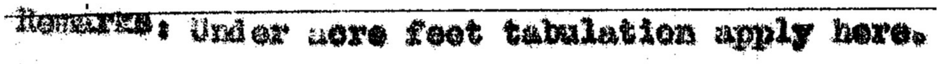
Appendix 4B
El Paso Valley Unit
Diversions and Waste Notes from Water Distribution Reports

1919:



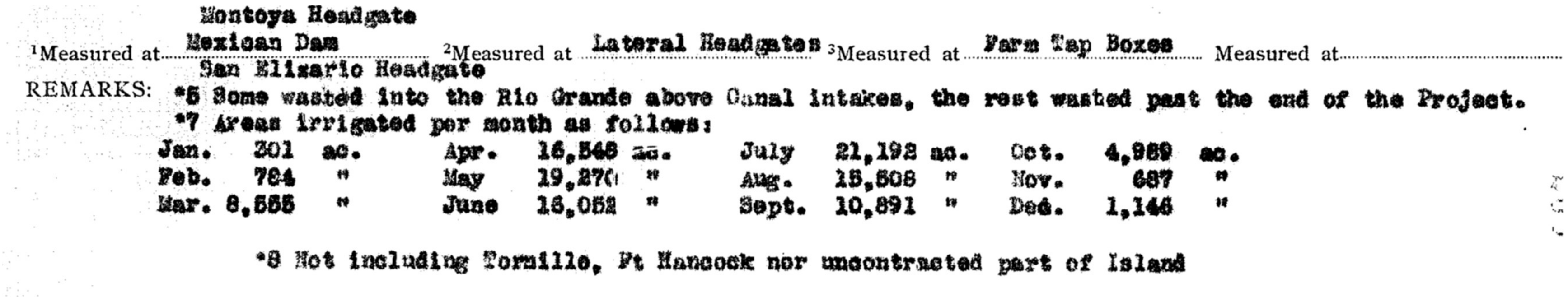
[1]Measured at *1 [2]Measured at [3]Measured at Measured at

REMARKS: Monthly deliveries to farms per acre apply to areas irrigated each month; No estimate for March; Apr. - 15,240 acres; May 15,588; June 18,114; July 14,926; Aug. 17,195; Sept. 8,226; Oct. 220; Nov. 1,198; During last months of year the irrigated acreage was reported each month by ditchriders. *2. This flow includes wasteways: - Montoyo, Escarate, River, Clint Lateral, Salatral Lateral, San Elizario Wasteways No. 2, 3 and 4. Of this flow that of the Montoyo and Escarate Wasteways join the flow that is available for diversion to the El Paso Valley system. The remainder is available for diversion to the independent Tornillo Irrigation District.



Remarks: Under acre feet tabulation apply here.

1920:



[1]Measured at Montoya Headgate Mexican Dam San Elizario Headgate [2]Measured at Lateral Headgates [3]Measured at Farm Tap Boxes Measured at

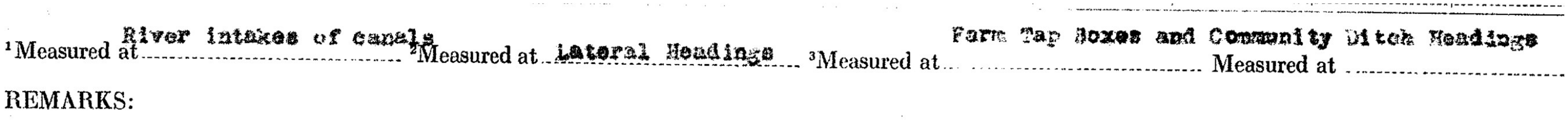
REMARKS: *5 Some wasted into the Rio Grande above Canal intakes, the rest wasted past the end of the Project.
*7 Areas irrigated per month as follows:

Jan.	201	ac.	Apr.	16,546	ac.	July	21,192	ac.	Oct.	4,989	ac.
Feb.	784	"	May	19,270	"	Aug.	15,608	"	Nov.	687	"
Mar.	8,555	"	June	16,052	"	Sept.	10,891	"	Dec.	1,146	"

*8 Not including Tornillo, Ft Hancock nor uncontracted part of Island

1921:

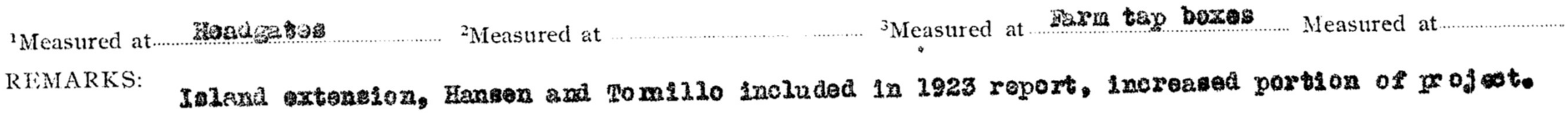
Remarks: *1 To Project only



¹Measured at River intakes of canals ²Measured at Lateral Headings ³Measured at Farm Tap Boxes and Community Ditch Headings Measured at

REMARKS:

1923:



¹Measured at Headgates ²Measured at ³Measured at Farm tap boxes Measured at

REMARKS: Island extension, Hansen and Tornillo included in 1923 report, increased portion of project.

1931:

¹ Diversion amount exclusive of waste at head gates for sand sluicing, etc.
² Reservoirs connected with distributing system only.
³ Diversions plus inflow from reservoirs and other sources less delivery to reservoirs.

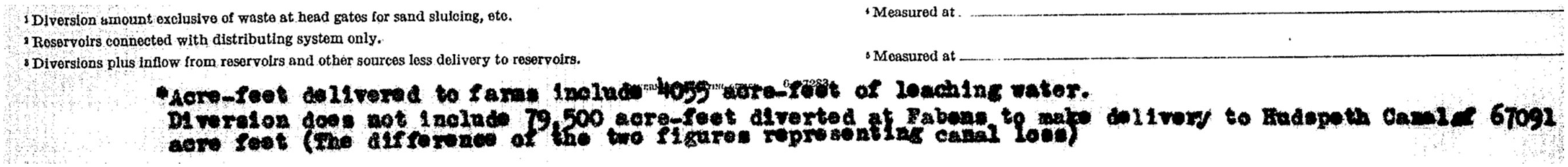
⁴ Measured at

⁵ Measured at

* Includes 4357 leaching water.

** Figures expressed three significant figures.

1933:



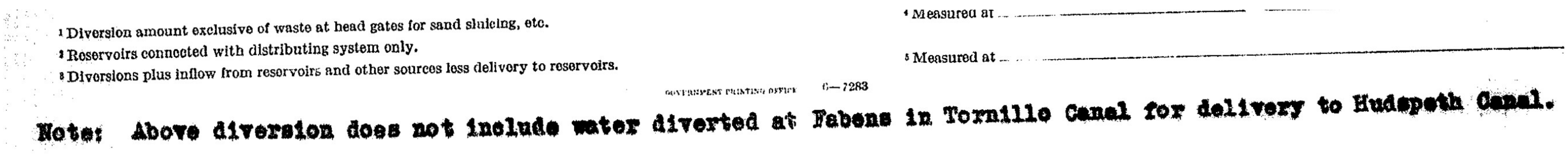
¹ Diversion amount exclusive of waste at head gates for sand sluicing, etc.
² Reservoirs connected with distributing system only.
³ Diversions plus inflow from reservoirs and other sources less delivery to reservoirs.

⁴ Measured at

⁵ Measured at

*Acre-feet delivered to farms include 4055 acre-feet of leaching water.
Diversion does not include 79,500 acre-feet diverted at Fabens to make delivery to Hudspeth Canal of 67091 acre feet (The difference of the two figures representing canal loss)

1934:



¹ Diversion amount exclusive of waste at head gates for sand sluicing, etc.
² Reservoirs connected with distributing system only.
³ Diversions plus inflow from reservoirs and other sources less delivery to reservoirs.

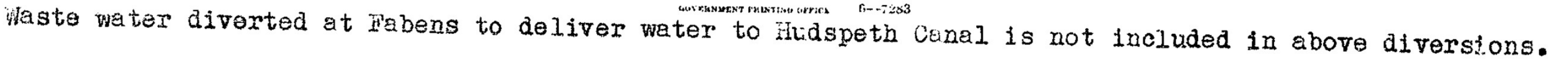
⁴ Measured at

⁵ Measured at

GOVERNMENT PRINTING OFFICE 6—7283

Note: Above diversion does not include water diverted at Fabens in Tornillo Canal for delivery to Hudspeth Canal.

1937:


GOVERNMENT PRINTING OFFICE 6--7283

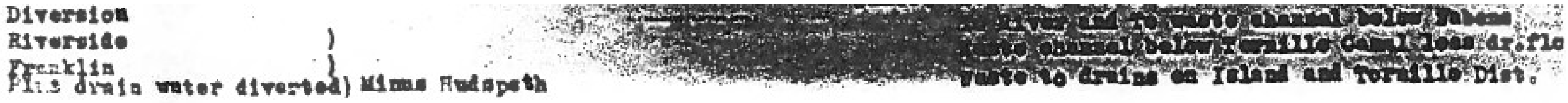
Waste water diverted at Fabens to deliver water to Hudspeth Canal is not included in above diversions.

1938:


Diversions:
Franklin
Riverside

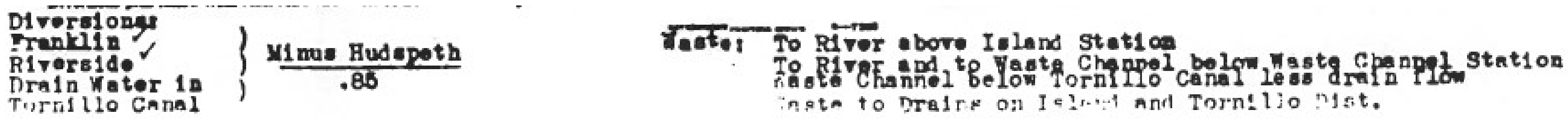
Wasteways:
Ascarate
Riverside 1&2
Island [illegible]
Client to [illegible]
and [illegible]

1939:


Diversion
Riverside)
Franklin)
Plus drain water diverted) Minus Hudspeth

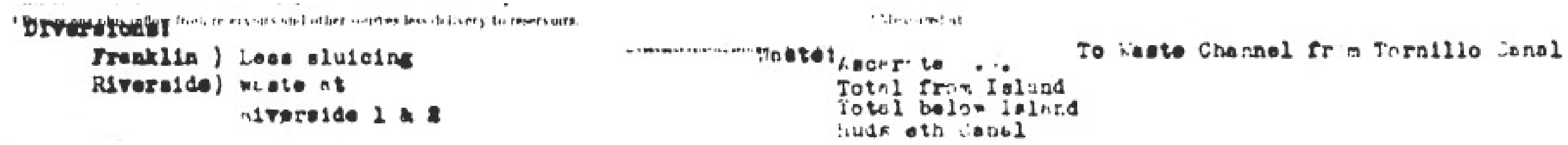
To River and to waste channel below Fabens
Waste channel below Tornillo Canal less dr.flo
Waste to drains on Island and Tornillo Dist.

1940:


Diversions
Franklin ✓)
Riverside ✓) Minus Hudspeth
Drain Water in) .85
Tornillo Canal

Waste: To River above Island Station
To River and to Waste Channel below Waste Channel Station
Waste Channel below Tornillo Canal less drain flow
Waste to Drains on Island and Tornillo Dist.

1941:


¹ Diversions plus inflow from reservoirs and other sources less delivery to reservoirs.
Diversions¹
Franklin) Less sluicing
Riverside) waste at
Riverside 1 & 2

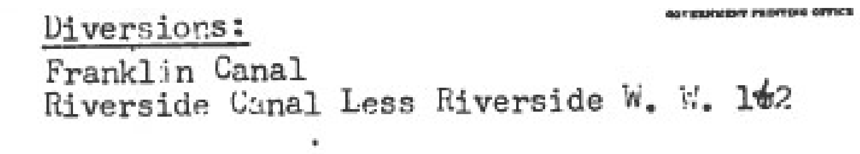
Waste: Ascarate
Total from Island
Total below Island
Hudspeth Canal
To Waste Channel from Tornillo Canal

1942:


¹ Diversions plus inflow from reservoirs and other sources less delivery to reservoirs.
Diversions
Franklin) Less slucing waste at
Riverside) Riverside 1 & 2

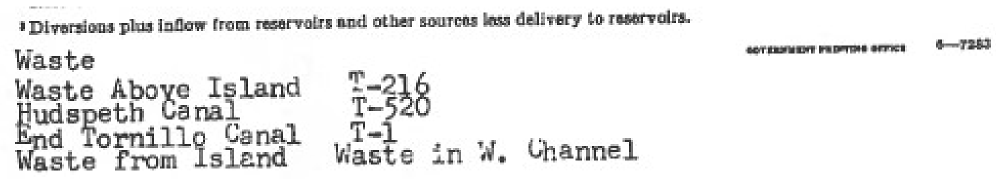
Waste: Ascarate
Total from Island
Total below Island
Hudspeth Canal
To Waste Channel from
Tornillo Canal to drains
above Fabens

1943:

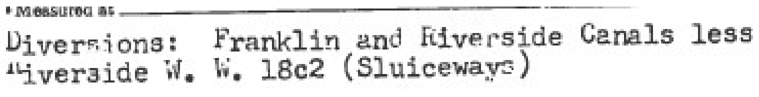


Diversions:
Franklin Canal
Riverside Canal Less Riverside W. W. 1&2

1944:


* Diversions plus inflow from reservoirs and other sources less delivery to reservoirs.

Waste	
Waste Above Island	T-216
Hudspeth Canal	T-520
End Tornillo Canal	T-1
Waste from Island	Waste in W. Channel

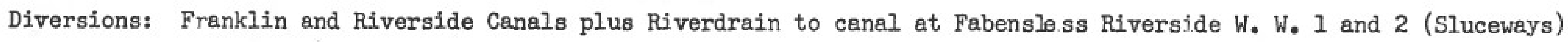

* Measured at

Diversions: Franklin and Riverside Canals less Riverside W. W. 1&2 (Sluiceways)

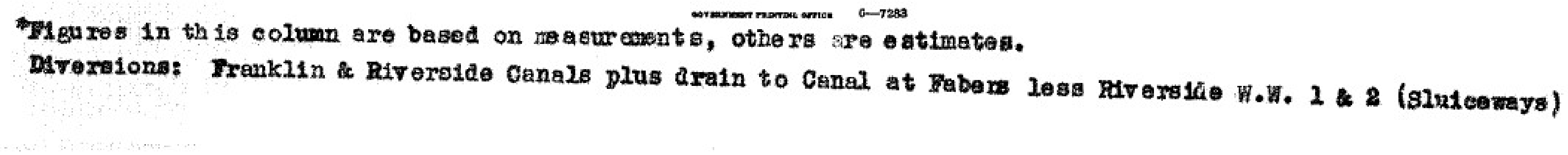
1945:


Diversions: Franklin and Riverside Canals less Riverside W. W. 1&2 (Sluice Ways)

1946:

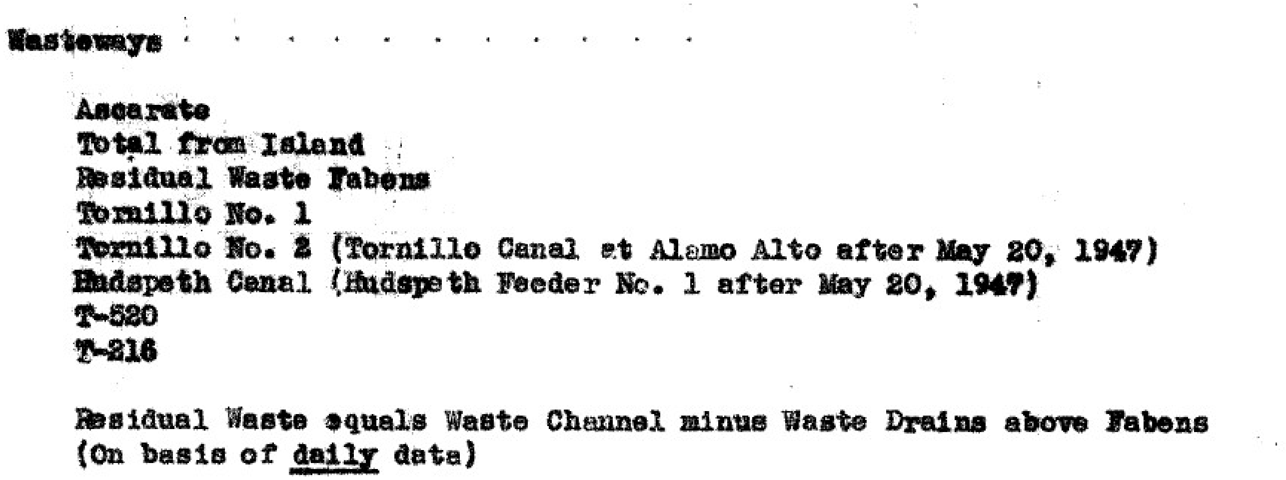

Diversions: Franklin and Riverside Canals plus Riverdrain to canal at Fabens less Riverside W. W. 1 and 2 (Sluceways)

1947:



*Figures in this column are based on measurements, others are estimates.

Diversions: Franklin & Riverside Canals plus drain to Canal at Fabens less Riverside W.W. 1 & 2 (Sluiceways)

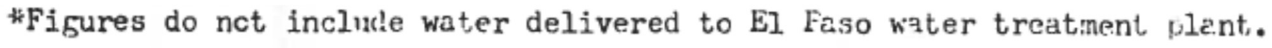


Wasteways . . . .

Ascarate
Total from Island
Residual Waste Fabens
Tornillo No. 1
Tornillo No. 2 (Tornillo Canal at Alamo Alto after May 20, 1947)
Hudspeth Canal (Hudspeth Feeder No. 1 after May 20, 1947)
T-520
T-216

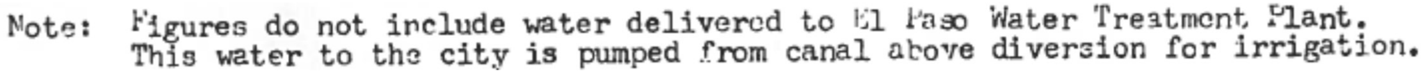
Residual Waste equals Waste Channel minus Waste Drains above Fabens
(On basis of daily data)

1948:



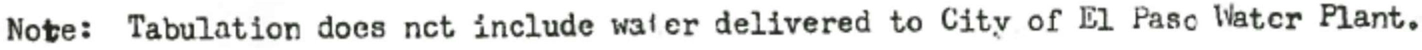
*Figures do not include water delivered to El Paso water treatment plant.

1949:



Note: Figures do not include water delivered to El Paso Water Treatment Plant.
This water to the city is pumped from canal above diversion for irrigation.

1950:



Note: Tabulation does not include water delivered to City of El Paso Water Plant.

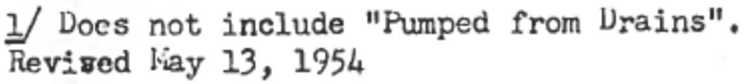
1951:

[1] Diversion amount exclusive of waste at head gates for sand sluicing, etc.
[2] Reservoirs connected with distributing system only.
[3] Diversions plus inflow from reservoirs and other sources less delivery to reservoirs.

[4] Measured at ____________________

NOTE: TABULATION DOES NOT INCLUDE WATER DELIVERED TO CITY OF EL PASO WATER TREATMENT PLANT.
(OVER)

1953:

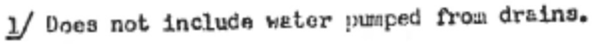


1/ Does not include "Pumped from Drains".
Revised May 13, 1954

1954:

1/ Does not include watdr pumped from drains.

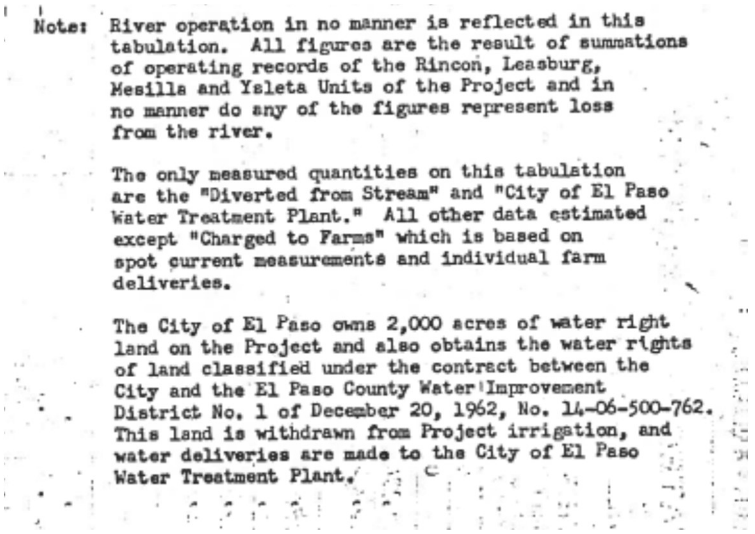
1964:



1/ Does not include water pumped from drains.

1965:

1/ No water pumped from drains during 1965.

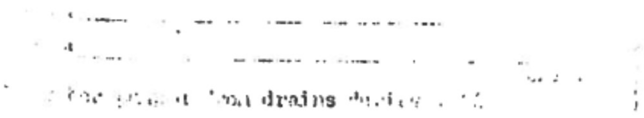


Note: River operation in no manner is reflected in this tabulation. All figures are the result of summations of operating records of the Rincon, Leasburg, Mesilla and Ysleta Units of the Project and in no manner do any of the figures represent loss from the river.

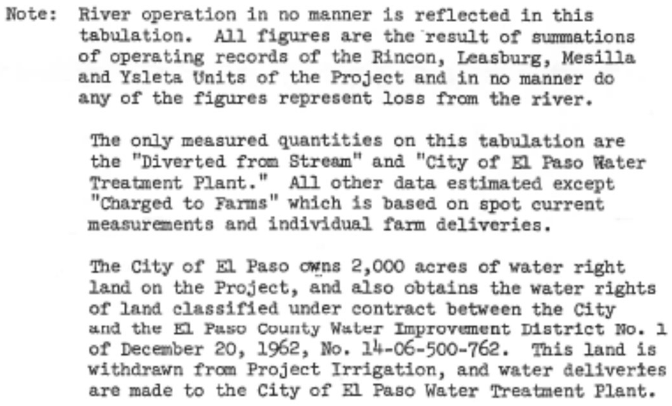
The only measured quantities on this tabulation are the "Diverted from Stream" and "City of El Paso Water Treatment Plant." All other data estimated except "Charged to Farms" which is based on spot current measurements and individual farm deliveries.

The City of El Paso owns 2,000 acres of water right land on the Project and also obtains the water rights of land classified under the contract between the City and the El Paso County Water Improvement District No. 1 of December 20, 1962, No. 14-06-500-762. This land is withdrawn from Project irrigation, and water deliveries are made to the City of El Paso Water Treatment Plant.

1966:



[illegible] drains [illegible]



Note: River operation in no manner is reflected in this tabulation. All figures are the result of summations of operating records of the Rincon, Leasburg, Mesilla and Ysleta Units of the Project and in no manner do any of the figures represent loss from the river.

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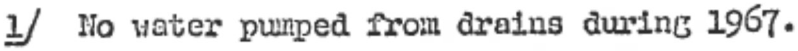
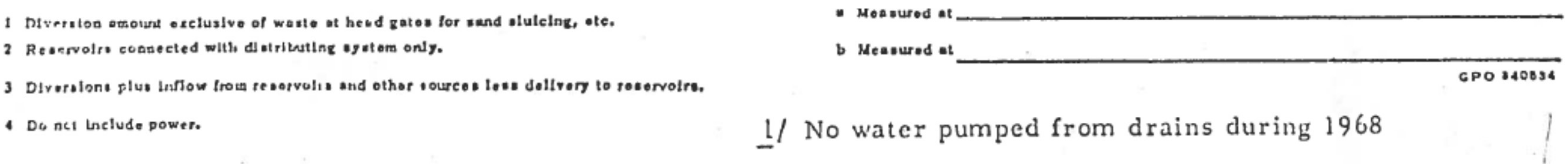
<u>1967:</u>



1/ No water pumped from drains during 1967.

<u>1968:</u>



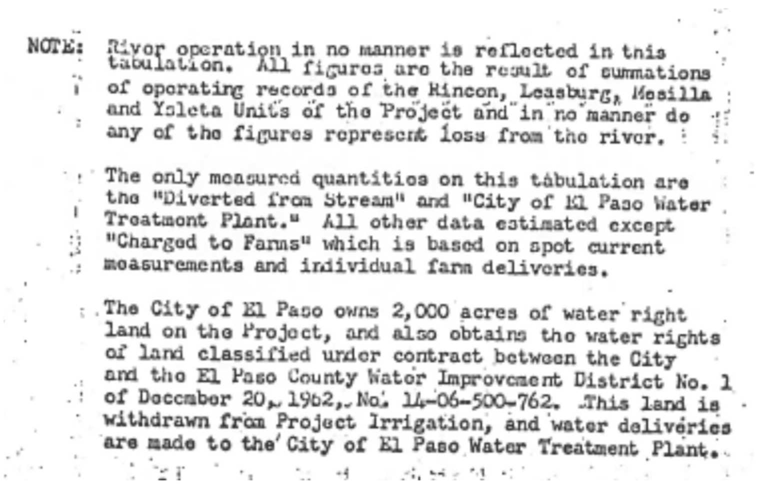
1 Diversion amount exclusive of waste at head gates for sand sluicing, etc.
2 Reservoirs connected with distributing system only.
3 Diversions plus inflow from reservoirs and other sources less delivery to reservoirs.
4 Do not include power.

a Measured at ____________________

b Measured at ____________________

GPO 840834

1/ No water pumped from drains during 1968



NOTE: River operation in no manner is reflected in this tabulation. All figures are the result of summations of operating records of the Rincon, Leasburg, Mesilla and Ysleta Units of the Project and in no manner do any of the figures represent loss from the river.

The only measured quantities on this tabulation are the "Diverted from Stream" and "City of El Paso Water Treatment Plant." All other data estimated except "Charged to Farms" which is based on spot current measurements and individual farm deliveries.

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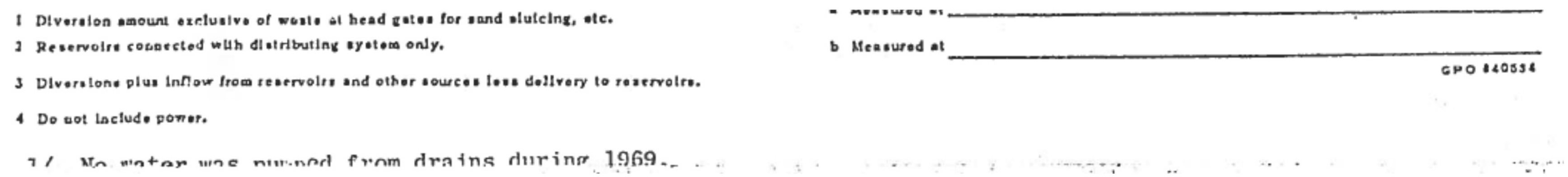
<u>1969:</u>



1 Diversion amount exclusive of waste at head gates for sand sluicing, etc.

2 Reservoirs connected with distributing system only.

3 Diversions plus inflow from reservoirs and other sources less delivery to reservoirs.

4 Do not include power.

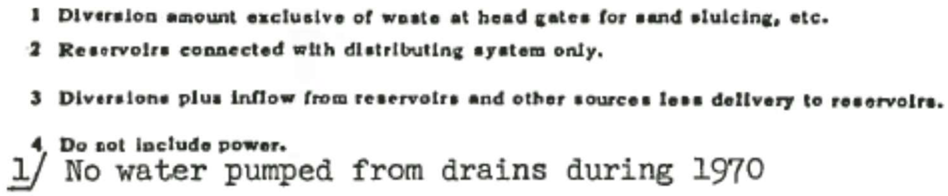
a Measured at ____________________

b Measured at ____________________

GPO 840534

1/ No water was pumped from drains during 1969.

<u>1970:</u>



1 Diversion amount exclusive of waste at head gates for sand sluicing, etc.

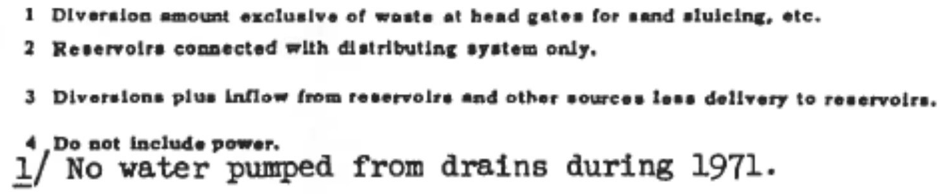
2 Reservoirs connected with distributing system only.

3 Diversions plus inflow from reservoirs and other sources less delivery to reservoirs.

4 Do not include power.

1/ No water pumped from drains during 1970

<u>1971:</u>



1 Diversion amount exclusive of waste at head gates for sand sluicing, etc.

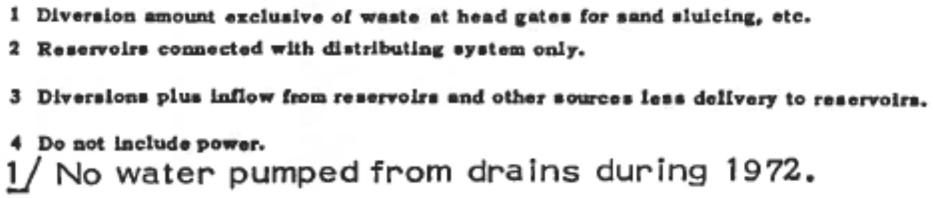
2 Reservoirs connected with distributing system only.

3 Diversions plus inflow from reservoirs and other sources less delivery to reservoirs.

4 Do not include power.

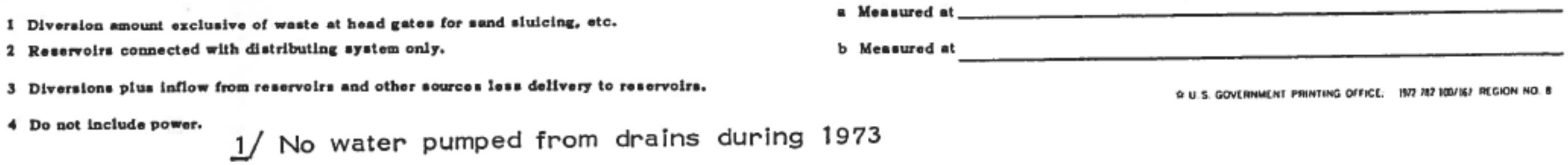
1/ No water pumped from drains during 1971.

1972:



1 Diversion amount exclusive of waste at head gates for sand sluicing, etc.
2 Reservoirs connected with distributing system only.
3 Diversions plus inflow from reservoirs and other sources less delivery to reservoirs.
4 Do not include power.
1/ No water pumped from drains during 1972.

1973:



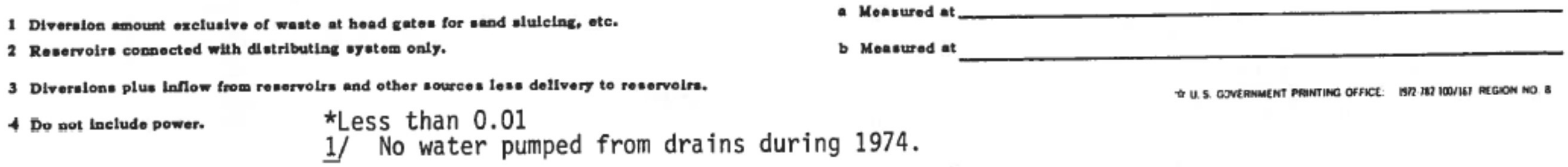
1 Diversion amount exclusive of waste at head gates for sand sluicing, etc.
2 Reservoirs connected with distributing system only.
3 Diversions plus inflow from reservoirs and other sources less delivery to reservoirs.
4 Do not include power.

a Measured at __________
b Measured at __________

☆ U.S. GOVERNMENT PRINTING OFFICE: 1972 782 100/167 REGION NO. 8

1/ No water pumped from drains during 1973

1974:



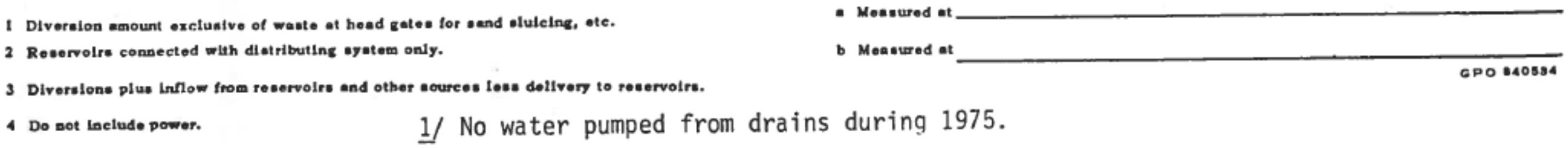
1 Diversion amount exclusive of waste at head gates for sand sluicing, etc.
2 Reservoirs connected with distributing system only.
3 Diversions plus inflow from reservoirs and other sources less delivery to reservoirs.
4 Do not include power.

a Measured at __________
b Measured at __________

☆ U.S. GOVERNMENT PRINTING OFFICE: 1972 782 100/167 REGION NO. 8

*Less than 0.01
1/ No water pumped from drains during 1974.

1975:



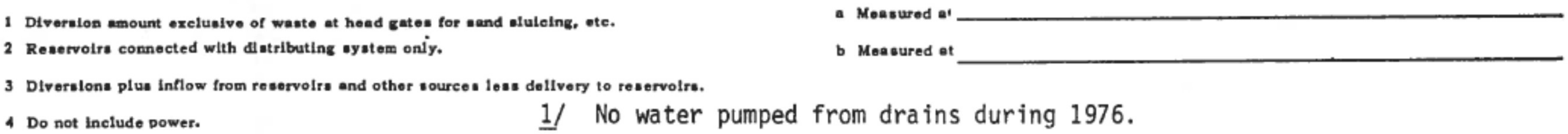
1 Diversion amount exclusive of waste at head gates for sand sluicing, etc.
2 Reservoirs connected with distributing system only.
3 Diversions plus inflow from reservoirs and other sources less delivery to reservoirs.
4 Do not include power.

a Measured at __________
b Measured at __________

GPO 840534

1/ No water pumped from drains during 1975.

1976:

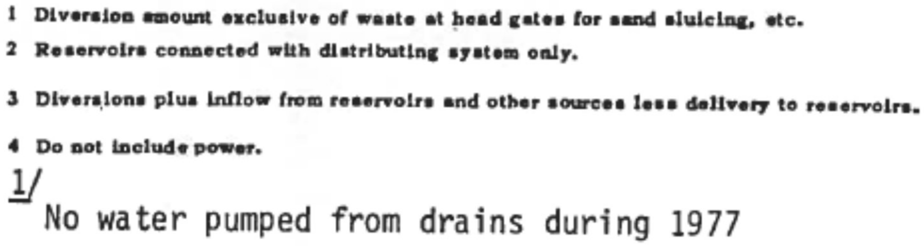


1 Diversion amount exclusive of waste at head gates for sand sluicing, etc.
2 Reservoirs connected with distributing system only.
3 Diversions plus inflow from reservoirs and other sources less delivery to reservoirs.
4 Do not include power.

a Measured at __________
b Measured at __________

1/ No water pumped from drains during 1976.

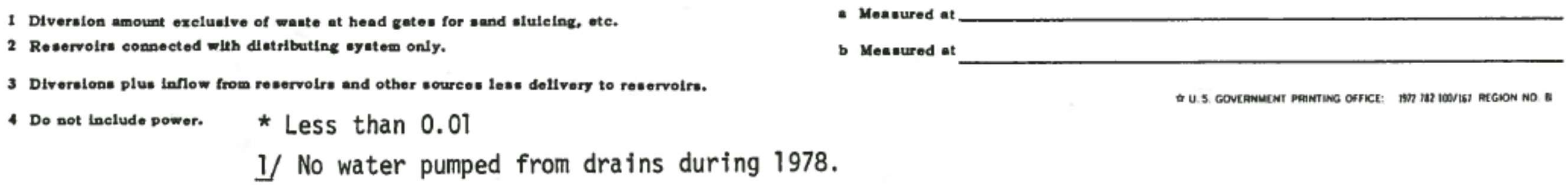
<u>1977:</u>



1 Diversion amount exclusive of waste at head gates for sand sluicing, etc.
2 Reservoirs connected with distributing system only.
3 Diversions plus inflow from reservoirs and other sources less delivery to reservoirs.
4 Do not include power.

1/ No water pumped from drains during 1977

<u>1978:</u>



1 Diversion amount exclusive of waste at head gates for sand sluicing, etc.
2 Reservoirs connected with distributing system only.
3 Diversions plus inflow from reservoirs and other sources less delivery to reservoirs.
4 Do not include power.

a Measured at __________
b Measured at __________

☆ U.S. GOVERNMENT PRINTING OFFICE: 1977 782 100/167 REGION NO. 8

* Less than 0.01

1/ No water pumped from drains during 1978.

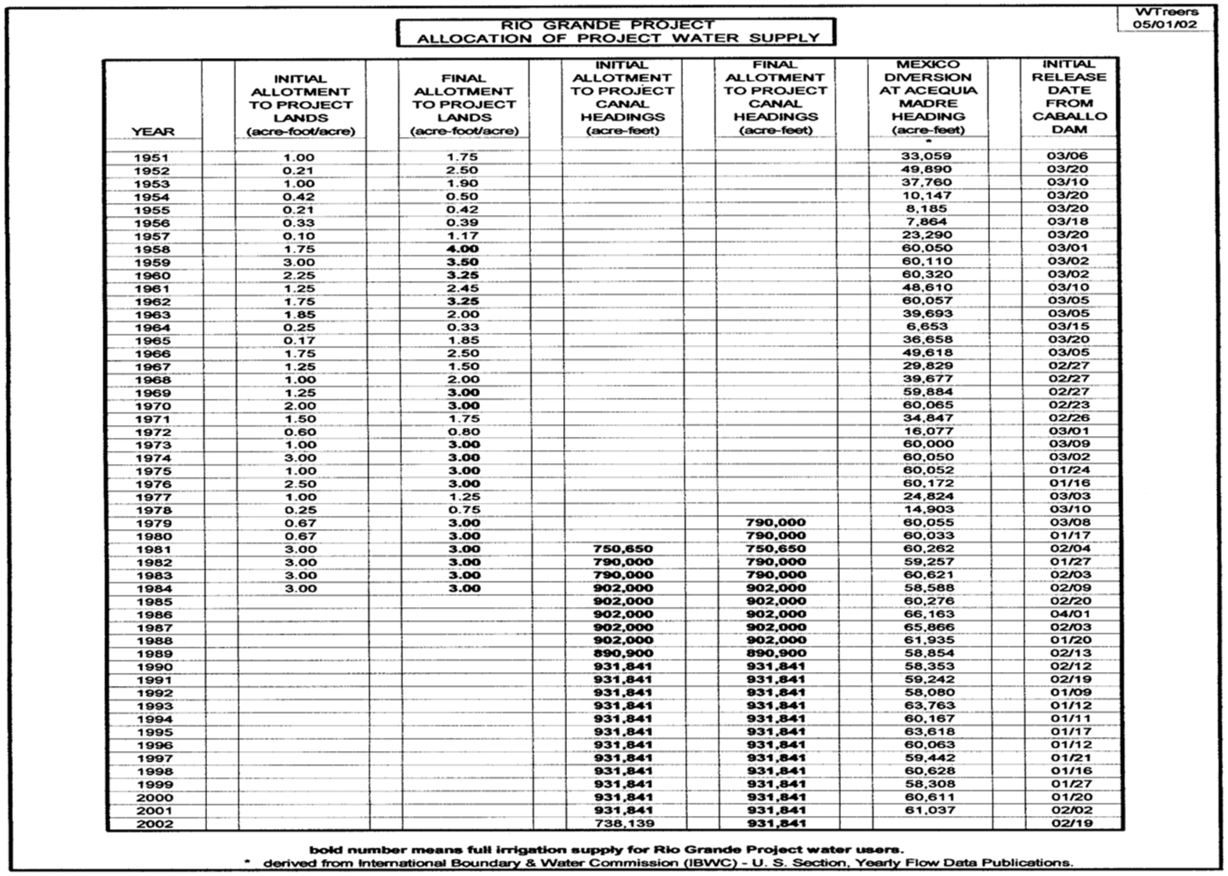
There are no notes for the years not listed (1918, 1922, 1924 – 1930, 1932, 1935 – 1936, 1952, and 1955 – 1963).

Appendix 4C

Example Allotment and Allocation Records

Various Years 1951 – 2015

from US BOR Presentation TCEQ_BOR_121103.ppt, obtained from Bert Cortez in 2004



WTreers
05/01/02

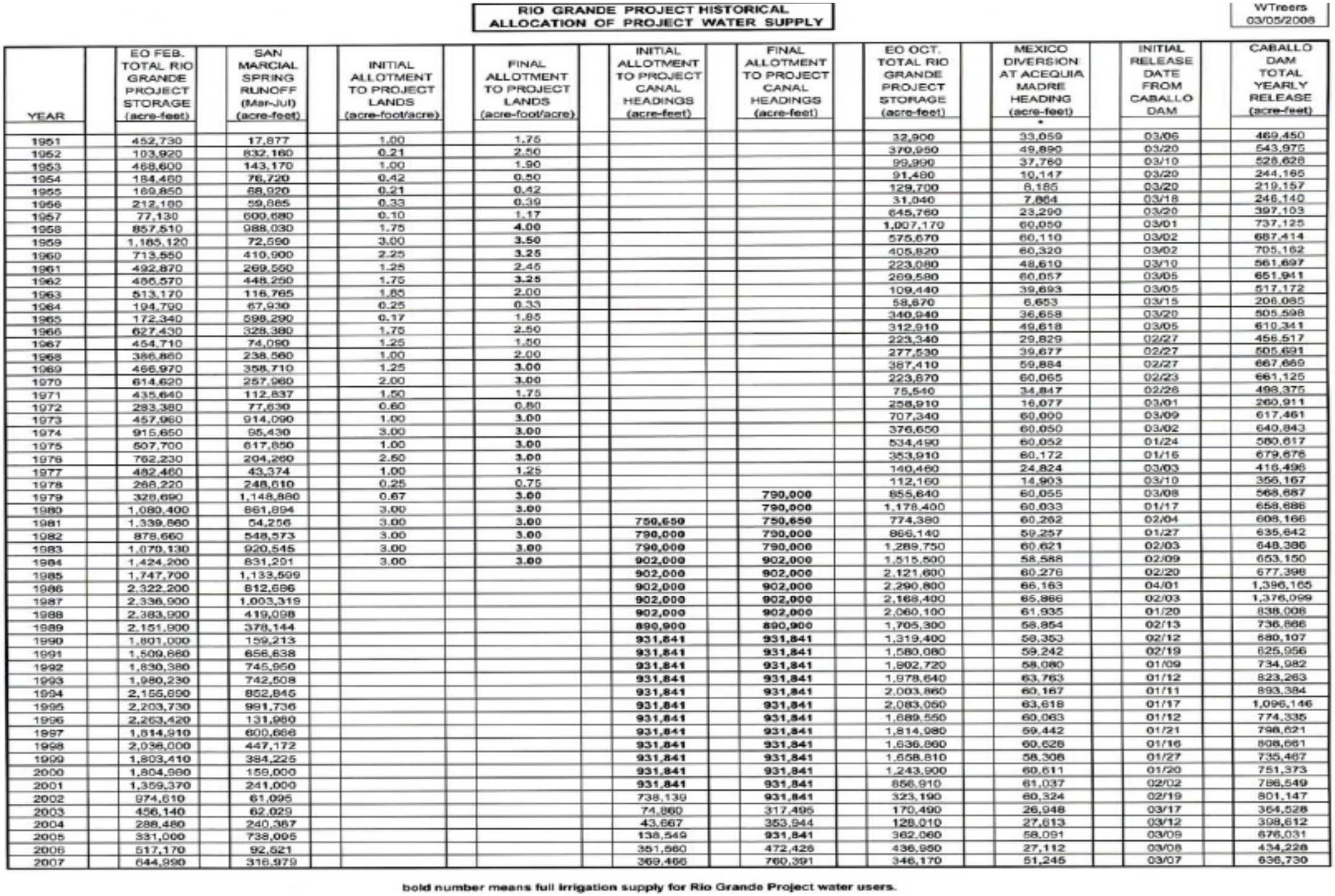
RIO GRANDE PROJECT
ALLOCATION OF PROJECT WATER SUPPLY

YEAR	INITIAL ALLOTMENT TO PROJECT LANDS (acre-foot/acre)	FINAL ALLOTMENT TO PROJECT LANDS (acre-foot/acre)	INITIAL ALLOTMENT TO PROJECT CANAL HEADINGS (acre-feet)	FINAL ALLOTMENT TO PROJECT CANAL HEADINGS (acre-feet)	MEXICO DIVERSION AT ACEQUIA MADRE HEADING (acre-feet) *	INITIAL RELEASE DATE FROM CABALLO DAM
1951	1.00	1.75			33,059	03/06
1952	0.21	2.50			49,890	03/20
1953	1.00	1.90			37,760	03/10
1954	0.42	0.50			10,147	03/20
1955	0.21	0.42			8,185	03/20
1956	0.33	0.39			7,864	03/18
1957	0.10	1.17			23,290	03/20
1958	1.75	**4.00**			60,050	03/01
1959	3.00	**3.50**			60,110	03/02
1960	2.25	**3.25**			60,320	03/02
1961	1.25	2.45			48,610	03/10
1962	1.75	**3.25**			60,057	03/05
1963	1.85	2.00			39,693	03/05
1964	0.25	0.33			6,653	03/15
1965	0.17	1.85			36,658	03/20
1966	1.75	2.50			49,618	03/05
1967	1.25	1.50			29,829	02/27
1968	1.00	2.00			39,677	02/27
1969	1.25	**3.00**			59,884	02/27
1970	2.00	**3.00**			60,065	02/23
1971	1.50	1.75			34,847	02/26
1972	0.60	0.80			16,077	03/01
1973	1.00	**3.00**			60,000	03/09
1974	3.00	**3.00**			60,050	03/02
1975	1.00	**3.00**			60,052	01/24
1976	2.50	**3.00**			60,172	01/16
1977	1.00	1.25			24,824	03/03
1978	0.25	0.75			14,903	03/10
1979	0.67	**3.00**		**790,000**	60,055	03/08
1980	0.67	**3.00**		**790,000**	60,033	01/17
1981	3.00	**3.00**	**750,650**	**750,650**	60,262	02/04
1982	3.00	**3.00**	**790,000**	**790,000**	59,257	01/27
1983	3.00	**3.00**	**790,000**	**790,000**	60,621	02/03
1984	3.00	**3.00**	**902,000**	**902,000**	58,588	02/09
1985			**902,000**	**902,000**	60,276	02/20
1986			**902,000**	**902,000**	66,163	04/01
1987			**902,000**	**902,000**	65,866	02/03
1988			**902,000**	**902,000**	61,935	01/20
1989			**890,900**	**890,900**	58,854	02/13
1990			**931,841**	**931,841**	58,353	02/12
1991			**931,841**	**931,841**	59,242	02/19
1992			**931,841**	**931,841**	58,080	01/09
1993			**931,841**	**931,841**	63,763	01/12
1994			**931,841**	**931,841**	60,167	01/11
1995			**931,841**	**931,841**	63,618	01/17
1996			**931,841**	**931,841**	60,063	01/12
1997			**931,841**	**931,841**	59,442	01/21
1998			**931,841**	**931,841**	60,628	01/16
1999			**931,841**	**931,841**	58,308	01/27
2000			**931,841**	**931,841**	60,611	01/20
2001			**931,841**	**931,841**	61,037	02/02
2002			738,139	**931,841**		02/19

bold number means full irrigation supply for Rio Grande Project water users.

* derived from International Boundary & Water Commission (IBWC) - U. S. Section, Yearly Flow Data Publications.

From US BOR Presentation mtg_200902Mexico_IBWC_EBID_EP1.pdf page 50



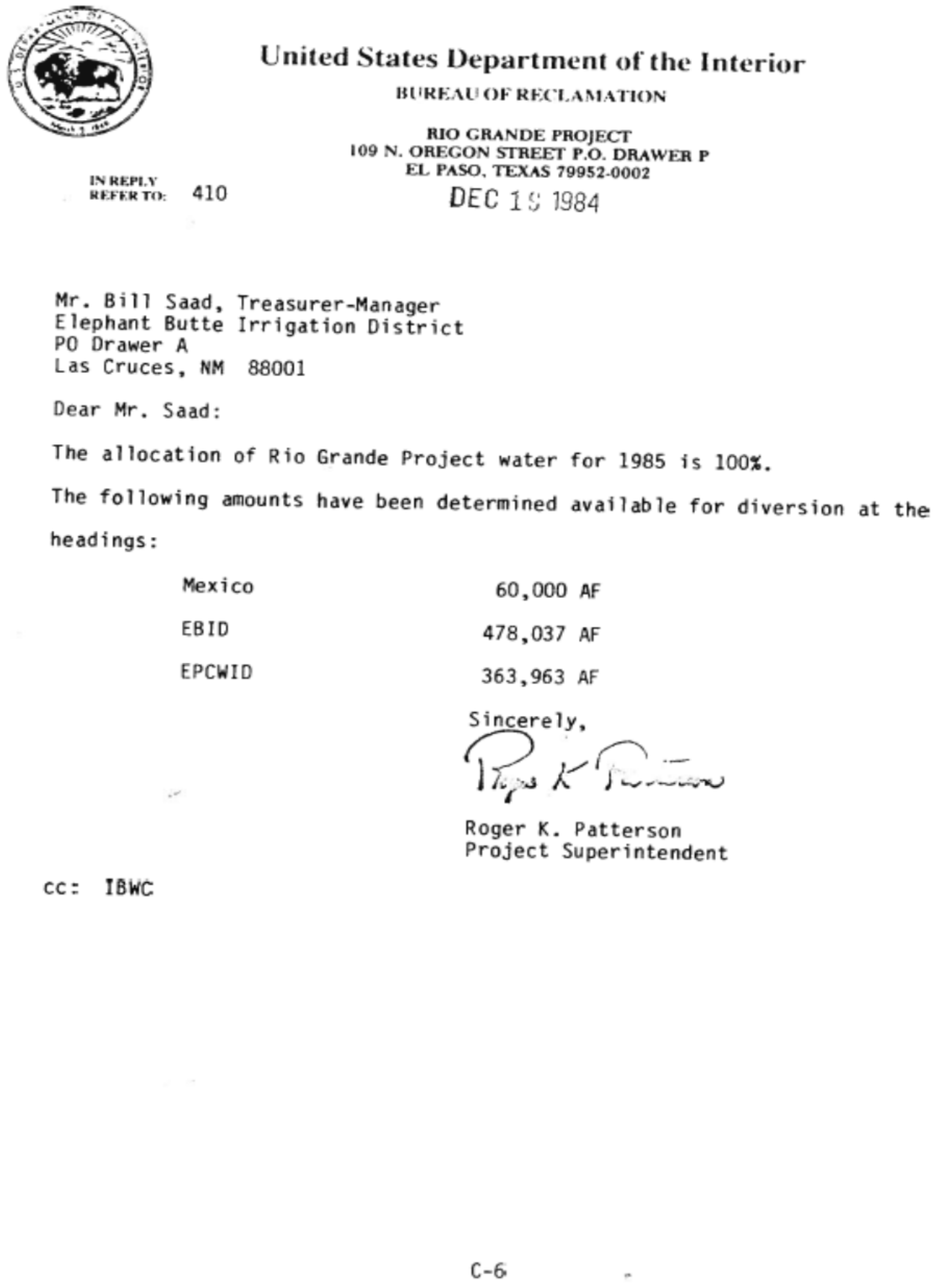
RIO GRANDE PROJECT HISTORICAL ALLOCATION OF PROJECT WATER SUPPLY

WTreers
03/05/2008

YEAR	EO FEB. TOTAL RIO GRANDE PROJECT STORAGE (acre-feet)	SAN MARCIAL SPRING RUNOFF (Mar-Jul) (acre-feet)	INITIAL ALLOTMENT TO PROJECT LANDS (acre-foot/acre)	FINAL ALLOTMENT TO PROJECT LANDS (acre-foot/acre)	INITIAL ALLOTMENT TO PROJECT CANAL HEADINGS (acre-feet)	FINAL ALLOTMENT TO PROJECT CANAL HEADINGS (acre-feet)	EO OCT. TOTAL RIO GRANDE PROJECT STORAGE (acre-feet)	MEXICO DIVERSION AT ACEQUIA MADRE HEADING (acre-feet) *	INITIAL RELEASE DATE FROM CABALLO DAM	CABALLO DAM TOTAL YEARLY RELEASE (acre-feet)
1951	452,730	17,877	1.00	1.75			32,900	33,059	03/06	469,450
1952	103,920	832,160	0.21	2.50			370,950	49,890	03/20	543,975
1953	468,600	143,170	1.00	1.90			99,990	37,760	03/10	528,628
1954	184,460	76,720	0.42	0.50			91,480	10,147	03/20	244,165
1955	169,850	68,920	0.21	0.42			129,700	8,185	03/20	219,157
1956	212,180	59,885	0.33	0.39			31,040	7,864	03/18	246,140
1957	77,130	600,680	0.10	1.17			645,760	23,290	03/20	397,103
1958	857,510	988,030	1.75	**4.00**			1,007,170	60,050	03/01	737,125
1959	1,185,120	72,590	3.00	**3.50**			575,670	60,110	03/02	687,414
1960	713,550	410,900	2.25	**3.25**			405,820	60,320	03/02	705,162
1961	492,870	269,550	1.25	2.45			223,080	48,610	03/10	561,697
1962	486,570	448,250	1.75	**3.25**			269,580	60,057	03/05	651,941
1963	513,170	116,765	1.85	2.00			109,440	39,693	03/05	517,172
1964	194,790	67,930	0.25	0.33			58,670	6,653	03/15	206,085
1965	172,340	598,290	0.17	1.85			340,940	36,658	03/20	505,598
1966	627,430	328,380	1.75	2.50			312,910	49,618	03/05	610,341
1967	454,710	74,090	1.25	1.50			223,340	29,829	02/27	456,517
1968	386,860	238,560	1.00	2.00			277,530	39,677	02/27	505,691
1969	466,970	358,710	1.25	**3.00**			387,410	59,884	02/27	667,669
1970	614,620	257,960	2.00	**3.00**			223,870	60,065	02/23	661,125
1971	435,640	112,837	1.50	1.75			75,540	34,847	02/26	498,375
1972	283,380	77,630	0.60	0.80			258,910	16,077	03/01	260,911
1973	457,960	914,090	1.00	**3.00**			707,340	60,000	03/09	617,461
1974	915,650	95,430	3.00	**3.00**			376,650	60,050	03/02	640,843
1975	507,700	617,850	1.00	**3.00**			534,490	60,052	01/24	580,617
1976	762,230	204,260	2.60	**3.00**			353,910	60,172	01/16	679,676
1977	482,460	43,374	1.00	1.25			140,460	24,824	03/03	416,496
1978	268,220	248,610	0.25	0.75			112,160	14,903	03/10	356,167
1979	328,690	1,148,880	0.67	**3.00**		**790,000**	855,640	60,055	03/08	568,687
1980	1,080,400	861,894	3.00	**3.00**		**790,000**	1,178,400	60,033	01/17	658,686
1981	1,339,860	54,256	3.00	**3.00**	**750,650**	**750,650**	774,380	60,262	02/04	608,166
1982	878,660	548,573	3.00	**3.00**	**790,000**	**790,000**	866,140	59,257	01/27	635,642
1983	1,070,130	920,545	3.00	**3.00**	**790,000**	**790,000**	1,289,750	60,621	02/03	648,386
1984	1,424,200	831,291	3.00	**3.00**	**902,000**	**902,000**	1,515,500	58,588	02/09	653,150
1985	1,747,700	1,133,599			**902,000**	**902,000**	2,121,600	60,276	02/20	677,398
1986	2,322,200	812,686			**902,000**	**902,000**	2,290,800	66,163	04/01	1,396,165
1987	2,336,900	1,003,319			**902,000**	**902,000**	2,168,400	65,866	02/03	1,376,099
1988	2,383,900	419,098			**902,000**	**902,000**	2,060,100	61,935	01/20	838,008
1989	2,151,900	378,144			**890,900**	**890,900**	1,705,300	58,854	02/13	736,866
1990	1,801,000	159,213			**931,841**	**931,841**	1,319,400	58,353	02/12	680,107
1991	1,509,680	656,638			**931,841**	**931,841**	1,580,080	59,242	02/19	625,956
1992	1,830,380	745,950			**931,841**	**931,841**	1,802,720	58,080	01/09	734,982
1993	1,980,230	742,508			**931,841**	**931,841**	1,978,640	63,763	01/12	823,263
1994	2,155,690	852,845			**931,841**	**931,841**	2,003,860	60,167	01/11	893,384
1995	2,203,730	991,736			**931,841**	**931,841**	2,083,050	63,618	01/17	1,096,146
1996	2,263,420	131,980			**931,841**	**931,841**	1,689,550	60,063	01/12	774,335
1997	1,814,910	600,686			**931,841**	**931,841**	1,814,980	59,442	01/21	798,621
1998	2,036,000	447,172			**931,841**	**931,841**	1,636,860	60,628	01/16	808,661
1999	1,803,410	384,225			**931,841**	**931,841**	1,658,810	58,308	01/27	735,467
2000	1,804,980	159,000			**931,841**	**931,841**	1,243,900	60,611	01/20	751,373
2001	1,359,370	241,000			**931,841**	**931,841**	856,910	61,037	02/02	786,549
2002	974,610	61,095			738,139	**931,841**	323,190	60,324	02/19	801,147
2003	456,140	62,029			74,860	317,495	170,490	26,948	03/17	364,528
2004	288,480	240,387			43,667	353,944	128,010	27,613	03/12	398,612
2005	331,000	738,095			138,549	**931,841**	382,060	58,091	03/09	676,031
2006	517,170	92,621			351,660	472,426	436,950	27,112	03/08	434,228
2007	644,990	316,979			369,466	760,391	346,170	51,245	03/07	636,730

bold number means full irrigation supply for Rio Grande Project water users.

From USBR "Annual Operating Plan 1984 Operations, 1985 Outlook"



United States Department of the Interior
BUREAU OF RECLAMATION

RIO GRANDE PROJECT
109 N. OREGON STREET P.O. DRAWER P
EL PASO, TEXAS 79952-0002

IN REPLY
REFER TO: 410

DEC 19 1984

Mr. Bill Saad, Treasurer-Manager
Elephant Butte Irrigation District
PO Drawer A
Las Cruces, NM 88001

Dear Mr. Saad:

The allocation of Rio Grande Project water for 1985 is 100%.

The following amounts have been determined available for diversion at the headings:

Mexico	60,000 AF
EBID	478,037 AF
EPCWID	363,963 AF

Sincerely,

Roger K. Patterson
Project Superintendent

cc: IBWC

D. Crop Production and Water Utilization

1. Project

a. The initial release of water from Caballo Reservoir for the irrigation season was made on February 9, 1984. A full allotment of 902,000 AF was declared available for Mexico and the U.S. Districts on February 4, 1984. A total amount of 653,153 AF was released from storage during 1984 to satisfy water user orders. A gross amount of 761,141 AF was delivered at the diversion points within the project. The Caballo Dam was closed on October 3, 1984 ending the irrigation season.

b. Of the 159,650 acres of water right land for the U.S. Districts, 90,640 acres are allocated to the EBID and 69,010 acres are allocated to the EPCWID. A total acreage of 126,395 acres were in production for an overall crop value of $111,679,417. An average crop value for all crops grown by the U.S. Districts amounted to $884 per acre. (Crop value information is from preliminary data.)

2. EBID

a. Of the EBID 90,640 acres of water right land, 79,201 acres were irrigated during 1984. The district had 1305 full time and 1071 part time farms operating during the year. The district utilized a gross total of 411,128 AF of their allocated 478,037 AF of irrigation water during the year.

b. Crop production realized in the Rincon and Mesilla Valleys, for all crops, amounted to $81,121,835 (estimated), not including multiple crops. The average crop value was $1,024 per acre.

From USBR "Annual Operating Plan 1984 Operations, 1985 Outlook"

c. The major crops grown in Rincon and Mesilla Valley were:

(1) Vegetables (17,260 acres) (peppers, onions and lettuce)	$40,908,329
(2) Pecans (13,160 acres)	$17,849,734
(3) Forage (24,355 acres) (alfalfa and silage)	$11,973,014
(4) Field Crops (18,510 acres) (cotton)	$ 9,789,041 (Estimate)

3. <u>EPCWID</u>

a. Of the 69,010 acres of water right land, 47,194 acres were irrigated during 1984. The district had 705 full time and 1202 part time farms operating during the year. The district utilized a gross total of 289,976 AF of their allocated 363,963 AF of irrigation water during 1984.

b. Crop production realized in the El Paso Valley and Upper Valley (Texas), for all crops, amounted to $30,557,582 not including multiple crops. The average crop value was $647 per acre.

c. The major crops grown were:

(1) Field crops (23,105 acres) (cotton)	$17,514,415
(2) Pecans (5,031 acres)	4,851,142
(3) Forage (11,003 acres) (alfalfa, pasture and silage)	4,168,411
(4) Cereals (10,082 acres) (wheat, sorghums, oats, corn and barley)	3,640,520

mtg_200709Mexico_IBWC_EBID_EP1.pdf

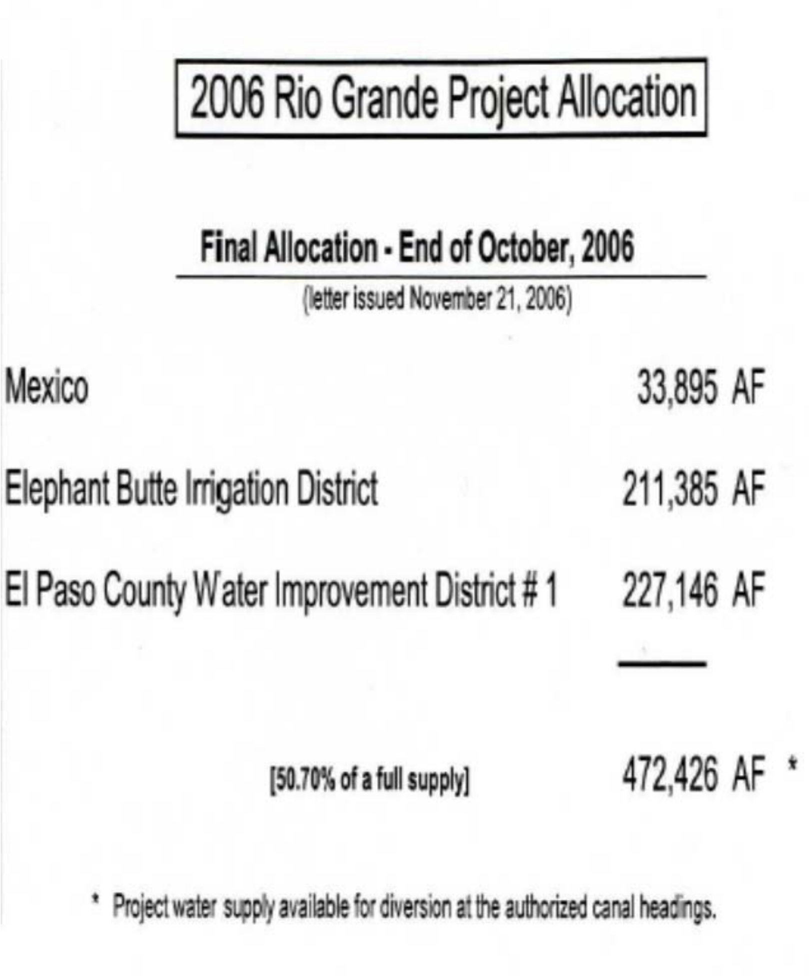
2007 Rio Grande Project Allocation

Updated Allocation - End of August, 2007

(letter issued September 18, 2007)

Mexico	58,769 AF
Elephant Butte Irrigation District	311,517 AF
El Paso County Water Improvement District # 1	390,105 AF
[81.60% of a full supply]	760,391 AF *

* Project water supply available for diversion at the authorized canal headings.



2006 Rio Grande Project Allocation

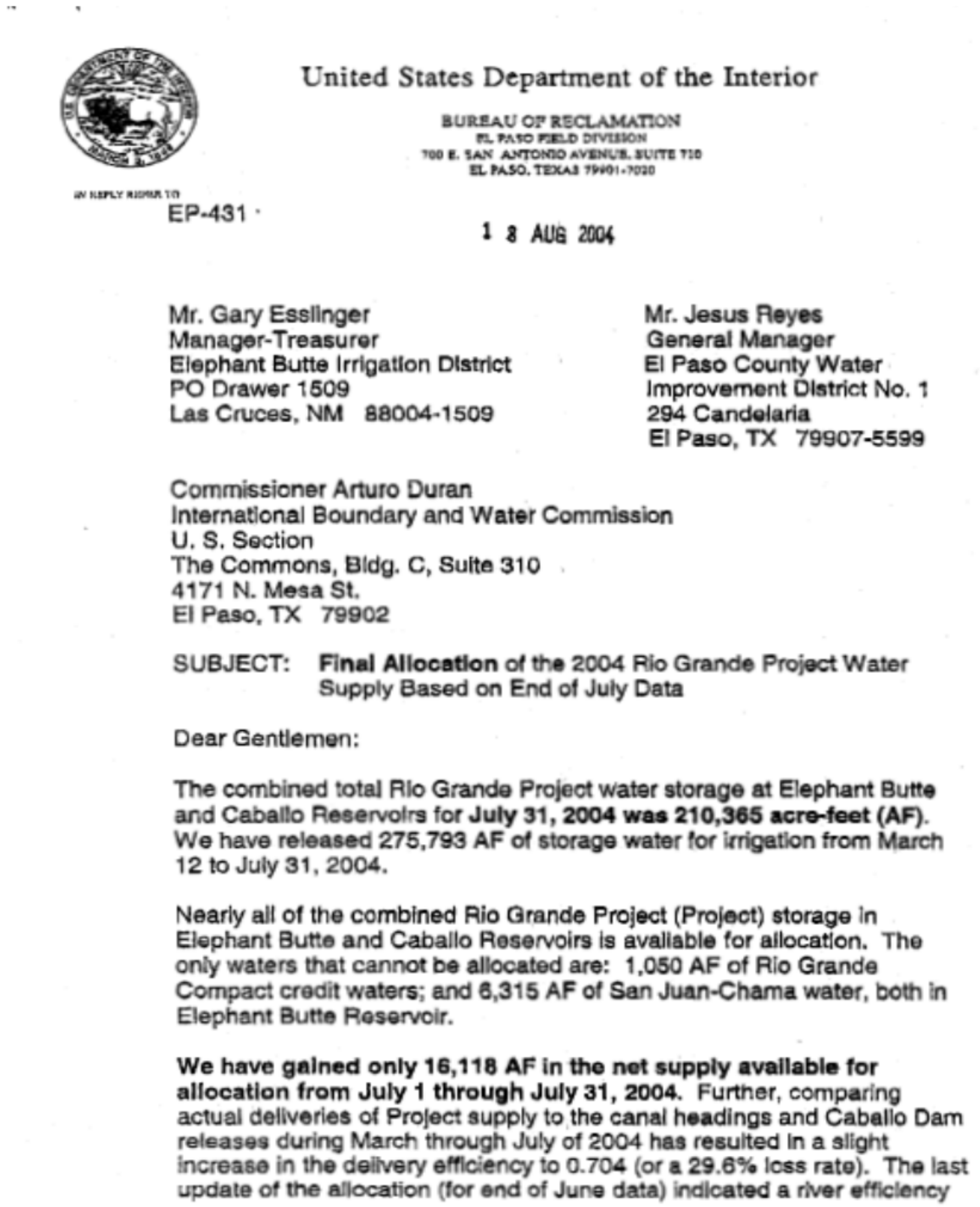
Final Allocation - End of October, 2006

(letter issued November 21, 2006)

Mexico	33,895 AF
Elephant Butte Irrigation District	211,385 AF
El Paso County Water Improvement District # 1	227,146 AF
[50.70% of a full supply]	472,426 AF *

* Project water supply available for diversion at the authorized canal headings.

2004 Allocation Letter



United States Department of the Interior

BUREAU OF RECLAMATION
EL PASO FIELD DIVISION
700 E. SAN ANTONIO AVENUE, SUITE 710
EL PASO, TEXAS 79901-7020

IN REPLY REFER TO:
EP-431

18 AUG 2004

Mr. Gary Esslinger
Manager-Treasurer
Elephant Butte Irrigation District
PO Drawer 1509
Las Cruces, NM 88004-1509

Mr. Jesus Reyes
General Manager
El Paso County Water
Improvement District No. 1
294 Candelaria
El Paso, TX 79907-5599

Commissioner Arturo Duran
International Boundary and Water Commission
U. S. Section
The Commons, Bldg. C, Suite 310
4171 N. Mesa St.
El Paso, TX 79902

SUBJECT: **Final Allocation** of the 2004 Rio Grande Project Water Supply Based on End of July Data

Dear Gentlemen:

The combined total Rio Grande Project water storage at Elephant Butte and Caballo Reservoirs for **July 31, 2004 was 210,365 acre-feet (AF).** We have released 275,793 AF of storage water for irrigation from March 12 to July 31, 2004.

Nearly all of the combined Rio Grande Project (Project) storage in Elephant Butte and Caballo Reservoirs is available for allocation. The only waters that cannot be allocated are: 1,050 AF of Rio Grande Compact credit waters; and 6,315 AF of San Juan-Chama water, both in Elephant Butte Reservoir.

We have gained only 16,118 AF in the net supply available for allocation from July 1 through July 31, 2004. Further, comparing actual deliveries of Project supply to the canal headings and Caballo Dam releases during March through July of 2004 has resulted in a slight increase in the delivery efficiency to 0.704 (or a 29.6% loss rate). The last update of the allocation (for end of June data) indicated a river efficiency of 0.6875 (31.25% losses). The river losses for the present net supply available for allocation have decreased by 2,852 AF since last month's allocation update. However, this decrease in river losses (2,852 AF) and increase in net supply (16,118 AF) totaling 18,970 AF still is less than the increase in river losses last month (44,537 AF). Therefore, Reclamation will not increase the allocation due to continuing decreased river efficiency of delivering Project supply to the Project canal headings. As agreed in our meeting with Elephant Butte Irrigation District, El Paso County Water Improvement District No. 1, the International Boundary & Water Commission, and Mexico on July 30, 2004, **Reclamation declares the allocation of last month's update as the final allocation for the 2004 irrigation season**. The following is the final allocation:

ACRE-FEET

Mexico	27,197
Elephant Butte Irrigation District	185,507
El Paso County Water Improvement District No. 1	141,240
TOTAL:	353,944

This final allocation represents only 37.98% of a full irrigation season supply for the entire Project. Last month's updated allocation was the same.

Please find enclosed:

- Enclosure No. 1 which summarizes modifications in the allocation procedures.
- Enclosure No. 2 which provides the details of the calculations for this month's allocation.
- Enclosure No. 3 which details the estimated Rio Grande Compact credit waters and San Juan-Chama water, both in Elephant Butte Reservoir.
- Enclosure No. 4 which summarizes the 2004 allocations to date.

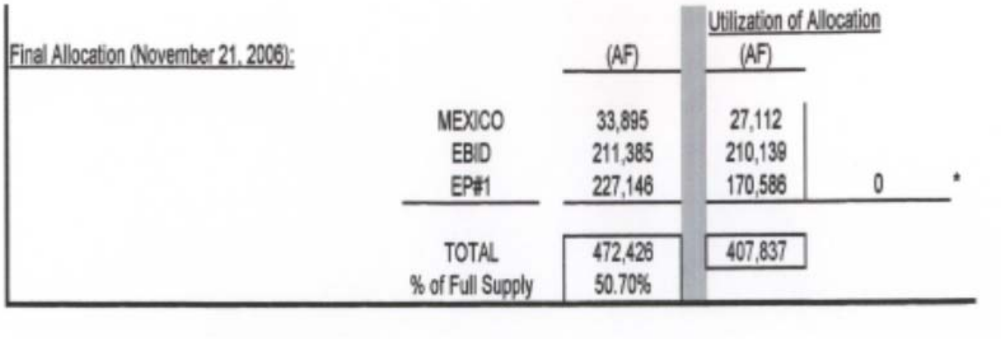
Actual provisional flow data at the San Marcial gauging stations indicate that the flow for the 2004 spring runoff (March – July) was approximately 240,390 AF (41.95% of the 30-year average flow). Since 1996, we have now had 8 years with below normal runoff into Elephant Butte Reservoir. The only year with above normal runoff was 1997. Enclosed is Reclamation's latest Project reservoirs operational plan with projections of the reservoirs' storage levels for the remainder of 2004. Elephant Butte Reservoir's low point is projected to be 48,450 AF on September 29th. See Enclosure No. 5.

Sincerely,

Norma A. Sosa
for Filiberto Cortez
Manager, El Paso Field Division

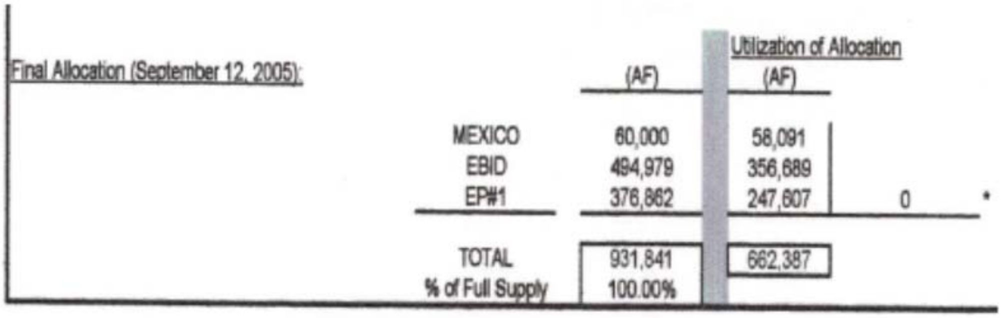
Enclosures (5)

mtg_200709Mexico_IBWC_EBID_EP1.pdf



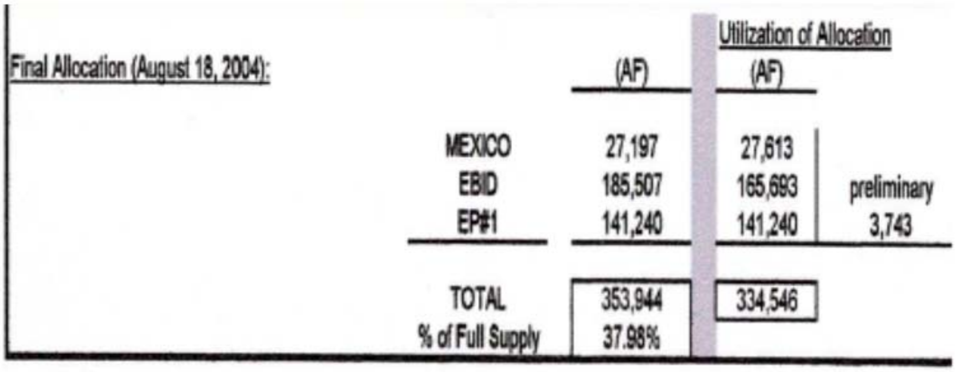
Final Allocation (November 21, 2006):

	(AF)	Utilization of Allocation (AF)	
MEXICO	33,895	27,112	
EBID	211,385	210,139	
EP#1	227,146	170,586	0 *
TOTAL	472,426	407,837	
% of Full Supply	50.70%		



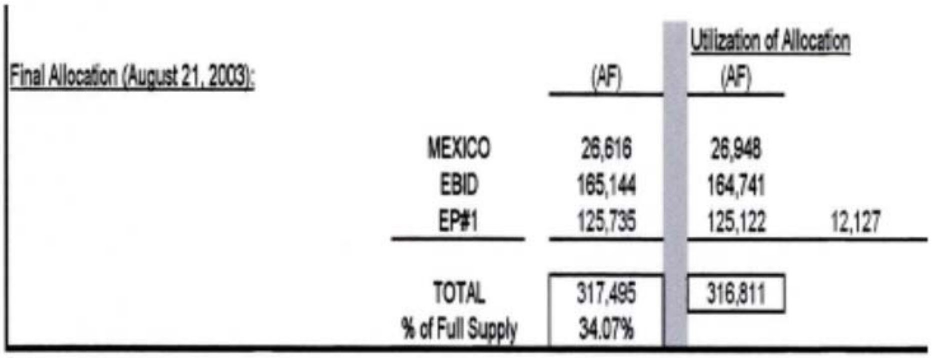
Final Allocation (September 12, 2005):

	(AF)	Utilization of Allocation (AF)	
MEXICO	60,000	58,091	
EBID	494,979	356,689	
EP#1	376,862	247,607	0 *
TOTAL	931,841	662,387	
% of Full Supply	100.00%		



Final Allocation (August 18, 2004):

	(AF)	Utilization of Allocation (AF)	
MEXICO	27,197	27,613	
EBID	185,507	165,693	preliminary
EP#1	141,240	141,240	3,743
TOTAL	353,944	334,546	
% of Full Supply	37.98%		



Final Allocation (August 21, 2003):

	(AF)	Utilization of Allocation (AF)	
MEXICO	26,616	26,948	
EBID	165,144	164,741	
EP#1	125,735	125,122	12,127
TOTAL	317,495	316,811	
% of Full Supply	34.07%		

1	Rio Grande Project Allocation for 2015 (Data as of June 30, 2015)	ac-ft	
2	Elephant Butte Reservoir Storage	342,023	^
3	Caballo Reservoir Storage	17,310	^
4	Total Rio Grande Project Storage	359,333	
5	Estimated Rio Grande Compact Credit Waters	-15,760	*
6	Estimated San Juan-Chama Water	-3,363	**
7	Water Released from Storage	175,756	
8	Total Usable Water Available for Release	515,966	
9	Carryover Obligation using Estimated Diversion Ratio	15,530	
10	Estimate End-of-Season Adjustment of Project Water for Reservoir Evaporation/Dead storage	-15,000	/
11	Total Usable Water Available for Current Year Allocation	485,436	
12	EBID Allocation Balance (Previous Year)	8,652	-
13	EPCWID Allocation Balance (Previous Year)	2,685	-
14	EBID Allocation Balance (End-of-Year)	0	
15	EPCWID Allocation Balance (End-of-Year)	0	
16	Storage for EBID and EPCWID Allocation Balance (End-of-Year)	0	
17	Current Usable Water	500,966	
18	End-of-Year Release for Diversion Ratio	500,966	
19	D1 Delivery	311,540	
20	Mexico's Current Diversion Allocation	35,355	
21	Multiyear Extreme Drought D2 Correction Factor	0.83	//
22	Gross D2 Diversion Allocation	464,340	
23	EPCWID ACE Conservation Credit (evaluation postponed until EOY)	0	
24	Net D2 Current Year Diversion Allocation for EBID and EPCWID	428,985	
25	D2 Current Year Diversion Allocation for EPCWID	185,432	
26	Total EPCWID Diversion Allocation (w/o Conservation Credit)	188,117	
27	EPCWID Diversion (w/o Conservation Credit or 67/155ths of Row 30)	188,117	
28	Diversion Ratio	0.730	+
29	Diversion Ratio Adjustment	-135,261	
30	Sum of Release and Diversion Ratio Adjustment	365,705	
31	EBID D2 Current Year Diversion Allocation	243,553	
32	Difference between EBID Diversion Ratio Allocation and D2 Diversion Allocation	0	
33	EBID Diversion Ratio Allocation	133,581	
34	EBID Diversion Allocation	133,581	
35	Total EBID Diversion Allocation (includes 88/155th of Value in Row 30)	142,233	
36	Total EPCWID Allocation (includes Row 21 and 67/155th of Value in Row 30)	188,117	
37	District to District Allocation Transfer (OA 1.11 Excess Carryover Balance)	0	
38	Total EBID Diversion Allocation (After Transfer)	142,233	
39	Total EPCWID Allocation (After Transfer)	188,117	
40	Total EBID, EPCWID, and Mexico Allocation	365,705	

^ Figures Current as of April 30, 2015

* Estimated per URGWOM Model - NM Credit = 9,998 AF CO Credit = 5,762 AF July 6,. 2015

** Estimated San Juan Chama water as of July 6, 2015

\+ 2014 Weighted Diversion Ratio

// Figure Based on MultiYear Drought Analysis

ENCLOSURE NO. 1

Status Check of 1906 Treaty Obligation to Deliver Proportionately the Same Amount of Water Supply to the U. S. Lands & Mexico's Canal Heading

U. S. Districts Proportional Delivery to Lands

Water Supply to U. S. Irrigation Districts' Lands = 311,540 - 35,355 = 276,184

Current Allotments as Percentage of Full Supply Allotments to U. S. Lands =

276,184 / 155,000 = 1.78183 AF/acre

1.78183 / 3.024 = **58.92%**

Mexico's Proportional Diversion at Its Canal Heading

Mexico's Acequia Madre Heading Allotment = 35,355

Current Allotment as Percentage of Full Supply Allotment to Canal Heading =

35,355 / 60,000 = **58.93%**

Appendix 4D
Example Accounting Records
1979, 1995, and 2015

SN-144

E.B.I.D. Diversions

1979 Irrigation Season

Acre - Feet

Diversion Point	Total Diversion	Less Delivered to Texas	Net Delivered to EBID
*Arrey Canal	73,492	-----	73,492
*Leasburg Canal	98,945	-----	98,945
Eastside Canal	56,053	3,530	52,523
Westside Canal	145,010	29,022	115,988
Percha Lateral	649	-----	649
Del Rio Lateral	2,907	-----	2,907
Pumped from River	101	-----	101
Total	377,157	32,552	344,605
Authorized Waste Credited to EBID			794
		Total Delivery to EBID	343,811 A.F.

*Irrigations above the metering station have been included as part of this diversion.

Water Allocation Charges to the
El Paso County Water Improvement District No. 1
1983 Irrigation Season
Acre-Feet

	September 1 through October 7 Deliveries	Total Deliveries To Date
Charges for Initial Release (Our letter dated March 2, 1983)		8,259
Deliveries to Mesilla Valley, Texas by both Districts	6,954	37,965
City of El Paso	2,300	17,475
Franklin Canal	13,120	82,807
Riverside Canal	27,340	155,633
Less Ascarate Wasteway	6,160	38,290
Total Deliveries	43,554	263,849
*Socorro Ponds into Riverside Canal	0	- 3,480
Gross Allocation Charge	43,554	260,369
Credited Waste to District	- 2,690	- 4,335
Net Allocation Charge	40,864	256,034
Allocation		315,548
Balance		59,514

*This figure is to be deducted as this was previously charged as allocated waters and included 409 A.F. charged as part of the initial release.

RIO GRANDE PROJECT
ELEPHANT BUTTE IRRIGATION DISTRICT
WATER ALLOTMENT CHARGES
OCTOBER 1995(R)

	GROSS DIVERSIONS OCTOBER	TO DATE	DELIVERIES TO TEXAS OCTOBER	TO DATE	NET DELIVERIES OCTOBER	TO DATE
ARREY CANAL	7581	87896			7581	87896
PERCHA LAT.	89	857			89	857
LEASBURG CANAL	10005	116184			10005	116184
CALIF. EXT.	174	493			174	493
EASTSIDE CANAL	5550	64530	666	7744	4884	56787
DEL RIO LAT.	131	2154			131	2154
WESTSIDE CANAL	14015	167472	4518	53282	9498	114190
PUMPED FROM RIVER	55	351			55	351
GROSS TOTALS	37600	439937	5184	61026	32416	378911
CHARGES AT RIVER BELOW CABALLO					0	0
TOTAL CHARGES					32416	378911
CREDIT TO DISTRICT (-) (ARREY CANAL BYPASS)					0	11391
NET ALLOTMENT CHARGE					32416	367520
DISTRICT ALLOTMENT						494979
DISTRICT BALANCE						127459

** GREENWOOD AND DURAN RIVER PUMPS (EBID DATA)

LA UNION EAST
OCTOBER (R)

DAY	N.M. ORDER	TEXAS ORDER	TOTAL ORDER	% N.M.	% TEX	L.U.EAST TOTAL DELIVERY	W.W.32	NET DELIVERY	N.M. CHARGE % OF NET	TEXAS CHARGE % OF NET
1	10	50	60	17%	83%	121	99	22	4	18
2	10	50	60	17%	83%	119	61	58	10	48
3	10	50	60	17%	83%	115	57	58	10	48
4	10	50	60	17%	83%	116	58	58	10	48
5	10	20	30	33%	67%	116	54	62	21	41
6	10	20	30	33%	67%	118	83	35	12	23
7	10	20	30	33%	67%	130	109	21	7	14
8	30	10	40	75%	25%	125	94	31	23	8
9	30	10	40	75%	25%	97	54	43	32	11
10	30	10	40	75%	25%	97	48	49	37	12
11	30	10	40	75%	25%	95	60	35	26	9
12	10	30	40	25%	75%	113	46	67	17	50
13	10	30	40	25%	75%	115	40	75	19	56
14	10	30	40	25%	75%	113	77	36	9	27
15	30	50	80	38%	63%	108	98	10	4	6
16	30	50	80	38%	63%	105	41	64	24	40
17	30	50	80	38%	63%	104	44	60	23	38
18	30	50	80	38%	63%	103	19	84	32	53
19	40	40	80	50%	50%	102	33	69	35	35
20	40	40	80	50%	50%	117	52	65	33	33
21	40	40	80	0%	0%	94	59	35	0	0
22	0	0	0	0%	0%	0	0	0	0	0
23	0	0	0	0%	0%	0	0	0	0	0
24	0	0	0	0%	0%	0	0	0	0	0
25	0	0	0	0%	0%	0	0	0	0	0
26	0	0	0	0%	0%	0	0	0	0	0
27	0	0	0	0%	0%	0	0	0	0	0
28	0	0	0	0%	0%	0	0	0	0	0
29	0	0	0	0%	0%	0	0	0	0	0
30	0	0	0	0%	0%	0	0	0	0	0
31	0	0	0	0%	0%	0	0	0	0	0
SFD	460	710	1170			2323	1286	1037	384	618
AF	912	1408	2321			4608	2551	2057	761	1226

LA UNION WEST
OCTOBER (R)

DAY	N.M. ORDER	TEXAS ORDER	TOTAL ORDER	% N.M.	% TEX	TOTAL DELIVERY	N.M. CHARGE	TEXAS CHARGE
1	30	10	40	75%	25%	44	33	11
2	30	10	40	75%	25%	50	38	13
3	30	10	40	75%	25%	48	36	12
4	30	10	40	75%	25%	58	44	15
5	50	10	60	83%	17%	50	42	8
6	50	10	60	83%	17%	50	42	8
7	50	10	60	83%	17%	48	40	8
8	40	10	50	80%	20%	45	36	9
9	40	10	50	80%	20%	48	38	10
10	40	10	50	80%	20%	55	44	11
11	40	10	50	80%	20%	62	50	12
12	20	15	35	57%	43%	66	38	28
13	20	15	35	57%	43%	65	37	28
14	20	15	35	57%	43%	63	36	27
15	70	10	80	88%	13%	58	51	7
16	70	10	80	88%	13%	59	52	7
17	70	10	80	88%	13%	68	60	9
18	70	10	80	88%	13%	84	74	11
19	70	10	80	88%	13%	85	74	11
20	70	10	80	0%	0%	94	0	0
21	70	10	80	0%	0%	65	0	0
22	0	0	0	0%	0%	1	0	0
23	0	0	0	0%	0%	0	0	0
24	0	0	0	0%	0%	0	0	0
25	0	0	0	0%	0%	0	0	0
26	0	0	0	0%	0%	0	0	0
27	0	0	0	0%	0%	0	0	0
28	0	0	0	0%	0%	0	0	0
29	0	0	0	0%	0%	0	0	0
30	0	0	0	0%	0%	0	0	0
31	0	0	0	0%	0%	0	0	0
SFD	980	225	1205			1266	862	244
AF	1944	446	2390			2511	1710	484

WESTSIDE CANAL DELIVERIES
OCTOBER 95 (R)

DAY	WESTSIDE HEADING (1)	LUE & LUW TX-CHRGE (2)	115% OF TX-CHRG(2) (3)	W.W. 32 (4)	EBID WATER (1)-(3+4)
1	330	29	34	99	197
2	342	61	70	61	211
3	340	60	69	57	214
4	330	63	72	58	200
5	314	50	57	54	203
6	312	32	36	83	193
7	326	22	25	109	192
8	310	17	19	94	197
9	301	20	23	54	224
10	303	23	27	48	228
11	348	21	24	60	264
12	371	79	90	46	235
13	388	84	97	40	251
14	398	54	62	77	259
15	380	14	16	98	266
16	400	47	54	41	305
17	399	46	53	44	302
18	403	63	72	19	312
19	371	45	52	33	286
20	312	33	37	52	223
21	88	0	0	59	29
22	0	0	0	0	0
23	0	0	0	0	0
24	0	0	0	0	0
25	0	0	0	0	0
26	0	0	0	0	0
27	0	0	0	0	0
28	0	0	0	0	0
29	0	0	0	0	0
30	0	0	0	0	0
31	0	0	0	0	0
SFD	7066	862	992	1286	4788
AF	14015	1710	1967	2551	9498

THREE SAINTS DELIVERIES
OCTOBER 95 (R)

DAY	N.M. ORDER	TEXAS ORDER	TOTAL ORDER	% N.M.	% TEX	TOTAL DELIVERY (1)	N.M. CHARGE	TEXAS CHARGE (2)	120% OF (2)
1	90	10	100	90%	10%	100	90	10	12
2	90	10	100	90%	10%	100	90	10	12
3	90	10	100	90%	10%	100	90	10	12
4	108	12	120	90%	10%	112	101	11	13
5	108	12	120	90%	10%	124	112	12	15
6	108	12	120	90%	10%	123	111	12	15
7	117	13	130	90%	10%	116	104	12	14
8	117	13	130	90%	10%	120	108	12	14
9	117	13	130	90%	10%	123	111	12	15
10	117	13	130	90%	10%	133	120	13	16
11	167	19	185	90%	10%	138	124	14	17
12	167	19	185	90%	10%	158	142	16	19
13	167	19	185	90%	10%	155	140	16	19
14	189	21	210	90%	10%	156	140	16	19
15	189	21	210	90%	10%	157	141	16	19
16	189	21	210	90%	10%	158	142	16	19
17	189	21	210	90%	10%	159	143	16	19
18	221	25	245	90%	10%	185	167	19	22
19	221	25	245	90%	10%	202	182	20	24
20	221	25	245	90%	10%	179	161	18	21
21	0	0	0	90%	10%	0	0	0	0
22	0	0	0	90%	10%	0	0	0	0
23	0	0	0	90%	10%	0	0	0	0
24	0	0	0	90%	10%	0	0	0	0
25	0	0	0	90%	10%	0	0	0	0
26	0	0	0	90%	10%	0	0	0	0
27	0	0	0	90%	10%	0	0	0	0
28	0	0	0	90%	10%	0	0	0	0
29	0	0	0	90%	10%	0	0	0	0
30	0	0	0	90%	10%	0	0	0	0
31	0	0	0	90%	10%	0	0	0	0
SFD	2979	331	3310			2798	2518	280	336
AF	5909	657	6565			5550	4995	555	666

RIO GRANDE PROJECT
ELEPHANT BUTTE IRRIGATION DISTRICT
WATER ALLOTMENT CHARGES
OCTOBER 95 (R)

DATE	ARREY	PERCHA	LEASBURG	EASTSIDE	DEL RIO	WESTSIDE	L.U.WEST	L.U.EAST	W.W.32
1	142	0	211	100	3	330	44	121	99
2	94	0	211	100	0	342	50	119	61
3	125	1	211	100	0	340	48	115	57
4	139	6	214	112	0	330	58	116	58
5	146	10	214	124	0	314	50	116	54
6	143	6	214	123	5	312	50	118	83
7	149	1	210	116	0	326	48	130	109
8	149	1	210	120	0	310	45	125	94
9	151	1	210	123	0	301	48	97	54
10	150	6	210	133	0	303	55	97	48
11	155	5	286	138	0	348	62	95	60
12	157	3	286	158	15	371	66	113	46
13	229	5	286	155	18	388	65	115	40
14	279	0	280	156	0	398	63	113	77
15	278	0	280	157	0	380	58	108	98
16	275	0	280	158	15	400	59	105	41
17	311	0	280	159	0	399	68	104	44
18	325	0	317	185	0	403	84	103	19
19	323	0	317	202	10	371	85	102	33
20	102	0	317	179	0	312	94	117	52
21	0	0	0	0	0	88	65	94	59
22	0	0	0	0	0	0	1	0	0
23	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0
31	0	0	0	0	0	0	0	0	0
SFD	3822	45	5044	2798	66	7066	1266	2323	1286
AF	7581	89	10005	5550	131	14015	2511	4608	2551

RIO GRANDE PROJECT
EL PASO COUNTY WATER IMPROVEMENT DISTRICT NO. 1
WATER ALLOTMENT CHARGES
OCTOBER 1995

ACRE-FEET

		DELIVERIES FOR MONTH	TOTAL DELIVERIES TO DATE
DELIVERIES TO MESILLA VALLEY TEXAS BY BOTH DISTRICTS		2,177	48,514
L.U.E. & L.U.W. (TX)	1,686		
THREE SAINTS LATERAL	575		
CITY OF EL PASO		5,660	56,041
FRANKLIN CANAL		3,467	97,241
LESS ASCARATE WASTEWAY		0	20,164
RIVERSIDE CANAL		21,925	279,455
CABALLO DAM RELEASE		0	3,068
GROSS TOTAL		33,229	464,156
CREDIT TO DISTRICT		4,520	82,356
NET ALLOTMENT CHARGE		28,709	279,723
DISTRICT ALLOTMENT			376,862
DISTRICT BALANCE			97,139

** See water charges for June thru August credits due to excess releases.

RIO GRANDE PROJECT
COMPUTED DELIVERIES
LA UNION EAST
EL PASO COUNTY WATER IMPROVEMENT DISTRICT NO. 1
OCTOBER 1995

DAY	N.M. ORDER	TEXAS ORDER	TOTAL ORDER	% N.M.	% TEX	TOTAL DELIV.	BYPASS WW #32	WATER PASS 32	N.M. CHARGE	TEXAS CHARGE
1	10	50	60	0.17	0.83	121	99	22	4	18
2	10	50	60	0.17	0.83	119	61	58	10	48
3	10	50	60	0.17	0.83	115	57	58	10	48
4	10	20	30	0.33	0.67	116	58	58	19	39
5	10	20	30	0.33	0.67	116	54	62	21	41
6	10	20	30	0.33	0.67	118	83	35	12	23
7	30	10	40	0.75	0.25	130	109	21	16	5
8	30	10	40	0.75	0.25	125	94	31	23	8
9	30	10	40	0.75	0.25	97	54	43	32	11
10	30	10	40	0.75	0.25	97	48	49	37	12
11	10	30	40	0.25	0.75	95	60	35	9	26
12	10	30	40	0.25	0.75	113	46	67	17	50
13	10	30	40	0.25	0.75	115	40	75	19	56
14	30	50	80	0.38	0.63	113	77	36	14	23
15	30	50	80	0.38	0.63	108	98	10	4	6
16	30	50	80	0.38	0.63	105	41	64	24	40
17	30	50	80	0.38	0.63	104	44	60	23	38
18	40	40	80	0.50	0.50	103	19	84	42	42
19	40	40	80	0.50	0.50	102	33	69	35	35
20	40	40	80	0.50	0.50	117	52	65	33	33
21	0	0	0	0.00	0.00	94	59	35	0	0
22	0	0	0	0.00	0.00	0	0	0	0	0
23	0	0	0	0.00	0.00	0	0	0	0	0
24	0	0	0	0.00	0.00	0	0	0	0	0
25	0	0	0	0.00	0.00	0	0	0	0	0
26	0	0	0	0.00	0.00	0	0	0	0	0
27	0	0	0	0.00	0.00	0	0	0	0	0
28	0	0	0	0.00	0.00	0	0	0	0	0
29	0	0	0	0.00	0.00	0	0	0	0	0
30	0	0	0	0.00	0.00	0	0	0	0	0
31	0	0	0	0.00	0.00	0	0	0		
SFD	450	660	1110	0.41	0.59	2323	1286	1037	400	602
AF	893	1309	2202			4608	2551	2057	793	1195

C4Y

TOTAL CHARGES FOR OCT. : 23049

FOR 1995 - 274063

RIO GRANDE PROJECT
COMPUTED DELIVERIES
LA UNION WEST
EL PASO COUNTY WATER IMPROVEMENT DISTRICT NO. 1
OCTOBER 1995

DAY	N.M. ORDER	TEXAS ORDER	TOTAL ORDER	% N.M.	% TEX	TOTAL DELIVERY	N.M. CHARGE	TEXAS CHARGE
1	30	10	40	0.75	0.25	44	33	11
2	30	10	40	0.75	0.25	50	38	13
3	30	10	40	0.75	0.25	48	36	12
4	50	10	60	0.83	0.17	58	48	10
5	50	10	60	0.83	0.17	50	42	8
6	50	10	60	0.83	0.17	50	42	8
7	40	10	50	0.80	0.20	48	38	10
8	40	10	50	0.80	0.20	45	36	9
9	40	10	50	0.80	0.20	48	38	10
10	40	10	50	0.80	0.20	55	44	11
11	20	15	35	0.57	0.43	62	35	27
12	20	15	35	0.57	0.43	66	38	28
13	20	15	35	0.57	0.43	65	37	28
14	70	10	80	0.88	0.13	63	55	8
15	70	10	80	0.88	0.13	58	51	7
16	70	10	80	0.88	0.13	59	52	7
17	70	10	80	0.88	0.13	68	60	9
18	70	10	80	0.88	0.13	84	74	11
19	70	10	80	0.88	0.13	85	74	11
20	70	10	80	0.88	0.13	94	82	12
21	0	0	0	0.00	0.00	65	0	0
22	0	0	0	0.00	0.00	1	0	0
23	0	0	0	0.00	0.00	0	0	0
24	0	0	0	0.00	0.00	0	0	0
25	0	0	0	0.00	0.00	0	0	0
26	0	0	0	0.00	0.00	0	0	0
27	0	0	0	0.00	0.00	0	0	0
28	0	0	0	0.00	0.00	0	0	0
29	0	0	0	0.00	0.00	0	0	0
30	0	0	0	0.00	0.00	0	0	0
31	0	0		0.00	0.00	0		
SFD	950	215	1165	0.82	0.18	1266	952.4	248
AF	1884	426	2311			2511	1889	491

RIO GRANDE PROJECT
COMPUTED DELIVERIES
THREE SAINTS LATERAL
EL PASO COUNTY WATER IMPROVEMENT DISTRICT NO. 1
OCTOBER 1995

DAY	3 SAINTS Q (1)	WW23A Q (2)	(1)-(2) (3)	3 SAINTS ORDER FOR TEXAS	EPCWID#1 WATER CHARGED
1	5	5	0	10	5
2	4	4	0	10	4
3	7	5	2	10	7
4	9	4	5	11	9
5	22	8	14	12	14
6	21	5	16	12	16
7	22	9	13	12	13
8	26	15	11	12	12
9	27	17	10	12	12
10	23	11	12	13	13
11	24	11	13	14	14
12	24	8	16	16	16
13	27	12	15	16	16
14	20	13	7	16	16
15	22	18	4	16	16
16	24	10	14	16	16
17	26	0	26	16	26
18	24	0	24	19	24
19	26	6	20	20	20
20	30	13	17	18	18
21	23	19	4	0	4
22	4	4	0	0	0
23	0	0	0	0	0
24	0	0	0	0	0
25	0	0	0	0	0
26	0	0	0	0	0
27	0	0	0	0	0
28	0	0	0	0	0
29	0	0	0	0	0
30	0	0	0	0	0
31	0	0		0	
TOTAL SF	440	197	243	280	290
TOTAL AF	873	391	482	555	575

RIO GRANDE PROJECT
EL PASO COUNTY WATER IMPROVEMENT DISTRICT NO. 1
WATER ALLOTMENT CHARGES
OCTOBER 1995

FLOW IN SFD

DAY	FRANKLIN	ASCARATE	RIVERSIDE	TOTAL DELIVERY
1	44	0	365	409
2	43	0	354	397
3	41	0	372	413
4	41	0	368	409
5	43	0	363	406
6	42	0	355	397
7	44	0	347	391
8	45	0	355	400
9	55	0	382	437
10	65	0	401	466
11	64	0	388	452
12	64	0	386	450
13	55	0	332	387
14	44	0	280	324
15	43	0	283	326
16	42	0	371	413
17	58	0	380	438
18	58	0	380	438
19	56	0	379	435
20	56	0	322	378
21	53	0	268	321
22	50	0	269	319
23	55	0	404	459
24	74	0	379	453
25	86	0	375	461
26	91	0	398	489
27	74	0	377	451
28	64	0	339	403
29	67	0	339	406
30	66	0	396	462
31	65	0	347	412
SFD	1748	0	11054	12802
AF	3467	0	21925	25392

RIO GRANDE PROJECT
EL PASO COUNTY WATER IMPROVEMENT DISTRICT #1
CREDIT SUMMARY
OCTOBER 1995

DAY	TOTAL DIVERT.	ORDER	DIFF. +/-	R.S.H. WASTE	SYSTEM WASTE	EPCWID CHARGE	TOTAL WASTE	USBR/ EBID WASTE	EPCWID WASTE	EPCWID CREDIT
1	409	390	19	232	289	390	521	19	274	19
2	397	390	7	266	246	390	512	7	240	7
3	413	390	23	236	223	390	459	23	205	23
4	409	390	19	209	206	390	415	19	191	0
5	406	446	-40	164	172	446	336	-40	336	0
6	397	446	-49	124	217	446	341	-49	341	0
7	391	446	-55	106	374	446	480	-55	480	0
8	400	390	10	136	316	390	452	10	308	10
9	437	390	47	128	248	390	376	47	210	47
10	466	390	76	70	85	390	155	76	24	76
11	452	390	62	16	127	390	143	62	77	62
12	450	295	155	15	88	331	103	119	0	119
13	387	295	92	99	340	295	439	92	266	92
14	324	295	29	186	433	295	619	29	410	29
15	326	250	76	259	412	250	671	76	351	76
16	413	250	163	117	114	266	231	147	0	147
17	438	250	188	85	163	250	248	188	13	0
18	438	250	188	99	210	250	309	188	60	188
19	435	253	182	89	339	253	428	182	193	182
20	378	253	125	218	431	253	649	125	331	125
21	321	350	-29	442	415	350	857	-29	857	0
22	319	350	-31	473	407	350	880	-31	880	0
23	459	350	109	169	248	350	417	109	161	109
24	453	350	103	55	271	350	326	103	189	103
25	461	350	111	22	282	350	304	111	193	111
26	489	350	139	22	330	350	352	139	219	139
27	451	350	101	92	460	350	552	101	379	101
28	403	350	53	132	432	350	564	53	390	53
29	406	350	56	99	410	350	509	56	365	56
30	462	0	462	7	313	57	320	405	0	405
31	412	0		7	0					
SFD	12,802	9,999	2,391	4,374	8,601	10,108	12,968	2,282	7,943	2,279
AF	25,393	19,833	4,743	8,676	17,060	20,049	25,722	4,526	15,755	4,520

ELEPHANT BUTTE IRRIGATION DISTRICT

WATER ALLOTMENT CHARGES

October-13

SUBJECT TO REVISION

	GROSS DIVERSIONS (AC-FT)		DIVERTED TO TEXAS (AC-FT)		NET DIVERSIONS (AC-FT)	
		TO DATE		**TO DATE**		**TO DATE**
ARREY CANAL	0	31,634			0	31,634
PERCHA LATERAL	0	104			0	104
LEASBURG CANAL	0	34,812			0	34,812
CALIFORNIA EXTENTION	0	243			0	243
EASTSIDE CANAL	0	27,628	0	-1,319	0	26,309
DEL RIO LATERAL	0	1,884			0	1,884
WESTSIDE CANAL	0	76,752	0	-26,714	0	50,038
PUMPED FROM RIVER**	0	25			0	25
GROSS TOTAL	0	173,083	0	-28,033	0	145,050

	NET DIVERSION	**TO DATE**
TOTAL CHARGES (AC-FT)	0	145,050
CREDIT AT ARREY (-)	0	0
CREDIT AT LEASBURG (-)	0	0
ADJUSTMENT FOR CHARGE AT HEADING (+)	**0**	**3,926**
NET ALLOTMENT CHARGE	**0**	**148,976**

DISTRICT ALLOTMENT	**0**
2009 Carryover Transfer	**0**
DISTRICT BALANCE	**-148,976**

** GREENWOOD AND DURAN RIVER PUMPS (EBID DATA)

DRAFT - EPCWID Diversion Allocation Charges for September 2015

Diversion Location	Metered Volume	Adjustment for Conveyance Losses for NM Deliveries	Normal Diversion Allocation Charges for Month	Beginning-of-Month Totals	End-of-Month Totals
	ac-ft	ac-ft	ac-ft	ac-ft	ac-ft
L U E Canal - TX	3,207	100%	3,207	10,962	14,169
L U W Canal - TX	1,886	100%	1,886	3,156	5,042
Three Saints Lateral	317	100%	317	654	971
Total Mesilla Valley (Texas)			5,411	14,771	20,182
Umbenhauer/Robertson Water Treatment Plant	3,008	100%	3,008	9,936	12,944
Franklin Canal	4,973	100%	4,973	16,735	21,707
United States - Ysleta del Sur Agreement	0	100%	0	107	107
United States Section - IBWC (Construction Water)	0	100%	0	0	0
Jonathan W. Rogers Water Treatment Plant	5,353	100%	5,353	14,685	20,038
Riverside Canal	14,565	100%	14,565	55,592	70,156
Haskell R. Street WWTP Effluent	-1,428	100%	-1,428	-4,032	-5,461
Credit for Diversions greater than Orders (El Paso Valley)	0	100%	0	-1,438	-1,438
August Allocation Charges for ACE Credit Calculation			36,917		
Total Diversions for ACE Credit Calculation			31,882	115,433	147,314
Net Charges for Release from Caballo (Aug 23 @ 1100)	44,791	100%	44,791	15,016	**59,807**
Total Allotment Diversions Charges				**106,065**	**165,872**
Diversion Allocation				188,117	188,117
Est. Annual Conservation Credit Diversion Allocation					11,651
Accrued Conservation Credit Diversion Allocation					11,651
Total Diversion Allocation					199,768
District Allotment Balance					22,245
EOY Allocation Balance					**33,896**

Appendix 6A

Inputs for Hueco Annual CFB Models

1903 – 1937

1. Introduction

The CFB Models contain canal and farm budget calculations on an annual time-step for units overlying the Hueco ground water basin, including El Paso Valley (EPCWID), HCCRD, and JID Units 1 – 3. The annual Hueco CFB Models are from 1903 – 1937. This appendix describes the inputs used in the annual Hueco CFB Models.

2. Annual Hueco CFB Model Inputs

2.1 Surface Water Supplies

Surface water supplies were input into the CFB Models using flow data from the surface water dataset ("SWDataSet") prepared by SWE. The following table summarizes the annual surface water supplies used in the Hueco CFB Models for the 1903 – 1937 period.

Irrigation Unit	**Surface Water Supplies (1903 – 1937)**
El Paso Valley (EPCWID)	Franklin Canal (1903 – 1937) - Ascarate Wasteway (1916 – 1937) + Riverside Canal (1928 – 1937)
HCCRD	1915 – 1924: Calculated (irrigated acres x 4 feet) 1925 – 1937: Tornillo Canal Waste End + Tornillo Drain
JID Unit 1	Acequia Madre (1903 – 1937) + Cuidad Juarez Sewage (1926 – 1937) + River Diversions (1930 – 1937); split proportionally between units using irrigated acreage
JID Unit 2	
JID Unit 3	

Available surface water flows from 1903 – 1937 have been compiled, but there are significant data gaps during this period. SWE coordinated with MMA to estimate the missing 1903 – 1937 annual data. The start dates for different canals, wasteways, and drains were provided by MMA. These estimates are described in detail below.

<u>El Paso Valley 1903 – 1937</u>

Annual data for the Franklin Canal date back to 1914 (missing data in 1917). Prior to the construction of the American Dam in 1938, the Franklin Canal diverted at the International Dam. Franklin Canal diversion data from 1903 – 1913 and 1917 were estimated using an annual 1918 – 1938 regression with streamflows for the Rio Grande at El Paso gage. The Franklin Canal diversions were estimated as the minimum of the computed canal flow using the regression and the estimated capacity of the canal (320 cubic feet per second ["cfs"]). The Franklin Canal diversions were also limited to an irrigation season of March to November.

The Ascarate Wasteway was constructed around 1916, but annual flow records are only available after 1938. Annual Ascarate Wasteway flows from 1916 – 1937 were estimated using a 1938 – 1949 annual regression with the Franklin Canal.

The Riverside Canal was constructed around 1928 and the annual records for the Riverside Canal from 1928 – 1937 are complete.

Hudspeth County 1903 – 1937

Irrigation in HCCRD commenced around 1915 with the construction of ditches that diverted water from the Rio Grande and HCCRD was organized in 1924 (Reclamation, 2013). The HCCRD flows were measured starting in the 1920s. Measurement of the Tornillo Drain flows began in 1923 and measurement of the Hudspeth Canal (Tornillo End) began in 1925. The total flow to HCCRD was assumed to be the sum of the Tornillo Drain and the Hudspeth Canal (Tornillo End). According to the HCCRD water supply schematic (see report **Figure 6-4)**, the Hudspeth Canal (Tornillo End) began in 1925. There are no Hudspeth Canal (Tornillo End) flow records from 1925 – 1934. The Hudspeth Canal (Tornillo End) flows are estimated from 1925 – 1934 using a water balance approach, calculated as the Tornillo Canal heading flow minus an assumed seepage loss minus farm headgate demands for the Tornillo acres minus Tornillo Waste.

Various regression equations to estimate diversions for the Tornillo Drain and Hudspeth Canal (Tornillo End) from 1915 – 1924 were tested and did not yield good fits. Therefore, the diversions from 1915 – 1924 were estimated as the total irrigated acres multiplied by four feet.

Juarez Units 1903 – 1937

Diversion records for Acequia Madre are available from 1924 – 1925 and 1930 – 1936. Missing data for 1903 – 1923, 1926 – 1929, and 1937 were estimated using an annual 1930 – 1936 regression with the Rio Grande at El Paso gaged flows. The Acequia Madre diversions were estimated as the minimum of the computed canal flow using the regression and the estimated capacity of the canal (300 cfs). The Acequia Madre diversions were also limited to an irrigation season of March to November. A water balance calculation was conducted to check that the estimated combined diversions at Franklin Canal and Acequia Madre did not exceed the total Rio Grande flow at El Paso gage.

The Sewage Flow from 1926 – 1937 was estimated to be 49 percent of the Cuidad Juarez (“JMAS”) pumping using methodology described in the report**.** There are no data for JMAS pumping prior to 1926, although the annual JMAS pumping was less than 500 af in the late 1920s. Because of the lack of data and the small magnitude of the JMAS pumping, no Sewage Flows were computed to include in the surface water supply to Juarez prior to 1926. Sewage Flow available to the farms from 1926 – 1937 was limited to the irrigation season of March – October.

Annual estimates of River Diversions from 1930 – 1936 from the 1938 Rio Grande Joint Investigation (“RGJI”) were used in the CFB Models (USNRC, 1938). Due to similar hydrological conditions, annual data for 1937 was assumed to be equal to 1936. The extent of the River Diversions prior to 1930 is unknown and there are little flow data to estimate these diversions. The River Diversions prior to 1930 were not included in the surface water supply to Juarez.

The total JID water supplies from 1903 – 1937 were distributed to the JID units based on the irrigated area in each unit. This distribution of water is consistent with the water distribution used during this period in Carreno (1957), except in the drought years 1903 – 1906 in which water was assumed to only be available to JID Unit 1.

2.2 Irrigated Area

Available irrigated area data from 1903 – 1937 were compiled for use in the CFB Models of the Hueco area irrigation units. There are no data on primary acres in Texas and Mexico and all irrigated lands for these areas are assumed to be supplemental acres.

Irrigated area in Texas (El Paso Valley and HCCRD) from 1903 – 1937 are from the 1938 RGJI. The 1938 RGJI records are not complete from 1903 – 1937, and missing irrigated area data were estimated using interpolation/extrapolation of the years with data. The reported and estimated irrigated acreage data used in the CFB Models are shown in the table below.

The irrigated area data for JID was obtained from various reports for use in the Hueco GW Model (USNRC, 1938 and IBWC, 1989). Similar to El Paso Valley and HCCRD, the irrigated acreage for years of no data were interpolated between the available reported acreage. The total acreage was distributed into the three JID units primarily using the reported distribution from Carreno (1957), except from 1903 – 1906, it was assumed that during low flows all diversions would go to JID Unit 1. In 1904, it was assumed that there were zero irrigated acres since there were no flows at the Rio Grande at El Paso gage that year from March – July.

The irrigated area used in the annual Hueco CFB Models is summarized in the table below.

District	**Supplemental Acres 1903 – 1937**
El Paso Valley (EPCWID)	1903 – 1906: Set equal to 1907 acreage from RGJI (USNRC, 1938) 1907, 1914, and 1920 – 1937: Acreage from RGJI (USNRC, 1938) 1915 – 1916: Set equal to 1914 acreage from RGJI (USNRC, 1938) 1918 – 1919 and 1936 – 1937: Reclamation Water Distribution Reports (Accounting DataSet) 1908 – 1913: Linear interpolation between 1907 and 1914 acreage from RGJI (USNRC, 1938)
HCCRD	1903 – 1914: Assumed zero irrigated acres (MMA) 1915 – 1919: Linear interpolation between zero acres in 1914 to 1920 acreage from RGJI (USNRC, 1938) 1920 – 1937: Acreage from RGJI (USNRC, 1938)
JID	1903, 1905, 1908 – 1914, 1916 – 1922, 1927 – 1929, and 1931 – 1937: Acreage interpolated from IBWC (1989) and RGJI (USNRC, 1938), data provided by MMA 1904, 1906, 1915, and 1930 – 1949: Acreage from IBWC (1989) 1907 and 1923 – 1926: Acreage from RGJII (USNRC, 1938)

2.3 Crop Irrigation Requirement and Excess Effective Precipitation

For the 1903 – 1937 annual Hueco CFB Models, the CIR is the average annual 1936 – 1937 CIR from DE reduced by 5 percent. There is no assumed excess effective precipitation simulated in the 1903 – 1937 annual CFB Models.

2.4 Conveyance and Other Losses

The total canal loss and wasteway flows loss is a user-specified percent of the total diversions for each annual CFB Model. These percentages do not vary from year-to-year. The total canal loss is set to 40% for all irrigation units from 1903 – 1937. The wasteway flow percentage is set to 10% for the El Paso Valley irrigation unit and 0% for the other irrigation units.

2.4.1 Incidental Canal Loss and Canal Seepage

The incidental canal loss is computed based on a user specified a percentage of the total canal loss and is set at 6%.

2.5 Maximum On-Farm Irrigation Efficiency (“MFE”)

The MFE is a user-specified percent for each annual CFB Model. The MFE does not vary from year-to year. The MFE is currently set at 68% for all irrigation units.

2.6 On-Farm Loss Split

The surface runoff percentage is a user-specified percent for each annual CFB Model that does not vary from year-to year. The surface runoff percentage is currently set at the 6%for all irrigation units. The deep percolation percent is computed as one minus the surface runoff percent (94%).

2.7 Soil Moisture Reservoir

The soil moisture reservoir (inches) for the annual Hueco CFB Models are set equal to the values used in the monthly CFB Models.

2.8 Ground Water Pumping

There is no ground water pumping for irrigation supply on the Hueco lands from 1903 – 1937. However, the structure to simulate the supplemental and primary pumping has been added to the annual Hueco CFB Models.

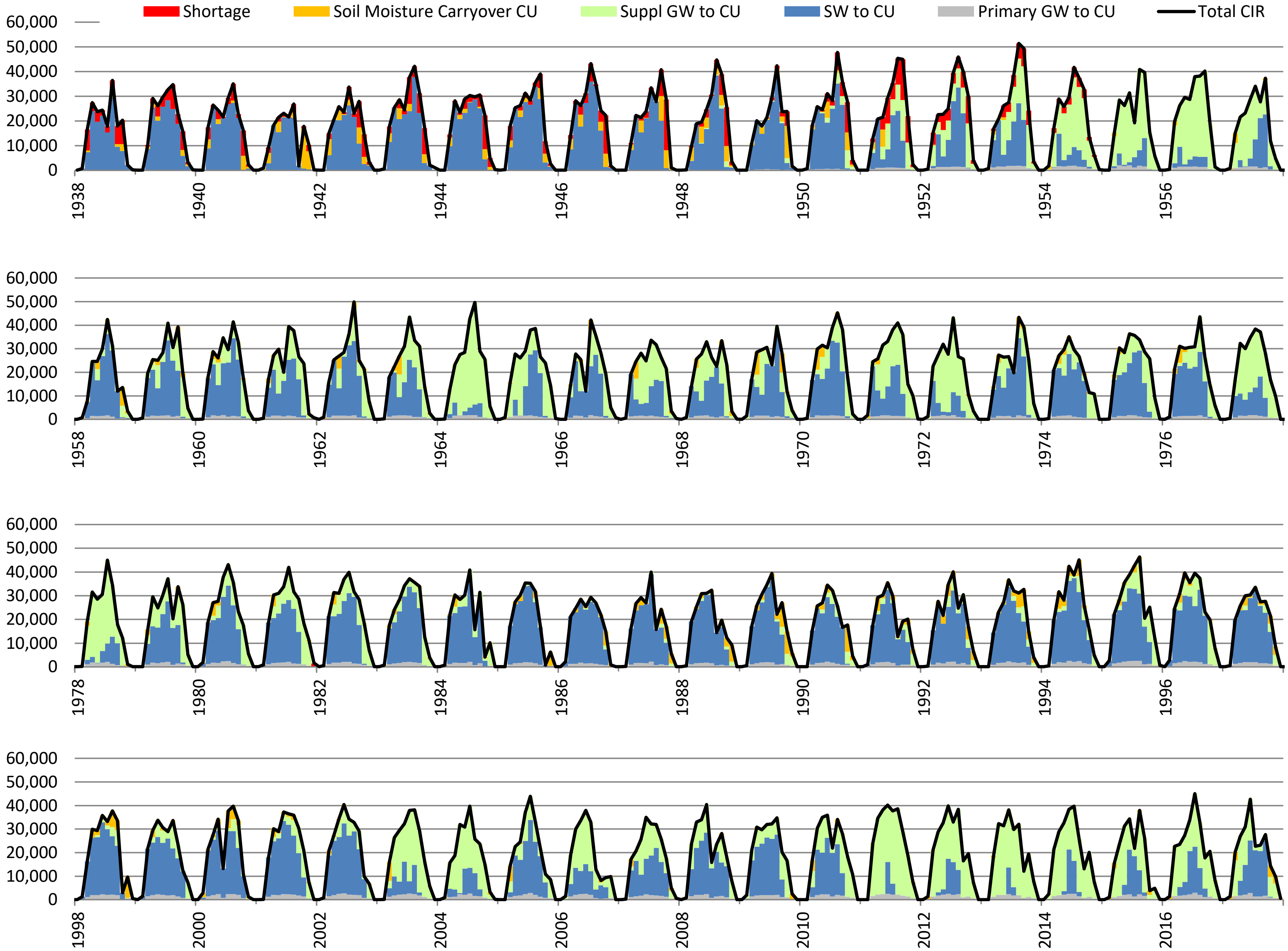
Appendix 6B
District-Wide Summaries of CFB Model Outputs
1938 – 2017

Monthly On-Farm Consumptive Use

EBID Total

1938 - 2017

(Acre-Feet)

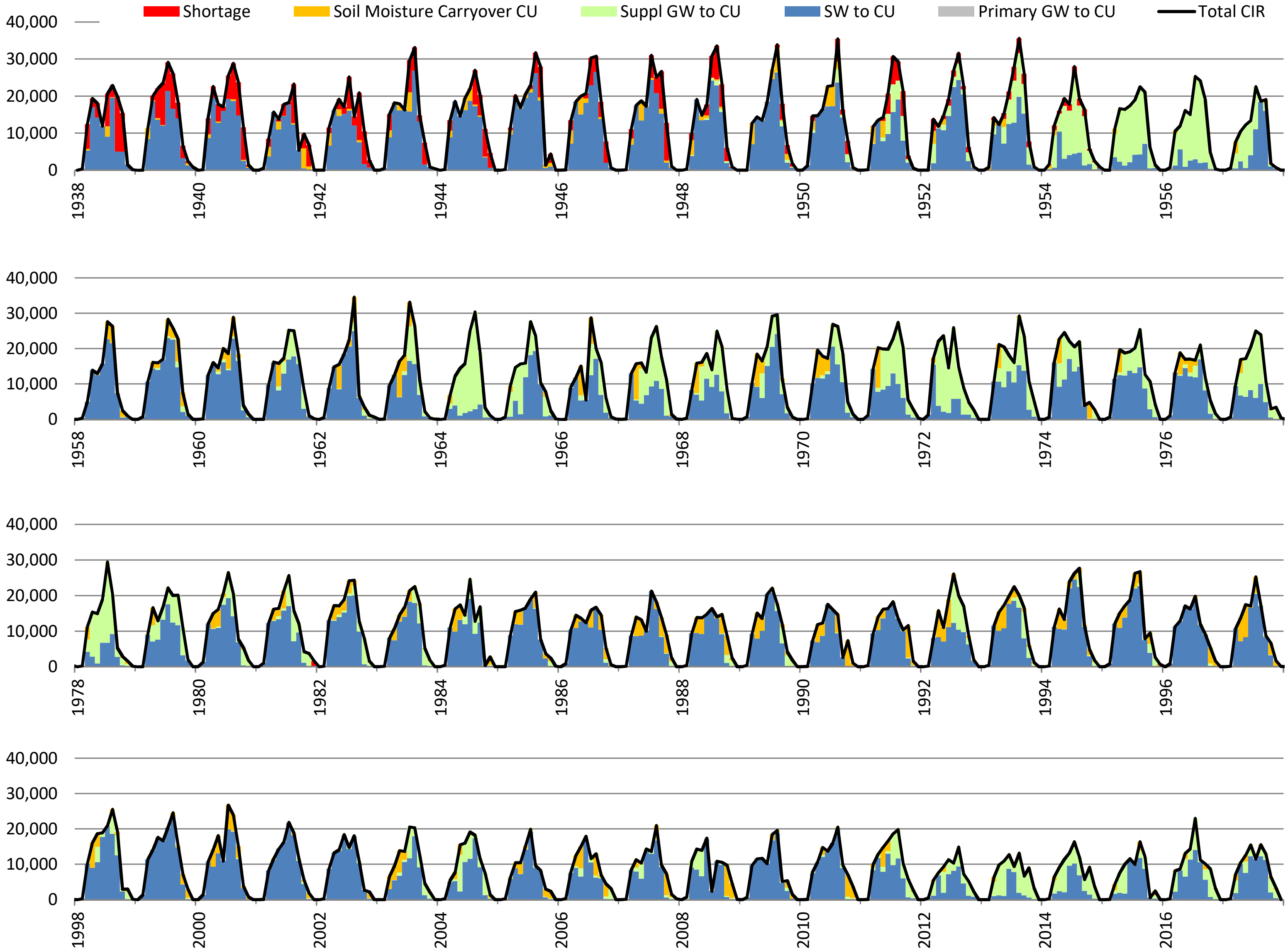


Monthly On-Farm Consumptive Use

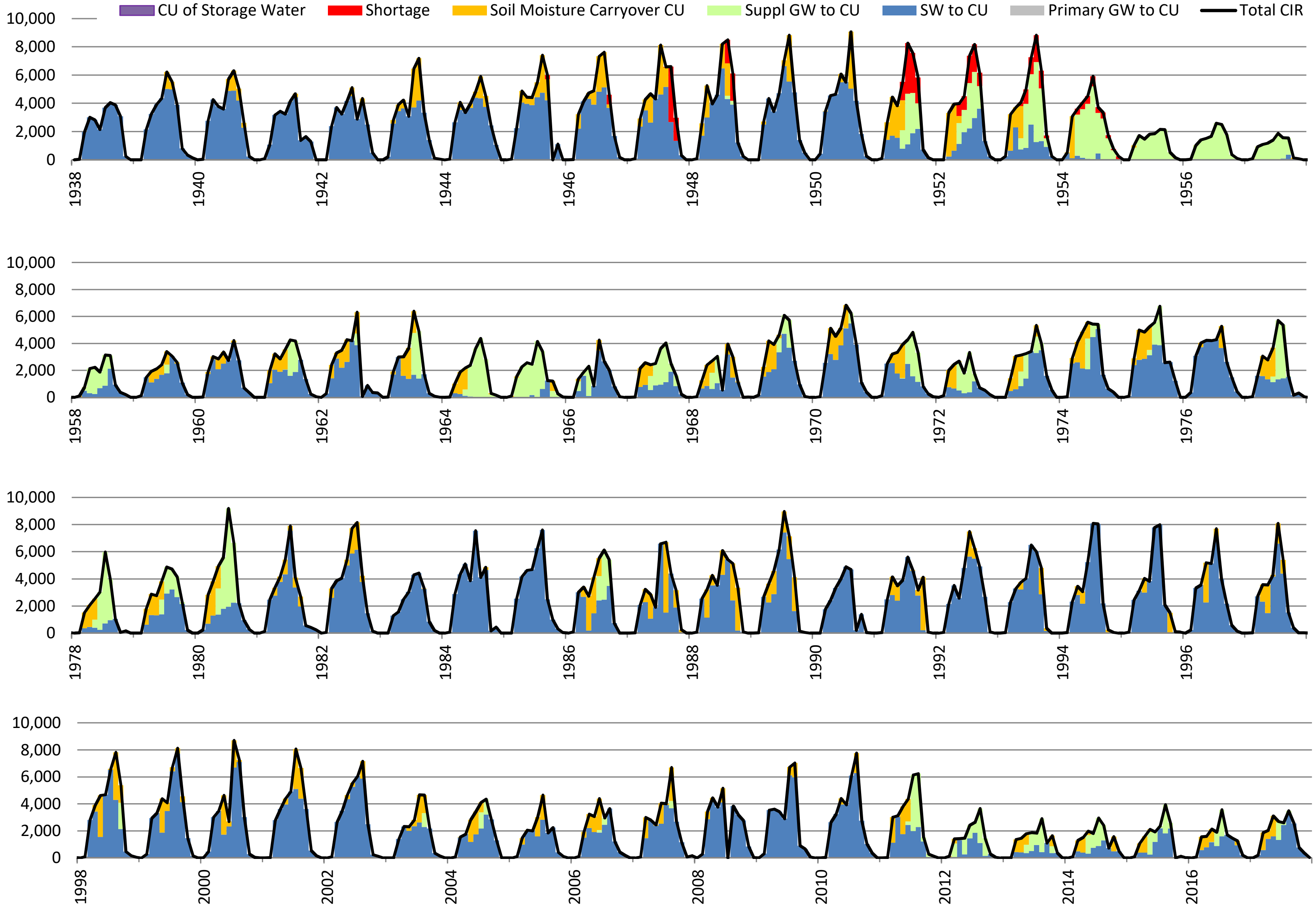
EPCWID Total

1938 - 2017

(Acre-Feet)



Monthly On-Farm Consumptive Use
HCCRD
1938 - 2017
(Acre-Feet)

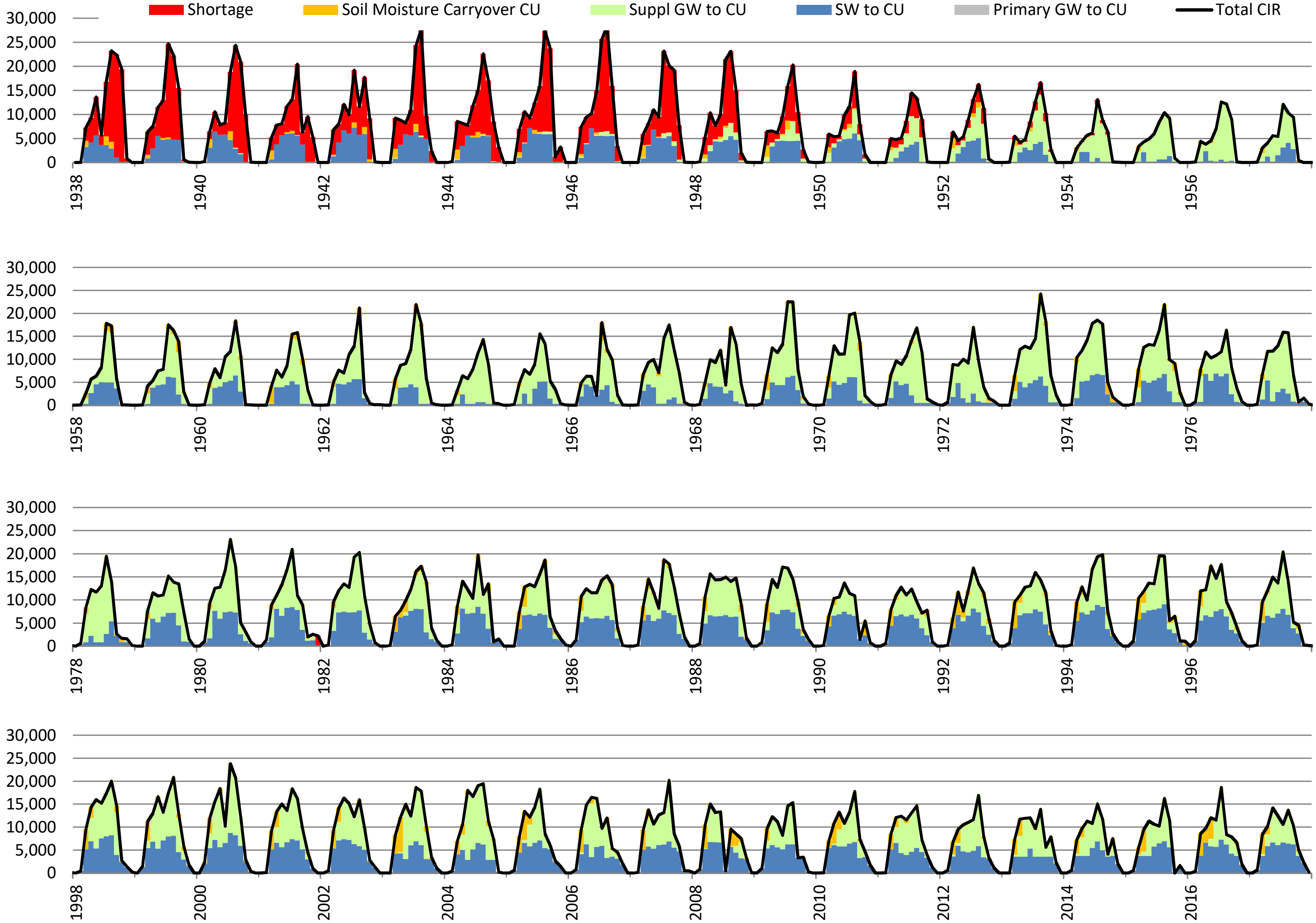


Monthly On-Farm Consumptive Use

JID Total

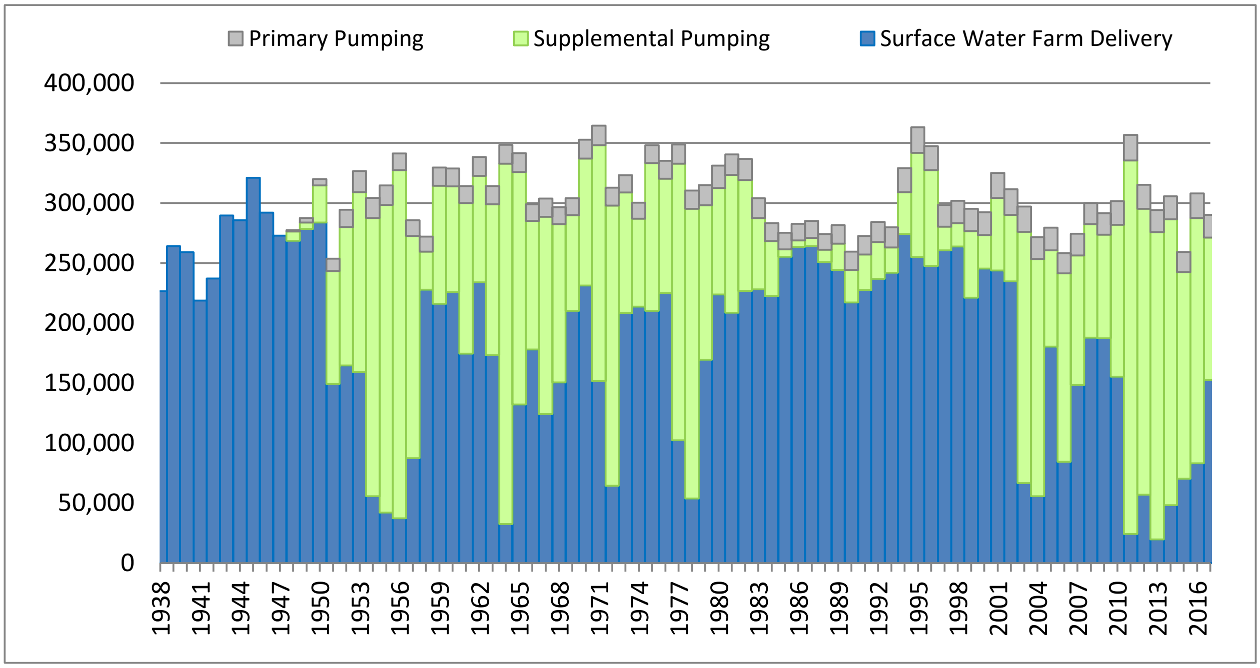
1938 - 2017

(Acre-Feet)

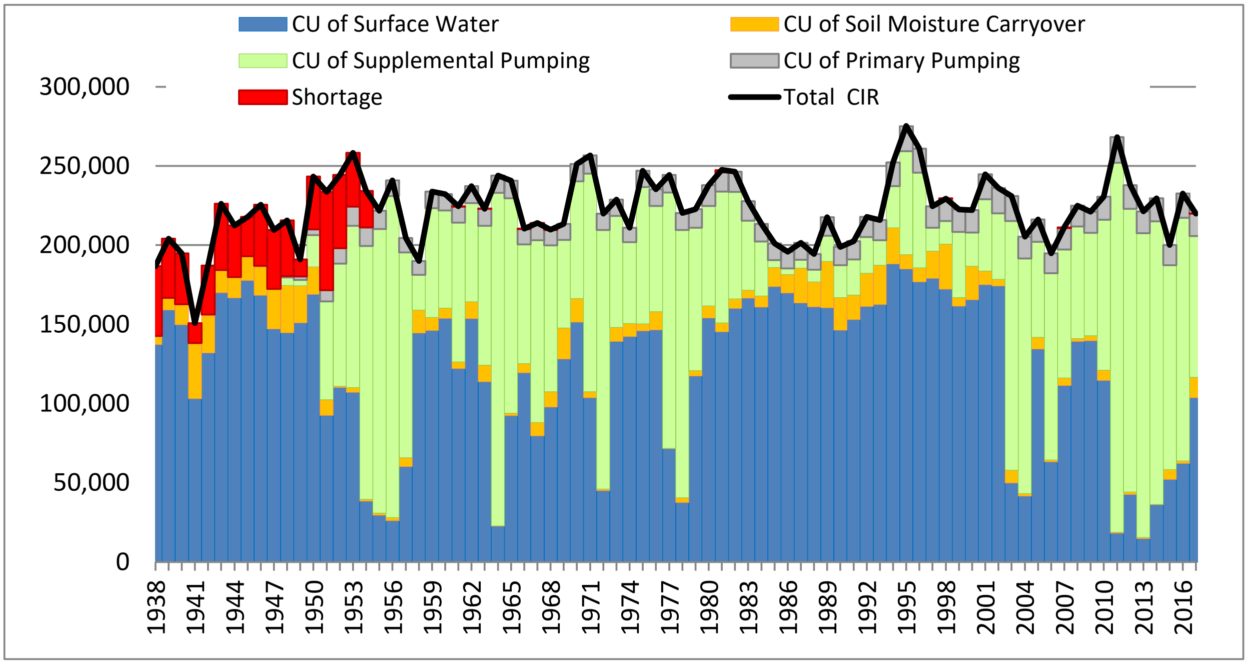


Canal and Farm Water Budget
EBID Total
1938 - 2017
Annual Values

Annual Farm Deliveries (Acre-Feet)



Annual CIR and Consumptive Use (Acre-Feet)



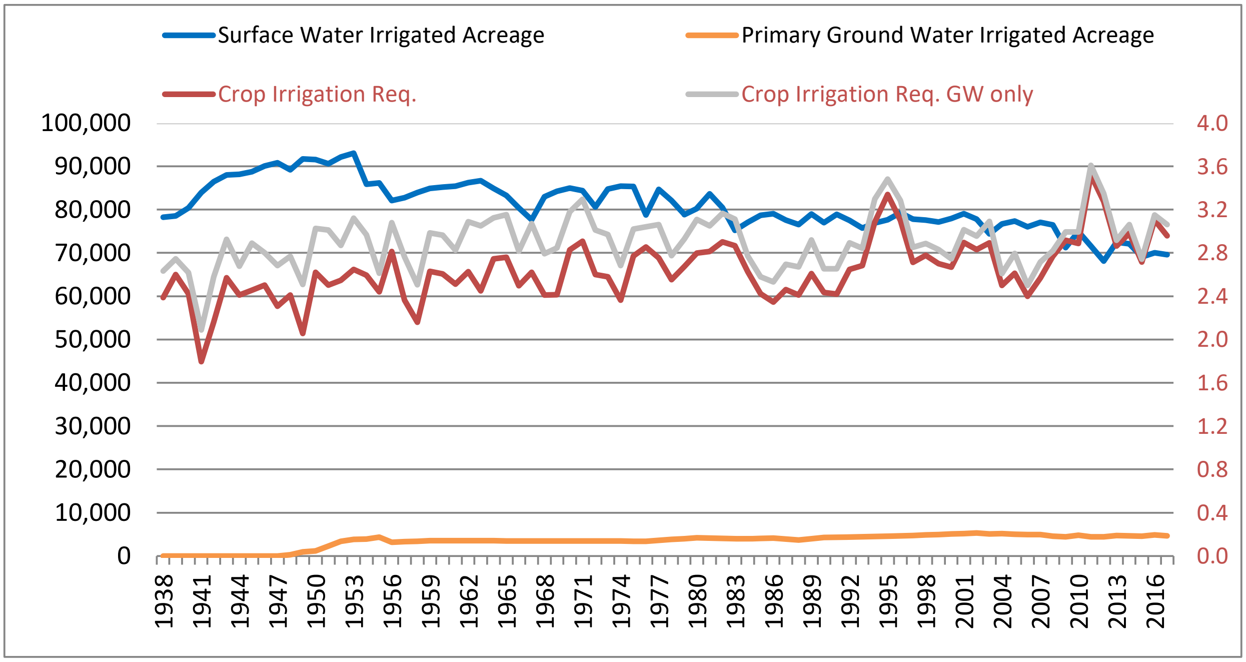
Canal and Farm Water Budget

EBID Total

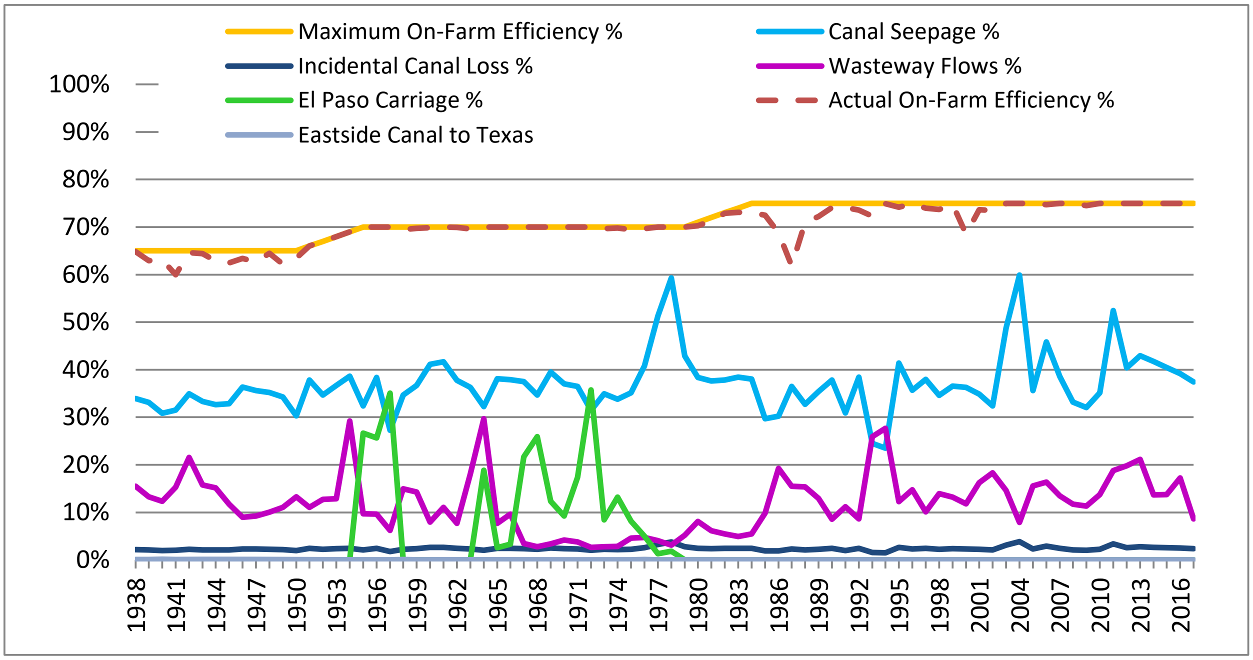
1938 - 2017

Annual Values

Irrigated Area (Acres) and Unit CIR (feet)

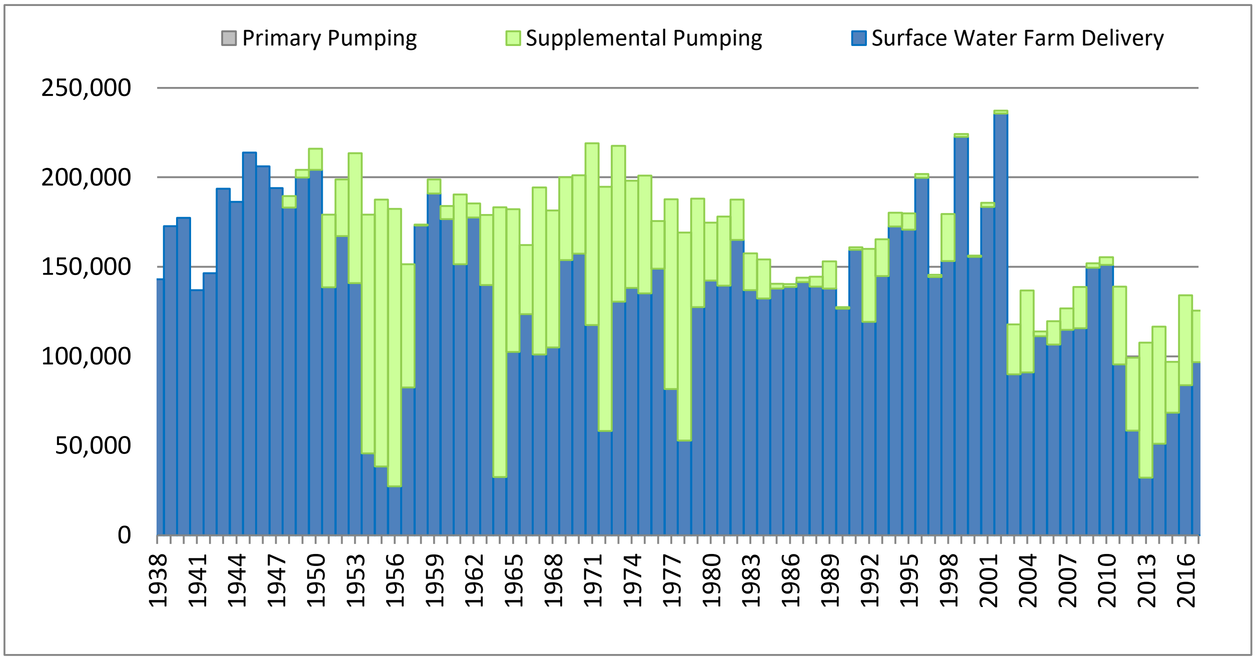


Loss and Efficiency Percentages

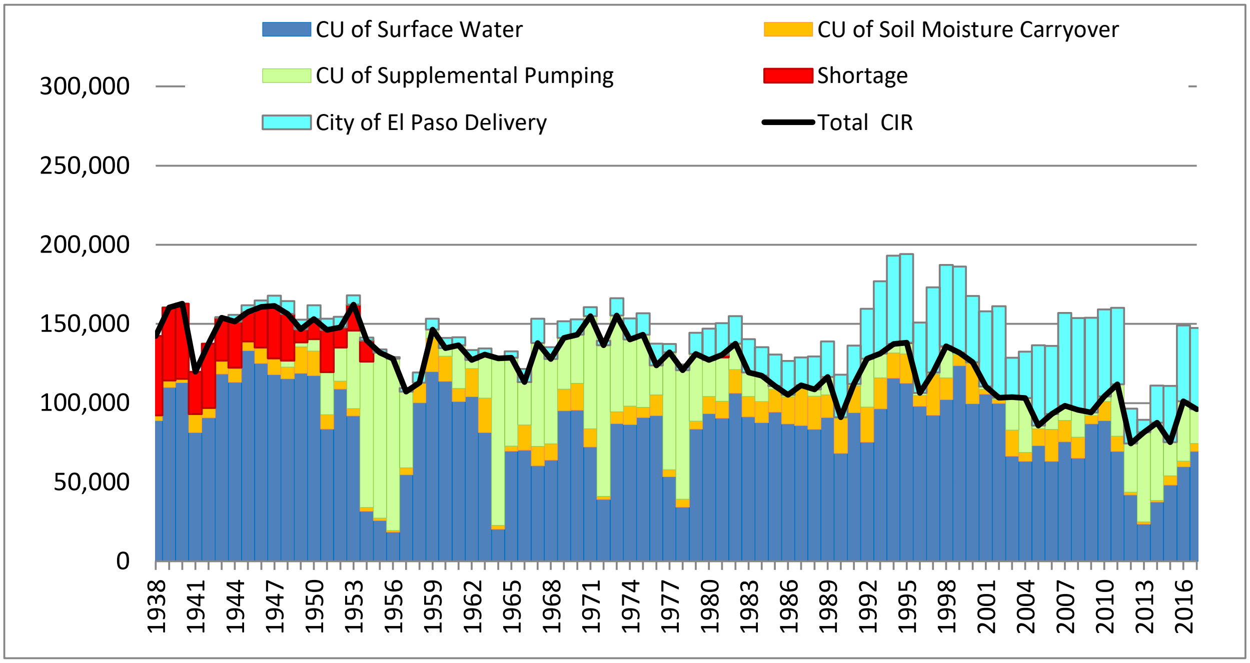


Canal and Farm Water Budget
EPCWID Total
1938 - 2017
Annual Values

Annual Farm Deliveries (Acre-Feet)



Annual CIR, Consumptive Use, and Municipal Diversions (Acre-Feet)



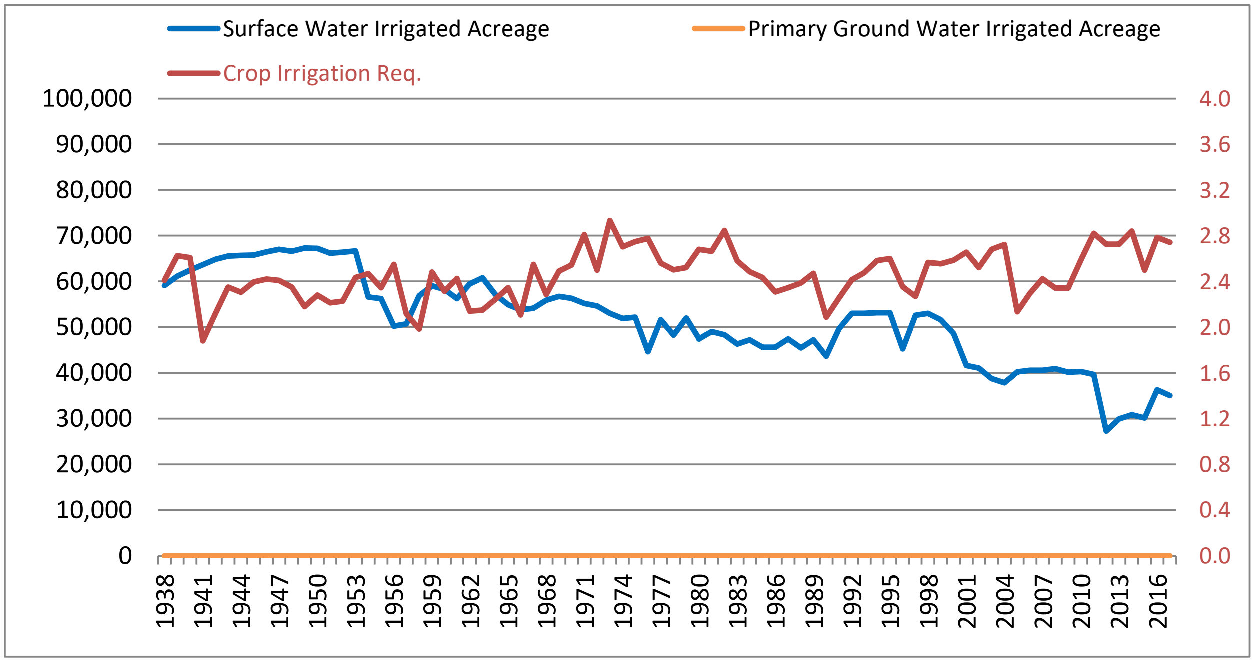
Canal and Farm Water Budget

EPCWID Total

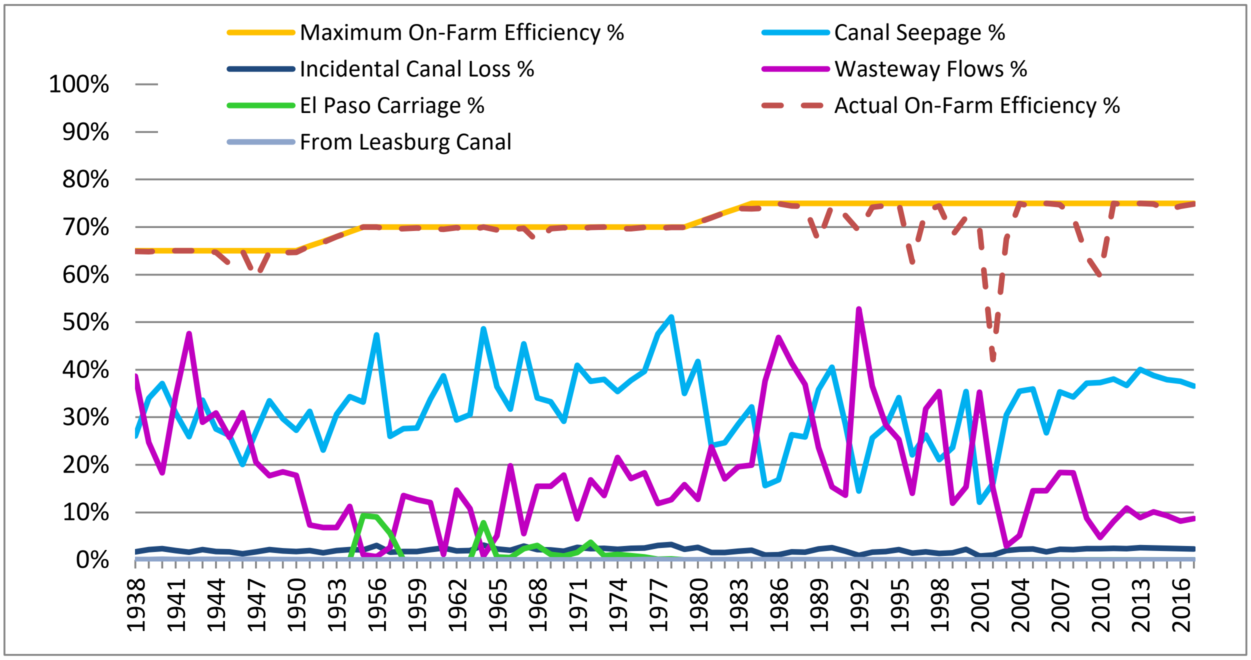
1938 - 2017

Annual Values

Irrigated Area (Acres) and Unit CIR (feet)



Loss and Efficiency Percentages



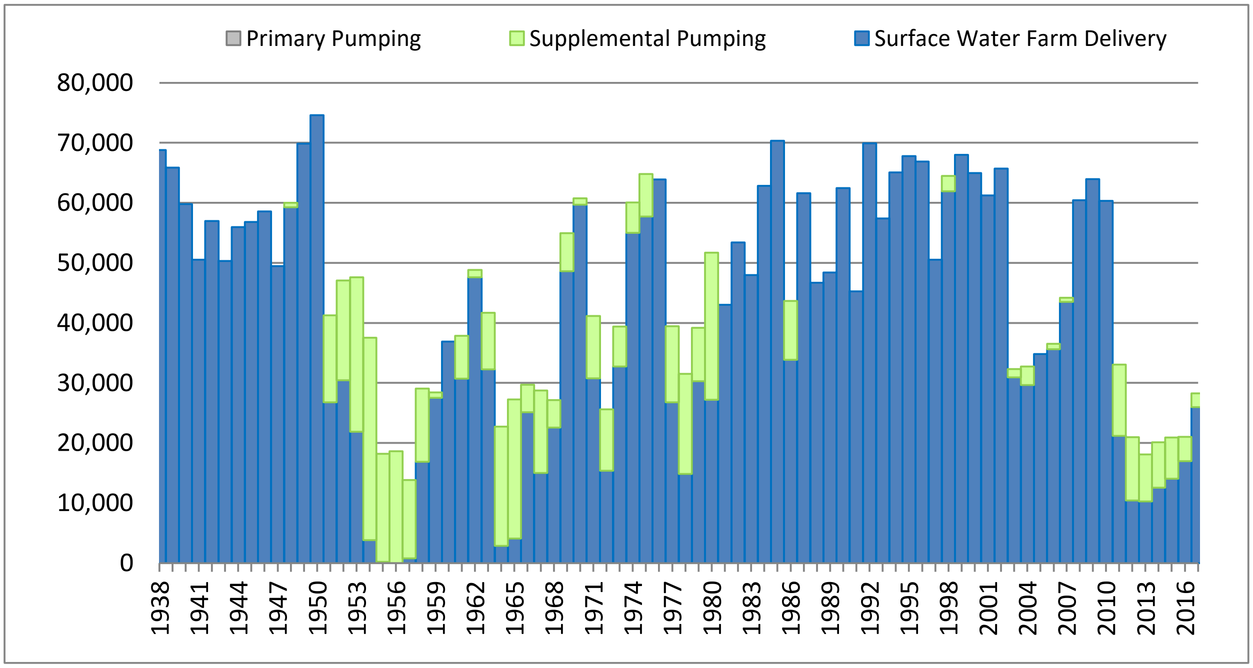
Canal and Farm Water Budget

HCCRD

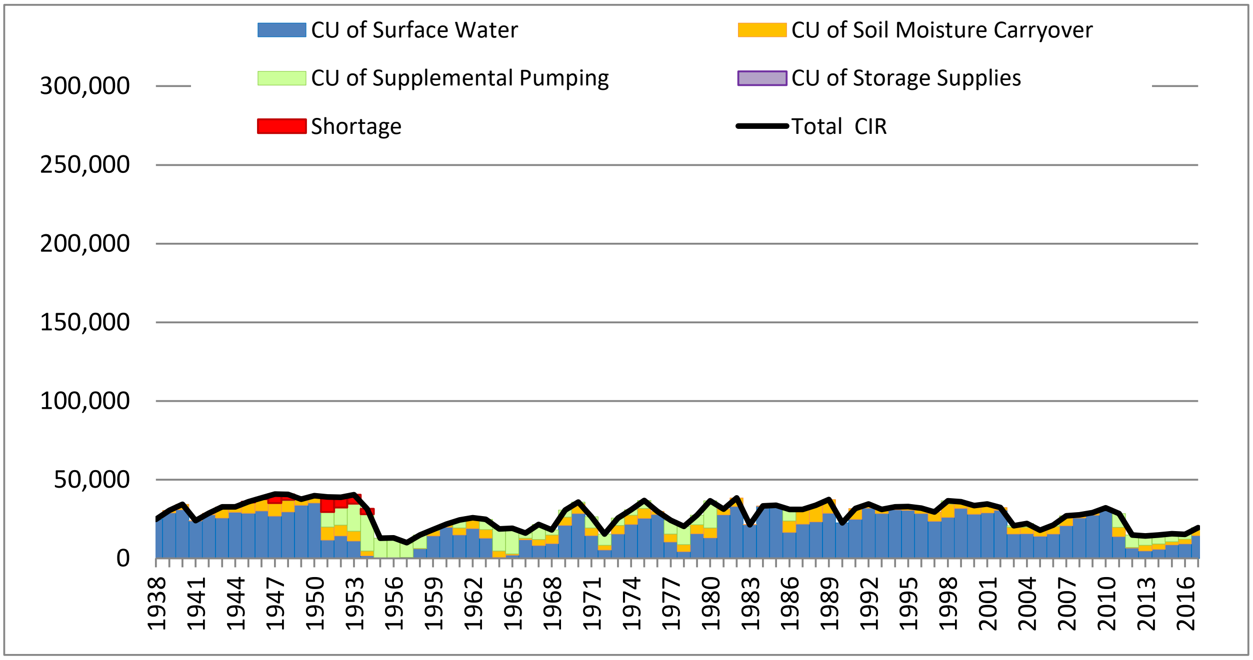
1938 - 2017

Annual Values

Annual Farm Deliveries (Acre-Feet)



Annual CIR and Consumptive Use (Acre-Feet)



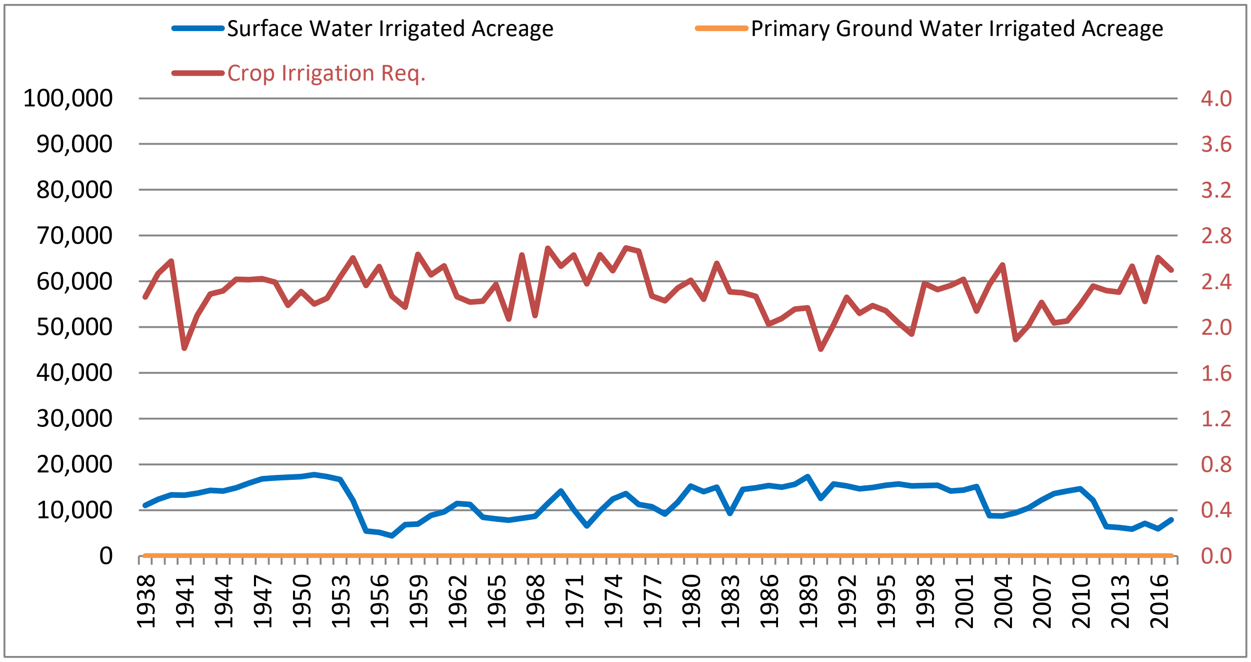
Canal and Farm Water Budget

HCCRD

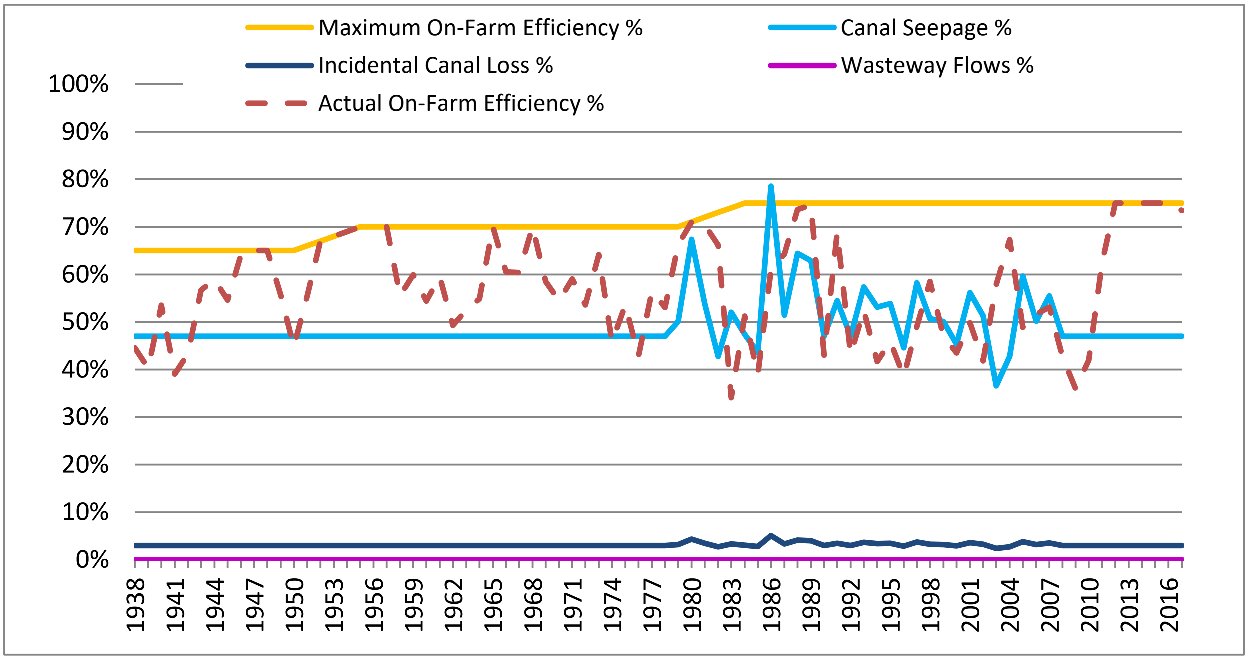
1938 - 2017

Annual Values

Irrigated Area (Acres) and Unit CIR (feet)



Loss and Efficiency Percentages



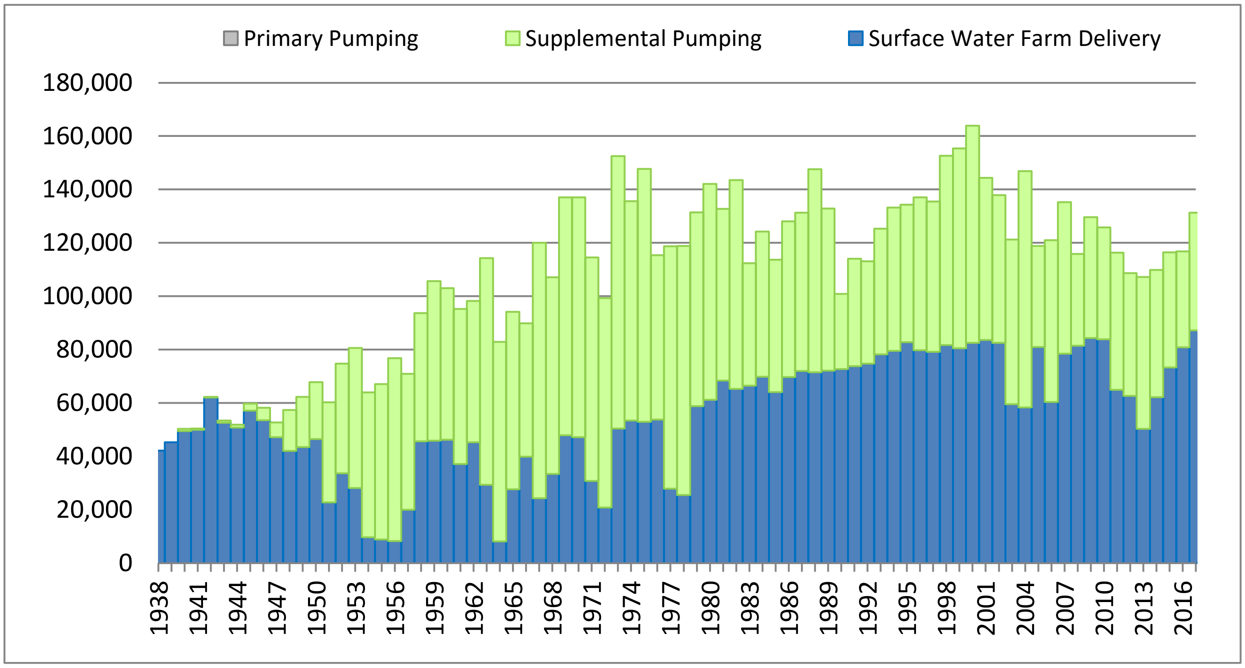
Canal and Farm Water Budget

JID Total

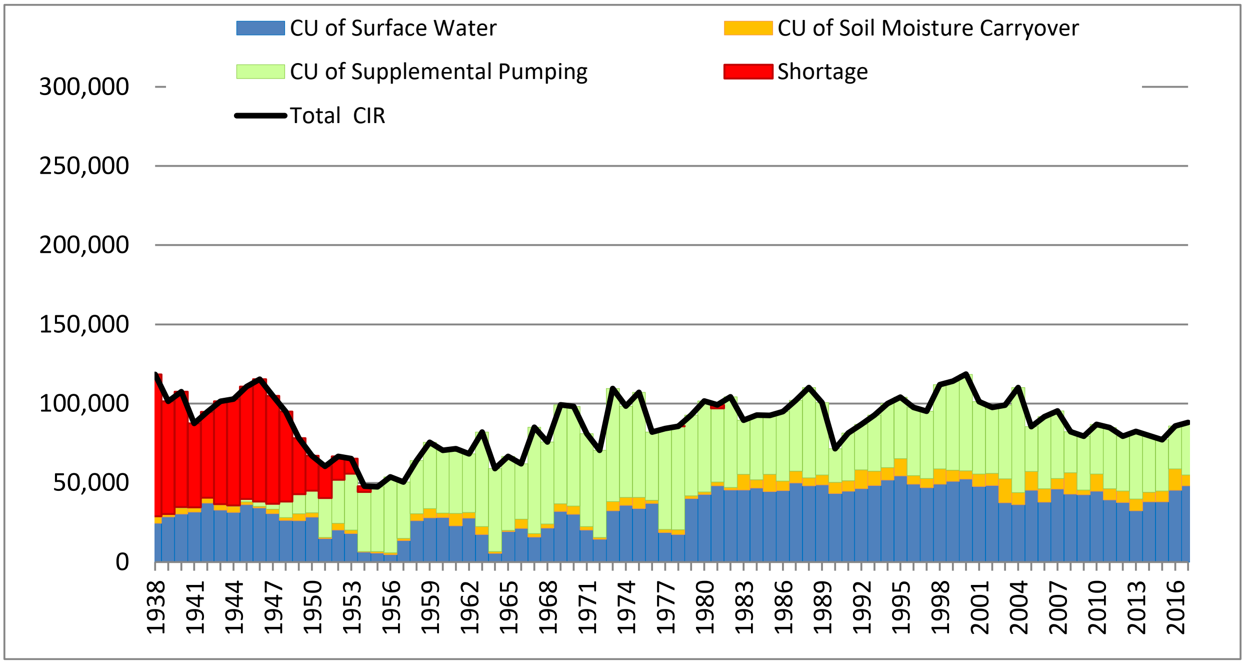
1938 - 2017

Annual Values

Annual Farm Deliveries (Acre-Feet)



Annual CIR and Consumptive Use (Acre-Feet)



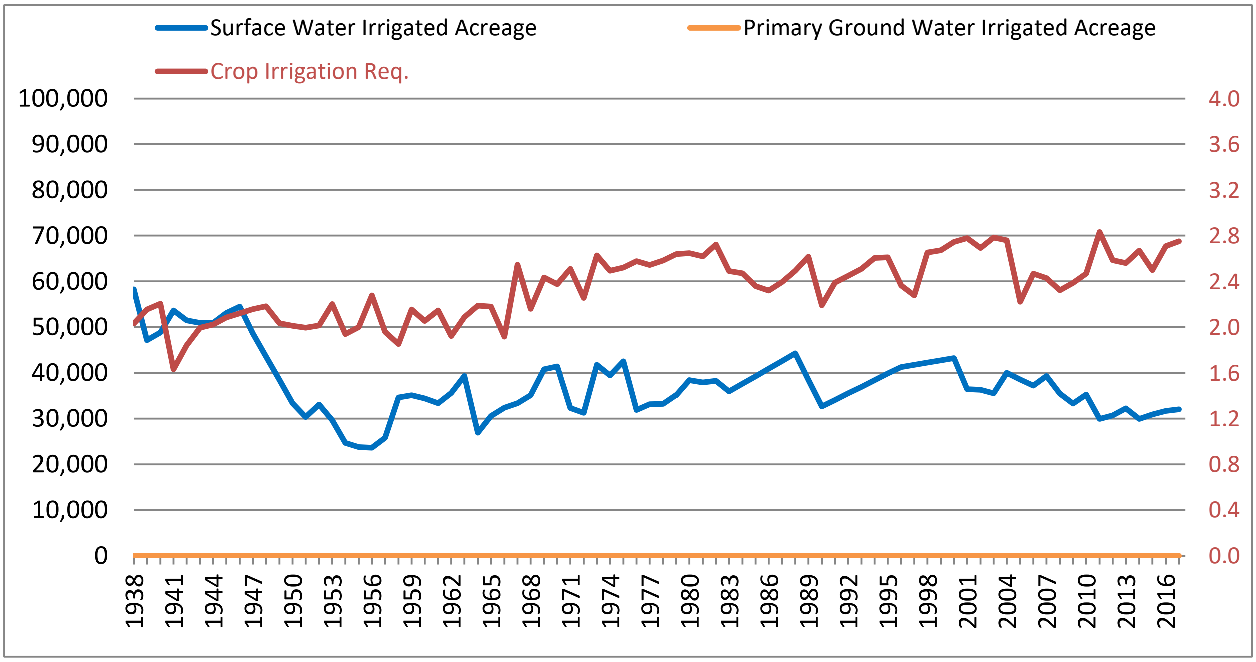
Canal and Farm Water Budget

JID Total

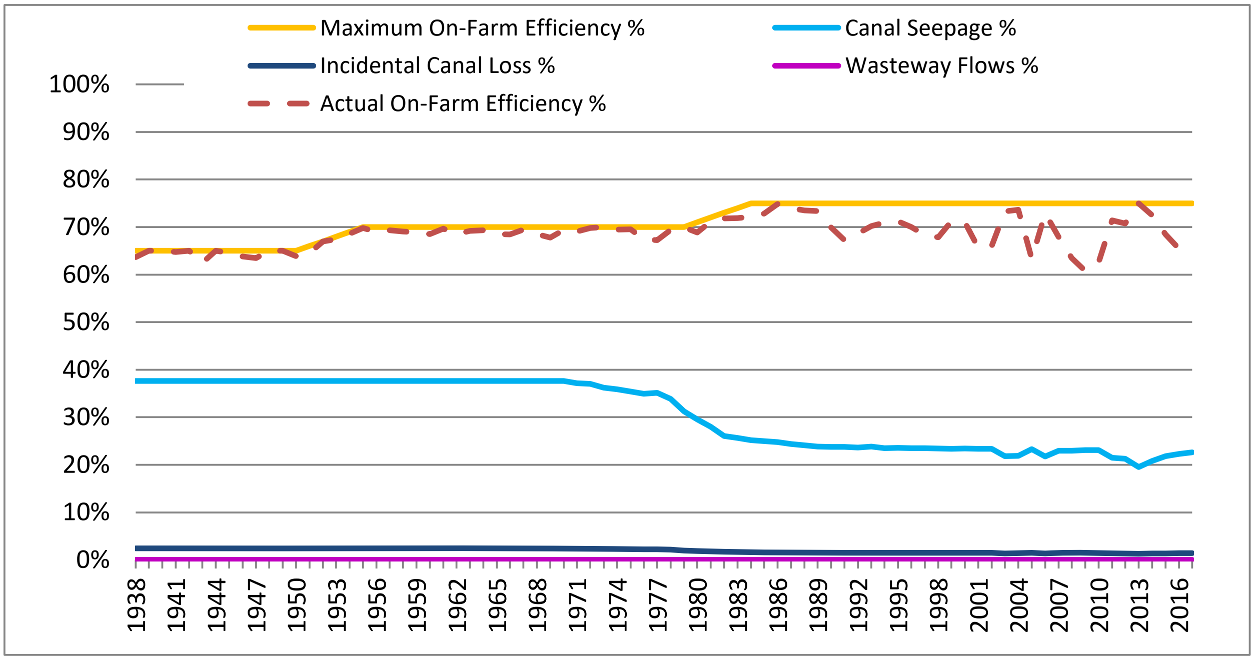
1938 - 2017

Annual Values

Irrigated Area (Acres) and Unit CIR (feet)



Loss and Efficiency Percentages

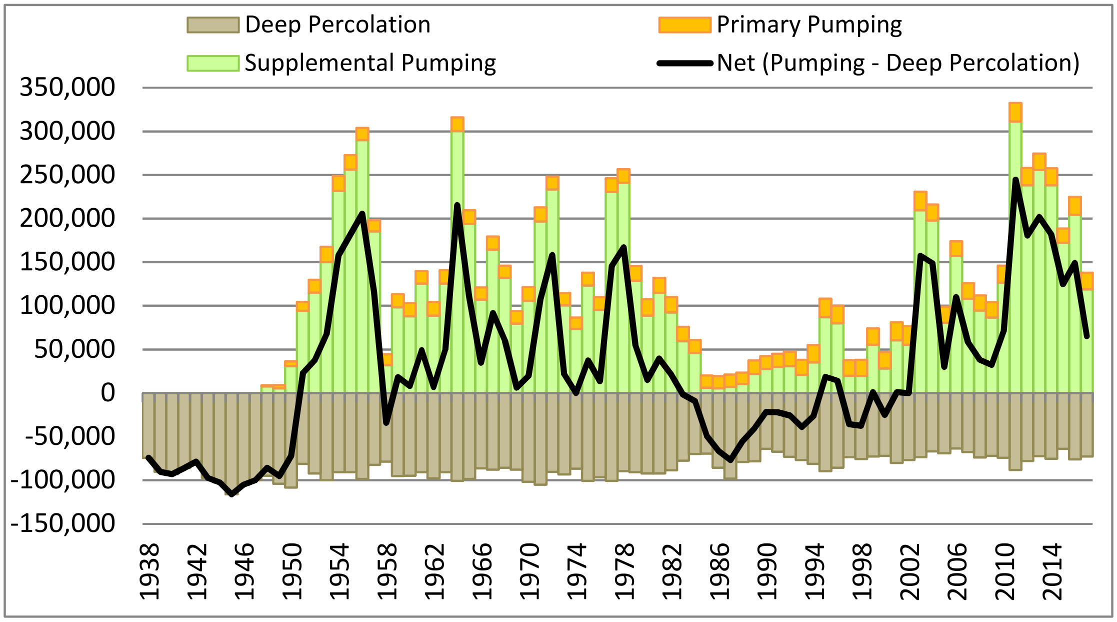


Canal and Farm Water Budget

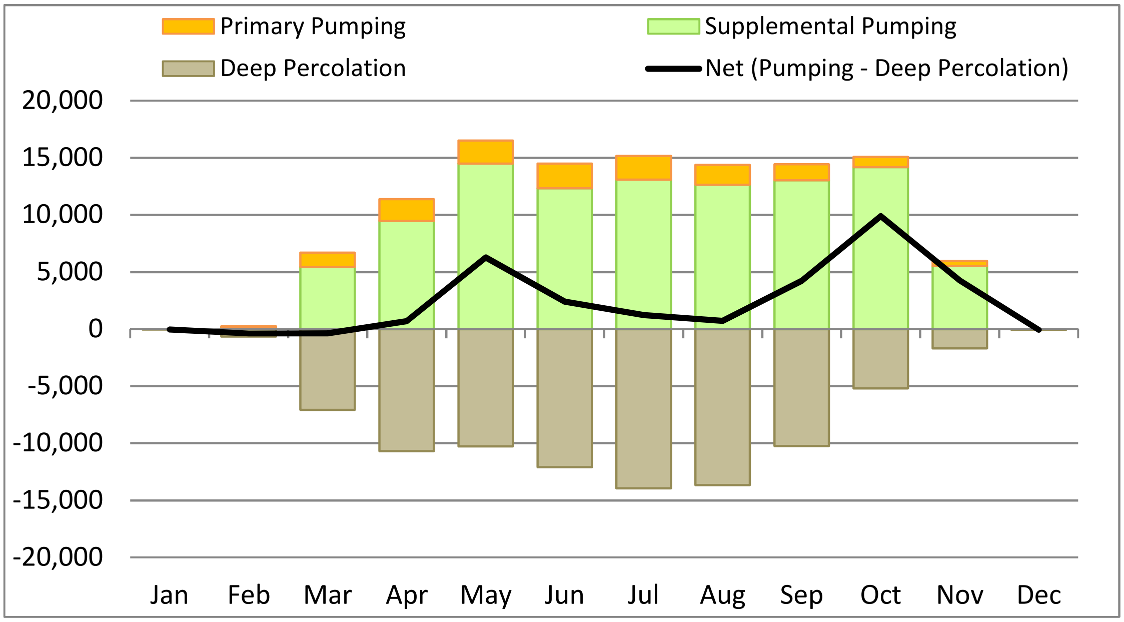
EBID Total

1938 - 2017

Annual Pumping and Deep Percolation (Acre-Feet)



Average Monthly Pumping and Deep Percolation (Acre-Feet)

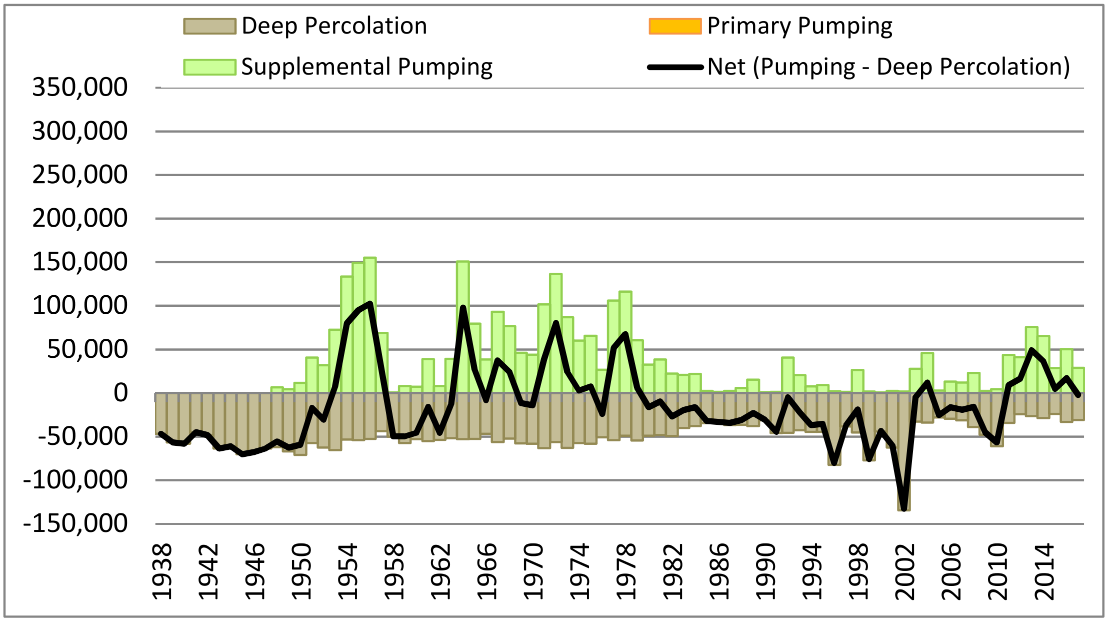


Canal and Farm Water Budget

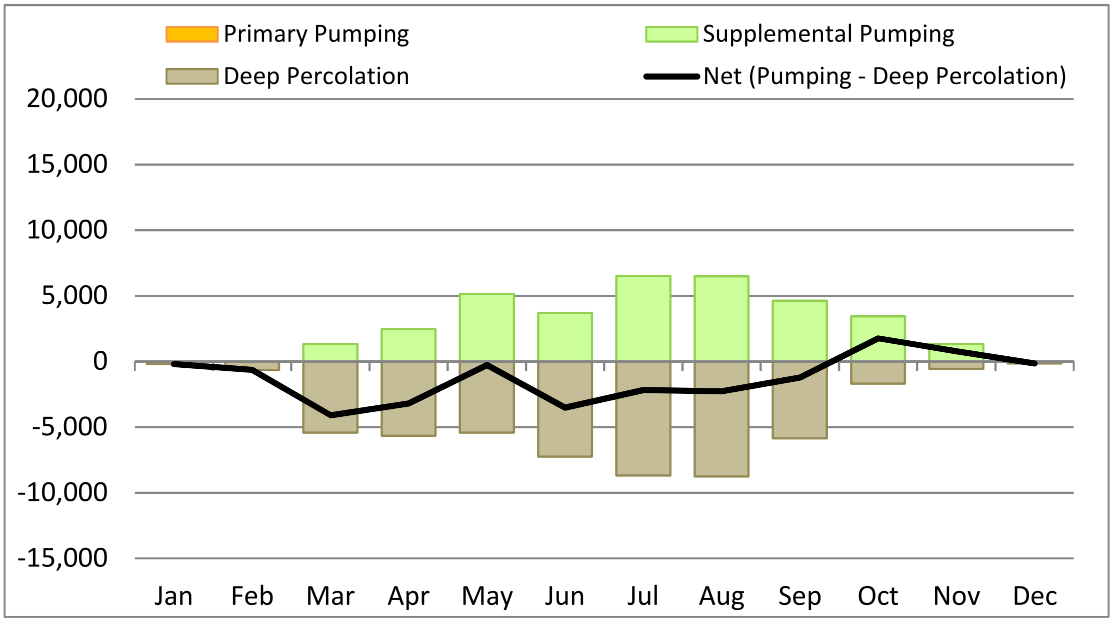
EPCWID Total

1938 - 2017

Annual Pumping and Deep Percolation (Acre-Feet)

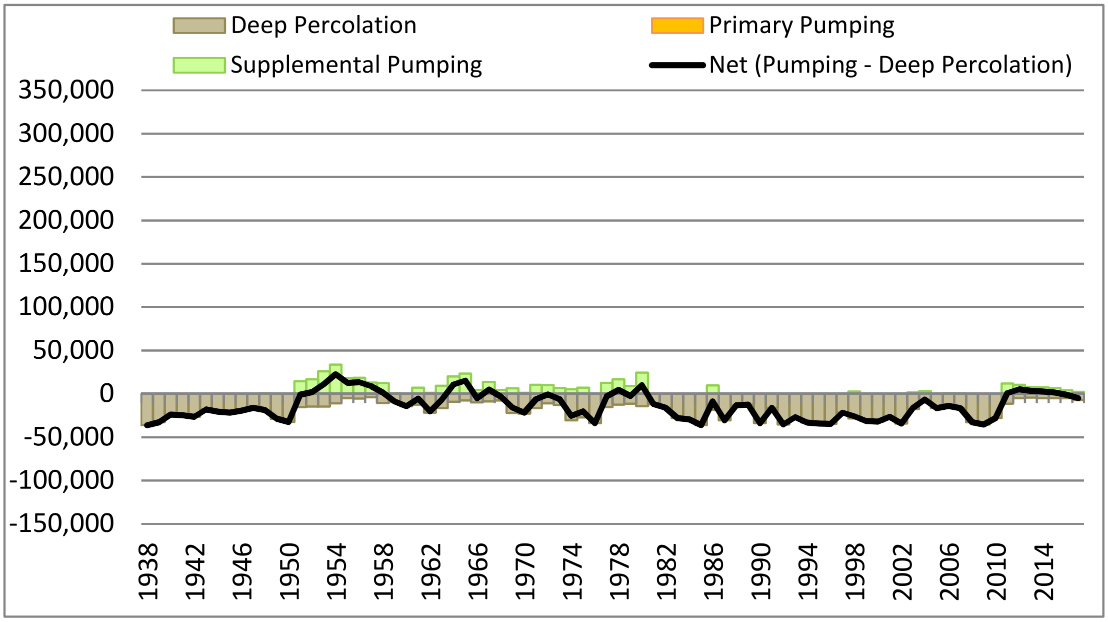


Average Monthly Pumping and Deep Percolation (Acre-Feet)

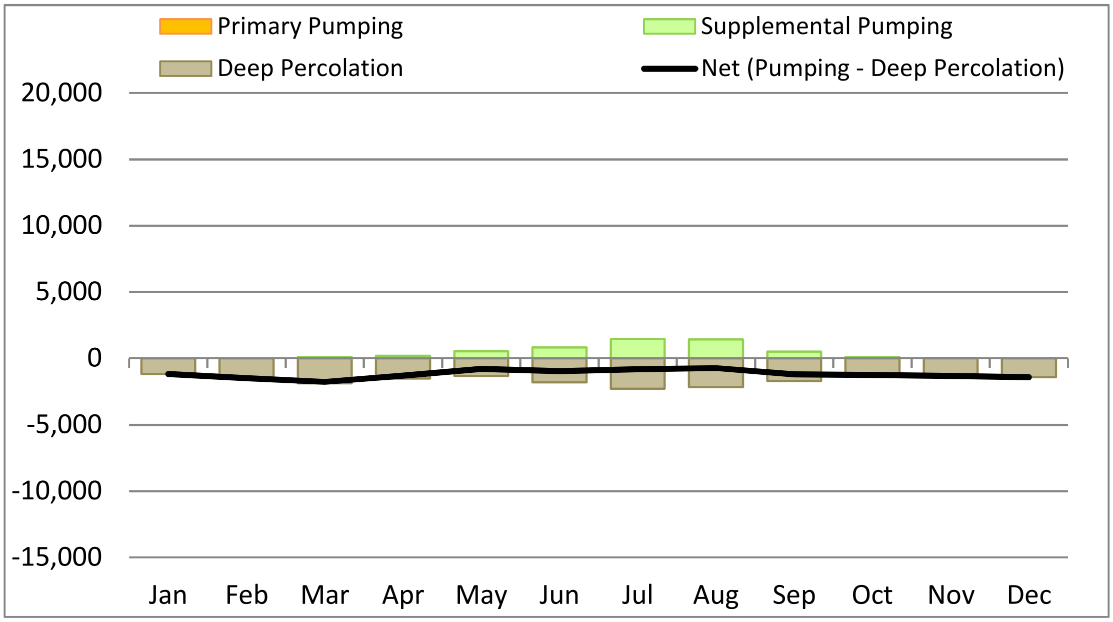


Canal and Farm Water Budget
HCCRD
1938 - 2017

Annual Pumping and Deep Percolation (Acre-Feet)

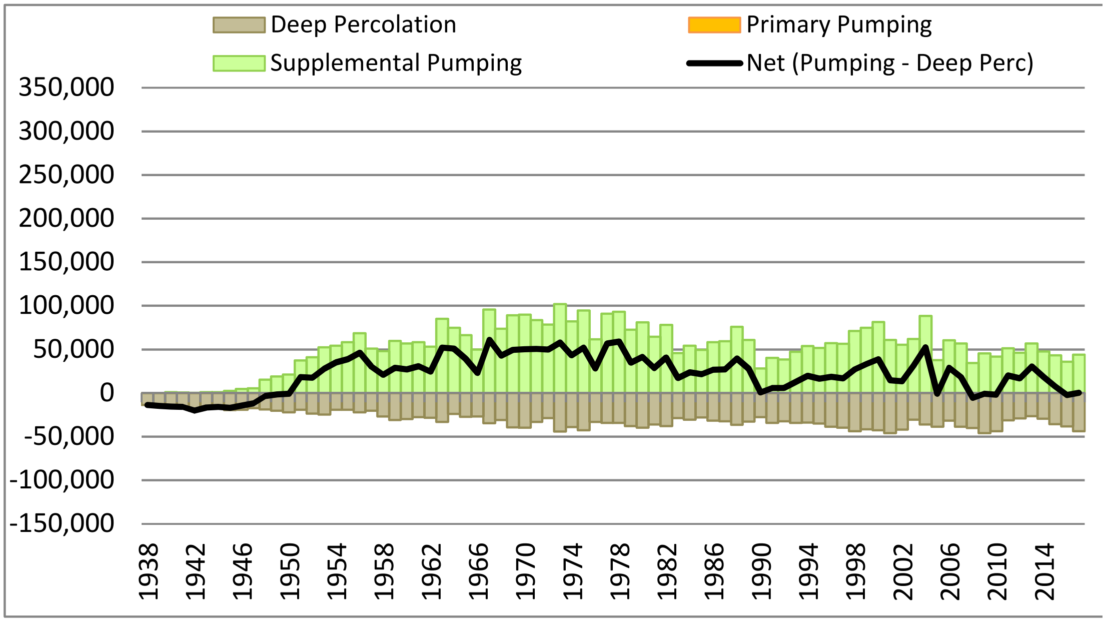


Average Monthly Pumping and Deep Percolation (Acre-Feet)

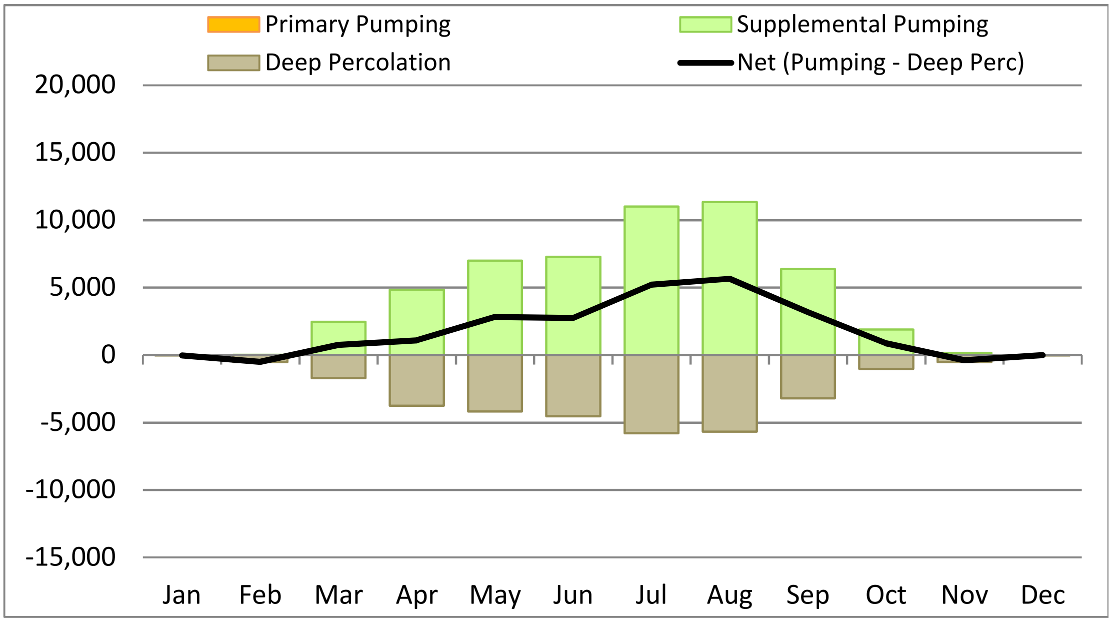


Canal and Farm Water Budget
JID Total
1938 - 2017

Annual Pumping and Deep Percolation (Acre-Feet)



Average Monthly Pumping and Deep Percolation (Acre-Feet)



Canal and Farm Water Budget

EBID Total

1938 - 2017

Monthly Averages (Acre-Feet)

Water User/Supply	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Surface Water Supply (AF)													
(1) Surface Water Diversion	893	6,753	43,273	49,503	46,206	62,578	68,270	63,932	40,999	9,681	1,699	1,241	395,029
(2) Total Canal Loss	451	2,818	19,072	15,218	18,682	26,469	26,480	23,306	12,883	3,821	927	649	150,777
(3) Wasteway Flows	268	2,025	4,762	5,901	5,686	5,782	6,617	6,809	5,665	2,016	465	405	46,399
(4) Eastside Canal to Texas	2	5	17	17	16	17	20	20	18	10	3	4	149
(5) El Paso Valley Carriage	25	146	889	2,072	1,437	1,629	1,889	1,399	982	15	0	0	10,482
(6) SW Farm Delivery (1)-(2)-(3)-(5)	146	1,759	18,533	26,296	20,385	28,680	33,264	32,399	21,451	3,819	303	184	187,221
Ground Water Supply (AF)													
(7) Suppl Ground Water Pumping	0	174	5,431	9,478	14,509	12,329	13,092	12,637	13,025	14,180	5,514	0	100,368
(8) Primary Ground Water Pumping	0	81	1,255	1,898	2,016	2,181	2,086	1,755	1,425	895	444	0	14,036
(9) Total Ground Water Pumping (7)+(8)	0	255	6,685	11,375	16,525	14,510	15,178	14,392	14,451	15,075	5,958	0	114,403
On-Farm Water Budget (AF)													
(10) Total Farm Deliveries (6)+(9)	146	2,014	25,219	37,671	36,910	43,190	48,442	46,791	35,902	18,894	6,261	184	301,624
(11) BOM Soil Moisture	3,626	4,127	4,821	5,807	5,860	4,503	4,582	4,882	4,855	4,103	2,691	3,054	
(12) CU of Surface Water	0	243	10,893	16,715	14,253	19,661	22,359	21,671	14,617	2,590	193	8	123,205
(13) CU of Soil Moisture Carryover	0	238	1,211	1,581	1,523	507	416	714	1,145	1,893	937	39	10,205
(14) CU of Supplemental Pumping	0	126	3,944	6,864	10,442	8,862	9,406	9,090	9,334	10,135	4,001	0	72,205
(15) CU of Primary Pumping	0	59	913	1,377	1,467	1,587	1,517	1,275	1,035	652	324	0	10,205
(16) Total CU (12)+(13)+(14)+(15)	0	667	16,962	26,537	27,684	30,618	33,698	32,750	26,131	15,269	5,454	47	215,819
(17) EOM Soil Moisture	3,726	4,821	5,807	5,860	4,499	4,582	4,882	4,739	4,023	2,386	1,760	3,117	
(18) Surface Runoff	1	16	209	391	329	399	498	506	368	160	49	4	2,930
(19) Deep Percolation	45	637	7,061	10,690	10,258	12,095	13,945	13,678	10,234	5,181	1,690	69	85,584
(20) Total On-Farm Loss (18)+(19)	47	653	7,270	11,081	10,587	12,494	14,443	14,185	10,602	5,341	1,738	73	88,514
(21) Balance (10)-(16)-(20)-((17)-(11))	0	0	0	0	0	0	0	0	0	0	0	0	0
(22) Shortage	0	1	499	169	580	647	781	904	1,332	2,065	226	39	7,242
(23) On-Farm Efficiency	70%	66%	70%	70%	70%	71%	70%	70%	70%	70%	67%	66%	

Canal and Farm Water Budget

EP#1 Total

1938 - 2017

Monthly Averages (Acre-Feet)

Water User/Supply	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Surface Water Supply (AF)													
(1) Surface Water Diversion	3,007	7,923	34,935	30,789	29,263	40,699	46,799	44,415	30,641	13,471	6,682	4,254	292,877
(2) Total Canal Loss	1,029	2,731	12,666	7,951	9,997	14,722	16,158	13,880	7,911	4,519	2,289	1,218	95,070
(3) Wasteway Flows	1,319	3,186	5,156	5,804	5,489	5,423	7,506	7,480	8,095	6,444	3,733	2,588	62,223
(4) From Leasburg Canal	2	5	17	17	16	17	20	20	18	10	3	4	149
(5) El Paso Valley Carriage	2	7	54	182	120	137	156	123	85	1	0	0	867
(6) SW Farm Delivery (1)-(2)-(3)-(5)+(4)	659	2,004	17,076	16,869	13,673	20,435	22,999	22,951	14,569	2,518	664	452	134,867
Ground Water Supply (AF)													
(7) Suppl Ground Water Pumping	0	20	1,335	2,466	5,160	3,720	6,511	6,495	4,628	3,447	1,330	0	35,112
(8) Primary Ground Water Pumping	0	0	0	0	0	0	0	0	0	0	0	0	0
(9) Total Ground Water Pumping (7)+(8)	0	20	1,335	2,466	5,160	3,720	6,511	6,495	4,628	3,447	1,330	0	35,112
On-Farm Water Budget (AF)													
(10) Total Farm Deliveries (6)+(9)	659	2,024	18,411	19,335	18,832	24,155	29,510	29,447	19,197	5,964	1,994	452	169,979
(11) BOM Soil Moisture	3,210	3,902	4,842	7,812	6,501	4,398	4,524	3,899	3,183	3,307	2,298	2,656	
(12) CU of Surface Water	0	334	8,022	10,580	9,389	13,190	15,409	15,615	9,286	1,691	384	37	83,938
(13) CU of Soil Moisture Carryover	0	68	876	2,427	2,258	735	1,138	897	501	1,292	527	20	10,739
(14) CU of Supplemental Pumping	0	15	949	1,752	3,668	2,620	4,602	4,596	3,285	2,470	966	0	24,923
(15) CU of Primary Pumping	0	0	0	0	0	0	0	0	0	0	0	0	0
(16) Total CU (12)+(13)+(14)+(15)	0	417	9,847	14,760	15,315	16,545	21,149	21,108	13,072	5,453	1,877	57	119,601
(17) EOM Soil Moisture	3,667	4,842	7,812	6,501	4,398	4,522	3,899	3,151	3,245	2,078	1,844	2,906	
(18) Surface Runoff	5	19	163	229	198	241	302	315	203	56	19	6	1,758
(19) Deep Percolation	197	648	5,430	5,657	5,422	7,245	8,683	8,772	5,861	1,685	552	139	50,290
(20) Total On-Farm Loss (18)+(19)	202	667	5,594	5,887	5,620	7,486	8,985	9,086	6,064	1,741	571	146	52,047
(21) Balance (10)-(16)-(20)-((17)-(11))	0	0	0	0	0	0	0	0	0	0	0	0	0
(22) Shortage	0	0	448	103	323	416	964	1,180	1,176	982	214	37	5,842
(23) On-Farm Efficiency	73%	66%	69%	71%	71%	70%	70%	70%	69%	70%	69%	66%	

Canal and Farm Water Budget

HCCRD

1938 - 2017

Monthly Averages (Acre-Feet)

	Water User/Supply	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
	Surface Water Supply (AF)													
(1)	Surface Water Diversion	3,598	4,106	7,048	8,516	8,008	8,867	11,017	11,131	10,619	7,561	5,041	4,255	89,766
(2)	Diversion to Storage	0	0	0	0	0	0	0	0	0	0	0	0	0
(3)	Diversion from Storage	0	0	0	0	0	0	0	0	0	0	0	0	0
(4)	Canal Loss on SW	2,094	2,250	3,254	4,654	4,645	4,410	5,310	5,635	6,090	4,542	2,849	2,396	48,128
(5)	Canal Loss on Storage	0	0	0	0	0	0	0	0	0	0	0	0	0
(6)	Wasteway Flows	0	0	0	0	0	0	0	0	0	0	0	0	0
(7)	Farm Delivery (1)+(3)-(2)-(4)-(5)-(6)	1,504	1,856	3,794	3,862	3,362	4,458	5,707	5,495	4,529	3,019	2,192	1,859	41,638
(8)	Suppl Ground Water Pumping	0	0	109	208	532	824	1,458	1,443	516	95	25	0	5,211
(9)	Primary Ground Water Pumping	0	0	0	0	0	0	0	0	0	0	0	0	0
(10)	Total Ground Water Pumping (8)+(9)	0	0	109	208	532	824	1,458	1,443	516	95	25	0	5,211
	On-Farm Water Budget (AF)													
(11)	Total Farm Deliveries (7)+(10)	1,504	1,856	3,904	4,070	3,894	5,282	7,165	6,938	5,045	3,114	2,217	1,859	46,849
(12)	BOM Soil Moisture	4,544	4,897	5,121	4,852	4,185	3,344	3,084	2,656	2,163	2,616	3,321	4,143	
(13)	CU of Surface Water	0	91	1,711	2,341	2,138	2,654	3,696	3,548	2,354	894	246	17	19,688
(14)	CU of Soil Moisture Carryover	0	6	467	700	860	474	521	666	202	173	5	0	4,074
(15)	CU of Storage Supplies	0	0	0	0	0	0	0	0	0	0	0	0	0
(16)	CU of Supplemental Pumping	0	0	77	145	375	579	1,026	1,020	362	67	17	0	3,669
(17)	CU of Primary Pumping	0	0	0	0	0	0	0	0	0	0	0	0	0
(18)	Total CU	0	97	2,255	3,187	3,373	3,707	5,244	5,233	2,918	1,134	269	17	27,432
(19)	EOM Soil Moisture	4,830	5,121	4,852	4,185	3,344	3,067	2,656	2,119	2,521	3,204	3,892	4,514	
(20)	Surface Runoff	37	42	46	49	51	59	73	70	57	42	43	51	620
(21)	Deep Percolation	1,181	1,493	1,873	1,501	1,311	1,792	2,275	2,173	1,712	1,350	1,335	1,420	19,416
(22)	Total On-Farm Loss (20)+(21)	1,218	1,535	1,919	1,550	1,362	1,852	2,348	2,243	1,769	1,392	1,377	1,471	20,036
(23)	Balance (11)-(18)-(22)-((19)-(12))	0	0	0	0	0	0	0	0	0	0	0	0	0
(24)	Shortage	0	0	0	5	20	48	93	110	141	26	1	3	447
(25)	On-Farm Efficiency	39%	29%	60%	66%	68%	67%	68%	69%	67%	61%	47%	34%	

Canal and Farm Water Budget

JID Total

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Monthly Averages (Acre-Feet)

	Water User/Supply	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
	Surface Water Supply (AF)													
(1)	Surface Water Diversion	25	2,602	5,030	11,800	11,390	12,082	12,687	12,046	7,093	2,616	2,508	0	79,879
(2)	Total Canal Loss	7	614	1,399	3,777	3,747	3,895	4,079	3,877	2,219	621	587	0	24,822
(3)	Wasteway Flows	0	0	0	0	0	0	0	0	0	0	0	0	0
(4)	SW Farm Delivery (1)-(2)-(3)	18	1,988	3,631	8,023	7,644	8,186	8,608	8,168	4,874	1,995	1,921	0	55,057
	Ground Water Supply (AF)													
(5)	Suppl Ground Water Pumping	0	13	2,457	4,832	7,003	7,291	11,012	11,337	6,385	1,901	158	0	52,389
(6)	Primary Ground Water Pumping	0	0	0	0	0	0	0	0	0	0	0	0	0
(7)	Total Ground Water Pumping (5)+(6)	0	13	2,457	4,832	7,003	7,291	11,012	11,337	6,385	1,901	158	0	52,389
	On-Farm Water Budget (AF)													
(8)	Total Farm Deliveries (4)+(7)	18	2,001	6,088	12,855	14,646	15,477	19,620	19,505	11,258	3,896	2,080	0	107,446
(9)	BOM Soil Moisture	2,672	2,850	3,976	1,635	1,176	1,299	1,571	1,348	1,163	1,087	1,190	2,544	
(10)	CU of Surface Water	0	286	2,545	5,032	4,815	5,182	5,594	5,457	3,292	1,358	632	0	34,192
(11)	CU of Soil Moisture Carryover	0	56	2,402	932	304	103	356	288	376	363	96	42	5,317
(12)	CU of Supplemental Pumping	0	9	1,736	3,494	5,104	5,285	7,943	8,159	4,580	1,371	112	0	37,793
(13)	CU of Primary Pumping	0	0	0	0	0	0	0	0	0	0	0	0	0
(14)	Total CU (10)+(11)+(12)+(13)	0	351	6,683	9,458	10,223	10,569	13,893	13,904	8,247	3,092	839	42	77,303
(15)	EOM Soil Moisture	2,672	3,976	1,635	1,176	1,299	1,539	1,348	1,103	863	834	1,888	2,501	
(16)	Surface Runoff	0	9	47	105	123	129	165	167	100	24	10	0	879
(17)	Deep Percolation	18	515	1,699	3,752	4,177	4,539	5,785	5,680	3,211	1,033	532	0	30,941
(18)	Total On-Farm Loss (16)+(17)	18	524	1,747	3,857	4,300	4,669	5,950	5,847	3,311	1,057	541	0	31,820
(19)	Balance (8)-(14)-(18)-((15)-(9))	0	0	0	0	0	0	0	0	0	0	0	0	0
(20)	Shortage	0	0	689	773	569	862	2,084	2,740	1,836	925	154	27	10,659
(21)	On-Farm Efficiency	75%	68%	70%	67%	69%	68%	67%	68%	70%	70%	68%	0%	

Canal and Farm Water Budget

EBID Total

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Annual Totals (Acre-Feet)

Year	SW Acres	Primary GW Acres	Total CIR	Excess Effective Precip	Surface Water Divers	Total Canal Loss	Wasteway Flows	Eastside Canal to Texas	El Paso Valley Carriage	SW Farm Delivery	Suppl Ground Water Pumping	Primary Ground Water Pumping	Total Ground Water Pumping	CU of Surface Water	CU of SM Carryover	CU of Suppl GW Pumping	CU of Primary GW Pumping	Total CU	Surface Runoff	Deep Perc	Change in Soil Moisture	Shortage
1938	78,237	0	186,810	860	468,254	168,755	72,487	453	0	226,559	0	0	0	137,344	5,359	0	0	142,703	4,956	74,340	380	44,107
1939	78,533	0	204,202	772	512,935	180,490	67,856	492	0	264,098	0	0	0	159,167	7,501	0	0	166,668	6,036	90,538	71	37,534
1940	80,379	0	194,781	1,469	472,715	155,000	58,233	632	0	258,851	0	0	0	149,793	13,012	0	0	162,805	6,204	93,057	-268	31,976
1941	83,944	0	150,766	11,240	428,114	143,523	65,540	275	0	218,775	0	0	0	103,104	35,236	0	0	138,340	5,732	85,976	-939	12,425
1942	86,482	0	187,104	3,236	575,274	213,633	123,681	918	0	237,042	0	0	0	131,939	24,260	0	0	156,198	5,248	78,724	-261	30,906
1943	88,035	0	226,199	2,369	594,190	210,322	93,683	722	0	289,464	0	0	0	170,067	14,358	0	0	184,424	6,503	97,550	82	41,774
1944	88,116	0	212,450	163	570,079	197,829	86,137	618	0	285,496	0	0	0	166,841	13,123	0	0	179,964	6,841	102,620	-327	32,486
1945	88,714	0	217,788	313	602,349	210,411	70,351	449	0	321,139	0	0	0	177,711	15,258	0	0	192,969	7,746	116,195	352	24,819
1946	90,099	0	225,511	2,186	558,552	216,027	50,136	291	0	292,098	0	0	0	168,434	18,429	0	0	186,863	7,007	105,110	-573	38,648
1947	90,829	0	209,674	4,068	516,168	195,324	47,712	242	0	272,890	0	0	0	147,133	25,318	0	0	172,450	6,669	100,036	-522	37,224
1948	89,162	258	215,703	8,977	511,646	191,588	51,190	257	0	268,610	7,744	1,107	8,851	144,776	29,939	5,034	719	180,468	6,311	94,662	-332	35,235
1949	91,701	928	190,915	4,013	530,898	193,479	58,748	303	0	278,368	5,425	3,607	9,031	151,023	23,441	3,526	2,344	180,334	6,940	104,093	-331	10,578
1950	91,521	1,168	243,258	44	521,122	167,954	69,083	278	0	283,807	30,751	5,439	36,190	169,030	17,390	19,988	3,535	209,944	7,225	108,382	-463	33,314
1951	90,608	2,292	233,607	2,738	306,343	123,298	33,842	146	0	149,057	94,060	10,452	104,512	92,662	9,887	62,079	6,899	171,527	4,850	81,364	-348	62,079
1952	92,109	3,389	244,392	466	326,705	120,519	41,474	89	0	164,623	115,297	14,557	129,854	110,226	814	77,249	9,753	198,042	4,859	92,319	-62	46,350
1953	93,045	3,859	258,288	2,830	330,476	128,998	42,461	63	0	158,954	149,987	17,728	167,715	107,110	3,134	101,991	12,055	224,291	4,573	99,961	-180	33,997
1954	85,834	3,930	234,292	66	187,831	77,265	54,856	13	0	55,696	231,648	17,007	248,656	38,430	1,177	159,837	11,735	211,179	3,538	90,811	-98	23,087
1955	86,153	4,378	221,748	1,422	144,314	49,730	13,993	9	38,488	42,095	256,194	16,462	272,656	29,466	1,422	179,336	11,524	221,748	3,541	90,884	-119	0
1956	82,110	3,192	240,893	3,469	156,405	63,810	15,106	3	40,130	37,357	289,988	14,026	304,014	26,150	1,933	202,992	9,818	240,893	3,840	98,571	-161	0
1957	82,740	3,309	204,642	3,105	294,134	85,347	18,273	30	103,079	87,406	185,182	13,129	198,311	60,346	5,479	129,628	9,190	204,642	3,214	82,501	-387	0
1958	83,923	3,425	189,992	2,912	472,955	174,390	70,592	250	0	227,723	31,794	12,405	44,199	144,581	14,473	22,256	8,683	189,992	3,059	78,517	29	0
1959	84,920	3,542	233,933	807	462,929	180,744	66,072	98	0	216,016	98,319	15,144	113,462	146,124	8,385	68,823	10,601	233,933	3,707	95,137	-275	0
1960	85,162	3,535	232,307	4,920	467,868	204,752	37,212	143	0	225,761	88,063	14,956	103,019	153,871	6,323	61,644	10,469	232,307	3,699	94,935	-180	0
1961	85,388	3,527	224,562	771	391,130	173,436	43,152	74	0	174,468	125,495	14,271	139,767	122,038	4,394	87,847	9,990	224,269	3,535	90,735	-359	230
1962	86,191	3,520	237,361	1,556	448,492	179,997	34,403	247	0	233,845	88,897	15,536	104,433	153,672	10,586	62,228	10,875	237,361	3,806	97,678	-47	0
1963	86,669	3,513	222,950	2,109	400,866	154,809	72,683	109	0	173,265	125,541	15,252	140,793	113,877	10,484	87,879	10,676	222,916	3,533	90,684	-256	27
1964	84,881	3,505	244,051	1,332	189,234	64,917	56,139	23	35,721	32,434	300,222	15,756	315,979	22,674	193	210,156	11,029	244,051	3,920	100,604	-14	0
1965	83,259	3,498	240,699	781	268,540	108,901	20,669	35	6,894	132,041	193,859	15,717	209,577	92,429	1,530	135,702	11,002	240,663	3,843	98,642	-128	0
1966	80,402	3,490	210,452	477	381,033	153,727	36,712	21	12,730	177,845	107,181	13,966	121,147	119,401	6,011	75,027	9,776	210,214	3,364	86,334	-77	159
1967	77,675	3,483	214,129	1,199	354,625	141,415	12,103	30	76,884	124,193	164,335	15,208	179,543	79,667	8,466	115,035	10,645	213,814	3,417	87,704	-100	273
1968	82,959	3,476	209,735	2,128	437,441	161,389	12,169	0	113,347	150,536	131,982	13,885	145,867	97,832	9,672	92,388	9,720	209,611	3,335	85,587	-177	105
1969	84,211	3,468	213,353	4,872	497,059	208,849	16,725	27	61,202	210,257	79,509	14,264	93,773	128,069	19,642	55,656	9,985	213,353	3,420	87,789	-44	0
1970	84,948	3,461	251,282	1,325	489,786	192,963	20,334	45	45,208	231,236	105,709	15,746	121,455	151,355	14,909	73,996	11,022	251,282	3,968	101,840	-366	0
1971	84,363	3,454	256,610	373	378,566	146,923	14,256	33	65,697	151,657	196,598	16,228	212,827	103,711	3,906	137,619	11,360	256,596	4,100	105,245	-121	0
1972	80,598	3,446	219,897	1,508	228,424	76,337	5,938	39	81,681	64,430	233,421	14,805	248,226	45,101	1,038	163,395	10,363	219,897	3,517	90,279	-86	0
1973	84,757	3,439	228,721	1,780	403,624	150,012	11,220	85	34,019	208,289	100,415	14,566	114,981	139,188	9,046	70,290	10,196	228,721	3,637	93,344	-203	0
1974	85,380	3,432	211,079	3,968	444,941	159,973	12,569	90	58,615	213,694	73,282	13,186	86,468	142,362	8,190	51,298	9,230	211,079	3,377	86,672	-80	0
1975	85,346	3,424	247,046	635	421,494	157,430	19,313	68	34,393	210,290	123,095	14,862	137,957	145,869	4,599	86,167	10,404	247,038	3,918	100,557	-272	0
1976	78,721	3,417	235,173	251	479,793	207,947	22,775	225	23,969	224,878	95,372	14,820	110,193	146,602	11,436	66,761	10,374	235,173	3,770	96,751	-52	0
1977	84,682	3,611	244,296	1,015	255,660	139,416	10,401	106	3,372	102,364	230,500	15,910	246,410	71,655	154	161,350	11,137	244,296	3,924	100,709	-13	0
1978	82,112	3,805	220,224	4,322	168,907	106,564	5,291	39	3,146	53,867	241,202	15,254	256,456	37,707	2,989	168,842	10,678	220,215	3,491	89,606	-249	0
1979	78,877	3,999	222,835	2,573	344,644	157,227	17,894	137	0	169,386	128,651	16,946	145,596	117,361	3,553	90,055	11,862	222,830	3,544	90,951	-195	0
1980	80,285	4,191	237,858	340	437,718	178,502	35,296	165	0	223,756	88,867	18,495	107,362	153,984	7,647	63,095	13,132	237,858	3,601	92,423	-230	0
1981	83,655	4,118	247,658	855	387,881	155,193	23,916	134	0	208,639	114,857	17,082	131,939	145,384	5,691	82,697	12,299	246,072	2,980	92,382	-71	1,420
1982	80,489	4,045	246,380	2,688	417,387	167,820	22,705	146	0	226,717	92,509	17,521	110,030	160,026	6,033	67,532	12,790	246,380	2,273	88,648	-46	0
1983	75,177	3,973	227,867	1,263	421,218	172,322	20,767	153	0	227,976	59,415	16,632	76,047	166,624	4,969	43,967	12,308	227,867	1,482	77,564	-241	0
1984	77,047	4,017	213,536	8,931	411,371	166,272	22,524	149	0	222,425	45,721	14,934	60,655	160,929	7,115	34,291	11,201	213,536	885	69,885	-102	0
1985	78,697	4,062	201,046	4,982	435,425	137,345	42,719	146	0	255,215	6,095	13,932	20,027	173,864	12,161	4,571	10,449	201,046	878	69,382	328	0
1986	79,017	4,107	195,805	9,589	542,723	174,519	104,435	186	0	263,583	5,349	13,825	19,174	169,719	11,705	4,012	10,369	195,805	1,086	85,816	4	0

Canal and Farm Water Budget

EBID Total

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Annual Totals (Acre-Feet)

Year	SW Acres	Primary GW Acres	Total CIR	Excess Effectiv e Precip	Surface Water Divers	Total Canal Loss	Wastew ay Flows	Eastside Canal to Texas	El Paso Valley Carriage	SW Farm Delivery	Suppl Ground Water Pumping	Primary Ground Water Pumping	Total Ground Water Pumping	CU of Surface Water	CU of SM Carryover	CU of Suppl GW Pumping	CU of Primary GW Pumping	Total CU	Surface Runoff	Deep Perc	Change in Soil Moisture	Shortage
1987	77,597	3,913	201,494	1,600	578,161	224,439	89,603	213	0	263,906	7,036	14,125	21,161	163,541	22,082	5,277	10,594	201,494	1,241	98,010	-1,307	0
1988	76,536	3,718	194,524	2,198	502,474	174,654	76,963	183	0	250,674	10,287	13,234	23,521	161,113	15,770	7,715	9,926	194,524	999	78,931	-22	0
1989	78,962	3,991	217,738	5,823	495,146	186,509	64,145	166	0	244,326	21,759	15,625	37,384	160,556	29,143	16,319	11,719	217,737	989	78,157	-1,264	0
1990	76,997	4,264	198,863	406	423,642	170,308	36,197	127	0	217,010	27,269	15,200	42,469	146,359	20,652	20,452	11,400	198,863	811	64,059	-355	0
1991	78,899	4,322	202,470	9,411	406,711	133,599	45,566	143	0	227,403	29,770	15,377	45,148	152,969	15,635	22,328	11,533	202,465	852	67,286	162	0
1992	77,522	4,380	217,836	8,104	469,534	192,048	40,391	168	0	236,927	30,570	16,847	47,417	161,261	21,012	22,927	12,635	217,836	928	73,338	-647	0
1993	75,743	4,438	215,887	5,805	504,268	131,490	130,705	181	0	241,891	20,973	16,931	37,904	162,425	25,033	15,730	12,699	215,887	971	76,747	-1,151	0
1994	76,909	4,496	252,300	2,556	579,107	144,805	160,076	201	0	274,025	35,043	19,901	54,944	188,271	22,822	26,282	14,926	252,300	1,028	81,214	-464	0
1995	77,620	4,554	275,185	746	583,589	256,903	71,638	200	0	254,849	87,001	21,196	108,197	184,872	9,113	65,251	15,897	275,133	1,135	89,627	-237	0
1996	79,246	4,612	260,841	189	523,547	198,764	77,276	135	0	247,373	80,010	20,139	100,149	176,799	8,930	60,008	15,104	260,841	1,086	85,794	-17	0
1997	77,795	4,732	224,583	4,418	526,669	212,810	53,196	132	0	260,531	19,692	18,117	37,808	179,175	17,052	14,769	13,587	224,583	932	73,653	-69	0
1998	77,550	4,852	229,482	1,476	535,351	197,039	74,450	137	0	263,725	19,418	18,779	38,197	172,141	28,543	14,563	14,084	229,332	958	75,713	-340	107
1999	77,150	4,972	222,455	2,449	461,886	179,696	60,818	117	0	221,255	55,186	18,788	73,974	161,500	5,475	41,389	14,091	222,455	923	72,885	-86	0
2000	77,933	5,091	222,077	990	494,468	190,938	58,132	115	0	245,283	28,099	18,879	46,978	165,537	21,306	21,074	14,159	222,077	913	72,152	-240	0
2001	79,061	5,140	244,672	491	522,126	193,555	84,596	84	0	243,890	60,336	20,845	81,182	175,126	8,660	45,252	15,634	244,672	1,016	80,252	-72	0
2002	77,782	5,350	236,008	6,793	497,064	171,315	91,074	57	0	234,618	55,472	21,224	76,695	174,144	4,342	41,604	15,918	236,008	973	76,855	-210	0
2003	74,377	5,096	231,019	3,847	198,434	102,893	29,033	17	0	66,490	209,601	21,035	230,637	49,868	8,173	157,201	15,777	231,019	929	73,353	-681	0
2004	76,665	5,153	205,290	1,761	195,883	124,802	15,409	28	0	55,645	197,768	18,193	215,961	41,734	1,579	148,326	13,645	205,284	849	67,053	-132	0
2005	77,358	5,008	216,277	6,363	387,238	146,543	60,286	52	0	180,357	80,279	18,910	99,189	134,505	7,380	60,210	14,182	216,277	874	69,013	-551	0
2006	76,019	4,941	194,879	1,445	242,254	118,060	39,685	26	0	84,483	156,896	16,839	173,735	63,188	1,389	117,672	12,629	194,879	807	63,748	-101	0
2007	77,030	4,980	211,361	4,730	326,312	133,838	43,950	33	0	148,492	107,868	18,082	125,950	111,369	4,959	80,901	13,561	210,791	858	67,753	-413	511
2008	76,486	4,574	224,979	161	354,763	125,245	41,582	35	0	187,901	94,442	17,518	111,960	139,345	1,664	70,832	13,138	224,979	937	74,028	-7	0
2009	71,210	4,397	221,049	4,711	342,857	116,881	38,740	27	0	187,208	86,515	17,808	104,323	139,591	3,216	64,886	13,356	221,049	911	71,972	-200	0
2010	74,875	4,794	230,701	2,249	317,854	118,847	43,565	25	0	155,417	126,565	19,536	146,101	114,683	6,442	94,924	14,652	230,701	942	74,437	-380	0
2011	71,592	4,411	268,215	1,352	94,843	52,899	17,790	5	0	24,149	311,145	21,450	332,595	18,112	656	233,359	16,088	268,215	1,115	88,071	-55	0
2012	68,110	4,415	237,859	1,203	153,008	65,700	30,284	10	0	57,014	238,292	19,859	258,152	42,761	1,484	178,719	14,894	237,859	985	77,807	-124	0
2013	72,494	4,706	221,413	687	59,397	27,128	12,554	4	0	19,711	255,945	18,392	274,337	14,783	877	191,959	13,794	221,413	919	72,593	-73	0
2014	72,124	4,646	229,569	576	114,714	50,906	15,664	9	0	48,135	238,214	19,282	257,496	36,101	346	178,660	14,461	229,569	955	75,453	-29	0
2015	69,057	4,559	200,022	6,572	163,111	70,232	22,451	12	0	70,416	172,025	16,750	188,775	52,189	6,243	129,019	12,563	200,014	810	63,988	-468	0
2016	70,031	4,853	232,729	1,161	202,286	84,300	34,869	14	0	83,103	204,422	20,578	225,000	62,327	1,651	153,317	15,433	232,729	963	76,063	-138	0
2017	69,602	4,616	219,984	4,437	295,363	117,643	25,419	22	0	152,280	118,975	18,802	137,778	103,626	12,963	89,232	14,102	219,923	919	72,625	-284	14
Avg	80,856	3,458	223,070	2,735	395,029	150,777	46,399	149	10,482	187,221	100,368	14,036	114,403	123,205	10,205	72,205	10,205	215,819	2,930	85,584	-226	7,242
Max	93,045	5,350	275,185	11,240	602,349	256,903	160,076	918	113,347	321,139	311,145	21,450	332,595	188,271	35,236	233,359	16,088	275,133	7,746	116,195	380	62,079
Min	68,110	0	150,766	44	59,397	27,128	5,291	0	0	19,711	0	0	0	14,783	154	0	0	138,340	807	63,748	-1,307	0
Avg 38-78	85,241	2,443	221,729	2,265	406,143	154,590	42,331	197	20,453	188,573	104,904	10,372	115,276	117,037	10,314	73,074	7,214	207,640	4,590	93,830	-184	14,081
Avg 79-07	77,862	4,501	223,042	3,546	443,180	168,766	58,395	129	0	215,891	64,889	17,505	82,394	149,460	12,342	48,120	13,038	222,960	1,269	77,677	-302	70
Avg 08-17	71,558	4,597	228,652	2,311	209,820	82,978	28,292	16	0	98,533	184,654	18,998	203,652	72,352	3,554	138,491	14,248	228,645	946	74,704	-176	1

Canal and Farm Water Budget

EPCWID Total

1938 - 2017

Annual Totals (Acre-Feet)

Year	SW Acres	Primary GW Acres	Total CIR	Excess Effective Precip	Surface Water Divers	Total Canal Loss	Wasteway Flows	From Leasburg Canal	El Paso Valley Carriage	SW Farm Delivery	Suppl Ground Water Pumping	Primary Ground Water Pumping	Total Ground Water Pumping	CU of Surface Water	CU of SM Carryover	CU of Suppl GW Pumping	CU of Primary GW Pumping	Total CU	Surface Runoff	Deep Perc	Change in Soil Moisture	Shortage
1938	59,117	0	142,413	797	424,658	117,781	164,361	453	0	142,969	0	0	0	88,800	3,472	0	0	92,273	3,127	46,912	55	50,140
1939	61,153	0	160,498	641	441,315	159,875	109,265	492	0	172,667	0	0	0	109,786	4,464	0	0	114,250	3,777	56,656	-168	46,249
1940	62,450	0	162,795	1,247	419,544	165,923	76,830	632	0	177,422	0	0	0	112,982	2,407	0	0	115,389	3,881	58,217	-5	47,406
1941	63,669	0	119,843	3,713	419,841	138,169	144,958	275	0	136,990	0	0	0	81,405	11,697	0	0	93,103	2,997	44,950	-338	26,740
1942	64,816	0	137,561	2,225	588,478	162,510	280,371	918	0	146,515	0	0	0	90,640	6,278	0	0	96,918	3,205	48,075	-140	40,644
1943	65,506	0	154,008	1,335	547,890	196,218	158,706	722	0	193,688	0	0	0	118,310	8,579	0	0	126,889	4,237	63,554	-83	27,119
1944	65,699	0	151,476	200	467,774	137,304	144,770	618	0	186,317	0	0	0	113,003	9,306	0	0	122,309	4,076	61,135	-100	29,167
1945	65,747	0	157,525	289	460,629	128,412	118,843	449	0	213,824	0	0	0	133,027	5,994	0	0	139,020	4,677	70,161	-3	18,504
1946	66,477	0	160,803	1,738	432,302	92,452	133,920	291	0	206,221	0	0	0	124,941	10,115	0	0	135,057	4,511	67,666	-84	25,747
1947	66,992	0	161,404	2,751	380,950	109,076	78,180	242	0	193,937	0	0	0	118,024	10,144	0	0	128,168	4,242	63,636	-176	33,236
1948	66,554	0	156,342	5,998	391,550	139,446	69,333	257	0	183,027	6,469	0	6,469	115,298	7,403	4,205	0	126,906	4,145	62,179	-311	29,436
1949	67,342	0	146,692	2,521	400,305	126,554	74,198	303	0	199,855	4,287	0	4,287	118,772	16,774	2,787	0	138,332	4,466	66,984	-470	8,360
1950	67,183	0	153,093	29	383,232	111,210	68,084	278	0	204,216	11,697	0	11,697	117,384	15,434	7,603	0	140,421	4,723	70,847	-6	12,672
1951	66,166	0	146,328	2,203	233,125	77,529	17,182	146	0	138,561	40,598	0	40,598	83,644	9,095	26,794	0	119,534	3,426	57,488	-107	26,794
1952	66,356	0	147,856	657	243,560	59,806	16,624	89	0	167,220	31,687	0	31,687	108,828	5,060	21,230	0	135,118	3,282	62,357	-154	12,738
1953	66,664	0	162,188	1,864	232,601	75,888	15,865	63	0	140,911	72,508	0	72,508	91,891	4,557	49,305	0	145,753	2,988	65,306	-52	16,435
1954	56,594	0	139,649	6	87,553	31,981	9,881	13	0	45,704	133,519	0	133,519	31,536	2,478	92,128	0	126,142	2,083	53,476	-207	13,507
1955	56,229	0	131,832	976	70,629	24,952	764	9	6,562	38,360	149,275	0	149,275	25,838	1,501	104,493	0	131,832	2,111	54,180	-41	0
1956	50,245	0	128,065	1,406	68,361	34,409	468	3	6,165	27,321	155,143	0	155,143	18,422	1,043	108,600	0	128,065	2,053	52,686	-28	0
1957	50,705	0	107,220	1,807	128,695	35,607	3,354	30	7,185	82,578	68,841	0	68,841	54,725	4,306	48,189	0	107,220	1,703	43,722	-102	0
1958	56,879	0	112,867	1,607	302,957	89,094	41,049	250	0	173,064	621	0	621	100,060	12,372	435	0	112,867	1,954	50,152	726	0
1959	59,023	0	146,499	630	330,004	97,436	41,714	98	0	190,951	7,821	0	7,821	119,814	21,210	5,475	0	146,499	2,236	57,396	-613	0
1960	58,228	0	134,753	3,041	339,424	122,084	40,860	143	0	176,622	7,350	0	7,350	113,610	15,998	5,145	0	134,753	2,070	53,122	-498	0
1961	56,266	0	136,549	1,458	262,805	108,268	3,098	74	0	151,513	38,974	0	38,974	101,042	8,188	27,281	0	136,511	2,143	55,003	-264	38
1962	59,457	0	127,261	937	328,435	102,773	48,334	247	0	177,575	7,823	0	7,823	104,043	17,742	5,476	0	127,261	2,086	53,534	210	0
1963	60,783	0	130,593	1,291	246,101	79,987	26,482	109	0	139,741	39,280	0	39,280	81,383	21,714	27,496	0	130,593	2,014	51,692	-440	0
1964	57,118	0	128,187	1,083	82,130	42,502	688	23	6,429	32,533	150,698	0	150,698	20,309	2,390	105,488	0	128,187	2,061	52,908	6	0
1965	54,868	0	128,565	591	184,583	71,589	9,328	35	1,169	102,532	79,636	0	79,636	69,585	3,235	55,745	0	128,565	2,049	52,601	-87	0
1966	53,753	0	113,199	360	268,564	90,558	53,145	21	1,259	123,623	38,596	0	38,596	70,305	15,867	27,017	0	113,190	1,825	46,841	30	9
1967	54,139	0	138,032	1,044	230,900	111,584	12,785	30	5,500	101,060	93,325	0	93,325	60,294	12,411	65,328	0	138,032	2,187	56,129	-164	0
1968	55,904	0	127,810	812	231,858	83,956	35,970	0	6,983	104,950	76,571	0	76,571	63,873	10,337	53,600	0	127,810	2,042	52,414	-62	0
1969	56,726	0	141,249	3,106	320,514	113,439	49,675	27	3,616	153,810	46,185	0	46,185	95,071	13,848	32,330	0	141,249	2,250	57,749	-104	0
1970	56,291	0	143,159	867	312,140	96,735	55,662	45	2,476	157,313	43,853	0	43,853	95,509	16,954	30,697	0	143,159	2,263	58,087	-195	0
1971	55,192	0	154,968	575	253,641	110,389	21,841	33	4,014	117,430	101,572	0	101,572	72,245	11,623	71,100	0	154,968	2,464	63,237	-139	0
1972	54,636	0	136,562	976	147,544	59,021	24,884	39	5,455	58,222	136,499	0	136,499	39,059	1,954	95,549	0	136,562	2,191	56,226	-21	0
1973	52,995	0	155,398	2,366	288,808	116,749	39,199	85	2,467	130,477	87,061	0	87,061	86,967	7,489	60,943	0	155,398	2,447	62,814	-260	0
1974	51,896	0	140,206	3,619	348,859	131,505	75,192	90	4,055	138,197	59,988	0	59,988	86,477	11,738	41,991	0	140,206	2,230	57,226	-123	0
1975	52,154	0	143,232	757	323,920	130,251	55,519	68	2,971	135,247	65,734	0	65,734	90,757	6,461	46,014	0	143,232	2,261	58,033	-212	0
1976	44,617	0	123,777	236	382,868	161,592	70,253	225	2,333	148,914	26,612	0	26,612	91,980	13,169	18,628	0	123,777	1,975	50,683	-76	0
1977	51,590	0	132,055	874	218,763	110,722	25,963	106	378	81,807	105,936	0	105,936	53,460	4,440	74,155	0	132,055	2,112	54,211	-53	0
1978	48,257	0	120,733	2,455	161,026	87,492	20,397	39	326	52,849	116,214	0	116,214	34,262	5,122	81,349	0	120,733	1,902	48,817	-199	0
1979	51,995	0	131,000	1,624	271,509	101,106	42,965	137	0	127,575	60,615	0	60,615	83,550	5,020	42,431	0	131,000	2,117	54,340	61	0
1980	47,452	0	127,171	467	331,701	147,304	42,312	165	0	142,249	32,432	0	32,432	93,235	10,910	23,026	0	127,171	1,900	48,758	-262	0
1981	49,045	0	130,576	686	275,498	70,554	65,588	134	0	139,490	38,525	0	38,525	90,494	10,657	27,738	0	128,889	1,558	48,287	-60	1,687
1982	48,311	0	137,463	3,004	290,708	76,167	49,615	146	0	165,072	22,423	0	22,423	106,193	14,902	16,368	0	137,463	1,266	49,358	-49	0
1983	46,276	0	119,430	737	273,444	83,039	53,660	153	0	136,897	20,654	0	20,654	91,327	12,819	15,284	0	119,430	768	40,195	-237	0
1984	47,194	0	117,242	5,583	288,535	98,907	57,476	149	0	132,302	21,787	0	21,787	87,578	13,325	16,340	0	117,242	482	38,041	-140	0
1985	45,605	0	110,962	1,895	301,392	50,185	113,438	146	0	137,914	2,580	0	2,580	94,300	14,642	1,935	0	110,877	439	34,685	-459	84
1986	45,606	0	105,211	4,525	392,722	70,437	183,715	186	0	138,756	1,543	0	1,543	86,709	17,345	1,158	0	105,211	438	34,637	1	0

Canal and Farm Water Budget

EPCWID Total

1938 - 2017

Annual Totals (Acre-Feet)

Year	SW Acres	Primary GW Acres	Total CIR	Excess Effective Precip	Surface Water Divers	Total Canal Loss	Wasteway Flows	From Leasburg Canal	El Paso Valley Carriage	SW Farm Delivery	Suppl Ground Water Pumping	Primary Ground Water Pumping	Total Ground Water Pumping	CU of Surface Water	CU of SM Carryover	CU of Suppl GW Pumping	CU of Primary GW Pumping	Total CU	Surface Runoff	Deep Perc	Change in Soil Moisture	Shortage
1987	47,428	0	111,207	983	461,784	129,374	191,174	213	0	141,448	2,562	0	2,562	85,755	23,531	1,922	0	111,207	466	36,812	-373	0
1988	45,492	0	108,549	1,151	389,803	107,183	143,885	183	0	138,918	5,606	0	5,606	83,347	20,997	4,205	0	108,549	463	36,550	-86	0
1989	47,185	0	116,519	3,133	359,635	136,960	84,963	166	0	137,877	15,186	0	15,186	90,883	14,246	11,389	0	116,519	482	38,093	-169	0
1990	43,624	0	91,051	301	305,144	131,673	46,975	127	0	126,623	871	0	871	68,290	22,108	653	0	91,051	398	31,475	381	0
1991	49,637	0	111,989	5,556	284,312	86,246	38,757	143	0	159,453	1,448	0	1,448	93,977	16,926	1,086	0	111,989	583	46,039	191	0
1992	53,048	0	128,025	5,571	375,218	57,923	198,110	168	0	119,354	40,684	0	40,684	75,215	22,296	30,513	0	128,025	576	45,510	-1,173	0
1993	53,044	0	131,357	3,905	400,398	109,288	146,378	181	0	144,913	20,559	0	20,559	96,375	19,563	15,419	0	131,357	538	42,535	-746	0
1994	53,187	0	137,398	2,464	413,793	123,710	117,724	201	0	172,560	7,716	0	7,716	115,716	15,895	5,787	0	137,398	563	44,506	-183	0
1995	53,145	0	138,087	761	444,460	161,404	112,567	200	0	170,689	9,151	0	9,151	112,453	18,558	6,863	0	137,874	562	44,398	-250	213
1996	45,246	0	106,476	232	319,415	75,167	44,711	135	0	199,672	2,231	0	2,231	97,908	6,895	1,673	0	106,476	1,043	82,394	999	0
1997	52,591	0	119,282	2,908	358,232	100,164	113,965	132	0	144,235	1,360	0	1,360	92,238	26,024	1,020	0	119,282	485	38,341	-1,043	0
1998	52,987	0	135,894	244	363,420	81,608	128,752	137	0	153,197	26,369	0	26,369	102,176	13,804	19,776	0	135,756	573	45,273	-170	138
1999	51,594	0	131,822	1,346	353,712	89,038	42,160	117	0	222,631	1,592	0	1,592	123,665	6,963	1,194	0	131,822	979	77,316	1,176	0
2000	48,638	0	125,752	404	331,214	124,895	50,799	115	0	155,636	700	0	700	99,496	25,731	525	0	125,752	558	44,111	-1,174	0
2001	41,579	0	110,389	473	354,055	45,734	124,954	84	0	183,452	2,381	0	2,381	105,537	3,066	1,786	0	110,389	793	62,634	1,001	0
2002	41,024	0	103,410	3,605	347,379	59,395	52,466	57	0	235,575	1,745	0	1,745	99,680	2,420	1,309	0	103,410	1,702	134,422	-184	0
2003	38,763	0	103,878	2,530	139,332	45,253	4,084	17	0	90,013	27,833	0	27,833	66,411	16,593	20,875	0	103,878	413	32,599	-1,587	0
2004	37,860	0	103,096	1,384	159,353	60,155	8,128	28	0	91,097	45,607	0	45,607	63,113	5,777	34,205	0	103,096	427	33,749	-47	0
2005	40,207	0	85,821	2,736	235,712	90,199	34,361	52	0	111,203	2,670	0	2,670	73,109	10,709	2,002	0	85,821	356	28,112	-35	0
2006	40,542	0	93,144	340	186,887	53,183	27,170	26	0	106,560	13,141	0	13,141	63,136	20,153	9,855	0	93,144	374	29,551	-281	0
2007	40,569	0	98,244	2,758	261,060	98,240	48,045	33	0	114,807	11,901	0	11,901	75,496	13,503	8,926	0	97,925	396	31,281	-241	319
2008	40,911	0	95,794	192	255,579	93,151	46,737	35	0	115,726	22,989	0	22,989	65,151	13,401	17,242	0	95,794	494	38,989	286	0
2009	40,142	0	94,008	3,280	288,658	114,029	25,228	27	0	149,428	2,575	0	2,575	86,741	5,336	1,931	0	94,008	606	47,853	795	0
2010	40,306	0	104,285	1,216	271,460	107,704	12,745	25	0	151,035	4,420	0	4,420	88,741	12,229	3,315	0	104,285	773	61,078	-890	0
2011	39,659	0	111,805	981	185,638	75,090	15,031	5	0	95,522	43,464	0	43,464	69,460	9,747	32,598	0	111,805	434	34,312	-630	0
2012	27,307	0	74,406	232	116,600	45,494	12,704	10	0	58,413	40,863	0	40,863	41,874	1,885	30,647	0	74,406	310	24,509	4	0
2013	29,903	0	81,476	265	66,233	28,225	5,910	4	0	32,102	75,462	0	75,462	23,597	1,282	56,597	0	81,476	336	26,555	-67	0
2014	30,822	0	87,552	210	105,263	43,414	10,667	9	0	51,190	65,354	0	65,354	37,411	1,125	49,015	0	87,552	364	28,772	-12	0
2015	30,134	0	75,296	2,669	136,068	54,892	12,645	12	0	68,543	28,455	0	28,455	48,240	5,714	21,341	0	75,296	303	23,947	-212	0
2016	36,308	0	101,078	518	161,482	64,516	13,152	14	0	83,829	50,303	0	50,303	59,681	3,669	37,727	0	101,078	419	33,114	-40	0
2017	35,031	0	96,036	1,992	184,547	71,795	16,093	22	0	96,680	28,821	0	28,821	69,434	4,987	21,616	0	96,036	392	30,983	-159	0
Avg	51,448	0	125,443	1,674	292,877	95,070	62,223	149	867	134,867	35,112	0	35,112	83,938	10,739	24,923	0	119,601	1,758	50,290	-139	5,842
Max	67,342	0	162,795	5,998	588,478	196,218	280,371	918	7,185	235,575	155,143	0	155,143	133,027	26,024	108,600	0	155,398	4,723	134,422	1,176	50,140
Min	27,307	0	74,406	6	66,233	24,952	468	0	0	27,321	0	0	0	18,422	1,043	0	0	74,406	303	23,947	-1,587	0
Avg 38-78	58,694	0	140,079	1,490	302,167	103,484	59,463	197	1,691	137,725	48,887	0	48,887	85,545	9,131	34,063	0	128,739	2,792	56,562	-123	11,340
Avg 79-07	46,858	0	116,222	2,114	319,649	91,879	81,686	129	0	146,213	15,237	0	15,237	90,254	14,668	11,216	0	116,138	748	46,690	-177	84
Avg 08-17	35,052	0	92,173	1,155	177,153	69,831	17,091	16	0	90,247	36,270	0	36,270	59,033	5,937	27,203	0	92,173	443	35,011	-93	0

Canal and Farm Water Budget

HCCRD

1938 - 2017

Annual Totals (Acre-Feet)

Year	SW Acres	Primary GW Acres	Total CIR	Excess Effective Precip	Surface Water Divers	Excess Diversions to Storage	Diversion from Storage	Canal Loss from SW Supplies	Canal Loss from Storage Supplies	Wasteway Flows	SW Farm Delivery	From Storage Farm Delivery	Suppl Ground Water Pumping	Primary Ground Water Pumping	Total Ground Water Pumping	CU of Surface Water	CU of SM Carryover	CU of Storage Supplies	CU of Suppl GW Pumping	Total CU	Surface Runoff	Deep Perc	Change in Soil Moisture	Shortage
1938	11,033	0	24,976	416	137,564	0	0	68,782	0	0	68,782	0	0	0	0	24,976	0	0	0	24,976	2,420	36,303	424	0
1939	12,400	0	30,601	403	131,689	0	0	65,845	0	0	65,845	0	0	0	0	28,869	1,732	0	0	30,601	2,188	32,815	20	0
1940	13,347	0	34,384	474	119,587	0	0	59,794	0	0	59,794	0	0	0	0	30,937	3,447	0	0	34,384	1,592	23,879	-5	0
1941	13,312	0	24,173	38	101,087	0	0	50,544	0	0	50,544	0	0	0	0	23,916	257	0	0	24,173	1,649	24,741	-2	0
1942	13,710	0	28,823	504	113,985	0	0	56,993	0	0	56,993	0	0	0	0	27,742	1,081	0	0	28,823	1,780	26,705	-26	0
1943	14,316	0	32,761	494	100,613	0	0	50,307	0	0	50,307	0	0	0	0	25,703	7,059	0	0	32,761	1,209	18,140	-150	0
1944	14,187	0	32,859	285	111,882	0	0	55,941	0	0	55,941	0	0	0	0	29,309	3,550	0	0	32,859	1,365	20,469	104	0
1945	14,905	0	36,010	320	113,660	0	0	56,830	0	0	56,830	0	0	0	0	28,700	7,023	0	0	35,723	1,441	21,617	-163	286
1946	15,917	0	38,451	871	117,160	0	0	58,580	0	0	58,580	0	0	0	0	30,086	7,681	0	0	37,766	1,296	19,439	7	685
1947	16,882	0	40,893	299	98,978	0	0	49,489	0	0	49,489	0	0	0	0	26,999	8,292	0	0	35,290	1,083	16,239	-260	5,602
1948	17,060	0	40,798	441	118,480	0	0	59,240	0	0	59,240	0	788	0	788	29,513	7,189	0	512	37,214	1,313	19,697	150	3,585
1949	17,224	0	37,713	1,270	139,761	0	0	69,881	0	0	69,881	0	0	0	0	33,813	3,901	0	0	37,713	1,922	28,824	118	0
1950	17,318	0	40,022	0	149,175	0	0	74,588	0	0	74,588	0	0	0	0	35,350	4,671	0	0	40,022	2,158	32,364	4	0
1951	17,752	0	39,108	978	53,574	0	0	26,787	0	0	26,787	0	14,462	0	14,462	11,654	8,365	0	9,545	29,563	927	15,561	-400	9,545
1952	17,318	0	38,998	788	60,898	0	0	30,449	0	0	30,449	0	16,606	0	16,606	14,325	6,872	0	11,126	32,322	776	14,752	-66	6,675
1953	16,675	0	40,613	229	43,802	0	0	21,901	0	0	21,901	0	25,722	0	25,722	11,033	6,259	0	17,491	34,783	667	14,573	-200	5,830
1954	12,127	0	31,590	0	7,638	0	0	3,819	0	0	3,819	0	33,707	0	33,707	1,735	3,058	0	23,258	28,051	436	11,197	-180	3,538
1955	5,455	0	12,900	151	447	0	0	224	0	0	224	0	17,991	0	17,991	112	194	0	12,594	12,900	205	5,259	-12	0
1956	5,180	0	13,103	143	4	0	0	2	0	0	2	0	18,623	0	18,623	0	67	0	13,036	13,103	210	5,378	-5	0
1957	4,378	0	9,937	158	1,587	0	0	794	0	0	794	0	13,064	0	13,064	555	236	0	9,145	9,937	156	4,001	-20	0
1958	6,844	0	14,868	181	33,692	0	0	16,846	0	0	16,846	0	12,210	0	12,210	6,195	126	0	8,547	14,868	418	10,726	254	0
1959	6,992	0	18,426	131	55,067	0	0	27,534	0	0	27,534	0	912	0	912	14,400	3,388	0	639	18,426	378	9,703	-5	0
1960	8,907	0	21,889	731	73,763	0	0	36,882	0	0	36,882	0	0	0	0	19,743	2,146	0	0	21,889	556	14,265	14	0
1961	9,661	0	24,500	151	61,456	0	0	30,728	0	0	30,728	0	7,140	0	7,140	14,949	4,552	0	4,998	24,500	494	12,671	17	0
1962	11,429	0	25,907	343	95,171	0	0	47,586	0	0	47,586	0	1,239	0	1,239	19,087	5,953	0	867	25,907	841	21,586	41	0
1963	11,268	0	24,988	251	64,477	0	0	32,239	0	0	32,239	0	9,462	0	9,462	12,835	5,529	0	6,624	24,988	639	16,401	-27	0
1964	8,421	0	18,760	229	5,730	0	0	2,865	0	0	2,865	0	19,877	0	19,877	796	4,050	0	13,914	18,760	352	9,023	-449	0
1965	8,123	0	19,268	198	8,123	0	0	4,062	0	0	4,062	0	23,212	0	23,212	2,098	922	0	16,248	19,268	307	7,875	-15	0
1966	7,815	0	16,175	107	50,286	0	0	25,143	0	0	25,143	0	4,588	0	4,588	11,973	991	0	3,211	16,175	381	9,768	284	0
1967	8,244	0	21,687	223	30,011	0	0	15,006	0	0	15,006	0	13,766	0	13,766	8,166	3,885	0	9,636	21,687	350	8,985	-188	0
1968	8,649	0	18,179	1,040	45,116	0	0	22,558	0	0	22,558	0	4,584	0	4,584	9,506	5,463	0	3,209	18,179	305	7,837	68	0
1969	11,432	0	30,729	550	97,210	0	0	48,605	0	0	48,605	0	6,352	0	6,352	21,131	5,151	0	4,446	30,729	859	22,048	110	0
1970	14,177	0	35,897	149	119,369	0	0	59,685	0	0	59,685	0	1,075	0	1,075	28,464	6,680	0	752	35,897	889	22,828	95	0
1971	10,115	0	26,612	312	61,503	0	0	30,752	0	0	30,752	0	10,390	0	10,390	14,573	4,766	0	7,273	26,612	644	16,529	-220	0
1972	6,546	0	15,575	151	30,779	0	0	15,390	0	0	15,390	0	10,198	0	10,198	5,352	3,085	0	7,138	15,575	428	10,998	-118	0
1973	9,785	0	25,758	1,132	65,512	0	0	32,756	0	0	32,756	0	6,655	0	6,655	15,655	5,445	0	4,658	25,758	502	12,878	23	0
1974	12,446	0	31,019	4,187	110,025	0	0	55,013	0	0	55,013	0	5,073	0	5,073	21,603	5,865	0	3,551	31,019	1,195	30,682	-234	0
1975	13,662	0	36,798	1,023	115,457	0	0	57,729	0	0	57,729	0	7,056	0	7,056	25,421	6,438	0	4,939	36,798	1,066	27,370	-37	0
1976	11,268	0	30,010	306	127,756	0	0	63,878	0	0	63,878	0	0	0	0	28,048	1,963	0	0	30,010	1,324	33,978	-120	0
1977	10,740	0	24,384	791	53,599	0	0	26,800	0	0	26,800	0	12,646	0	12,646	10,471	5,061	0	8,852	24,384	604	15,497	-87	0
1978	9,175	0	20,454	1,031	29,691	0	0	14,846	0	0	14,846	0	16,657	0	16,657	4,471	4,323	0	11,660	20,454	481	12,336	-147	0
1979	11,768	0	27,554	509	64,844	0	0	34,547	0	0	30,297	0	8,867	0	8,867	15,802	5,545	0	6,207	27,554	449	11,530	-31	0
1980	15,237	0	36,715	410	96,113	0	0	68,914	0	0	27,199	0	24,480	0	24,480	13,051	6,283	0	17,381	36,715	562	14,425	-2	0
1981	14,028	0	31,484	547	100,744	0	0	57,706	0	0	43,038	0	0	0	0	27,660	3,824	0	0	31,484	387	12,004	-70	0
1982	15,030	0	38,442	3,211	97,967	0	0	44,575	0	0	53,392	0	0	0	0	32,986	5,456	0	0	38,442	415	16,192	-138	0
1983	9,316	0	21,503	220	107,419	0	0	59,441	0	0	47,978	0	0	0	0	21,471	32	0	0	21,503	533	27,887	-162	0
1984	14,546	0	33,433	3,077	126,709	0	0	63,877	0	0	62,832	0	0	0	0	33,227	206	0	0	33,433	375	29,637	-51	0
1985	14,880	0	33,761	144	131,174	0	0	60,804	0	0	70,370	0	0	0	0	33,761	0	0	0	33,761	457	36,138	1	0
1986	15,379	0	31,158	1,163	206,103	0	0	172,235	0	0	33,868	0	9,815	0	9,815	16,549	7,247	0	7,361	31,158	234	18,466	-514	0

Canal and Farm Water Budget

HCCRD

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Annual Totals (Acre-Feet)

Year	SW Acres	Primary GW Acres	Total CIR	Excess Effective Precip	Surface Water Divers	Excess Diversions to Storage	Diversion from Storage	Canal Loss from SW Supplies	Canal Loss from Storage Supplies	Wasteway Flows	SW Farm Delivery	From Storage Farm Delivery	Suppl Ground Water Pumping	Primary Ground Water Pumping	Total Ground Water Pumping	CU of Surface Water	CU of SM Carryover	CU of Storage Supplies	CU of Suppl GW Pumping	Total CU	Surface Runoff	Deep Perc	Change in Soil Moisture	Shortage
1987	15,043	0	31,213	582	136,058	0	0	74,472	0	0	61,586	0	0	0	0	21,763	9,450	0	0	31,213	387	30,577	-49	0
1988	15,640	0	33,740	271	148,399	0	0	101,685	0	0	46,714	0	0	0	0	23,258	10,481	0	0	33,740	168	13,234	-36	0
1989	17,309	0	37,547	443	146,093	0	0	97,687	0	0	48,406	0	0	0	0	28,714	8,833	0	0	37,547	157	12,422	-143	0
1990	12,599	0	22,763	215	124,916	0	0	62,458	0	0	62,458	0	0	0	0	22,763	0	0	0	22,763	432	34,101	430	0
1991	15,717	0	31,755	2,553	107,563	0	0	62,311	0	0	45,252	0	0	0	0	24,915	6,840	0	0	31,755	206	16,253	-247	0
1992	15,296	0	34,563	2,040	139,804	0	0	69,902	0	0	69,902	0	0	0	0	31,943	2,620	0	0	34,563	446	35,253	-30	0
1993	14,667	0	31,120	757	147,145	0	0	89,770	0	0	57,376	0	0	0	0	28,460	2,660	0	0	31,120	341	26,967	-88	0
1994	14,978	0	32,757	1,307	149,478	0	0	84,421	0	0	65,058	0	0	0	0	30,961	1,796	0	0	32,757	418	33,044	-97	0
1995	15,430	0	33,064	371	158,687	0	0	90,925	0	0	67,762	0	0	0	0	30,506	2,558	0	0	33,064	436	34,420	-13	0
1996	15,734	0	32,039	300	127,198	0	0	60,333	0	0	66,866	0	0	0	0	28,462	3,577	0	0	32,039	437	34,546	-13	0
1997	15,278	0	29,608	815	132,605	0	0	82,097	0	0	50,508	0	0	0	0	23,644	5,964	0	0	29,608	274	21,656	-86	0
1998	15,385	0	36,620	507	134,468	0	0	72,552	0	0	61,917	0	2,588	0	2,588	26,196	8,482	0	1,941	36,620	360	28,472	-79	0
1999	15,462	0	35,993	313	145,571	0	0	77,549	0	0	68,023	0	0	0	0	31,731	4,261	0	0	35,993	398	31,418	18	0
2000	14,192	0	33,532	576	125,418	0	0	60,478	0	0	64,940	0	0	0	0	28,108	5,424	0	0	33,532	407	32,176	-98	0
2001	14,379	0	34,750	471	151,892	0	0	90,681	0	0	61,211	0	0	0	0	29,056	5,694	0	0	34,750	336	26,509	-32	0
2002	15,189	0	32,501	2,044	144,560	0	0	78,849	0	0	65,712	0	0	0	0	30,635	1,866	0	0	32,501	436	34,437	-139	0
2003	8,769	0	20,816	1,181	50,563	0	0	19,656	0	0	30,907	0	1,395	0	1,395	15,637	4,132	0	1,047	20,816	222	17,533	-522	0
2004	8,740	0	22,226	1,493	54,317	0	0	24,685	0	0	29,632	0	3,132	0	3,132	15,752	4,125	0	2,349	22,226	125	9,858	46	0
2005	9,467	0	17,898	280	95,206	0	0	60,412	0	0	34,793	0	0	0	0	14,101	3,798	0	0	17,898	210	16,623	5	0
2006	10,517	0	21,174	125	76,380	0	0	40,747	0	0	35,633	0	900	0	900	15,544	4,956	0	675	21,174	187	14,801	31	0
2007	12,257	0	27,152	1,109	106,027	0	0	62,546	0	0	43,481	0	719	0	719	20,837	5,776	0	539	27,152	217	17,120	-24	0
2008	13,623	0	27,732	1,239	120,887	0	0	60,443	0	0	60,443	0	0	0	0	25,805	1,927	0	0	27,732	416	32,890	-50	0
2009	14,206	0	29,178	1,313	127,955	0	0	63,977	0	0	63,977	0	0	0	0	27,491	1,687	0	0	29,178	448	35,390	-87	0
2010	14,700	0	32,266	426	120,704	0	0	60,352	0	0	60,352	0	0	0	0	30,324	1,942	0	0	32,266	353	27,926	-16	0
2011	12,154	0	28,649	377	42,403	0	0	21,202	0	0	21,202	0	11,849	0	11,849	13,962	5,800	0	8,886	28,649	142	11,221	-580	0
2012	6,419	0	14,880	58	20,846	0	0	10,423	0	0	10,423	0	10,556	0	10,556	6,554	408	0	7,917	14,880	66	5,179	71	0
2013	6,227	0	14,358	80	20,508	0	0	10,254	0	0	10,254	0	7,830	0	7,830	4,880	3,606	0	5,872	14,358	57	4,464	-66	0
2014	5,868	0	14,855	46	25,158	0	0	12,579	0	0	12,579	0	7,536	0	7,536	5,891	3,311	0	5,652	14,855	63	4,966	19	0
2015	7,097	0	15,787	1,259	28,113	0	0	14,056	0	0	14,056	0	6,857	0	6,857	8,587	2,058	0	5,143	15,787	65	5,163	-9	0
2016	5,919	0	15,433	133	33,944	0	0	16,972	0	0	16,972	0	4,035	0	4,035	9,331	3,076	0	3,026	15,433	66	5,186	27	0
2017	7,891	0	19,717	129	51,986	0	0	25,993	0	0	25,993	0	2,249	0	2,249	14,494	3,536	0	1,687	19,717	92	7,273	97	0
Avg	12,157	0	27,879	670	89,766	0	0	48,128	0	0	41,638	0	5,211	0	5,211	19,688	4,074	0	3,669	27,432	620	19,416	-52	447
Max	17,752	0	40,893	4,187	206,103	0	0	172,235	0	0	74,588	0	33,707	0	33,707	35,350	10,481	0	23,258	40,022	2,420	36,303	430	9,545
Min	4,378	0	9,937	0	4	0	0	2	0	0	2	0	0	0	0	0	0	0	0	9,937	57	4,001	-580	0
Avg 38-78	11,615	0	27,576	524	74,521	0	0	37,261	0	0	37,261	0	7,660	0	7,660	17,324	4,066	0	5,314	26,704	922	17,706	-34	872
Avg 79-07	13,870	0	30,582	932	121,842	0	0	69,873	0	0	51,969	0	1,790	0	1,790	24,741	4,548	0	1,293	30,582	345	23,714	-74	0
Avg 08-17	9,410	0	21,285	506	59,250	0	0	29,625	0	0	29,625	0	5,091	0	5,091	14,732	2,735	0	3,818	21,285	177	13,966	-59	0

Canal and Farm Water Budget

JID Total

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Annual Totals (Acre-Feet)

Year	SW Acres	Primary GW Acres	Total CIR	Excess Effective Precip	Surface Water Divers	Total Canal Loss	Wasteway Flows	SW Farm Delivery	Suppl Ground Water Pumping	Primary Ground Water Pumping	Total Ground Water Pumping	CU of Surface Water	CU of SM Carryover	CU of Suppl GW Pumping	CU of Primary GW Pumping	Total CU	Surface Runoff	Deep Perc	Change in Soil Moisture	Shortage
1938	58,300	0	118,395	2,308	70,136	28,054	0	42,082	0	0	0	24,441	4,517	0	0	28,958	921	13,808	-134	89,437
1939	47,137	0	101,559	2,085	75,397	30,159	0	45,238	0	0	0	28,600	1,659	0	0	30,259	990	14,844	-71	71,300
1940	48,785	0	107,507	2,023	82,344	32,938	0	49,406	912	0	912	30,347	3,868	593	0	34,808	1,101	16,511	-175	72,699
1941	53,640	0	87,546	158	83,156	33,262	0	49,894	453	0	453	31,514	2,772	294	0	34,580	1,101	16,520	-155	52,966
1942	51,497	0	94,828	2,053	103,331	41,332	0	61,999	278	0	278	37,264	3,278	180	0	40,723	1,362	20,434	-20	54,105
1943	50,884	0	101,465	2,196	87,658	35,063	0	52,595	841	0	841	32,665	3,489	547	0	36,700	1,169	17,534	-164	64,765
1944	50,881	0	102,962	936	84,568	33,827	0	50,741	1,075	0	1,075	31,334	3,844	699	0	35,877	1,133	17,002	-183	67,085
1945	53,118	0	110,706	19	95,275	38,110	0	57,165	2,579	0	2,579	36,159	1,953	1,676	0	39,788	1,307	19,603	-80	70,918
1946	54,460	0	115,420	3,019	89,247	35,699	0	53,548	4,619	0	4,619	34,253	1,013	3,002	0	38,269	1,272	19,086	-38	77,151
1947	48,642	0	104,851	1,002	78,696	31,478	0	47,218	5,490	0	5,490	30,455	2,818	3,569	0	36,841	1,153	17,295	-215	68,010
1948	43,545	0	95,049	1,129	69,931	27,972	0	41,959	15,425	0	15,425	26,364	1,850	10,026	0	38,239	1,255	18,829	-78	56,809
1949	38,448	0	78,226	2,334	72,371	28,948	0	43,423	18,835	0	18,835	25,995	4,583	12,243	0	42,821	1,362	20,428	-196	35,405
1950	33,350	0	67,067	0	77,361	30,944	0	46,417	21,308	0	21,308	28,300	2,935	13,850	0	45,085	1,481	22,222	-89	21,982
1951	30,320	0	60,505	1,687	37,918	15,167	0	22,751	37,499	0	37,499	14,845	771	24,749	0	40,366	1,152	19,333	-50	20,139
1952	33,110	0	66,659	1,753	56,040	22,416	0	33,624	41,090	0	41,090	20,300	4,107	27,530	0	51,937	1,233	23,423	-157	14,722
1953	29,650	0	65,301	434	46,886	18,754	0	28,132	52,419	0	52,419	17,982	2,250	35,645	0	55,878	1,128	24,649	-92	9,424
1954	24,700	0	47,875	0	16,042	6,417	0	9,625	54,343	0	54,343	6,254	537	37,497	0	44,288	744	19,087	-12	3,587
1955	23,770	0	47,530	844	14,645	5,858	0	8,787	58,298	0	58,298	5,708	1,014	40,809	0	47,530	755	19,371	-48	0
1956	23,670	0	53,871	471	13,729	5,492	0	8,237	68,484	0	68,484	4,659	1,273	47,939	0	53,871	863	22,153	-14	0
1957	25,800	0	50,557	616	33,334	13,334	0	20,000	50,885	0	50,885	13,560	1,377	35,620	0	50,557	797	20,468	-78	0
1958	34,620	0	64,089	438	75,964	30,386	0	45,578	48,023	0	48,023	26,149	4,325	33,616	0	64,089	1,053	27,027	119	0
1959	35,090	0	75,584	681	76,462	30,585	0	45,877	59,706	0	59,706	27,826	5,964	41,794	0	75,584	1,204	30,910	-176	0
1960	34,400	0	70,645	2,741	77,032	30,813	0	46,219	56,774	0	56,774	28,157	2,747	39,742	0	70,645	1,159	29,739	121	0
1961	33,360	0	71,552	585	61,829	24,732	0	37,097	58,174	0	58,174	22,960	7,870	40,722	0	71,552	1,072	27,510	-405	0
1962	35,570	0	68,334	730	75,409	30,164	0	45,245	52,945	0	52,945	27,732	3,540	37,061	0	68,334	1,105	28,352	33	0
1963	39,290	0	82,047	937	48,772	19,509	0	29,263	85,023	0	85,023	17,322	5,208	59,516	0	82,047	1,286	33,000	-171	0
1964	26,930	0	58,935	783	13,591	5,436	0	8,155	74,728	0	74,728	5,388	1,238	52,309	0	58,935	932	23,932	-76	0
1965	30,560	0	66,638	549	46,119	18,448	0	27,671	66,453	0	66,453	19,220	901	46,517	0	66,638	1,059	27,178	-63	0
1966	32,370	0	62,037	390	66,505	26,602	0	39,903	49,962	0	49,962	21,237	5,826	34,974	0	62,037	1,053	27,015	-20	0
1967	33,390	0	85,016	905	40,496	16,198	0	24,298	95,675	0	95,675	15,783	2,260	66,972	0	85,016	1,350	34,642	-86	0
1968	35,080	0	75,732	3,582	55,702	22,281	0	33,421	73,671	0	73,671	21,515	2,647	51,570	0	75,732	1,205	30,923	-64	0
1969	40,770	0	99,251	2,270	79,714	31,886	0	47,828	89,144	0	89,144	31,855	4,994	62,401	0	99,251	1,541	39,551	-281	0
1970	41,370	0	98,291	198	78,534	31,414	0	47,120	89,952	0	89,952	30,101	5,224	62,966	0	98,291	1,542	39,580	-195	0
1971	32,330	0	81,121	1,065	50,939	20,143	0	30,796	83,737	0	83,737	20,168	2,337	58,616	0	81,121	1,288	33,071	-79	0
1972	31,270	0	70,527	917	34,323	13,515	0	20,808	78,427	0	78,427	14,332	1,296	54,899	0	70,527	1,116	28,654	-89	0
1973	41,730	0	109,649	2,836	82,036	31,614	0	50,422	102,053	0	102,053	32,295	5,918	71,437	0	109,649	1,715	44,027	-243	0
1974	39,470	0	98,383	7,027	86,379	32,950	0	53,429	82,191	0	82,191	35,711	5,138	57,534	0	98,383	1,526	39,160	-287	0
1975	42,520	0	107,235	1,710	84,866	31,944	0	52,922	94,789	0	94,789	33,708	7,175	66,352	0	107,235	1,662	42,651	-320	0
1976	31,887	0	82,127	300	85,570	31,821	0	53,749	61,613	0	61,613	36,983	2,015	43,129	0	82,127	1,298	33,311	-114	0
1977	33,154	0	84,309	1,706	44,460	16,626	0	27,834	90,912	0	90,912	18,565	2,106	63,638	0	84,309	1,336	34,288	-99	0
1978	33,231	0	85,767	2,452	39,789	14,323	0	25,466	93,325	0	93,325	17,316	3,113	65,328	0	85,756	1,336	34,301	-217	11
1979	35,159	0	92,791	755	87,994	29,239	0	58,755	72,619	0	72,619	40,090	1,868	50,833	0	92,791	1,478	37,934	-69	0
1980	38,392	0	101,614	605	89,215	28,047	0	61,168	80,866	0	80,866	42,612	1,588	57,415	0	101,614	1,545	39,645	-64	0
1981	37,885	0	99,187	920	97,312	28,976	0	68,337	64,424	0	64,424	48,200	2,427	46,385	0	97,013	1,162	36,011	-119	2,174
1982	38,277	0	104,240	6,307	90,199	24,994	0	65,205	78,272	0	78,272	45,557	1,545	57,138	0	104,240	968	37,770	41	0
1983	35,931	0	89,452	246	91,344	24,904	0	66,440	45,953	0	45,953	45,402	10,045	34,005	0	89,452	548	28,674	-523	0
1984	37,594	0	92,824	6,452	95,404	25,549	0	69,855	54,355	0	54,355	46,706	5,352	40,767	0	92,824	388	30,664	28	0
1985	39,257	0	92,620	169	87,352	23,236	0	64,116	49,576	0	49,576	44,573	10,865	37,182	0	92,620	355	28,068	-613	0
1986	40,920	0	94,940	2,364	94,574	24,933	0	69,641	58,388	0	58,388	45,168	5,982	43,791	0	94,940	400	31,607	90	0

Canal and Farm Water Budget

JID Total

1938 - 2017

Annual Totals (Acre-Feet)

Year	SW Acres	Primary GW Acres	Total CIR	Excess Effective Precip	Surface Water Divers	Total Canal Loss	Wasteway Flows	SW Farm Delivery	Suppl Ground Water Pumping	Primary Ground Water Pumping	Total Ground Water Pumping	CU of Surface Water	CU of SM Carryover	CU of Suppl GW Pumping	CU of Primary GW Pumping	Total CU	Surface Runoff	Deep Perc	Change in Soil Moisture	Shortage
1987	42,583	0	101,989	1,557	97,175	25,223	0	71,952	59,305	0	59,305	49,878	7,632	44,479	0	101,989	410	32,404	-296	0
1988	44,246	0	110,245	622	96,182	24,689	0	71,493	76,046	0	76,046	48,030	5,180	57,035	0	110,245	461	36,424	34	0
1989	38,448	0	100,596	826	96,585	24,513	0	72,072	60,707	0	60,707	48,767	6,299	45,531	0	100,596	415	32,780	-84	0
1990	32,650	0	71,493	546	97,349	24,624	0	72,725	28,132	0	28,132	43,248	7,145	21,099	0	71,493	350	27,630	115	0
1991	34,086	0	81,417	5,240	98,821	24,999	0	73,822	40,205	0	40,205	44,719	6,543	30,154	0	81,417	434	34,309	-178	0
1992	35,522	0	86,981	4,602	99,787	25,095	0	74,692	38,370	0	38,370	46,361	11,843	28,777	0	86,981	411	32,444	-564	0
1993	36,958	0	92,738	2,033	104,771	26,583	0	78,188	47,099	0	47,099	48,246	9,168	35,324	0	92,738	434	34,269	-179	0
1994	38,394	0	99,981	3,204	106,025	26,535	0	79,490	53,717	0	53,717	51,834	7,859	40,288	0	99,981	431	34,057	-105	0
1995	39,830	0	104,003	851	110,412	27,701	0	82,711	51,562	0	51,562	54,318	11,014	38,671	0	104,003	443	35,025	-433	0
1996	41,267	0	97,611	548	106,403	26,601	0	79,802	57,284	0	57,284	49,117	5,531	42,963	0	97,611	489	38,647	28	0
1997	41,752	0	95,121	1,961	105,541	26,375	0	79,166	56,359	0	56,359	46,835	6,016	42,269	0	95,121	503	39,745	13	0
1998	42,237	0	112,043	1,235	108,771	27,128	0	81,643	70,937	0	70,937	49,154	9,686	53,203	0	112,043	554	43,784	-317	0
1999	42,721	0	114,199	943	107,014	26,579	0	80,435	74,946	0	74,946	50,868	7,121	56,209	0	114,199	527	41,613	-80	0
2000	43,205	0	118,548	1,056	109,852	27,347	0	82,505	81,343	0	81,343	52,448	5,092	61,008	0	118,548	540	42,653	176	0
2001	36,411	0	101,179	1,041	111,273	27,671	0	83,602	60,705	0	60,705	47,685	7,965	45,529	0	101,179	585	46,177	-303	0
2002	36,298	0	97,643	4,808	109,800	27,311	0	82,489	55,416	0	55,416	48,393	7,688	41,562	0	97,643	529	41,785	-171	0
2003	35,535	0	98,967	4,303	77,386	17,938	0	59,448	61,779	0	61,779	37,438	15,195	46,334	0	98,967	385	30,418	-712	0
2004	39,968	0	110,218	5,425	76,011	17,716	0	58,295	88,507	0	88,507	36,211	7,626	66,380	0	110,218	459	36,242	-10	0
2005	38,518	0	85,565	1,802	107,613	26,681	0	80,932	37,866	0	37,866	45,274	11,892	28,400	0	85,565	488	38,561	-485	0
2006	37,170	0	91,715	431	78,591	18,197	0	60,394	60,596	0	60,596	37,916	8,351	45,447	0	91,715	402	31,745	-239	0
2007	39,311	0	95,447	3,308	103,789	25,330	0	78,459	56,792	0	56,792	46,162	6,691	42,594	0	95,447	488	38,584	61	0
2008	35,459	0	82,304	2,569	107,725	26,333	0	81,392	34,400	0	34,400	42,945	13,559	25,800	0	82,304	507	40,090	-592	0
2009	33,300	0	79,446	2,157	111,751	27,484	0	84,267	45,281	0	45,281	42,525	2,960	33,961	0	79,446	582	45,980	295	0
2010	35,220	0	86,940	1,618	111,152	27,269	0	83,883	41,860	0	41,860	44,662	10,884	31,395	0	86,940	557	43,972	-477	0
2011	29,953	0	84,804	806	84,120	19,199	0	64,921	51,441	0	51,441	39,152	7,071	38,580	0	84,804	396	31,254	-8	0
2012	30,719	0	79,453	383	80,889	18,322	0	62,567	46,124	0	46,124	37,687	7,173	34,593	0	79,453	370	29,256	-32	0
2013	32,209	0	82,454	653	63,496	13,175	0	50,321	56,887	0	56,887	32,410	7,379	42,665	0	82,454	335	26,467	-171	0
2014	29,917	0	79,881	280	79,760	17,660	0	62,100	47,717	0	47,717	38,041	6,052	35,788	0	79,881	373	29,478	7	0
2015	30,918	0	77,213	4,753	95,412	22,132	0	73,280	43,149	0	43,149	37,950	6,902	32,361	0	77,213	452	35,724	253	0
2016	31,677	0	85,826	780	105,964	25,143	0	80,821	35,903	0	35,903	45,334	13,565	26,927	0	85,826	483	38,190	-648	0
2017	32,014	0	88,074	629	114,941	27,702	0	87,240	44,083	0	44,083	48,150	6,862	33,062	0	88,074	554	43,769	-90	0
Avg	37,550	0	87,961	1,708	79,879	24,822	0	55,057	52,389	0	52,389	34,192	5,317	37,793	0	77,303	879	30,941	-140	10,659
Max	58,300	0	118,548	7,027	114,941	41,332	0	87,240	102,053	0	102,053	54,318	15,195	71,437	0	118,548	1,715	46,177	295	89,437
Min	23,670	0	47,530	0	13,591	5,436	0	8,155	0	0	0	4,659	537	0	0	28,958	335	13,808	-712	0
Avg 38-78	38,100	0	82,321	1,411	63,233	25,039	0	38,194	49,320	0	49,320	24,032	3,213	34,331	0	61,576	1,198	26,132	-116	20,744
Avg 79-07	38,639	0	97,771	2,212	98,019	25,335	0	72,684	59,384	0	59,384	46,249	7,283	44,165	0	97,696	572	35,851	-171	75
Avg 08-17	32,139	0	82,640	1,463	95,521	22,442	0	73,079	44,684	0	44,684	40,886	8,241	33,513	0	82,640	461	36,418	-146	0

Appendix 10A

Comparison of Model Runs
Integrated LRG Model

Table 10A-2a
Comparison of Integrated LRG Model Runs
All Pumping Off v. Historical Base Run
1985 - 2016 Annual Average
(1,000 acre-feet)

Run No.	1	2	2 - 1		
Simulated Input or Output	**Historical Base Run**	**All Pumping Off**	**All Pumping Off minus Historical Base Run**		
CHANGE IN PUMPING STRESS					
Irrigation Pumping	202.7	0.0	-202.7		
Non-Irrigation Pumping	240.0	0.0	-240.0		
WWTP Flows	125.6	20.5	-105.1		
Urban Deep Percolation	17.4	4.8	-12.7		
Total Change in Stress	299.6	-25.3	-324.9		
	Change in stress is pumping minus returns				
EFFECTS OF CHANGE IN PUMPING STRESS					
FHG Deliveries (Mar - Oct)				***% ΔStress***	***% Diff.***
EBID	179.3	210.1	30.8	*9%*	*17%*
EPCWID (incl. EPW)	153.1	161.3	8.2	*3%*	*5%*
HCCRD	36.5	36.8	0.3	*0%*	*1%*
Total	369.0	408.2	39.2	*12%*	*11%*
FHG Deliveries (Nov - Feb)					
EBID	0.0	0.1	0.1	*0%*	*782%*
EPCWID (incl. EPW)	8.6	8.5	-0.1	*0%*	*-1%*
HCCRD	0.8	0.7	-0.1	*0%*	*-7%*
Total	9.4	9.3	-0.1	*0%*	*-1%*
Irrigation Pumping					
EBID	123.0	0.0	-123.0		
EPCWID (Mesilla Valley)	2.8	0.0	-2.8		
EPCWID (El Paso Valley)	17.1	0.0	-17.1		
HCCRD	0.6	0.0	-0.6		
Total					
	Pumping turned off.	*Other values are simulated responses and are totaled.*			
Other Inflows/Outflows					
Reservoir Evaporation	174.9	183.1	8.1	*3%*	*5%*
Riparian ET	65.6	74.1	8.5	*3%*	*13%*
River Evaporation + Incidental Canal Loss	30.1	31.3	1.3	*0%*	*4%*
Total	270.6	288.6	17.9	*6%*	*7%*
Rio Grande at Fort Quitman					
Reservoir Spills	74.7	113.0	38.3	*12%*	*51%*
Nov-Feb Flows	30.4	56.7	26.3	*8%*	*87%*
Mar - Oct Flows	59.1	99.3	40.2	*12%*	*68%*
Underflow (GW Model)	0.3	0.3	0.0	*0%*	*7%*
Total	164.5	269.3	104.8	*32%*	*64%*

Table 10A-2a
Comparison of Integrated LRG Model Runs
All Pumping Off v. Historical Base Run
1985 - 2016 Annual Average
(1,000 acre-feet)

Run No.	1	2	2 - 1		
Simulated Input or Output	**Historical Base Run**	**All Pumping Off**	**All Pumping Off minus Historical Base Run**		
EFFECTS OF CHANGE IN PUMPING STRESS continued					
Change in Storage				*% ΔStress*	*% Diff.*
Reservoir Storage	-32.5	-43.3	-10.8	*-3%*	*33%*
Alluvial GW Storage (RW Model)	-34.8	-1.8	33.0	*10%*	*-95%*
Non-alluvial GW Storage (GW Models)	-117.5	-1.9	115.6	*36%*	*-98%*
Soil Moisture Storage	0.1	-0.1	-0.2	*0%*	*-249%*
Total	-184.7	-47.2	137.6	*42%*	*-74%*
Summary of Effects					
FHG Deliveries (Mar-Oct)	369.0	408.2	39.2	*12%*	*11%*
FHG Deliveries (Nov-Feb)	9.4	9.3	-0.1	*0%*	*-1%*
Irrigation Pumping	0.0	0.0	0.0	*0%*	*0%*
Riparian ET + Evaporation	270.6	288.6	17.9	*6%*	*7%*
Fort Quitman Flow	164.5	269.3	104.8	*32%*	*64%*
Change in Storage	-184.7	-47.2	137.6	*42%*	*-74%*
Total	628.7	928.2	299.5	*92%*	*48%*
OTHER EFFECTS OF CHANGE IN PUMPING STRESS					
Rio Grande at El Paso				*% ΔStress*	*% Diff.*
Reservoir Spills	107.6	149.9	42.3	*13%*	*39%*
Nov-Feb Flows	26.1	50.8	24.7	*8%*	*94%*
Mar - Oct Flows	262.7	288.4	25.7	*8%*	*10%*
Total	396.5	489.1	92.6	*28%*	*23%*
Surface Water Diversions (Mar - Oct)					
EBID	396.1	441.0	45.0	*14%*	*11%*
EPCWID (incl. EPW)	279.2	299.8	20.7	*6%*	*7%*
HCCRD	65.0	83.5	18.5	*6%*	*28%*
Total	740.2	824.4	84.2	*26%*	*11%*
Surface Water Diversions (Nov - Feb)					
EBID	0.0	0.0	0.0	*0%*	*0%*
EPCWID (incl. EPW)	21.8	24.5	2.8	*1%*	*13%*
HCCRD	18.6	26.3	7.7	*2%*	*42%*
Total	40.4	50.9	10.5	*3%*	*26%*

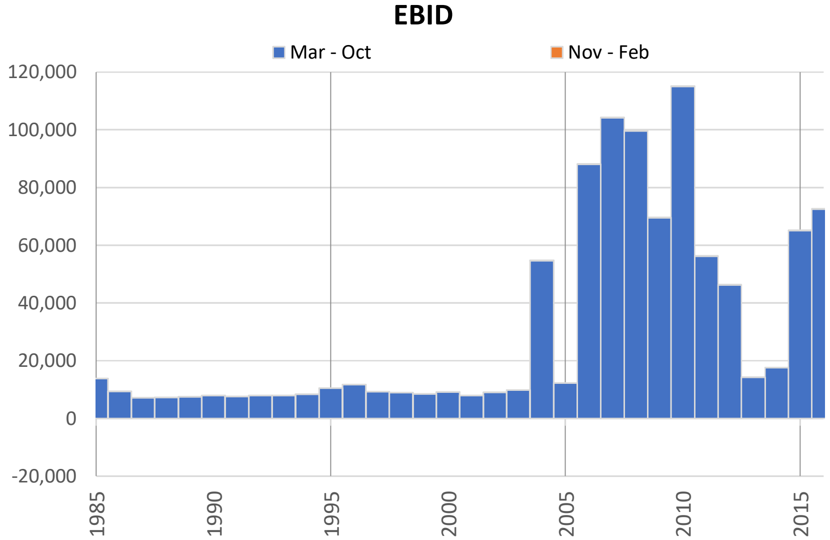
Table 10A-2b
Simulated Annual Differences in Integrated LRG Model Outputs
All Pumping Off minus Historical Base Run
1985 - 2016 (acre-feet)

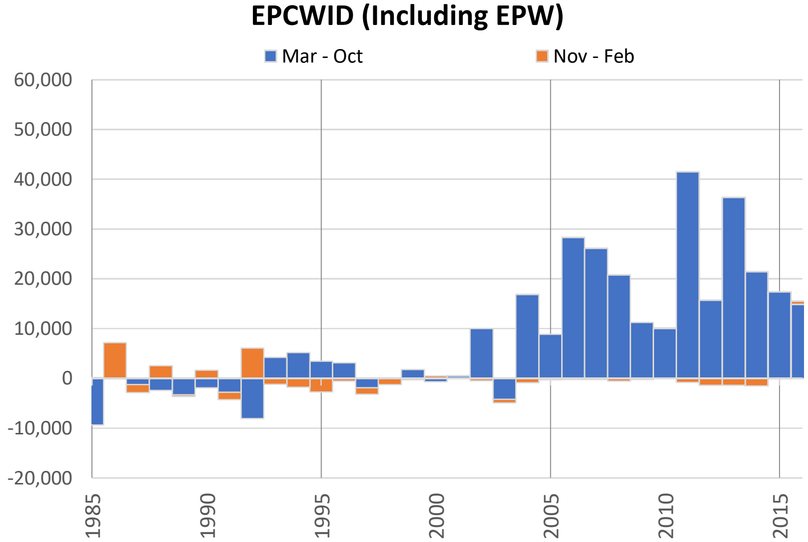
	Farm Headgate Deliveries						Other			Flows	
	EBID		EPCWID (incl. EPW)		HCCRD						
Year	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Net Reservoir Evaporation	Riparian ET	River Evaporation + Incidental Canal Loss	Rio Grande at El Paso	Rio Grande at Fort Quitman
1985	13,752	13,796	-9,318	-9,133	0	0	35,434	2,243	-2,769	-25,189	8,157
1986	9,364	9,449	-88	7,116	0	0	17,383	12,511	3,361	532,967	529,303
1987	7,183	7,255	-1,222	-2,846	0	0	-1	4,714	-598	61,174	112,749
1988	7,203	7,276	-2,401	188	0	0	841	4,721	-1,389	46,853	79,494
1989	7,530	7,585	-3,324	-3,623	0	0	1,061	5,912	-211	45,363	67,938
1990	7,865	7,927	-1,884	-245	0	0	2,873	5,256	-620	35,628	49,623
1991	7,562	7,628	-2,799	-4,238	0	0	3,299	4,150	-231	32,665	41,318
1992	7,890	7,971	-8,039	-1,966	0	0	885	6,013	324	112,218	125,300
1993	7,964	8,050	4,255	3,109	0	0	352	4,952	-954	74,439	99,426
1994	8,397	8,483	5,220	3,466	0	0	841	4,829	-794	81,777	109,177
1995	10,519	10,592	3,479	768	0	0	370	5,638	-482	115,357	149,653
1996	11,642	11,718	3,157	2,630	0	0	3,036	5,048	-1,125	51,341	68,452
1997	9,206	9,270	-1,879	-3,166	0	0	7,264	4,273	457	102,655	103,741
1998	8,864	8,941	134	-1,116	0	0	3,913	4,619	8	70,173	105,984
1999	8,471	8,527	1,782	1,501	0	0	7,773	5,183	-398	44,120	80,030
2000	9,098	9,150	-682	-160	0	0	7,514	6,892	-112	66,797	100,536
2001	7,883	7,921	517	530	0	0	9,947	7,541	-752	44,496	75,060
2002	8,989	9,018	10,021	9,567	0	0	18,020	6,649	-1,009	41,845	68,195
2003	9,834	9,918	-4,210	-4,884	0	0	23,645	7,959	-727	43,535	64,348
2004	54,665	54,783	16,825	16,007	0	0	23,607	9,902	1,196	109,421	94,140
2005	12,211	12,285	8,878	8,593	0	0	138	8,827	576	55,601	81,468
2006	88,100	88,148	28,289	28,112	0	0	22,941	9,442	1,911	114,014	88,824
2007	104,114	104,166	26,145	25,937	0	0	12,268	9,838	3,167	131,371	132,870
2008	99,615	99,663	20,764	20,263	0	0	4,278	11,044	3,726	126,154	144,529
2009	69,582	69,645	11,232	11,037	0	0	6,832	8,393	1,676	75,337	97,958
2010	115,017	115,112	10,030	10,163	0	0	5,136	8,219	2,502	75,430	98,316
2011	56,257	56,297	41,516	40,750	-1,113	-3,642	-1,172	17,941	5,950	194,312	169,622
2012	46,187	46,215	15,681	14,308	-1,272	-2,772	3,774	15,700	5,538	106,930	86,047
2013	14,200	14,227	36,357	35,005	4,177	4,675	6,076	15,182	6,300	129,345	65,762
2014	17,546	17,564	21,438	19,921	8,764	9,643	9,399	18,031	5,258	94,295	70,140
2015	65,141	65,167	17,379	17,281	-1,579	-766	10,340	15,400	5,571	96,945	102,146
2016	72,563	72,588	14,861	15,509	0	0	12,425	16,196	4,861	75,244	84,770
Avg 85-05	11,243	11,312	877	1,052	0	0	8,009	6,087	-297	83,011	105,433
Avg 85-16	30,763	30,823	8,191	8,137	281	223	8,140	8,538	1,257	92,582	104,846

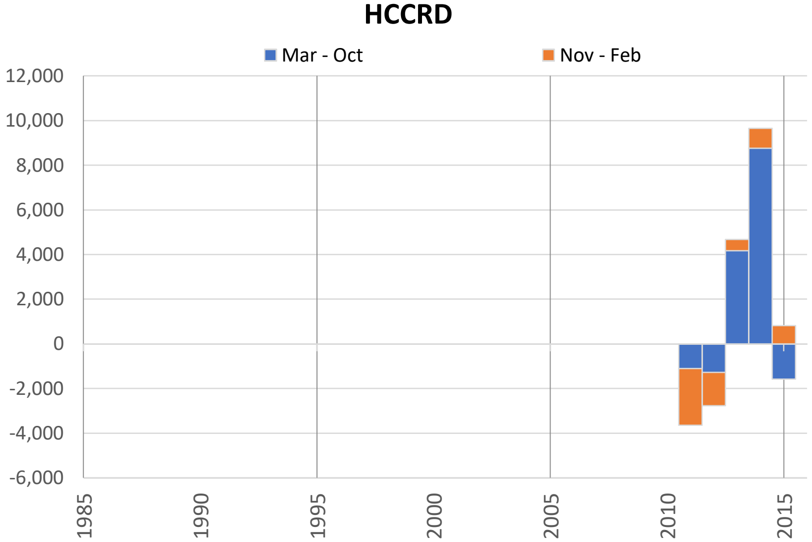
Figure 10A-2

Simulated Annual Differences in Integrated LRG Model Outputs
All Pumping Off minus Historical Base Run
1985 - 2016 (acre-feet)

Farm Headgate Deliveries


EBID


EPCWID (Including EPW)


HCCRD

*Note different scales.

Table 10A-3a
Comparison of Integrated LRG Model Runs
NM Pumping Off v. Historical Base Run
1985 - 2016 Annual Average
(1,000 acre-feet)

Run No.	**1**	**3**	**3 - 1**		
Simulated Input or Output	**Historical Base Run**	**NM Pump Off**	**NM Pump Off minus Historical Base Run**		
CHANGE IN PUMPING STRESS					
Irrigation Pumping	123.0	0.0	-123.0		
Non-Irrigation Pumping	240.0	204.4	-35.6		
WWTP Flows	125.6	114.8	-10.8		
Urban Deep Percolation	17.4	13.4	-4.1		
Total Change in Stress	219.9	76.2	-143.7		
		Change in stress is pumping minus returns			
EFFECTS OF CHANGE IN PUMPING STRESS					
FHG Deliveries (Mar - Oct)				***% ΔStress***	***% Diff.***
EBID	179.3	205.5	26.2	*18%*	*15%*
EPCWID (incl. EPW)	153.1	161.3	8.2	*6%*	*5%*
HCCRD	36.5	36.8	0.3	*0%*	*1%*
Total	369.0	403.6	34.6	*24%*	*9%*
FHG Deliveries (Nov - Feb)					
EBID	0.0	0.1	0.1	*0%*	*750%*
EPCWID (incl. EPW)	8.6	9.1	0.6	*0%*	*7%*
HCCRD	0.8	0.7	-0.1	*0%*	*-7%*
Total	9.4	9.9	0.6	*0%*	*6%*
Irrigation Pumping					
EBID	123.0	0.0	-123.0		
EPCWID (Mesilla Valley)	2.8	1.8	-1.0	*-1%*	*-37%*
EPCWID (El Paso Valley)	17.1	13.0	-4.1	*-3%*	*-24%*
HCCRD	0.6	0.0	-0.6	*0%*	*-100%*
Total	20.5	14.8	-5.7	*-4%*	*-28%*
Other Inflows/Outflows					
Net Reservoir Evaporation	174.9	182.0	7.0	*5%*	*4%*
Riparian ET	65.6	68.5	2.9	*2%*	*4%*
River Evaporation + Incidental Canal Loss	30.1	31.7	1.6	*1%*	*5%*
Total	270.6	282.2	11.6	*8%*	*4%*
Rio Grande at Fort Quitman					
Reservoir Spills	74.7	104.8	30.1	*21%*	*40%*
Nov-Feb Flows	30.4	49.6	19.2	*13%*	*63%*
Mar - Oct Flows	59.1	76.4	17.3	*12%*	*29%*
Underflow (GW Model)	0.3	0.3	0.0	*0%*	*5%*
Total	164.5	231.0	66.6	*46%*	*40%*

Table 10A-3a
Comparison of Integrated LRG Model Runs
NM Pumping Off v. Historical Base Run
1985 - 2016 Annual Average
(1,000 acre-feet)

Run No.	1	3	3 - 1		
Simulated Input or Output	Historical Base Run	NM Pump Off	NM Pump Off minus Historical Base Run		
EFFECTS OF CHANGE IN PUMPING STRESS continued					
Change in Storage				*% ΔStress*	*% Diff.*
Reservoir Storage	-32.5	-42.8	-10.3	*-7%*	*32%*
Alluvial GW Storage (RW Model)	-34.8	-24.3	10.5	*7%*	*-30%*
Non-alluvial GW Storage (GW Models)	-117.5	-105.4	12.1	*8%*	*-10%*
Soil Moisture Storage	0.1	0.1	0.0	*0%*	*-23%*
Total	-184.7	-172.4	12.4	*9%*	*-7%*
Summary of Effects					
FHG Deliveries (Mar-Oct)	369.0	403.6	34.6	*24%*	*9%*
FHG Deliveries (Nov-Feb)	9.4	9.9	0.6	*0%*	*6%*
Irrigation Pumping	20.5	14.8	-5.7	*-4%*	*-28%*
Riparian ET + Evaporation	270.6	282.2	11.6	*8%*	*4%*
Fort Quitman Flow	164.5	231.0	66.6	*46%*	*40%*
Change in Storage	-184.7	-172.4	12.4	*9%*	*-7%*
Total	649.2	769.2	120.0	*84%*	*18%*
OTHER EFFECTS OF CHANGE IN PUMPING STRESS					
Rio Grande at El Paso				*% ΔStress*	*% Diff.*
Reservoir Spills	107.6	145.1	37.5	*26%*	*35%*
Nov-Feb Flows	26.1	46.5	20.3	*14%*	*78%*
Mar - Oct Flows	262.7	279.4	16.6	*12%*	*6%*
Total	396.5	470.9	74.4	*52%*	*19%*
Surface Water Diversions (Mar - Oct)					
EBID	396.1	436.1	40.0	*28%*	*10%*
EPCWID (incl. EPW)	279.2	296.9	17.7	*12%*	*6%*
HCCRD	65.0	73.4	8.4	*6%*	*13%*
Total	740.2	806.3	66.1	*46%*	*9%*
Surface Water Diversions (Nov - Feb)					
EBID	0.0	0.0	0.0	*0%*	*0%*
EPCWID (incl. EPW)	21.8	25.1	3.3	*2%*	*15%*
HCCRD	18.6	22.0	3.5	*2%*	*19%*
Total	40.4	47.1	6.8	*5%*	*17%*

Table 10A-3b
Simulated Annual Differences in Integrated LRG Model Outputs
NM Pumping Off minus Historical Base Run
1985 - 2016 (acre-feet)

	Farm Headgate Deliveries						Other			Flows	
	EBID		EPCWID (incl. EPW)		HCCRD						
Year	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Net Reservoir Evaporation	Riparian ET	River Evaporation + Incidental Canal Loss	Rio Grande at El Paso	Rio Grande at Fort Quitman
1985	11,970	12,010	-6,223	-5,882	0	0	33,973	-2,140	-2,495	-55,902	-30,870
1986	7,325	7,408	1,225	7,272	0	0	17,383	8,793	4,001	509,451	469,021
1987	5,057	5,128	80	-3,443	0	0	-1	1,159	-93	43,904	58,974
1988	5,476	5,547	53	70	0	0	650	828	-709	29,921	33,695
1989	5,207	5,261	-525	-626	0	0	896	1,326	72	30,469	31,395
1990	5,523	5,585	-1,186	1,175	0	0	2,786	915	71	18,065	24,719
1991	5,217	5,280	-75	1,694	0	0	3,386	644	8	16,483	21,113
1992	6,084	6,162	-5,839	811	0	0	772	2,492	632	97,000	93,981
1993	6,125	6,209	1,214	1,271	0	0	265	1,234	-617	56,720	59,337
1994	6,565	6,649	488	481	0	0	612	988	-630	64,809	60,918
1995	8,215	8,288	288	404	0	0	367	1,692	-68	92,826	94,862
1996	9,201	9,277	96	-15	0	0	2,378	1,038	-661	40,526	39,373
1997	7,067	7,128	-2,322	636	0	0	6,324	657	290	73,271	60,864
1998	6,518	6,595	539	-554	0	0	3,459	881	121	53,408	64,796
1999	6,389	6,444	-939	-302	0	0	6,906	682	99	25,375	28,731
2000	6,727	6,778	335	1,038	0	0	6,852	1,300	0	46,328	46,182
2001	5,844	5,882	-542	-396	0	0	8,558	1,082	-90	32,874	31,869
2002	6,997	7,025	653	888	0	0	15,041	883	-112	31,801	32,589
2003	7,883	7,964	182	363	0	0	20,361	788	-38	19,509	22,951
2004	53,797	53,915	19,421	19,644	0	0	20,799	2,810	1,756	91,069	52,067
2005	11,389	11,463	7,603	8,005	0	0	-2,742	2,268	1,286	41,286	40,784
2006	73,271	73,316	26,933	27,098	0	0	19,664	2,692	2,147	93,256	51,239
2007	95,434	95,482	23,061	23,163	0	0	10,395	4,473	3,303	115,589	93,808
2008	88,439	88,485	20,672	20,796	0	0	2,697	5,311	3,662	114,999	105,010
2009	62,979	63,039	8,652	9,025	0	0	4,575	2,546	1,733	63,029	56,240
2010	95,463	95,534	7,575	7,677	0	0	3,532	2,450	2,951	68,341	61,784
2011	54,436	54,473	36,060	35,381	-1,113	-3,642	-4,396	9,540	6,011	166,876	129,972
2012	29,389	29,415	21,487	21,392	-1,272	-2,772	3,015	6,295	5,988	82,153	67,778
2013	9,862	9,887	45,684	45,132	4,177	4,675	6,115	8,281	7,331	103,992	53,190
2014	18,558	18,576	25,007	24,189	8,764	9,643	8,910	9,371	5,791	70,352	45,520
2015	56,256	56,281	17,947	17,971	-1,579	-766	9,988	6,525	5,810	78,733	73,844
2016	59,047	59,070	13,697	14,830	0	0	11,837	5,573	4,902	64,351	54,773
Avg 85-05	9,266	9,333	692	1,549	0	0	7,097	1,444	134	64,723	63,683
Avg 85-16	26,178	26,236	8,166	8,725	281	223	7,042	2,918	1,639	74,402	66,579

Figure 10A-3

Simulated Annual Differences in Integrated LRG Model Outputs

NM Pumping Off minus Historical Base Run

1985 - 2016 (acre-feet)

Farm Headgate Deliveries

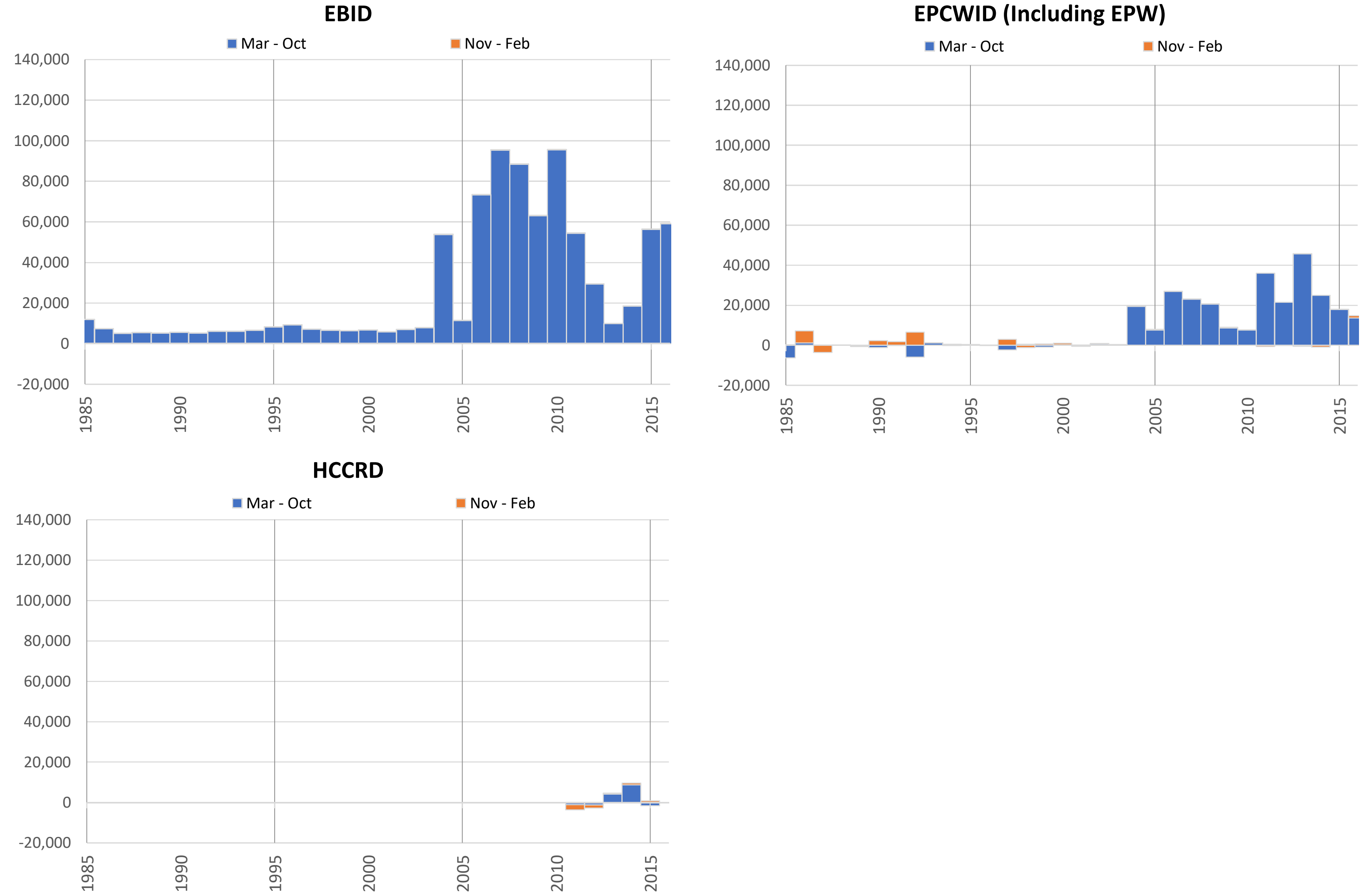


Table 10A-4a
Comparison of Integrated LRG Model Runs
TX Pumping Off v. Historical Base Run
1985 - 2016 Annual Average
(1,000 acre-feet)

Run No.	**1**	**4**	**4 - 1**		
Simulated Input or Output	**Historical Base Run**	**TX Pump Off**	**TX Pump Off minus Historical Base Run**		
CHANGE IN PUMPING STRESS					
Irrigation Pumping	20.5	0.0	-20.5		
Non-Irrigation Pumping	240.0	151.1	-88.9		
WWTP Flows	125.6	88.6	-37.0		
Urban Deep Percolation	17.4	8.8	-8.6		
Total Change in Stress	117.5	53.6	-63.8		
	Change in stress is pumping minus returns				
EFFECTS OF CHANGE IN PUMPING STRESS					
FHG Deliveries (Mar - Oct)				***% ΔStress***	***% Diff.***
EBID	179.3	184.5	5.1	*8%*	*3%*
EPCWID (incl. EPW)	153.1	153.0	-0.1	*0%*	*0%*
HCCRD	36.5	36.9	0.4	*1%*	*1%*
Total	369.0	374.4	5.4	*8%*	*1%*
FHG Deliveries (Nov - Feb)					
EBID	0.0	0.0	0.0	*0%*	*6%*
EPCWID (incl. EPW)	8.6	7.6	-1.0	*-2%*	*-11%*
HCCRD	0.8	0.8	0.0	*0%*	*1%*
Total	9.4	8.4	-1.0	*-2%*	*-10%*
Irrigation Pumping					
EBID	123.0	118.0	-5.0	*-8%*	*-4%*
EPCWID (Mesilla Valley)	2.8	0.0	-2.8		
EPCWID (El Paso Valley)	17.1	0.0	-17.1		
HCCRD	0.6	0.0	-0.6		
Total	123.0	118.0	-5.0	*-8%*	*-4%*
	Pumping turned off.	*Other values are simulated responses and are totaled.*			
Other Inflows/Outflows					
Reservoir Evaporation	174.9	175.5	0.6	*1%*	*0%*
Riparian ET	65.6	67.5	1.9	*3%*	*3%*
River Evaporation + Incidental Canal Loss	30.1	29.6	-0.5	*-1%*	*-2%*
Total	270.6	272.6	2.0	*3%*	*1%*
Rio Grande at Fort Quitman					
Reservoir Spills	74.7	74.0	-0.7	*-1%*	*-1%*
Nov-Feb Flows	30.4	29.3	-1.1	*-2%*	*-4%*
Mar - Oct Flows	59.1	64.4	5.3	*8%*	*9%*
Underflow (GW Model)	0.3	0.3	0.0	*0%*	*3%*
Total	164.5	168.0	3.5	*6%*	*2%*

Table 10A-4a
Comparison of Integrated LRG Model Runs
TX Pumping Off v. Historical Base Run
1985 - 2016 Annual Average
(1,000 acre-feet)

Run No.	1	4	4 - 1		
Simulated Input or Output	**Historical Base Run**	**TX Pump Off**	**TX Pump Off minus Historical Base Run**		
EFFECTS OF CHANGE IN PUMPING STRESS continued					
Change in Storage				***% ΔStress***	***% Diff.***
Reservoir Storage	-32.5	-32.9	-0.3	*0%*	*1%*
Alluvial GW Storage (RW Model)	-34.8	-30.6	4.2	*7%*	*-12%*
Non-alluvial GW Storage (GW Models)	-117.5	-72.4	45.1	*71%*	*-38%*
Soil Moisture Storage	0.1	0.1	0.0	*0%*	*34%*
Total	-184.7	-135.8	49.0	*77%*	*-27%*
Summary of Effects					
FHG Deliveries (Mar-Oct)	369.0	374.4	5.4	*8%*	*1%*
FHG Deliveries (Nov-Feb)	9.4	8.4	-1.0	*-2%*	*-10%*
Irrigation Pumping	123.0	118.0	-5.0	*-8%*	*-4%*
Riparian ET + Evaporation	270.6	272.6	2.0	*3%*	*1%*
Fort Quitman Flow	164.5	168.0	3.5	*6%*	*2%*
Change in Storage	-184.7	-135.8	49.0	*77%*	*-27%*
Total	751.6	805.6	53.9	*84%*	*7%*
OTHER EFFECTS OF CHANGE IN PUMPING STRESS					
Rio Grande at El Paso				***% ΔStress***	***% Diff.***
Reservoir Spills	107.6	109.6	2.0	*3%*	*2%*
Nov-Feb Flows	26.1	30.6	4.5	*7%*	*17%*
Mar - Oct Flows	262.7	275.0	12.3	*19%*	*5%*
Total	396.5	415.2	18.7	*29%*	*5%*
Surface Water Diversions (Mar - Oct)					
EBID	396.1	403.4	7.3	*11%*	*2%*
EPCWID (incl. EPW)	279.2	284.4	5.2	*8%*	*2%*
HCCRD	65.0	69.4	4.5	*7%*	*7%*
Total	740.2	757.2	17.0	*27%*	*2%*
Surface Water Diversions (Nov - Feb)					
EBID	0.0	0.0	0.0	*0%*	*0%*
EPCWID (incl. EPW)	21.8	21.0	-0.8	*-1%*	*-4%*
HCCRD	18.6	19.4	0.9	*1%*	*5%*
Total	40.4	40.4	0.0	*0%*	*0%*

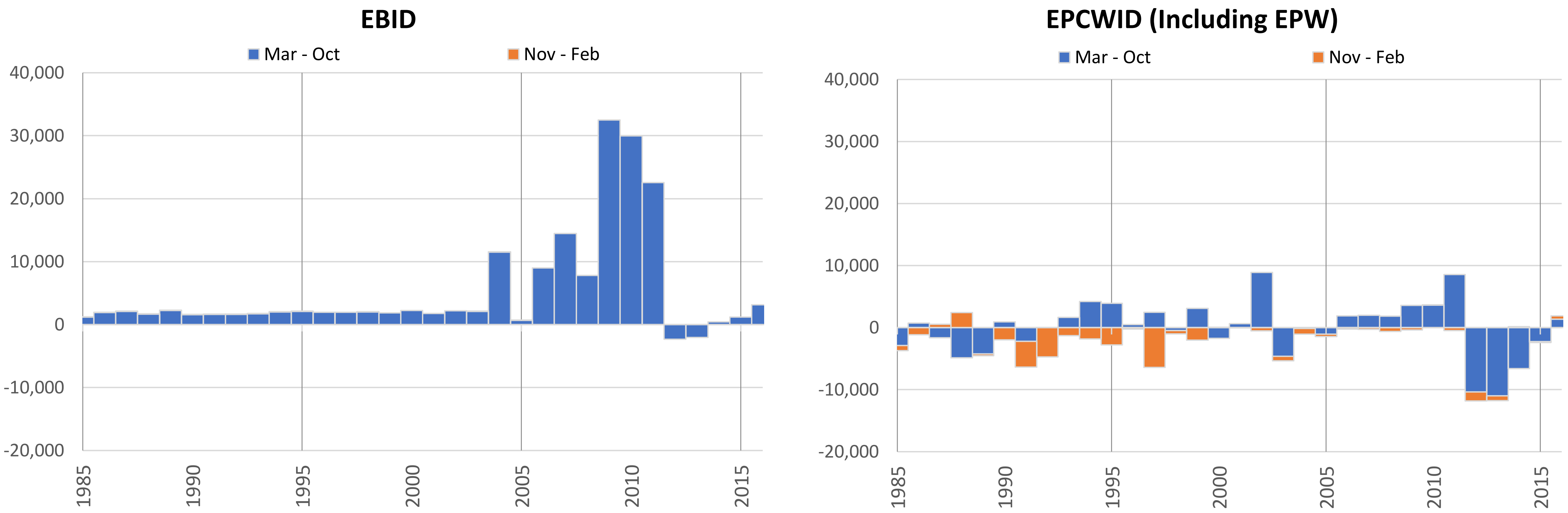
Table 10A-4b
Simulated Annual Differences in Integrated LRG Model Outputs
TX Pumping Off minus Historical Base Run
1985 - 2016 (acre-feet)

	Farm Headgate Deliveries						Other			Flows	
	EBID		EPCWID (incl. EPW)		HCCRD						
Year	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Net Reservoir Evaporation	Riparian ET	River Evaporation + Incidental Canal Loss	Rio Grande at El Paso	Rio Grande at Fort Quitman
1985	1,183	1,184	-2,907	-3,705	0	0	462	1,213	-251	22,752	-4,508
1986	1,919	1,921	733	-413	0	0	240	945	-203	25,240	-1,982
1987	2,095	2,097	-1,620	-1,072	0	0	0	747	-415	18,383	-4,595
1988	1,690	1,691	-4,861	-2,430	0	0	-38	812	-168	19,096	-2,619
1989	2,220	2,221	-4,225	-4,536	0	0	-211	1,097	-304	19,331	-3,241
1990	1,567	1,568	935	-1,024	0	0	-457	1,326	-198	27,640	-2,546
1991	1,608	1,609	-2,201	-6,351	0	0	-956	950	-227	24,636	-3,154
1992	1,601	1,602	-4	-4,734	0	0	-473	353	-795	2,962	-16,112
1993	1,726	1,726	1,667	367	0	0	-7	933	-550	14,180	-7,052
1994	2,009	2,010	4,218	2,413	0	0	99	1,024	-994	18,342	5,163
1995	2,085	2,086	3,919	1,127	0	0	-43	1,171	-392	23,132	4,438
1996	1,973	1,973	517	277	0	0	544	621	-732	11,911	-9,992
1997	1,943	1,943	2,467	-3,952	0	0	223	1,062	-491	30,664	1,114
1998	2,002	2,003	-457	-981	0	0	134	1,008	-160	24,746	-52
1999	1,852	1,852	3,083	1,086	0	0	10	1,182	-315	23,329	9,838
2000	2,225	2,225	-1,736	-1,719	0	0	766	1,196	-550	13,554	4,274
2001	1,761	1,761	615	563	0	0	1,658	1,405	-784	10,699	1,300
2002	2,185	2,185	8,908	8,389	0	0	3,675	1,175	-970	9,006	-2,859
2003	2,098	2,100	-4,609	-5,362	0	0	4,356	1,937	-977	23,672	6,113
2004	11,520	11,520	-149	-1,056	0	0	2,788	2,526	-44	36,474	12,975
2005	651	652	-1,075	-1,433	0	0	804	1,870	-365	13,606	6,110
2006	8,988	8,988	1,876	1,630	0	0	2,224	1,732	-385	20,605	1,488
2007	14,490	14,490	1,998	1,700	0	0	1,325	1,685	-86	13,168	4,396
2008	7,799	7,799	1,856	1,250	0	0	2,707	2,017	306	11,216	9,110
2009	32,504	32,504	3,576	3,222	0	0	2,405	1,781	137	15,978	10,490
2010	29,954	29,954	3,631	3,651	0	0	2,756	1,612	422	11,784	7,274
2011	22,542	22,542	8,553	8,065	-1,113	-3,642	-6,411	6,731	-407	65,167	58,292
2012	-2,321	-2,321	-10,362	-11,827	-1,272	-2,772	-2,459	2,593	-2,113	6,797	3,600
2013	-2,031	-2,031	-10,994	-11,754	4,019	4,740	1,095	1,730	-1,245	9,421	-3,282
2014	409	409	-6,581	-6,445	8,101	10,238	1,322	5,110	-856	9,725	4,050
2015	1,183	1,183	-2,259	-2,390	2,544	3,938	-56	5,313	-572	11,786	15,021
2016	3,167	3,167	1,357	1,892	0	0	146	5,122	-559	9,543	9,520
Avg 85-05	2,282	2,282	153	-1,169	0	0	646	1,169	-471	19,684	-352
Avg 85-16	5,144	5,144	-129	-1,111	384	391	582	1,874	-476	18,705	3,518

Figure 10A-4

Simulated Annual Differences in Integrated LRG Model Outputs
TX Pumping Off minus Historical Base Run
1985 - 2016 (acre-feet)

Farm Headgate Deliveries



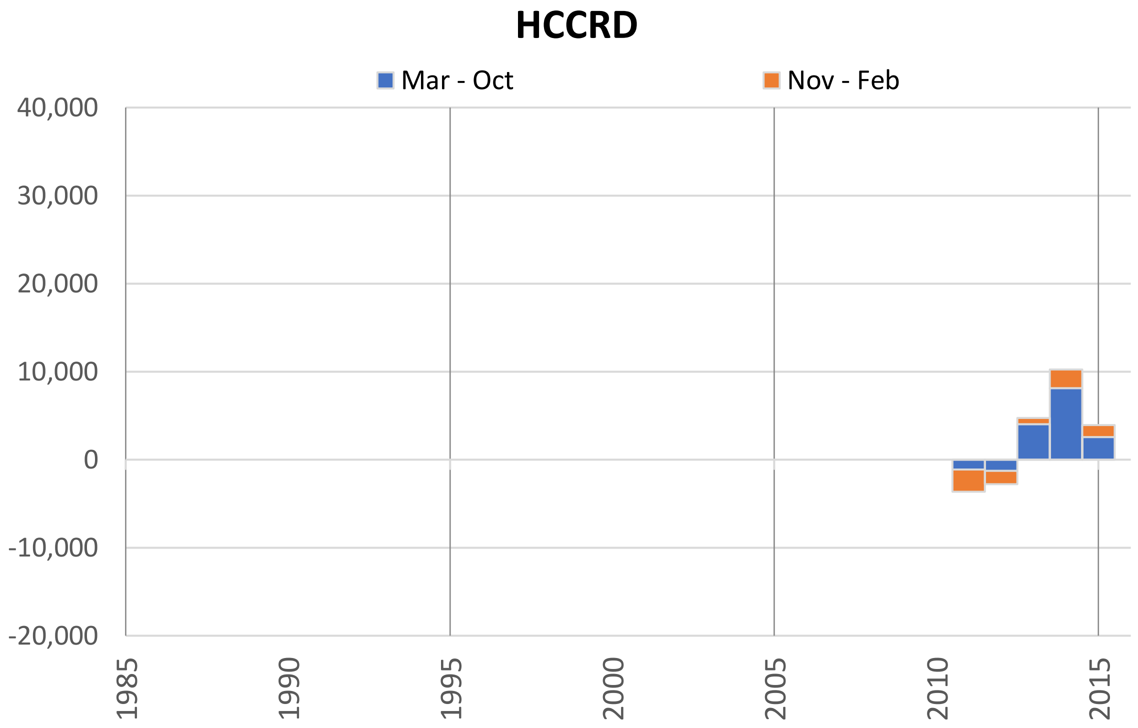


Table 10A-5a
Comparison of Integrated LRG Model Runs
MX Pumping Off v. Historical Base Run
1985 - 2016 Annual Average
(1,000 acre-feet)

Run No.	1	5	5 - 1		
Simulated Input or Output	**Historical Base Run**	**MX Pump Off**	**MX Pump Off minus Historical Base Run**		
CHANGE IN PUMPING STRESS					
Irrigation Pumping	59.2	0.0	-59.2		
Non-Irrigation Pumping	240.0	125.1	-115.0		
WWTP Flows	125.6	68.3	-57.3		
Urban Deep Percolation	17.4	17.4	0.0		
Total Change in Stress	156.2	39.3	-116.9		
		Change in stress is pumping minus returns			
EFFECTS OF CHANGE IN PUMPING STRESS					
FHG Deliveries (Mar - Oct)				***% ΔStress***	***% Diff.***
EBID	179.3	179.8	0.5	*0%*	*0%*
EPCWID (incl. EPW)	153.1	153.9	0.8	*1%*	*1%*
HCCRD	36.5	36.9	0.4	*0%*	*1%*
Total	369.0	370.7	1.7	*1%*	*0%*
FHG Deliveries (Nov - Feb)					
EBID	0.0	0.0	0.0	*0%*	*0%*
EPCWID (incl. EPW)	8.6	8.6	0.1	*0%*	*1%*
HCCRD	0.8	0.8	0.0	*0%*	*-2%*
Total	9.4	9.4	0.0	*0%*	*0%*
Irrigation Pumping					
EBID	123.0	122.4	-0.5	*0%*	*0%*
EPCWID (Mesilla Valley)	2.8	2.8	0.0	*0%*	*-1%*
EPCWID (El Paso Valley)	17.1	16.4	-0.7	*-1%*	*-4%*
HCCRD	0.6	0.2	-0.4	*0%*	*-69%*
Total	143.5	141.8	-1.6	*-1%*	*-1%*
Other Inflows/Outflows					
Reservoir Evaporation	174.9	175.2	0.2	*0%*	*0%*
Riparian ET	65.6	70.1	4.5	*4%*	*7%*
River Evaporation + Incidental Canal Loss	30.1	30.2	0.1	*0%*	*0%*
Total	270.6	275.4	4.8	*4%*	*2%*
Rio Grande at Fort Quitman					
Reservoir Spills	74.7	79.3	4.6	*4%*	*6%*
Nov-Feb Flows	30.4	38.7	8.3	*7%*	*27%*
Mar - Oct Flows	59.1	76.8	17.7	*15%*	*30%*
Underflow (GW Model)	0.3	0.3	0.0	*0%*	*3%*
Total	164.5	195.0	30.6	*26%*	*19%*

Table 10A-5a
Comparison of Integrated LRG Model Runs
MX Pumping Off v. Historical Base Run
1985 - 2016 Annual Average
(1,000 acre-feet)

Run No.	1	5	5 - 1		
Simulated Input or Output	**Historical Base Run**	**MX Pump Off**	**MX Pump Off minus Historical Base Run**		
EFFECTS OF CHANGE IN PUMPING STRESS continued					
Change in Storage				***% ΔStress***	***% Diff.***
Reservoir Storage	-32.5	-32.8	-0.3	*0%*	*1%*
Alluvial GW Storage (RW Model)	-34.8	-14.2	20.6	*18%*	*-59%*
Non-alluvial GW Storage (GW Models)	-117.5	-48.9	68.6	*59%*	*-58%*
Soil Moisture Storage	0.1	-0.1	-0.2	*0%*	*-199%*
Total	-184.7	-96.0	88.7	*76%*	*-48%*
Summary of Effects					
FHG Deliveries (Mar-Oct)	369.0	370.7	1.7	*1%*	*0%*
FHG Deliveries (Nov-Feb)	9.4	9.4	0.0	*0%*	*0%*
Irrigation Pumping	143.5	141.8	-1.6	*-1%*	*-1%*
Riparian ET + Evaporation	270.6	275.4	4.8	*4%*	*2%*
Fort Quitman Flow	164.5	195.0	30.6	*26%*	*19%*
Change in Storage	-184.7	-96.0	88.7	*76%*	*-48%*
Total	772.2	896.3	124.1	*106%*	*16%*
OTHER EFFECTS OF CHANGE IN PUMPING STRESS					
Rio Grande at El Paso				***% ΔStress***	***% Diff.***
Reservoir Spills	107.6	107.8	0.2	*0%*	*0%*
Nov-Feb Flows	26.1	26.3	0.1	*0%*	*1%*
Mar - Oct Flows	262.7	262.3	-0.4	*0%*	*0%*
Total	396.5	396.4	-0.1	*0%*	*0%*
Surface Water Diversions (Mar - Oct)					
EBID	396.1	397.0	1.0	*1%*	*0%*
EPCWID (incl. EPW)	279.2	279.0	-0.2	*0%*	*0%*
HCCRD	65.0	72.6	7.6	*7%*	*12%*
Total	740.2	748.6	8.4	*7%*	*1%*
Surface Water Diversions (Nov - Feb)					
EBID	0.0	0.0	0.0	*0%*	*0%*
EPCWID (incl. EPW)	21.8	21.7	-0.1	*0%*	*0%*
HCCRD	18.6	22.3	3.8	*3%*	*20%*
Total	40.4	44.0	3.7	*3%*	*9%*

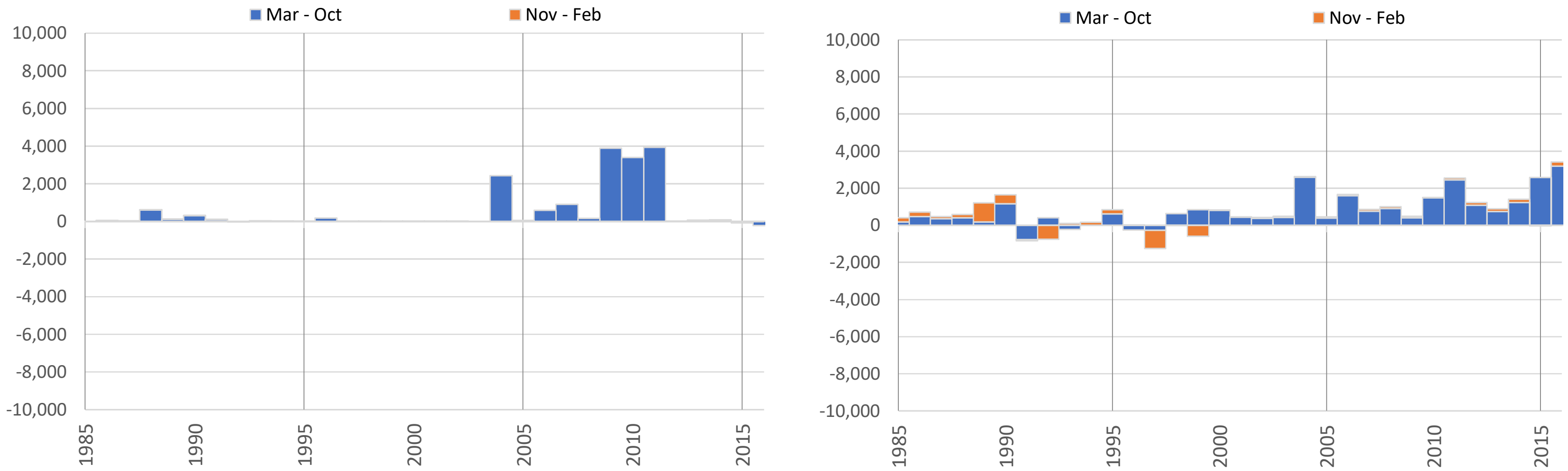
Table 10A-5b
Simulated Annual Differences in Integrated LRG Model Outputs
MX Pumping Off minus Historical Base Run
1985 - 2016 (acre-feet)

	Farm Headgate Deliveries						Other			Flows	
	EBID		EPCWID (incl. EPW)		HCCRD						
Year	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Net Reservoir Evaporation	Riparian ET	River Evaporation + Incidental Canal Loss	Rio Grande at El Paso	Rio Grande at Fort Quitman
1985	-3	-3	173	403	0	0	679	3,706	-474	-1,466	34,341
1986	34	34	469	712	0	0	1,071	3,406	-302	9,928	46,096
1987	14	14	349	465	0	0	0	3,181	-79	289	52,456
1988	599	599	405	582	0	0	-29	3,559	-203	170	42,418
1989	108	108	179	1,203	0	0	-65	4,162	48	763	34,502
1990	295	295	1,153	1,635	0	0	-164	3,973	111	1,600	31,607
1991	86	86	-774	-838	0	0	-214	3,196	297	1,739	27,963
1992	-23	-23	411	-339	0	0	-25	2,775	137	-5,488	22,408
1993	12	12	-226	-130	0	0	-15	3,068	106	2,154	33,323
1994	4	4	9	158	0	0	7	3,108	256	-349	33,358
1995	-3	-3	612	832	0	0	-71	3,041	-4	460	40,803
1996	171	171	-251	-240	0	0	-101	3,728	305	298	36,422
1997	10	10	-271	-1,257	0	0	-127	2,860	457	262	32,805
1998	15	15	634	630	0	0	-305	3,190	261	1,064	36,945
1999	1	1	835	239	0	0	-153	3,528	41	-1,311	39,188
2000	1	1	798	802	0	0	100	4,240	-63	-2,027	37,781
2001	0	0	436	460	0	0	215	5,164	-10	-1,598	36,372
2002	0	0	378	427	0	0	666	4,747	-33	-1,554	34,157
2003	-1	-1	418	477	0	0	787	5,657	-62	-2,213	31,367
2004	2,421	2,421	2,588	2,624	0	0	514	5,345	177	5,777	36,197
2005	33	33	394	444	0	0	-162	4,648	26	-937	33,597
2006	590	590	1,588	1,656	0	0	113	5,532	234	241	36,719
2007	900	900	765	860	0	0	-37	4,562	23	-2,306	30,300
2008	159	159	907	992	0	0	944	4,982	76	-1,781	31,713
2009	3,876	3,876	403	491	0	0	424	4,927	159	-3,939	32,804
2010	3,389	3,389	1,477	1,483	0	0	536	4,852	109	-3,840	33,316
2011	3,934	3,934	2,448	2,543	-1,113	-3,642	1,933	6,432	308	3,184	20,104
2012	14	14	1,074	1,230	-1,272	-2,772	114	6,285	178	-47	11,960
2013	55	55	738	893	2,581	3,168	159	3,449	106	-453	3,014
2014	83	83	1,219	1,398	7,509	9,363	233	6,811	75	-162	-2,022
2015	-76	-76	2,570	2,535	5,218	6,413	3	7,290	-71	-1,678	6,913
2016	-231	-231	3,181	3,412	0	0	44	7,886	-166	173	19,528
Avg 85-05	180	180	415	442	0	0	124	3,823	47	360	35,910
Avg 85-16	515	515	784	837	404	392	221	4,478	63	-95	30,577

Figure 10A-5

Simulated Annual Differences in Integrated LRG Model Outputs
MX Pumping Off minus Historical Base Run
1985 - 2016 (acre-feet)

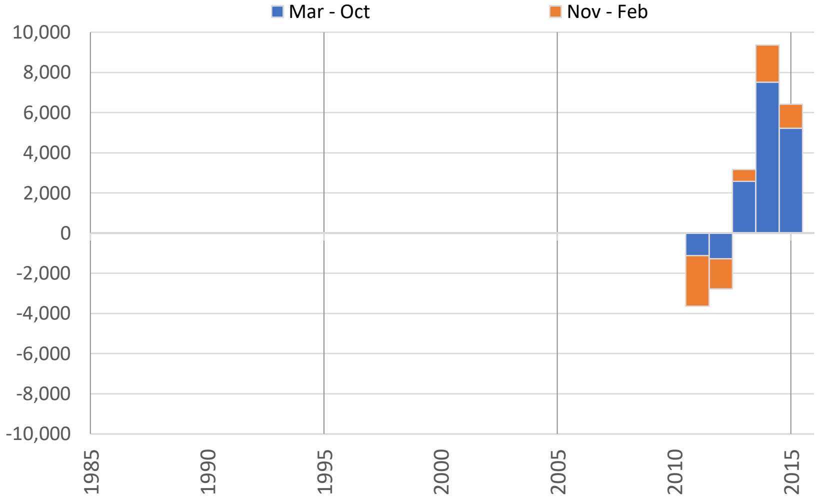
Farm Headgate Deliveries



EBID

EPCWID (Including EPW)

HCCRD



10/26/2019

Table 10A-6a
Comparison of Integrated LRG Model Runs
RM Pumping Off v. Historical Base Run
1985 - 2016 Annual Average
(1,000 acre-feet)

Run No.	1	6	6 - 1		
Simulated Input or Output	**Historical Base Run**	**RM Pump Off**	**RM Pump Off minus Historical Base Run**		
CHANGE IN PUMPING STRESS					
Irrigation Pumping	125.8	0.0	-125.8		
Non-Irrigation Pumping	240.0	175.1	-64.9		
WWTP Flows	125.6	104.0	-21.7		
Urban Deep Percolation	17.4	11.0	-6.4		
Total Change in Stress	222.7	60.2	-162.6		
Change in stress is pumping minus returns					
EFFECTS OF CHANGE IN PUMPING STRESS					
FHG Deliveries (Mar - Oct)				***% ΔStress***	***% Diff.***
EBID	179.3	209.7	30.4	*19%*	*17%*
EPCWID (incl. EPW)	153.1	161.7	8.6	*5%*	*6%*
HCCRD	36.5	36.8	0.3	*0%*	*1%*
Total	369.0	408.2	39.2	*24%*	*11%*
FHG Deliveries (Nov - Feb)					
EBID	0.0	0.1	0.1	*0%*	*778%*
EPCWID (incl. EPW)	8.6	9.2	0.6	*0%*	*7%*
HCCRD	0.8	0.7	-0.1	*0%*	*-7%*
Total	9.4	9.9	0.6	*0%*	*6%*
Irrigation Pumping					
EBID	123.0	0.0	-123.0		
EPCWID (Mesilla Valley)	2.8	0.0	-2.8		
EPCWID (El Paso Valley)	17.1	13.3	-3.9	*-2%*	*-23%*
HCCRD	0.6	0.0	-0.6	*0%*	*-100%*
Total	17.7	13.3	-4.4	*-3%*	*-25%*
	Pumping turned off.	*Other values are simulated responses and are totaled.*			
Other Inflows/Outflows					
Reservoir Evaporation	174.9	183.2	8.3	*5%*	*5%*
Riparian ET	65.6	68.9	3.3	*2%*	*5%*
River Evaporation + Incidental Canal Loss	30.1	31.7	1.6	*1%*	*5%*
Total	270.6	283.9	13.2	*8%*	*5%*
Rio Grande at Fort Quitman					
Reservoir Spills	74.7	109.4	34.7	*21%*	*46%*
Nov-Feb Flows	30.4	51.8	21.4	*13%*	*70%*
Mar - Oct Flows	59.1	77.8	18.7	*12%*	*32%*
Underflow (GW Model)	0.3	0.3	0.0	*0%*	*6%*
Total	164.5	239.3	74.8	*46%*	*45%*

Table 10A-6a
Comparison of Integrated LRG Model Runs
RM Pumping Off v. Historical Base Run
1985 - 2016 Annual Average
(1,000 acre-feet)

Run No.	1	6	6 - 1		
Simulated Input or Output	**Historical Base Run**	**RM Pump Off**	**RM Pump Off minus Historical Base Run**		
EFFECTS OF CHANGE IN PUMPING STRESS continued					
Change in Storage				*% ΔStress*	*% Diff.*
Reservoir Storage	-32.5	-44.5	-12.0	*-7%*	*37%*
Alluvial GW Storage (RW Model)	-34.8	-24.0	10.7	*7%*	*-31%*
Non-alluvial GW Storage (GW Models)	-117.5	-99.2	18.3	*11%*	*-16%*
Soil Moisture Storage	0.1	0.1	0.0	*0%*	*-39%*
Total	-184.7	-167.7	17.0	*10%*	*-9%*
Summary of Effects					
FHG Deliveries (Mar-Oct)	369.0	408.2	39.2	*24%*	*11%*
FHG Deliveries (Nov-Feb)	9.4	9.9	0.6	*0%*	*6%*
Irrigation Pumping	17.7	13.3	-4.4	*-3%*	*-25%*
Riparian ET + Evaporation	270.6	283.9	13.2	*8%*	*5%*
Fort Quitman Flow	164.5	239.3	74.8	*46%*	*45%*
Change in Storage	-184.7	-167.7	17.0	*10%*	*-9%*
Total	646.4	786.8	140.5	*86%*	*22%*
OTHER EFFECTS OF CHANGE IN PUMPING STRESS					
Rio Grande at El Paso				*% ΔStress*	*% Diff.*
Reservoir Spills	107.6	151.4	43.8	*27%*	*41%*
Nov-Feb Flows	26.1	51.5	25.4	*16%*	*97%*
Mar - Oct Flows	262.7	287.5	24.8	*15%*	*9%*
Total	396.5	490.4	93.9	*58%*	*24%*
Surface Water Diversions (Mar - Oct)					
EBID	396.1	440.3	44.2	*27%*	*11%*
EPCWID (incl. EPW)	279.2	299.3	20.1	*12%*	*7%*
HCCRD	65.0	73.1	8.2	*5%*	*13%*
Total	740.2	812.7	72.5	*45%*	*10%*
Surface Water Diversions (Nov - Feb)					
EBID	0.0	0.0	0.0	*0%*	*0%*
EPCWID (incl. EPW)	21.8	25.3	3.6	*2%*	*16%*
HCCRD	18.6	21.9	3.3	*2%*	*18%*
Total	40.4	47.3	6.9	*4%*	*17%*

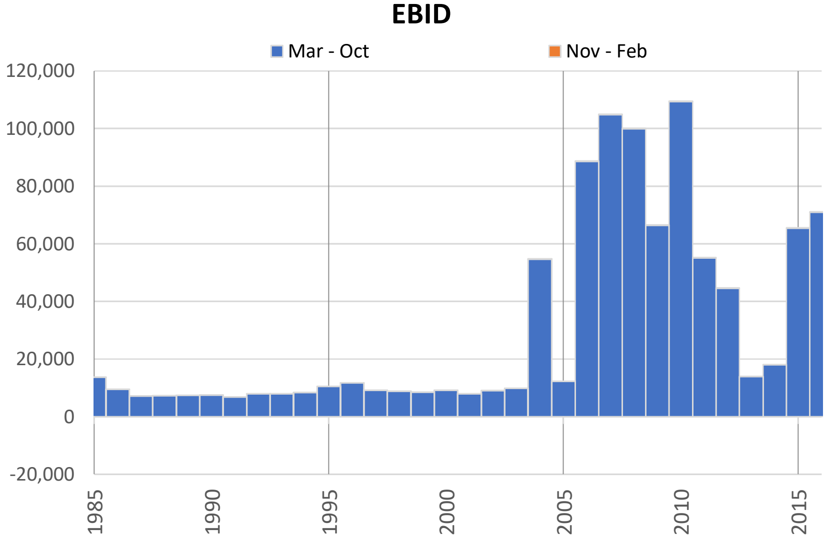
Table 10A-6b
Simulated Annual Differences in Integrated LRG Model Outputs
RM Pumping Off minus Historical Base Run
1985 - 2016 (acre-feet)

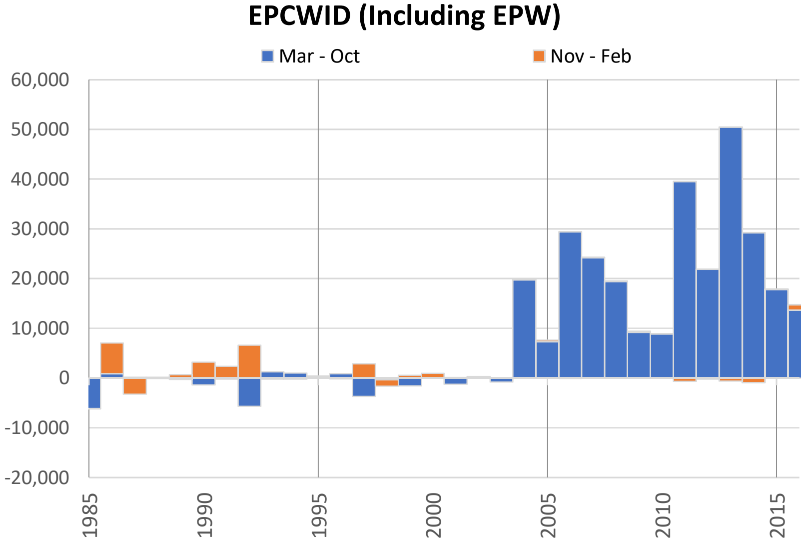
	Farm Headgate Deliveries						Other			Flows	
	EBID		EPCWID (incl. EPW)		HCCRD						
Year	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Net Reservoir Evaporation	Riparian ET	River Evaporation + Incidental Canal Loss	Rio Grande at El Paso	Rio Grande at Fort Quitman
1985	13,721	13,768	-6,117	-6,155	0	0	38,127	-1,470	-1,805	1,037	7,848
1986	9,453	9,539	914	7,086	0	0	17,383	9,487	4,005	537,762	496,593
1987	7,194	7,266	166	-3,037	0	0	-1	1,532	-195	61,487	69,208
1988	7,224	7,297	-85	67	0	0	904	1,128	-1,589	47,122	43,107
1989	7,317	7,372	-299	372	0	0	1,127	1,767	49	45,714	37,156
1990	7,528	7,590	-1,352	1,857	0	0	3,521	1,130	-214	27,592	25,965
1991	6,830	6,895	-217	2,142	0	0	4,265	792	-86	26,483	23,079
1992	7,947	8,029	-5,709	924	0	0	846	3,064	640	127,046	116,185
1993	7,931	8,016	1,305	1,119	0	0	314	1,640	-709	72,355	67,736
1994	8,412	8,496	992	792	0	0	747	1,358	-749	82,606	68,960
1995	10,506	10,579	312	426	0	0	439	2,213	-181	114,460	105,108
1996	11,676	11,752	871	750	0	0	2,840	1,335	-855	56,598	42,151
1997	9,163	9,228	-3,711	-818	0	0	7,422	1,005	439	97,171	71,968
1998	8,847	8,925	-350	-1,592	0	0	4,257	1,176	1	69,376	70,078
1999	8,423	8,479	-1,556	-980	0	0	8,508	938	-65	37,763	30,831
2000	9,130	9,183	18	923	0	0	7,608	1,882	193	73,647	60,656
2001	7,895	7,933	-1,254	-1,120	0	0	9,845	1,415	-195	47,263	35,362
2002	9,002	9,031	175	281	0	0	17,475	1,127	-399	45,339	34,772
2003	9,796	9,880	-799	-794	0	0	23,722	1,054	-174	33,571	25,526
2004	54,678	54,795	19,735	19,856	0	0	24,292	3,092	1,614	108,128	53,049
2005	12,199	12,272	7,319	7,672	0	0	687	2,582	668	54,436	42,335
2006	88,662	88,710	29,379	29,367	0	0	23,295	3,183	2,452	119,246	57,969
2007	104,873	104,925	24,174	24,218	0	0	12,108	4,899	3,507	133,394	100,188
2008	99,977	100,025	19,450	19,500	0	0	3,819	5,632	3,996	128,779	109,028
2009	66,443	66,506	9,207	9,436	0	0	6,131	2,909	1,746	80,538	62,705
2010	109,412	109,494	8,842	8,964	0	0	4,493	2,785	2,656	83,035	65,600
2011	55,107	55,146	39,488	38,810	-1,113	-3,642	-2,384	10,252	6,232	192,714	139,820
2012	44,558	44,585	21,876	21,661	-1,272	-2,772	3,675	6,962	5,973	102,308	74,194
2013	13,949	13,975	50,451	49,840	4,177	4,675	6,434	8,874	7,035	128,050	60,389
2014	18,039	18,056	29,180	28,265	8,764	9,643	9,745	10,064	5,993	94,589	53,303
2015	65,470	65,495	17,832	17,904	-1,579	-766	10,739	6,927	6,191	95,902	83,408
2016	71,007	71,032	13,606	14,723	0	0	12,409	6,028	5,278	79,592	59,600
Avg 85-05	11,184	11,254	493	1,418	0	0	8,301	1,821	19	84,141	72,746
Avg 85-16	30,386	30,446	8,558	9,139	281	223	8,275	3,336	1,608	93,910	74,809

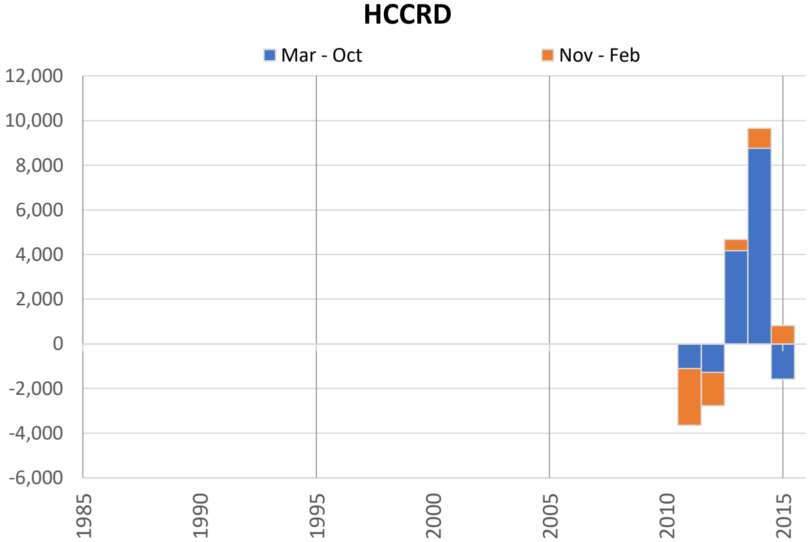
Figure 10A-6

Simulated Annual Differences in Integrated LRG Model Outputs
RM Pumping Off minus Historical Base Run
1985 - 2016 (acre-feet)

Farm Headgate Deliveries







*Note different scales.

10/26/2019

Table 10A-7a
Comparison of Integrated LRG Model Runs
TX Mesilla Pumping Off v. Historical Base Run
1985 - 2016 Annual Average
(1,000 acre-feet)

Run No.	1	7	7 - 1		
Simulated Input or Output	**Historical Base Run**	**TX Mesilla Pump Off**	**TX Mesilla Pump Off minus Historical Base Run**		
CHANGE IN PUMPING STRESS					
Irrigation Pumping	2.8	0.0	-2.8		
Non-Irrigation Pumping	240.0	215.9	-24.1		
WWTP Flows	125.6	114.8	-10.8		
Urban Deep Percolation	17.4	15.1	-2.4		
Total Change in Stress	99.8	86.0	-13.8		
	Change in stress is pumping minus returns				
EFFECTS OF CHANGE IN PUMPING STRESS					
FHG Deliveries (Mar - Oct)				***% ΔStress***	***% Diff.***
EBID	179.3	184.7	5.4	*39%*	*3%*
EPCWID (incl. EPW)	153.1	153.2	0.1	*1%*	*0%*
HCCRD	36.5	36.4	-0.1	*-1%*	*0%*
Total	369.0	374.4	5.4	*39%*	*1%*
FHG Deliveries (Nov - Feb)					
EBID	0.0	0.0	0.0	*0%*	*7%*
EPCWID (incl. EPW)	8.6	8.7	0.2	*1%*	*2%*
HCCRD	0.8	0.7	-0.1	*-1%*	*-15%*
Total	9.4	9.4	0.0	*0%*	*0%*
Irrigation Pumping					
EBID	123.0	117.7	-5.2	*-38%*	*-4%*
EPCWID (Mesilla Valley)	2.8	0.0	-2.8		
EPCWID (El Paso Valley)	17.1	17.4	0.3	*2%*	*2%*
HCCRD	0.6	0.6	0.0	*0%*	*7%*
Total	140.6	135.8	-4.9	*-35%*	*-3%*
	Pumping turned off.	*Other values are simulated responses and are totaled.*			
Other Inflows/Outflows					
Reservoir Evaporation	174.9	176.6	1.7	*12%*	*1%*
Riparian ET	65.6	66.1	0.4	*3%*	*1%*
River Evaporation + Incidental Canal Loss	30.1	30.3	0.2	*1%*	*1%*
Total	270.6	272.9	2.3	*17%*	*1%*
Rio Grande at Fort Quitman					
Reservoir Spills	74.7	80.7	6.0	*43%*	*8%*
Nov-Feb Flows	30.4	32.6	2.2	*16%*	*7%*
Mar - Oct Flows	59.1	59.9	0.8	*6%*	*1%*
Underflow (GW Model)	0.3	0.3	0.0	*0%*	*1%*
Total	164.5	173.4	9.0	*65%*	*5%*

Table 10A-7a
Comparison of Integrated LRG Model Runs
TX Mesilla Pumping Off v. Historical Base Run
1985 - 2016 Annual Average
(1,000 acre-feet)

Run No.	1	7	7 - 1		
Simulated Input or Output	Historical Base Run	TX Mesilla Pump Off	TX Mesilla Pump Off minus Historical Base Run		
EFFECTS OF CHANGE IN PUMPING STRESS continued					
Change in Storage				*% ΔStress*	*% Diff.*
Reservoir Storage	-32.5	-36.0	-3.4	*-25%*	*10%*
Alluvial GW Storage (RW Model)	-34.8	-31.8	3.0	*22%*	*-9%*
Non-alluvial GW Storage (GW Models)	-117.5	-115.4	2.1	*16%*	*-2%*
Soil Moisture Storage	0.1	0.1	0.0	*0%*	*22%*
Total	-184.7	-183.0	1.7	*13%*	*-1%*
Summary of Effects					
FHG Deliveries (Mar-Oct)	369.0	374.4	5.4	*39%*	*1%*
FHG Deliveries (Nov-Feb)	9.4	9.4	0.0	*0%*	*0%*
Irrigation Pumping	140.6	135.8	-4.9	*-35%*	*-3%*
Riparian ET + Evaporation	270.6	272.9	2.3	*17%*	*1%*
Fort Quitman Flow	164.5	173.4	9.0	*65%*	*5%*
Change in Storage	-184.7	-183.0	1.7	*13%*	*-1%*
Total	769.3	782.9	13.6	*99%*	*2%*
OTHER EFFECTS OF CHANGE IN PUMPING STRESS					
Rio Grande at El Paso				*% ΔStress*	*% Diff.*
Reservoir Spills	107.6	117.1	9.5	*69%*	*9%*
Nov-Feb Flows	26.1	31.3	5.2	*38%*	*20%*
Mar - Oct Flows	262.7	267.9	5.1	*37%*	*2%*
Total	396.5	416.3	19.8	*144%*	*5%*
Surface Water Diversions (Mar - Oct)					
EBID	396.1	403.8	7.7	*56%*	*2%*
EPCWID (incl. EPW)	279.2	281.3	2.1	*15%*	*1%*
HCCRD	65.0	64.9	0.0	*0%*	*0%*
Total	740.2	750.0	9.8	*71%*	*1%*
Surface Water Diversions (Nov - Feb)					
EBID	0.0	0.0	0.0	*0%*	*0%*
EPCWID (incl. EPW)	21.8	22.3	0.5	*4%*	*2%*
HCCRD	18.6	18.6	0.0	*0%*	*0%*
Total	40.4	40.8	0.5	*3%*	*1%*

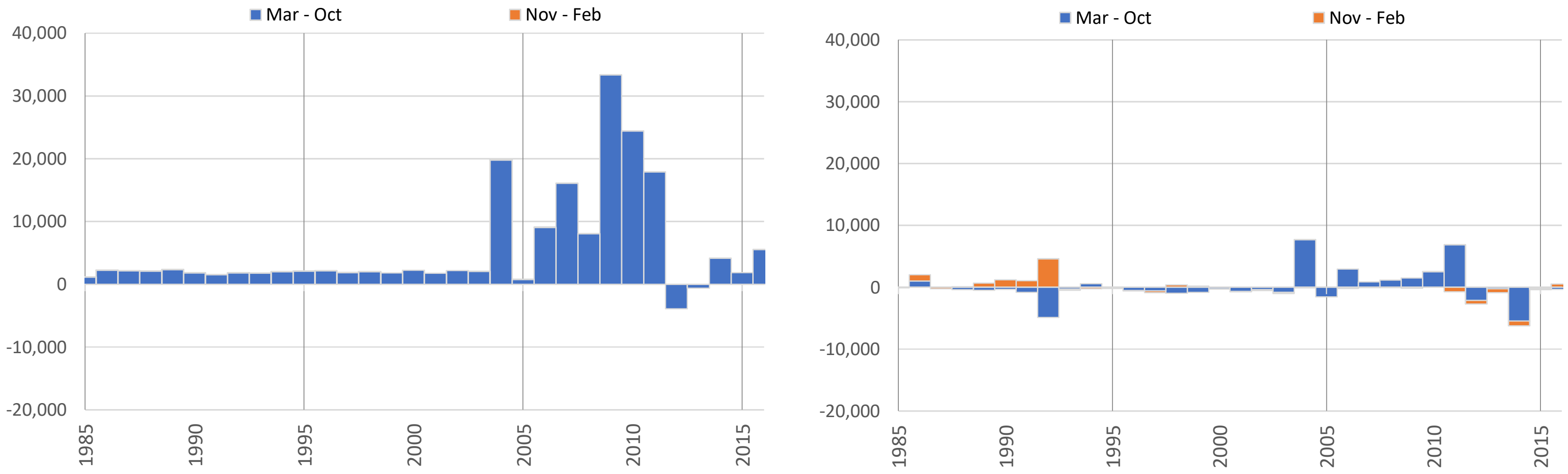
Table 10A-7b
Simulated Annual Differences in Integrated LRG Model Outputs
TX Mesilla Pumping Off minus Historical Base Run
1985 - 2016 (acre-feet)

	Farm Headgate Deliveries						**Other**			**Flows**	
	EBID		EPCWID (incl. EPW)		HCCRD						
Year	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Net Reservoir Evaporation	Riparian ET	River Evaporation + Incidental Canal Loss	Rio Grande at El Paso	Rio Grande at Fort Quitman
1985	1,129	1,130	-85	-72	0	0	7,083	242	-6	9,951	2,953
1986	2,225	2,228	1,012	2,032	0	0	8,371	1,866	806	112,493	96,507
1987	2,137	2,139	45	-180	0	0	0	518	-71	20,207	15,830
1988	2,081	2,083	-387	-265	0	0	257	354	-308	18,228	10,398
1989	2,317	2,317	-452	240	0	0	452	426	61	13,091	4,447
1990	1,834	1,835	-326	888	0	0	964	240	-78	9,555	1,643
1991	1,523	1,523	-799	279	0	0	1,177	155	-80	9,070	1,915
1992	1,819	1,820	-4,865	-253	0	0	408	1,066	545	33,612	25,763
1993	1,769	1,770	-286	-482	0	0	87	457	-280	19,342	12,064
1994	2,020	2,021	573	360	0	0	176	306	-699	18,865	9,194
1995	2,089	2,089	-188	-136	0	0	86	573	-69	22,992	11,733
1996	2,143	2,143	-525	-577	0	0	602	219	-220	12,112	727
1997	1,874	1,874	-544	-845	0	0	1,339	253	-256	17,672	3,489
1998	1,999	2,000	-977	-599	0	0	1,222	320	-20	24,517	13,314
1999	1,793	1,793	-819	-617	0	0	2,198	249	-73	12,246	2,527
2000	2,251	2,251	-220	-222	0	0	2,715	258	-302	13,516	2,464
2001	1,766	1,766	-677	-714	0	0	3,172	248	-52	11,990	1,579
2002	2,192	2,192	-379	-534	0	0	5,139	161	-133	10,967	-26
2003	2,038	2,040	-815	-1,020	0	0	6,627	231	-345	12,886	1,324
2004	19,801	19,801	7,688	7,584	0	0	4,814	1,254	949	49,534	21,828
2005	763	764	-1,521	-1,506	0	0	121	439	226	17,636	9,644
2006	9,031	9,031	2,940	2,779	0	0	2,124	573	295	20,959	5,172
2007	16,104	16,104	898	875	0	0	1,121	503	486	16,053	1,630
2008	8,068	8,068	1,194	1,165	-17	-17	1,597	452	822	14,384	1,817
2009	33,374	33,374	1,504	1,389	0	0	1,452	628	554	22,622	9,971
2010	24,407	24,407	2,525	2,543	0	0	1,298	516	767	19,152	8,789
2011	17,878	17,878	6,847	6,120	217	-1,987	22	1,536	1,081	33,902	10,886
2012	-3,900	-3,900	-2,092	-2,712	-1,272	-2,772	-1,221	-130	-338	8,563	4,721
2013	-634	-634	-224	-871	-150	-150	431	244	-88	10,331	707
2014	4,152	4,152	-5,423	-6,201	-388	-388	706	-244	1,670	-3,537	-1,124
2015	1,839	1,839	-168	-381	-1,644	-1,722	-325	58	67	10,366	-2,921
2016	5,538	5,538	-348	171	0	0	-502	256	338	11,108	-1,562
Avg 85-05	2,741	2,742	-217	160	0	0	2,239	468	-19	22,404	11,872
Avg 85-16	5,419	5,420	97	257	-102	-220	1,679	445	164	19,825	8,981

Figure 10A-7

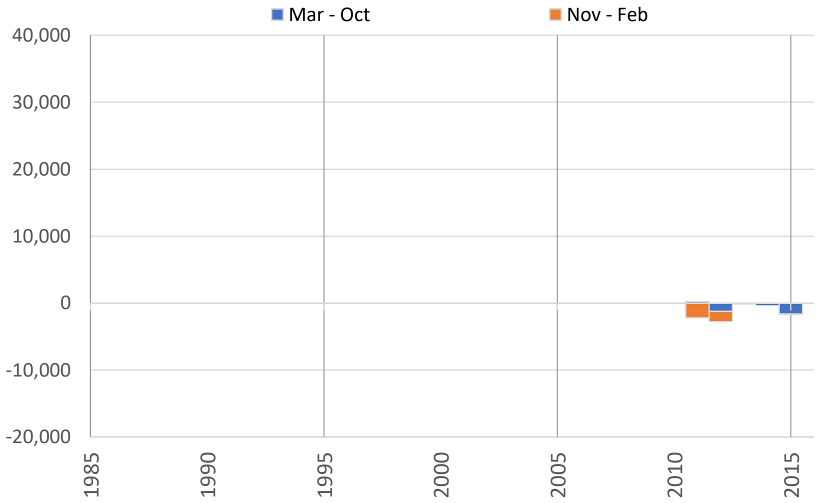
Simulated Annual Differences in Integrated LRG Model Outputs
TX Mesilla Pumping Off minus Historical Base Run
1985 - 2016 (acre-feet)

Farm Headgate Deliveries


EBID

EPCWID (Including EPW)

HCCRD



10/27/2019

Spronk Water Engineers , Inc.

Table 10A-8a
Comparison of Integrated LRG Model Runs
TX Non-Irrigation Pumping Off v. Historical Base Run
1985 - 2016 Annual Average
(1,000 acre-feet)

Run No.	**1**	**8**	**8 - 1**		
Simulated Input or Output	**Historical Base Run**	**TX Non-Irrigation Pump Off**	**TX Non-Irrigation Pump Off minus Historical Base Run**		
CHANGE IN PUMPING STRESS					
Non-Irrigation Pumping	240.0	151.1	-88.9		
WWTP Flows	125.6	88.6	-37.0		
Urban Deep Percolation	17.4	8.8	-8.6		
Total Change in Stress	96.9	53.6	-43.3		
	Change in stress is pumping minus returns				
EFFECTS OF CHANGE IN PUMPING STRESS					
FHG Deliveries (Mar - Oct)				***% ΔStress***	***% Diff.***
EBID	179.3	183.6	4.3	*10%*	*2%*
EPCWID (incl. EPW)	153.1	151.8	-1.4	*-3%*	*-1%*
HCCRD	36.5	35.6	-0.9	*-2%*	*-2%*
Total	369.0	371.0	2.0	*5%*	*1%*
FHG Deliveries (Nov - Feb)					
EBID	0.0	0.0	0.0	*0%*	*5%*
EPCWID (incl. EPW)	8.6	7.5	-1.1	*-3%*	*-13%*
HCCRD	0.8	0.7	-0.1	*0%*	*-12%*
Total	9.4	8.2	-1.2	*-3%*	*-13%*
Irrigation Pumping					
EBID	123.0	118.8	-4.1	*-10%*	*-3%*
EPCWID (Mesilla Valley)	2.8	2.7	-0.2	*0%*	*-6%*
EPCWID (El Paso Valley)	17.1	19.7	2.6	*6%*	*15%*
HCCRD	0.6	1.4	0.8	*2%*	*143%*
Total	143.5	142.6	-0.9	*-2%*	*-1%*
Other Inflows/Outflows					
Reservoir Evaporation	174.9	175.1	0.2	*0%*	*0%*
Riparian ET	65.6	66.0	0.4	*1%*	*1%*
River Evaporation + Incidental Canal Loss	30.1	29.7	-0.4	*-1%*	*-1%*
Total	270.6	270.8	0.2	*0%*	*0%*
Rio Grande at Fort Quitman					
Reservoir Spills	74.7	71.6	-3.1	*-7%*	*-4%*
Nov-Feb Flows	30.4	24.9	-5.5	*-13%*	*-18%*
Mar - Oct Flows	59.1	56.2	-2.9	*-7%*	*-5%*
Underflow (GW Model)	0.3	0.3	0.0	*0%*	*-1%*
Total	164.5	153.0	-11.5	*-27%*	*-7%*

Table 10A-8a
Comparison of Integrated LRG Model Runs
TX Non-Irrigation Pumping Off v. Historical Base Run
1985 - 2016 Annual Average
(1,000 acre-feet)

Run No.	1	8	8 - 1		
Simulated Input or Output	**Historical Base Run**	**TX Non-Irrigation Pump Off**	**TX Non-Irrigation Pump Off minus Historical Base Run**		
EFFECTS OF CHANGE IN PUMPING STRESS continued					
Change in Storage				***% ΔStress***	***% Diff.***
Reservoir Storage	-32.5	-32.0	0.6	*1%*	*-2%*
Alluvial GW Storage (RW Model)	-34.8	-30.7	4.0	*9%*	*-12%*
Non-alluvial GW Storage (GW Models)	-117.5	-72.1	45.4	*105%*	*-39%*
Soil Moisture Storage	0.1	0.1	0.0	*0%*	*12%*
Total	-184.7	-134.7	50.0	*115%*	*-27%*
Summary of Effects					
FHG Deliveries (Mar-Oct)	369.0	371.0	2.0	*5%*	*1%*
FHG Deliveries (Nov-Feb)	9.4	8.2	-1.2	*-3%*	*-13%*
Irrigation Pumping	143.5	142.6	-0.9	*-2%*	*-1%*
Riparian ET + Evaporation	270.6	270.8	0.2	*0%*	*0%*
Fort Quitman Flow	164.5	153.0	-11.5	*-27%*	*-7%*
Change in Storage	-184.7	-134.7	50.0	*115%*	*-27%*
Total	772.2	810.8	38.7	*89%*	*5%*
OTHER EFFECTS OF CHANGE IN PUMPING STRESS					
Rio Grande at El Paso				***% ΔStress***	***% Diff.***
Reservoir Spills	107.6	106.5	-1.1	*-3%*	*-1%*
Nov-Feb Flows	26.1	30.0	3.9	*9%*	*15%*
Mar - Oct Flows	262.7	275.6	12.8	*30%*	*5%*
Total	396.5	412.1	15.7	*36%*	*4%*
Surface Water Diversions (Mar - Oct)					
EBID	396.1	402.0	5.9	*14%*	*2%*
EPCWID (incl. EPW)	279.2	283.5	4.3	*10%*	*2%*
HCCRD	65.0	62.5	-2.4	*-6%*	*-4%*
JID	52.0	52.2	0.2	*0%*	*0%*
Total	792.2	800.2	8.0	*19%*	*1%*
Surface Water Diversions (Nov - Feb)					
EBID	0.0	0.0	0.0	*0%*	*0%*
EPCWID (incl. EPW)	21.8	20.8	-1.0	*-2%*	*-4%*
HCCRD	18.6	16.3	-2.3	*-5%*	*-12%*
Total	40.4	37.1	-3.2	*-7%*	*-8%*

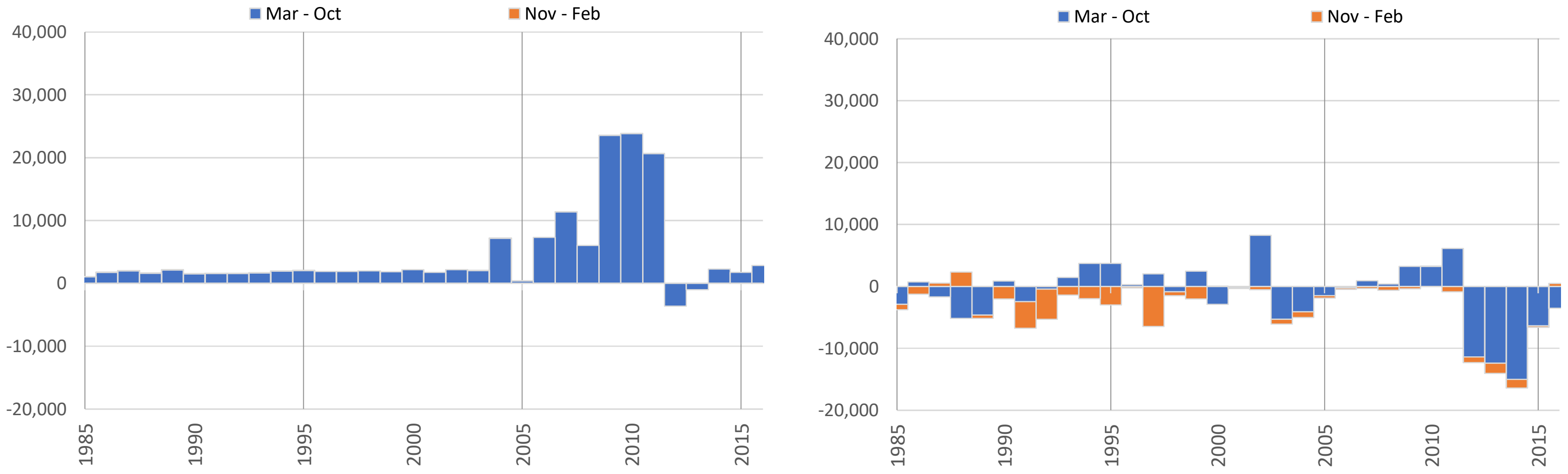
Table 10A-8b
Simulated Annual Differences in Integrated LRG Model Outputs
TX Non-Irrigation Pumping Off minus Historical Base Run
1985 - 2016 (acre-feet)

	Farm Headgate Deliveries						Other			Flows	
	EBID		EPCWID (incl. EPW)		HCCRD						
Year	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Net Reservoir Evaporation	Riparian ET	River Evaporation + Incidental Canal Loss	Rio Grande at El Paso	Rio Grande at Fort Quitman
1985	1,039	1,040	-2,889	-3,767	0	0	-1,747	648	-83	24,127	-12,528
1986	1,756	1,757	735	-487	0	0	-2,450	2	-335	-4,177	-37,763
1987	1,993	1,994	-1,661	-1,124	0	0	0	385	-386	17,047	-13,952
1988	1,605	1,607	-5,147	-2,839	0	0	-70	397	-103	18,681	-12,881
1989	2,146	2,146	-4,617	-5,146	0	0	-455	439	-233	20,266	-15,028
1990	1,522	1,523	878	-1,142	0	0	-615	679	-137	28,581	-12,082
1991	1,581	1,582	-2,467	-6,736	0	0	-1,138	423	-138	25,576	-12,682
1992	1,555	1,555	-416	-5,295	0	0	-609	-115	-746	9	-28,655
1993	1,680	1,681	1,457	89	0	0	-34	547	-419	13,189	-17,422
1994	1,972	1,973	3,745	1,787	0	0	45	628	-919	18,121	-5,861
1995	2,052	2,052	3,722	755	0	0	-67	778	-318	22,515	-7,883
1996	1,926	1,926	304	97	0	0	500	248	-691	12,342	-15,572
1997	1,920	1,920	2,045	-4,429	0	0	99	798	-410	31,718	-5,429
1998	1,983	1,983	-835	-1,502	0	0	11	694	-112	24,240	-10,078
1999	1,841	1,841	2,471	439	0	0	-305	755	-245	25,443	-4,294
2000	2,195	2,195	-2,893	-2,891	0	0	269	500	-389	16,352	-14,300
2001	1,756	1,756	-247	-312	0	0	1,005	514	-698	12,903	-14,489
2002	2,183	2,183	8,245	7,714	0	0	2,558	377	-891	11,060	-16,553
2003	2,059	2,061	-5,286	-6,049	0	0	2,982	1,135	-880	25,653	-5,310
2004	7,193	7,193	-4,100	-5,023	0	0	2,001	918	-199	26,572	-12,804
2005	361	362	-1,504	-1,877	0	0	942	766	-363	14,192	-9,855
2006	7,334	7,334	-233	-489	0	0	1,716	1,019	-495	17,269	-7,816
2007	11,394	11,394	908	598	0	0	1,157	977	-101	12,959	-8,126
2008	6,029	6,029	393	-226	1,074	1,174	1,262	1,210	222	11,385	-4,161
2009	23,568	23,568	3,251	2,884	0	0	1,874	1,270	-110	12,825	2,132
2010	23,829	23,829	3,227	3,238	0	0	2,618	1,261	185	10,156	2,152
2011	20,632	20,632	6,118	5,245	351	-1,810	1,102	3,190	359	32,176	2,941
2012	-3,633	-3,633	-11,367	-12,324	-1,272	-2,772	-1,753	701	-1,857	6,611	-8,903
2013	-1,011	-1,011	-12,399	-14,035	-8,931	-8,931	-1,342	-2,459	-1,433	6,396	-12,247
2014	2,287	2,287	-14,986	-16,410	-8,970	-8,960	535	-4,026	1,326	-5,820	-5,100
2015	1,747	1,747	-6,379	-6,608	-10,527	-10,356	-2,202	-2,121	-617	7,220	-9,361
2016	2,881	2,881	-3,514	-3,016	-824	-424	-2,779	496	-507	5,268	-34,182
Avg 85-05	2,015	2,016	-403	-1,797	0	0	139	548	-414	18,305	-13,591
Avg 85-16	4,293	4,293	-1,358	-2,465	-909	-1,002	160	407	-366	15,652	-11,503

Figure 10A-8

Simulated Annual Differences in Integrated LRG Model Outputs
TX Non-Irrigation Pumping Off minus Historical Base Run
1985 - 2016 (acre-feet)

Farm Headgate Deliveries


EBID

EPCWID (Including EPW)

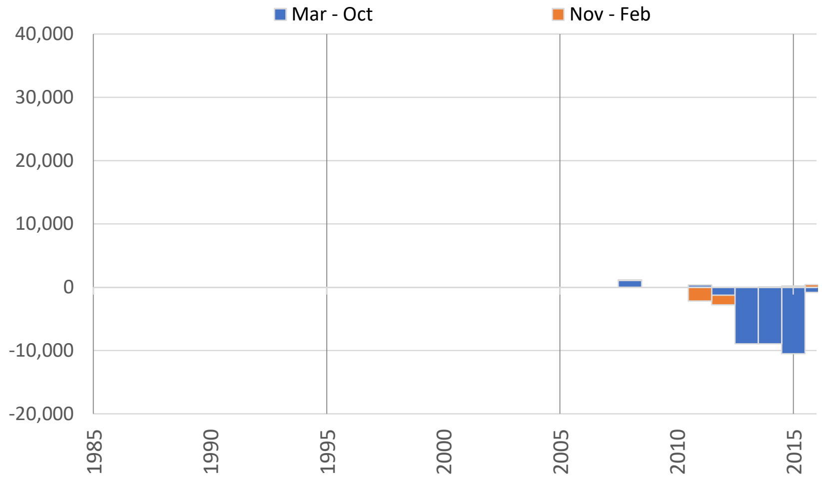

HCCRD

Table 10A-12a
Comparison of Integrated LRG Model Runs
D3 + Carryover v. D1/D2
1948 - 2017 Annual Average
(1,000 acre-feet)

Run No.	11	12	12 - 11	
Simulated Input or Output	**D1/D2**	**D3 + Carryover**	**D3 + Carryover minus D1/D2**	
EFFECTS OF CHANGE IN PROJECT ALLOCATION PROCEDURES				
FHG Deliveries (Mar - Oct)				***% Diff.***
EBID	175.5	133.4	-42.1	*-24%*
EPCWID (incl. EPW)	138.8	154.9	16.1	*12%*
HCCRD	33.8	35.1	1.3	*4%*
Total	348.2	323.4	-24.8	*-7%*
FHG Deliveries (Nov - Feb)				
EBID	0.0	0.0	0.0	*143%*
EPCWID (incl. EPW)	7.5	6.1	-1.4	*-18%*
HCCRD	1.7	1.1	-0.6	*-37%*
Total	9.1	7.2	-2.0	*-22%*
Irrigation Pumping				
EBID	134.6	176.6	42.0	*31%*
EPCWID (Mesilla Valley)	4.7	5.2	0.5	*11%*
EPCWID (El Paso Valley)	36.0	31.0	-5.1	*-14%*
HCCRD	4.5	2.7	-1.8	*-41%*
Total	179.8	215.4	35.6	*20%*
Other Inflows/Outflows				
Reservoir Evaporation	121.6	116.0	-5.6	*-5%*
Riparian ET	72.9	73.7	0.8	*1%*
River Evaporation + Incidental Canal Loss	30.3	28.9	-1.5	*-5%*
Total	224.8	218.5	-6.3	*-3%*
Rio Grande at Fort Quitman				
Reservoir Spills	34.2	25.4	-8.7	*-26%*
Nov-Feb Flows	24.1	26.9	2.7	*11%*
Mar - Oct Flows	44.6	53.4	8.8	*20%*
Underflow (GW Model)	0.2	0.3	0.0	*5%*
Total	103.1	106.0	2.9	*3%*
Change in Storage				
Reservoir Storage	-2.2	-0.3	1.8	*-85%*
Alluvial GW Storage (RW Model)	-20.4	-24.5	-4.0	*20%*
Non-alluvial GW Storage (GW Models)	-92.2	-95.6	-3.4	*4%*
Soil Moisture Storage	-0.1	0.1	0.1	*-174%*
Total	-114.9	-120.4	-5.5	*5%*

Table 10A-12a
Comparison of Integrated LRG Model Runs
D3 + Carryover v. D1/D2
1948 - 2017 Annual Average
(1,000 acre-feet)

Run No.	11	12	12 - 11	
Simulated Input or Output	**D1/D2**	**D3 + Carryover**	**D3 + Carryover minus D1/D2**	
EFFECTS OF CHANGE IN PROJECT ALLOCATION PROCEDURES continued				
Summary of Effects				***% Diff.***
FHG Deliveries (Mar-Oct)	348.2	323.4	-24.8	*-7%*
FHG Deliveries (Nov-Feb)	9.1	7.2	-2.0	*-22%*
Irrigation Pumping	179.8	215.4	35.6	*20%*
Riparian ET + Evaporation	224.8	218.5	-6.3	*-3%*
Fort Quitman Flow	103.1	106.0	2.9	*3%*
Change in Storage	-114.9	-120.4	-5.5	*5%*
Total	750.1	750.1	0.0	*0%*
OTHER EFFECTS OF CHANGE IN PROJECT ALLOCATION PROCEDURES				
Rio Grande at El Paso				***% Diff.***
Reservoir Spills	49.2	37.9	-11.3	*-23%*
Nov-Feb Flows	27.0	23.7	-3.2	*-12%*
Mar - Oct Flows	265.4	294.1	28.7	*11%*
Total	341.6	355.8	14.2	*4%*
Surface Water Diversions (Mar - Oct)				
EBID	404.8	331.8	-73.0	*-18%*
EPCWID (incl. EPW)	251.0	286.6	35.6	*14%*
HCCRD	55.8	63.4	7.6	*14%*
Total	711.6	681.8	-29.8	*-4%*
Surface Water Diversions (Nov - Feb)				
EBID	0.0	0.0	0.0	*0%*
EPCWID (incl. EPW)	21.6	18.0	-3.6	*-17%*
HCCRD	15.6	15.6	0.0	*0%*
Total	37.3	33.6	-3.7	*-10%*

Table 10A-12b
Simulated Annual Differences in Integrated LRG Model Outputs
D3 + Carryover minus D1/D2
1948 - 2017 (acre-feet)

	Farm Headgate Deliveries						Other			Flows	
	EBID		EPCWID (incl. EPW)		HCCRD						
Year	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Net Reservoir Evaporation	Riparian ET	River Evaporation + Incidental Canal Loss	Rio Grande at El Paso	Rio Grande at Fort Quitman
1948	-53,269	-53,289	-6,447	-7,316	0	0	3,256	-729	-1,907	-37,071	-28,748
1949	-38,688	-38,709	6,412	6,288	0	0	6,941	-126	-469	-7,848	-12,604
1950	-44,126	-44,139	5,551	4,367	0	0	9,214	73	-399	4,819	1,801
1951	6,340	6,338	59,094	56,504	9,118	3,734	-3,425	7,955	5,225	176,840	101,533
1952	-66,508	-66,544	12,801	14,180	-7,718	-15,284	-10,546	-452	-1,326	-13,610	14,254
1953	-1,976	-1,983	57,863	57,604	15,076	12,822	-26,832	6,329	2,582	113,625	50,945
1954	-19,190	-19,190	-16,746	-15,753	8,534	5,588	-19,955	464	-2,914	-39,968	12,221
1955	18,233	18,233	5,447	5,069	-43	-24	-15,991	607	-1,844	5,243	15
1956	12,008	12,008	1,729	1,866	1,204	1,235	-11,858	280	-2,886	2,193	12
1957	-45,543	-45,543	-192	-29	-3,874	-3,773	-1,683	606	5,333	-9,687	-2,980
1958	-136,446	-136,446	10,989	9,399	2,378	2,813	-248	195	-3,906	22,178	13,216
1959	-92,660	-92,660	23,099	19,065	-4,791	-4,509	2,399	1,244	-36	48,614	29,336
1960	-75,069	-75,069	18,631	17,610	0	0	154	2,311	446	41,196	33,187
1961	-130,196	-130,199	3,577	2,719	0	0	-5,097	3,900	-1,410	18,105	26,946
1962	-82,034	-82,037	2,646	-229	0	0	-3,214	-788	-1,631	-4,210	6,483
1963	-43,304	-43,304	36,534	34,121	4,951	3,355	-13,988	2,606	-299	60,956	30,966
1964	-2,376	-2,376	-7,923	-8,076	4,766	2,206	-21,139	90	-3,958	-24,108	6,351
1965	-109,599	-109,599	13,353	11,901	2,441	2,473	-5,181	1,293	-749	22,078	5,209
1966	-158,807	-158,807	8,585	6,462	-2,856	-3,250	10,126	3,970	-3,404	14,753	1,625
1967	-2,840	-2,840	42,598	39,174	8,357	7,666	-7,544	3,693	-2,932	53,136	5,585
1968	-76,746	-76,746	29,109	27,669	13,479	11,233	-5,525	5,443	-2,481	53,390	25,086
1969	-116,604	-116,611	18,341	17,675	-3,934	-10,682	-11,248	2,349	-2,786	17,815	41,408
1970	-137,793	-137,795	8,692	2,378	-1,836	-3,844	-10,358	1,282	-2,995	33,861	37,029
1971	-33,335	-33,335	10,533	7,065	2,566	2,395	-12,144	637	-3,478	5,872	2,132
1972	-5,717	-5,717	-1,333	-1,098	5,409	5,592	-8,905	-644	-6,986	-18,559	29
1973	-128,938	-128,939	13,334	12,588	2,262	1,856	-1,361	792	-3,324	40,734	14,026
1974	-123,524	-123,525	19,914	17,299	-7,626	-10,545	2,923	-36	-1,727	40,090	39,215
1975	-127,276	-127,281	15,770	11,091	4,396	92	-7,430	650	-3,549	16,621	28,978
1976	-91,521	-91,521	9,329	3,136	-872	-3,144	-6,245	-1,736	-3,302	-3,236	10,440
1977	-17,834	-17,834	-2,025	-4,823	1,538	2,083	-7,570	-1,773	-5,933	-21,542	844
1978	-37,863	-37,863	6,189	6,332	-1,537	-664	-2,049	-46	1,117	9,288	-2,308
1979	-143,287	-143,296	21,277	19,678	3,753	4,286	176	59	-4,170	-5,813	-3,546
1980	-102,950	-102,951	7,417	129	40	133	3,412	-1,231	-3,032	1,747	3,717
1981	-97,318	-97,318	12,332	7,823	0	0	1,437	-728	-2,399	11,543	544
1982	-108,268	-108,291	16,595	12,834	0	0	-200	638	-3,537	-5,050	3,796
1983	-88,016	-88,017	17,951	11,383	0	0	-10,644	-784	-2,840	5,490	-5,118
1984	-71,505	-71,523	13,082	9,793	0	0	682	-1,185	-3,206	-30,352	-35,381
1985	-36,708	-36,734	16,171	11,475	0	0	-1,743	-538	-689	-13,216	-28,697
1986	58,993	59,012	19,331	17,023	0	0	676	-1,396	1,335	-64,978	-76,390
1987	36,003	36,059	13,289	13,508	0	0	-925	-127	1,292	-27,948	-34,783
1988	20,023	20,074	12,216	12,261	0	0	-2,781	1,315	1,856	49,394	24,807

Table 10A-12b
Simulated Annual Differences in Integrated LRG Model Outputs
D3 + Carryover minus D1/D2
1948 - 2017 (acre-feet)

	Farm Headgate Deliveries						Other			Flows	
	EBID		EPCWID (incl. EPW)		HCCRD						
Year	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Net Reservoir Evaporation	Riparian ET	River Evaporation + Incidental Canal Loss	Rio Grande at El Paso	Rio Grande at Fort Quitman
1989	60,891	60,969	22,924	15,665	0	0	-7,933	650	1,850	42,321	11,875
1990	34,525	34,601	15,659	18,712	0	0	-10,868	1,097	1,915	52,432	32,358
1991	23,316	23,389	12,067	14,482	0	0	-11,686	965	2,118	50,618	31,726
1992	42,597	42,690	10,800	12,563	0	0	-13,676	-2,540	-276	-113,337	-121,874
1993	45,926	46,007	32,450	26,281	0	0	-4,993	-1,509	-911	-88,045	-97,794
1994	80,609	80,709	35,057	35,692	0	0	-3,288	1,049	1,829	43,045	-4,989
1995	100,408	100,538	39,567	32,273	0	0	-3,131	-1,289	-97	-121,341	-139,094
1996	107,962	108,084	29,837	31,517	0	0	-3,194	1,837	2,828	97,594	38,746
1997	58,846	58,949	22,937	27,047	0	0	-12,419	1,200	2,406	78,990	42,698
1998	61,532	61,576	34,328	29,174	0	0	-18,051	509	1,124	27,585	-5,472
1999	59,441	59,509	26,625	27,358	0	0	-31,349	1,177	2,241	75,916	41,045
2000	61,786	61,846	21,891	22,123	0	0	-31,890	1,481	1,754	78,573	48,056
2001	-24,681	-24,669	33,194	33,570	0	0	-24,898	4,015	1,685	154,077	112,277
2002	-62,682	-62,682	40,993	41,144	0	0	-44,805	3,152	71	107,884	74,023
2003	-177,539	-177,551	-33,226	-32,832	0	0	-41,437	-5,698	-7,246	-140,658	-79,547
2004	-93,798	-93,799	-15,809	-16,164	0	0	-12,093	-4,566	-6,924	-73,326	-44,912
2005	-81,097	-81,113	5,891	5,549	0	0	-15,750	-1,772	-3,145	-35,425	-43,008
2006	-81,531	-81,531	25,966	25,513	0	0	2,284	1,932	-4,346	56,186	20,632
2007	-109,048	-109,061	-5,274	-5,430	0	0	6,705	-2,227	-5,390	-53,236	-40,140
2008	-98,509	-98,532	14,057	13,666	-3,203	-3,687	17,442	-954	-3,478	-27,837	-33,157
2009	-154,153	-154,176	9,386	9,166	-82	-181	15,572	-2,426	-5,472	-43,212	-50,193
2010	-85,756	-85,777	22,182	22,101	0	0	7,411	565	-3,183	16,190	-7,015
2011	-11,070	-11,070	78,887	79,372	24,044	26,539	10,124	9,229	-2,252	115,619	7,148
2012	-22,300	-22,300	5,483	5,591	774	1,241	11,616	2,365	-1,884	13,301	23,044
2013	22,333	22,333	38,459	38,499	8,525	8,043	-14,505	7,224	4,935	68,216	14,301
2014	-39,983	-39,983	-32,279	-31,442	2,024	1,374	-3,466	-2,123	-6,899	-69,367	-3,985
2015	-26,607	-26,607	19,158	19,359	2,057	263	10,515	431	-3,196	39,189	3,321
2016	-49,388	-49,388	31,398	30,875	-1,431	-2,143	15,178	2,671	-2,966	59,507	16,663
2017	-94,759	-94,767	26,473	26,619	2,396	2,194	13,739	3,488	-2,708	40,182	13,141
Avg 48-17	-42,128	-42,116	16,060	14,688	1,290	678	-5,618	806	-1,470	14,200	2,872
Avg 85-16	-8,739	-8,707	18,863	18,303	1,022	983	-6,792	491	-910	11,085	-8,385

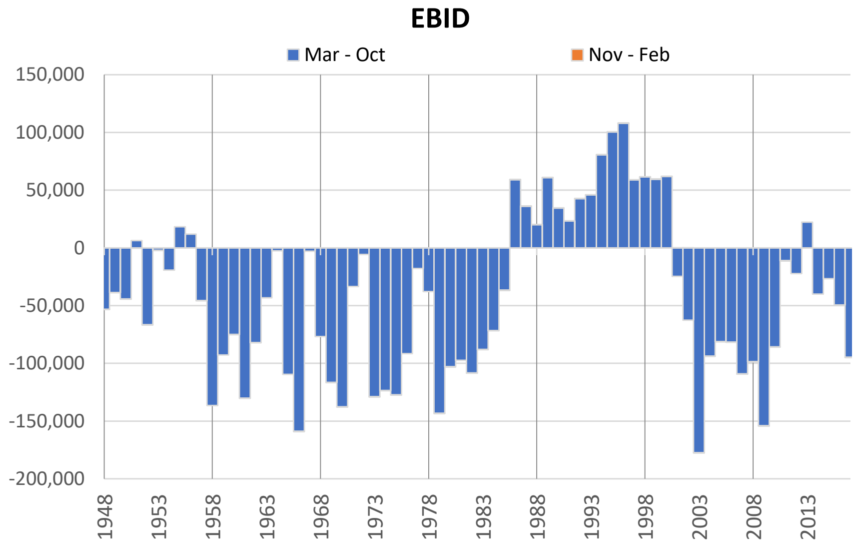
Figure 10A-12

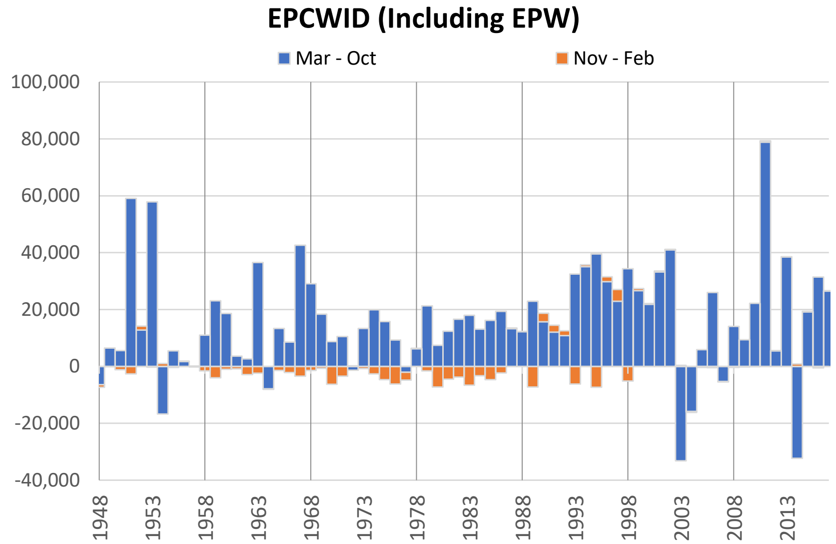
Simulated Annual Differences in Integrated LRG Model Outputs

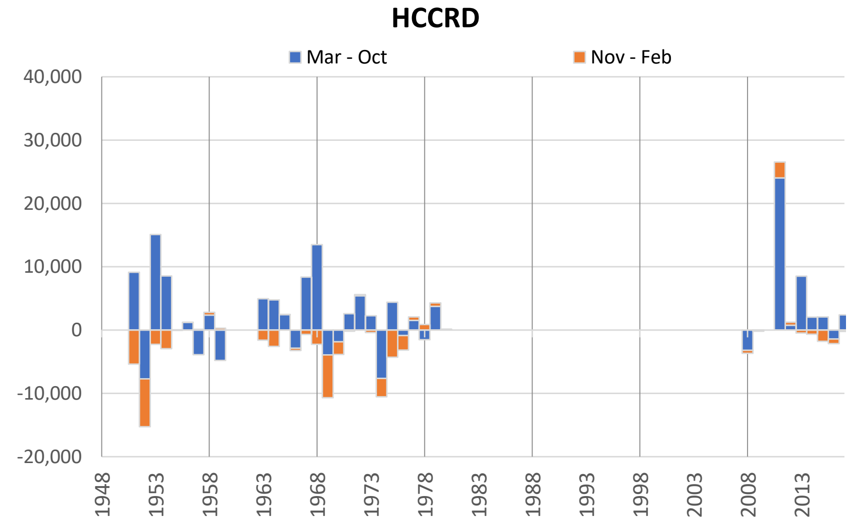
D3 + Carryover minus D1/D2

1948 - 2017 (acre-feet)

Farm Headgate Deliveries







*Note different scales.

Table 10A-13
Comparison of Integrated LRG Model Runs
Reduced Waste Run v. Historical Base Run
1985 - 2016 Annual Average
(1,000 acre-feet)

Run No.	1	13	13 - 1	
Simulated Input or Output	**Historical Base Run**	**Reduced Waste**	**Reduced Waste minus Historical Base Run**	
EFFECTS OF REDUCED WASTE (Limit Waste to 10%)				
FHG Deliveries (Mar - Oct)				*% Diff.*
EBID	179.3	207.9	28.6	*16%*
EPCWID (incl. EPW)	153.1	165.9	12.7	*8%*
HCCRD	36.5	35.5	-1.1	*-3%*
Total	369.0	409.3	40.3	*11%*
FHG Deliveries (Nov - Feb)				
EBID	0.0	0.0	0.0	*0%*
EPCWID (incl. EPW)	8.6	7.0	-1.6	*-18%*
HCCRD	0.8	3.1	2.3	*296%*
Total	9.4	10.1	0.7	*8%*
Irrigation Pumping				
EBID	123.0	98.6	-24.4	*-20%*
EPCWID (Mesilla Valley)	2.8	2.0	-0.8	*-29%*
EPCWID (El Paso Valley)	17.1	9.0	-8.1	*-48%*
HCCRD	0.6	2.7	2.2	*378%*
Total	143.5	112.3	-31.2	*-22%*
Other Inflows/Outflows				
Reservoir Evaporation	174.9	179.8	4.9	*3%*
Riparian ET	65.6	65.4	-0.2	*0%*
River Evaporation + Incidental Canal Loss	30.1	30.0	-0.1	*0%*
Total	270.6	275.2	4.6	*2%*
Rio Grande at Fort Quitman				
Reservoir Spills	74.7	87.2	12.5	*17%*
Nov-Feb Flows	30.4	36.1	5.7	*19%*
Mar - Oct Flows	59.1	34.0	-25.0	*-42%*
Underflow (GW Model)	0.3	0.3	0.0	*-1%*
Total	164.5	157.6	-6.8	*-4%*
Change in Storage				
Reservoir Storage	-32.5	-40.4	-7.9	*24%*
Alluvial GW Storage (RW Model)	-34.8	-29.7	5.1	*-15%*
Non-alluvial GW Storage (GW Models)	-117.5	-114.1	3.4	*-3%*
Soil Moisture Storage	0.1	-0.2	-0.3	*-303%*
Total	-184.7	-184.4	0.3	*0%*

Table 10A-13
Comparison of Integrated LRG Model Runs
Reduced Waste Run v. Historical Base Run
1985 - 2016 Annual Average
(1,000 acre-feet)

Run No.	1	13	13 - 1	
Simulated Input or Output	**Historical Base Run**	**Reduced Waste**	**Reduced Waste minus Historical Base Run**	
EFFECTS OF REDUCED WASTE (Limit Waste to 10%) continued				
Summary of Effects				***% Diff.***
FHG Deliveries (Mar-Oct)	369.0	409.3	40.3	*11%*
FHG Deliveries (Nov-Feb)	9.4	10.1	0.7	*8%*
Irrigation Pumping	143.5	112.3	-31.2	*-22%*
Riparian ET + Evaporation	270.6	275.2	4.6	*2%*
Fort Quitman Flow	164.5	157.6	-6.8	*-4%*
Change in Storage	-184.7	-184.4	0.3	*0%*
Total	772.2	780.1	8.0	*1%*
OTHER EFFECTS OF REDUCED WASTE (Limit Waste to 10%)				
Rio Grande at El Paso				***% Diff.***
Reservoir Spills	107.6	128.6	21.0	*20%*
Nov-Feb Flows	26.1	33.9	7.8	*30%*
Mar - Oct Flows	262.7	231.3	-31.5	*-12%*
Total	396.5	393.8	-2.7	*-1%*
Surface Water Diversions (Mar - Oct)				
EBID	396.1	416.2	20.1	*5%*
EPCWID (incl. EPW)	279.2	249.8	-29.3	*-11%*
HCCRD	65.0	44.1	-20.9	*-32%*
Total	740.2	710.1	-30.1	*-4%*
Surface Water Diversions (Nov - Feb)				
EBID	0.0	0.0	0.0	*0%*
EPCWID (incl. EPW)	21.8	23.6	1.9	*9%*
HCCRD	18.6	24.1	5.5	*30%*
Total	40.4	47.8	7.4	*18%*

Appendix 10B

Comparison of Historical Base Run to No New Mexico Pumping Run
Integrated LRG Model

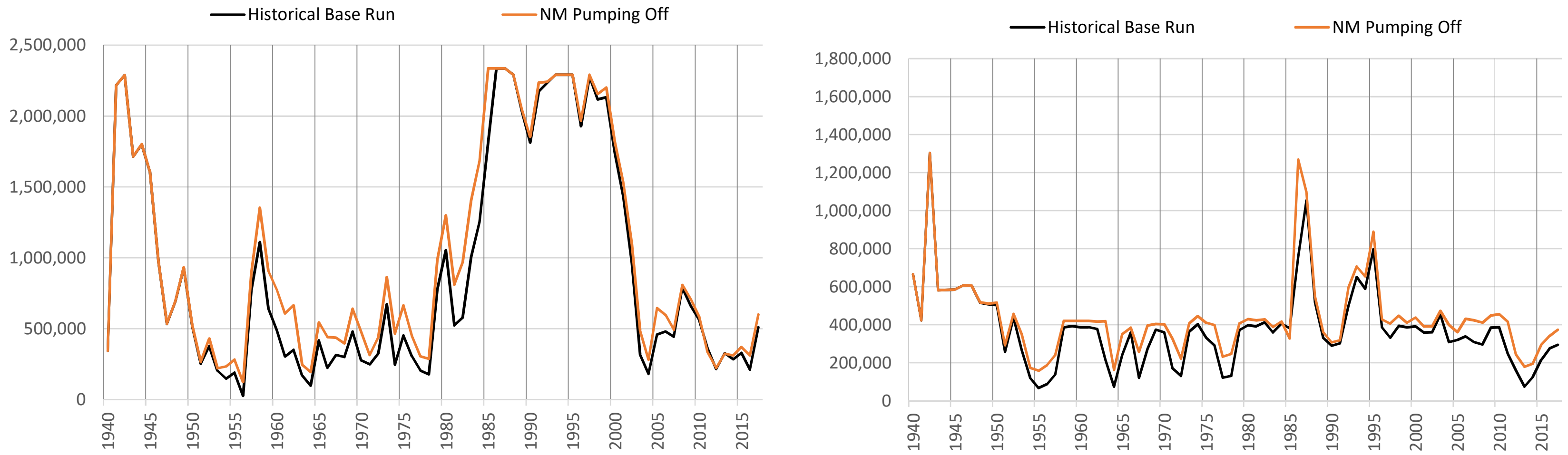
Figure 10B-1

NM Pumping Off v. Historical Base Run

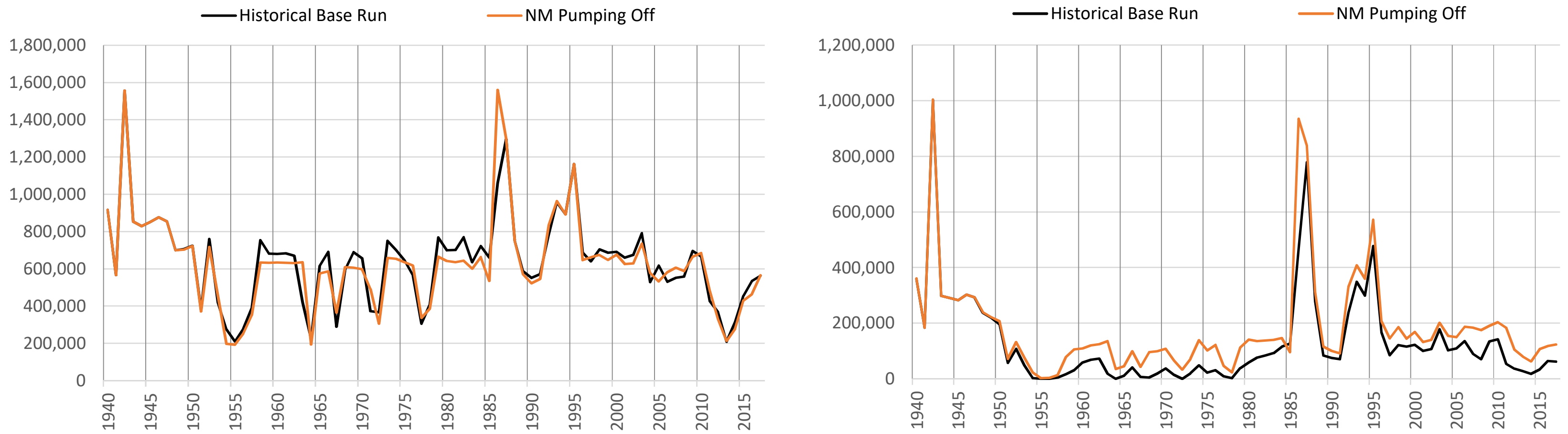
Integrated LRG Model

Annual Summary of Project Storage and Rio Grande Flows

1940 - 2017 (acre-feet)


Total Year-End Project Reservoir Storage

Rio Grande at El Paso


Rio Grande Below Caballo

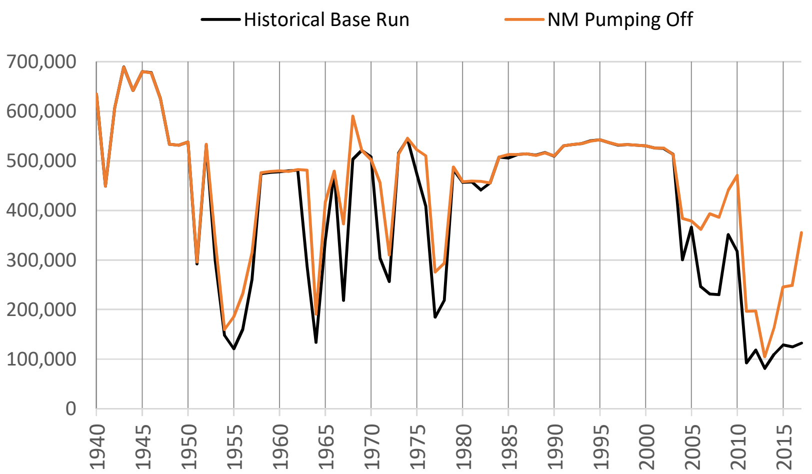
Rio Grande at Fort Quitman

Figure 10B-2

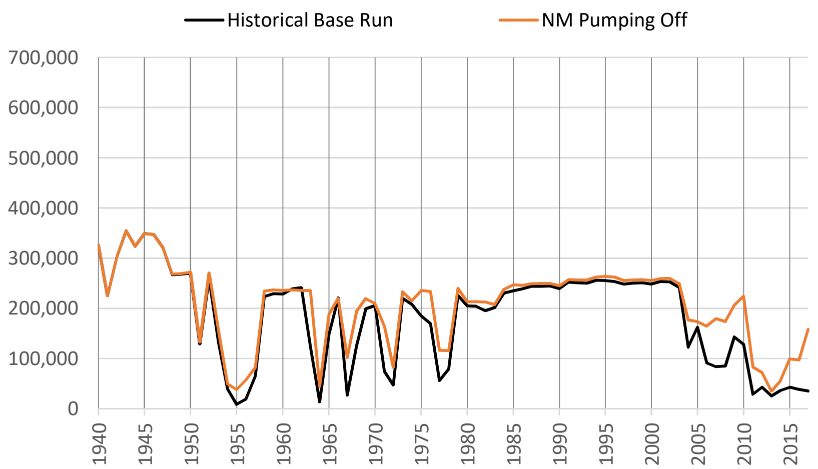
NM Pumping Off v. Historical Base Run
Integrated LRG Model
Annual Summary of Irrigation Operations
1940 - 2017 (acre-feet)

EBID Total

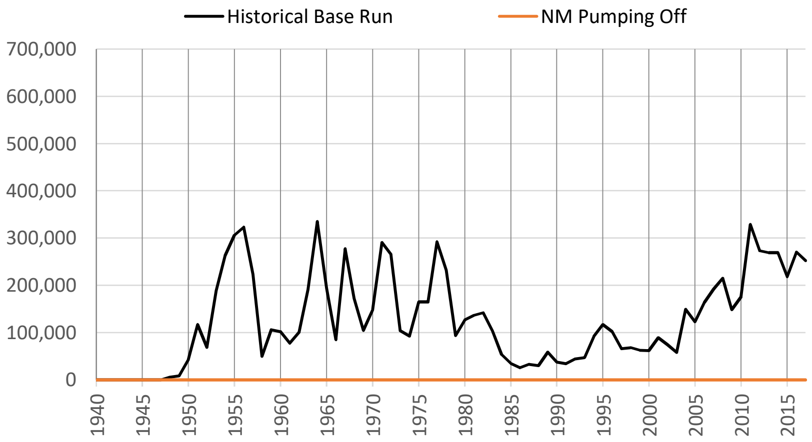
River Headgate Diversions



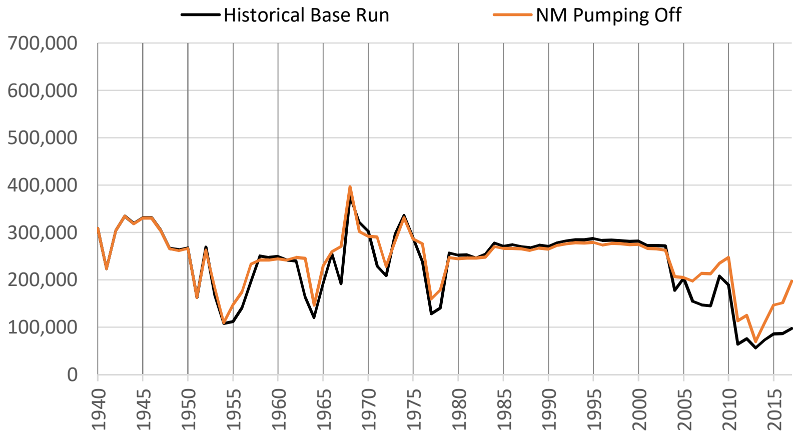
Farm Headgate Deliveries



Pumping



RHG Diversions - FHG Deliveries



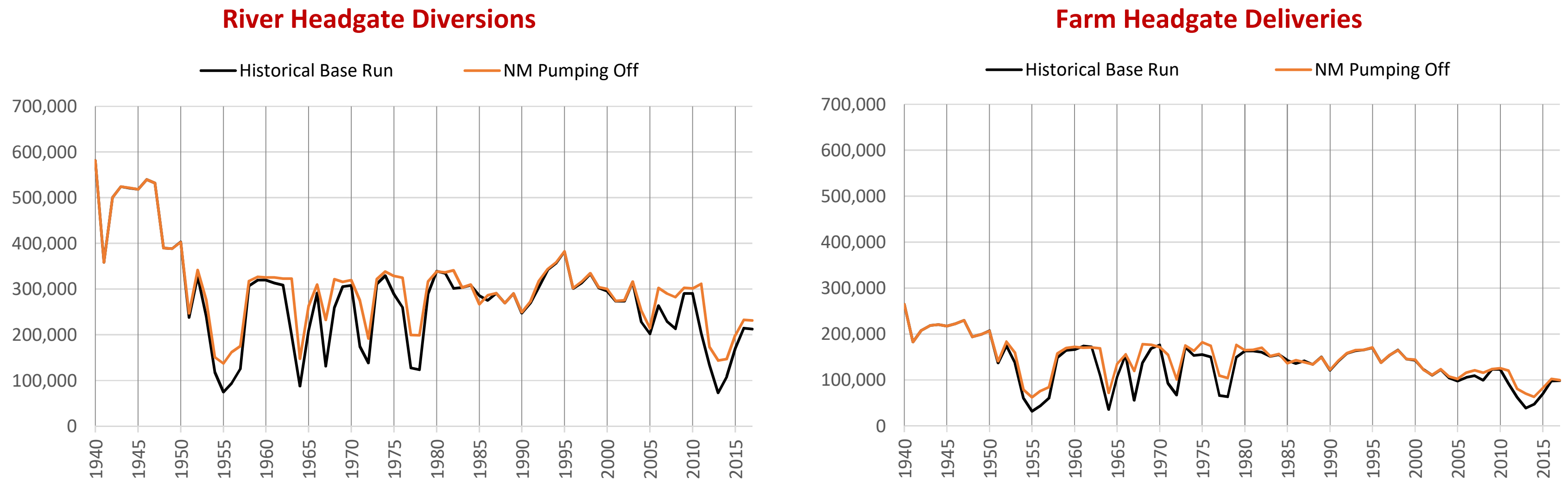
Supplemental and Primary

10/27/2019

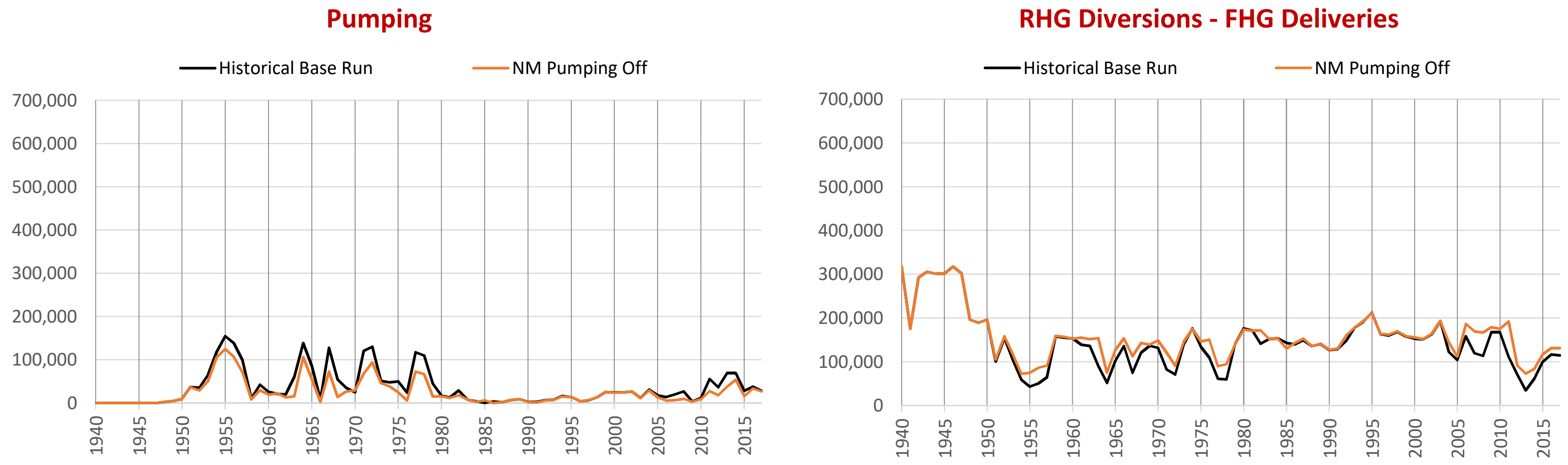
Figure 10B-3

NM Pumping Off v. Historical Base Run
Integrated LRG Model
Annual Summary of Irrigation Operations
1940 - 2017 (acre-feet)

EPCWID Total


River Headgate Diversions

Farm Headgate Deliveries


Pumping

RHG Diversions - FHG Deliveries

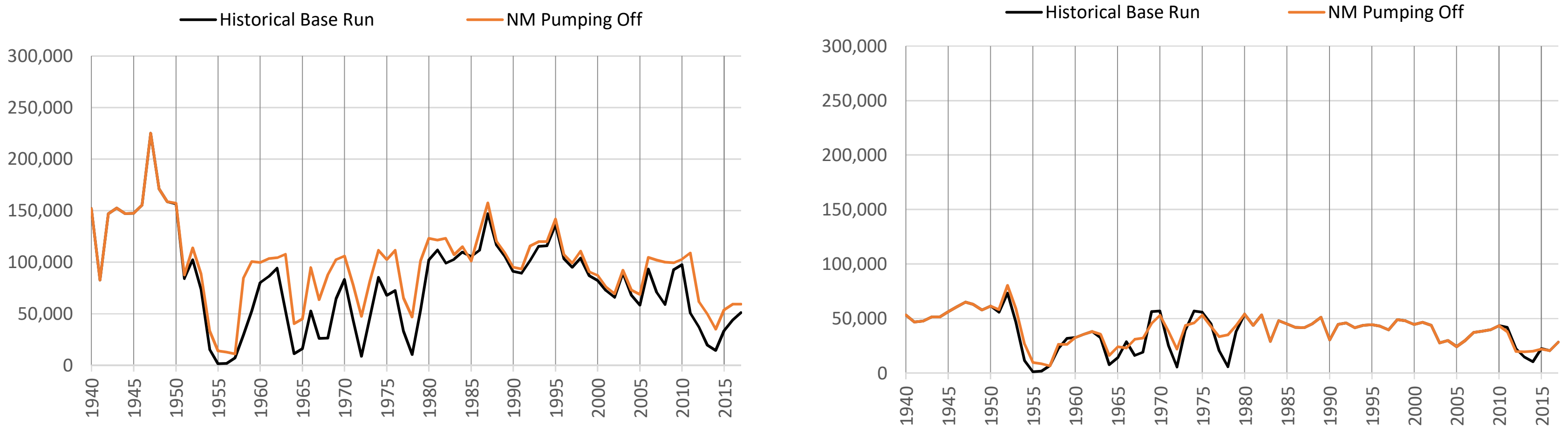
Figure 10B-4

NM Pumping Off v. Historical Base Run
Integrated LRG Model
Annual Summary of Irrigation Operations
1940 - 2017 (acre-feet)

HCCRD Total

River Headgate Diversions

Farm Headgate Deliveries



Pumping

RHG Diversions - FHG Deliveries

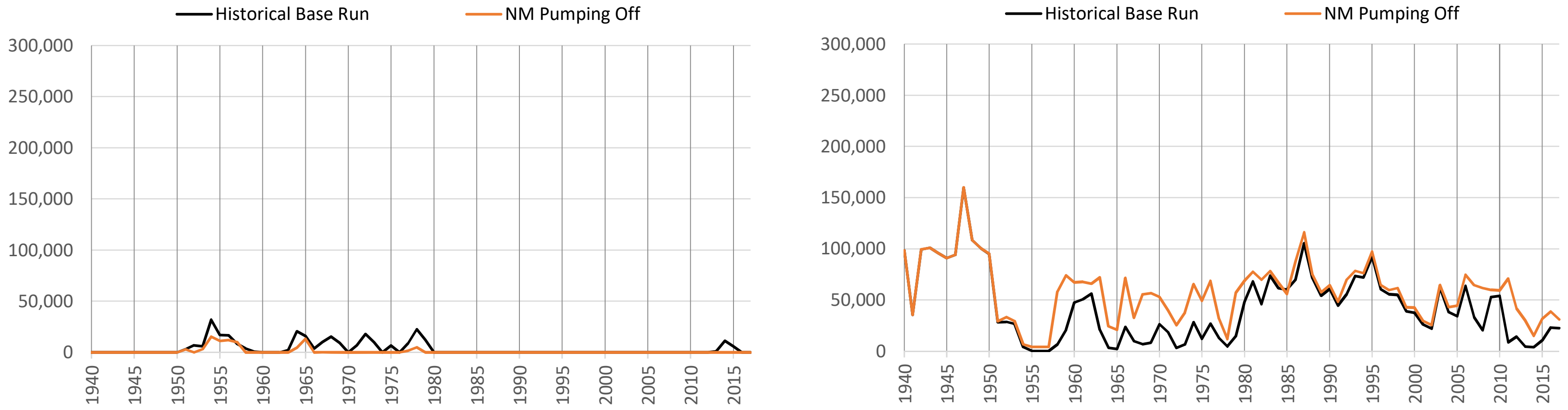


Figure 10B-5

NM Pumping Off v. Historical Base Run

Integrated LRG Model

Monthly RHG Diversions

1940 - 2017 (acre-feet)

EBID Total

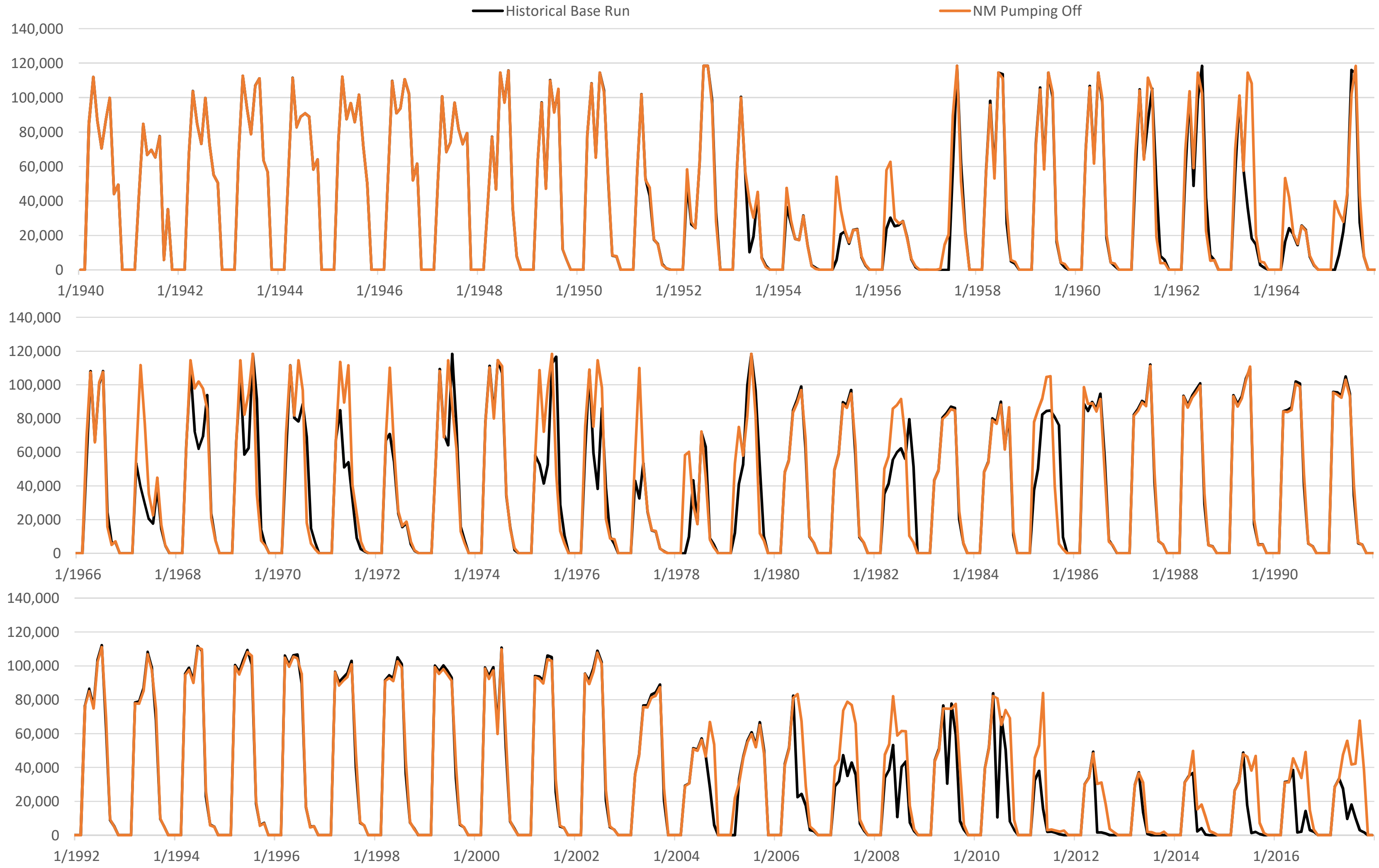


Figure 10B-6
NM Pumping Off v. Historical Base Run
Integrated LRG Model
Monthly RHG Diversions
1940 - 2017 (acre-feet)
EPCWID Total

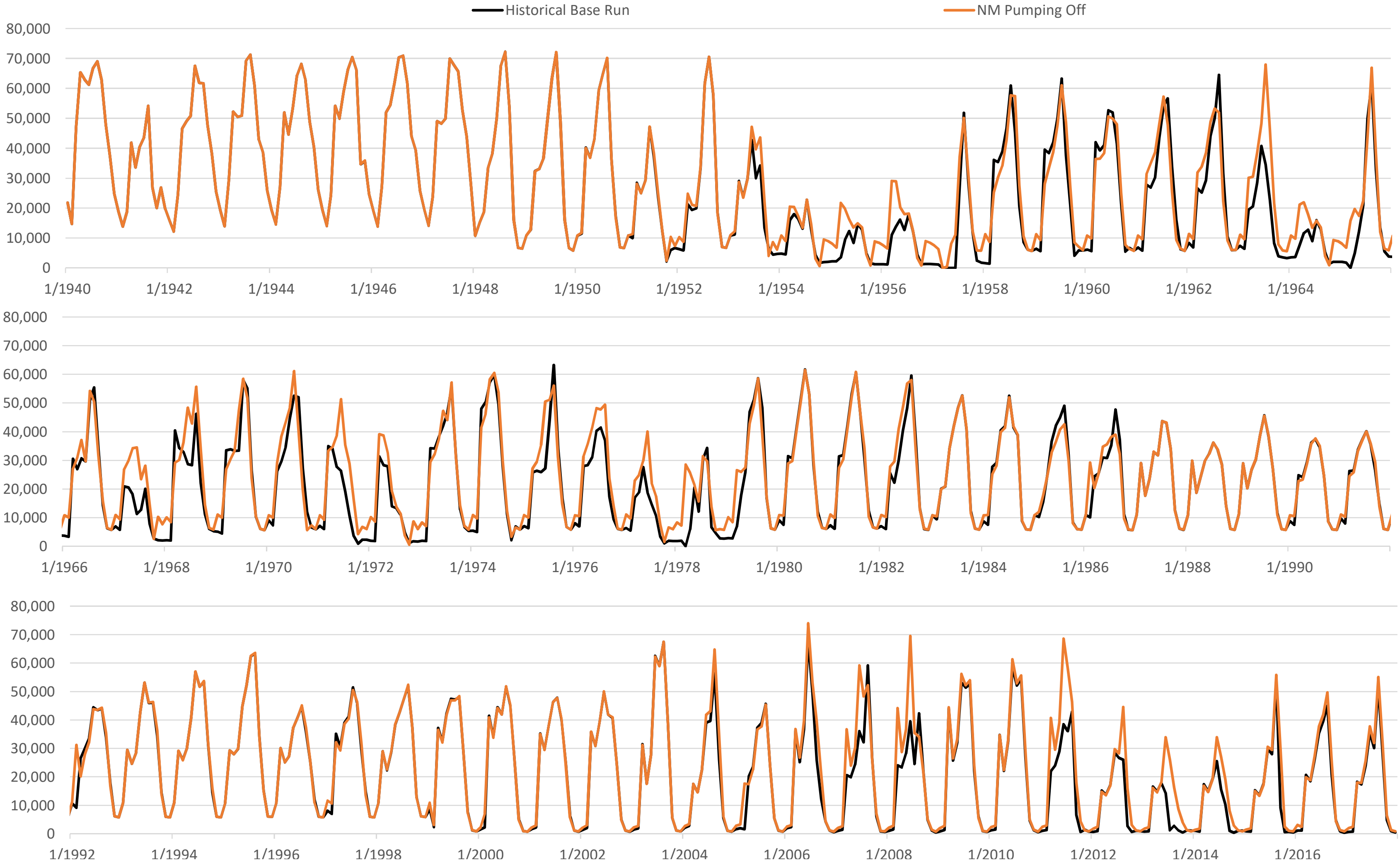


Figure 10B-7
NM Pumping Off v. Historical Base Run
Integrated LRG Model
Monthly RHG Diversions
1940 - 2017 (acre-feet)
HCCRD Total

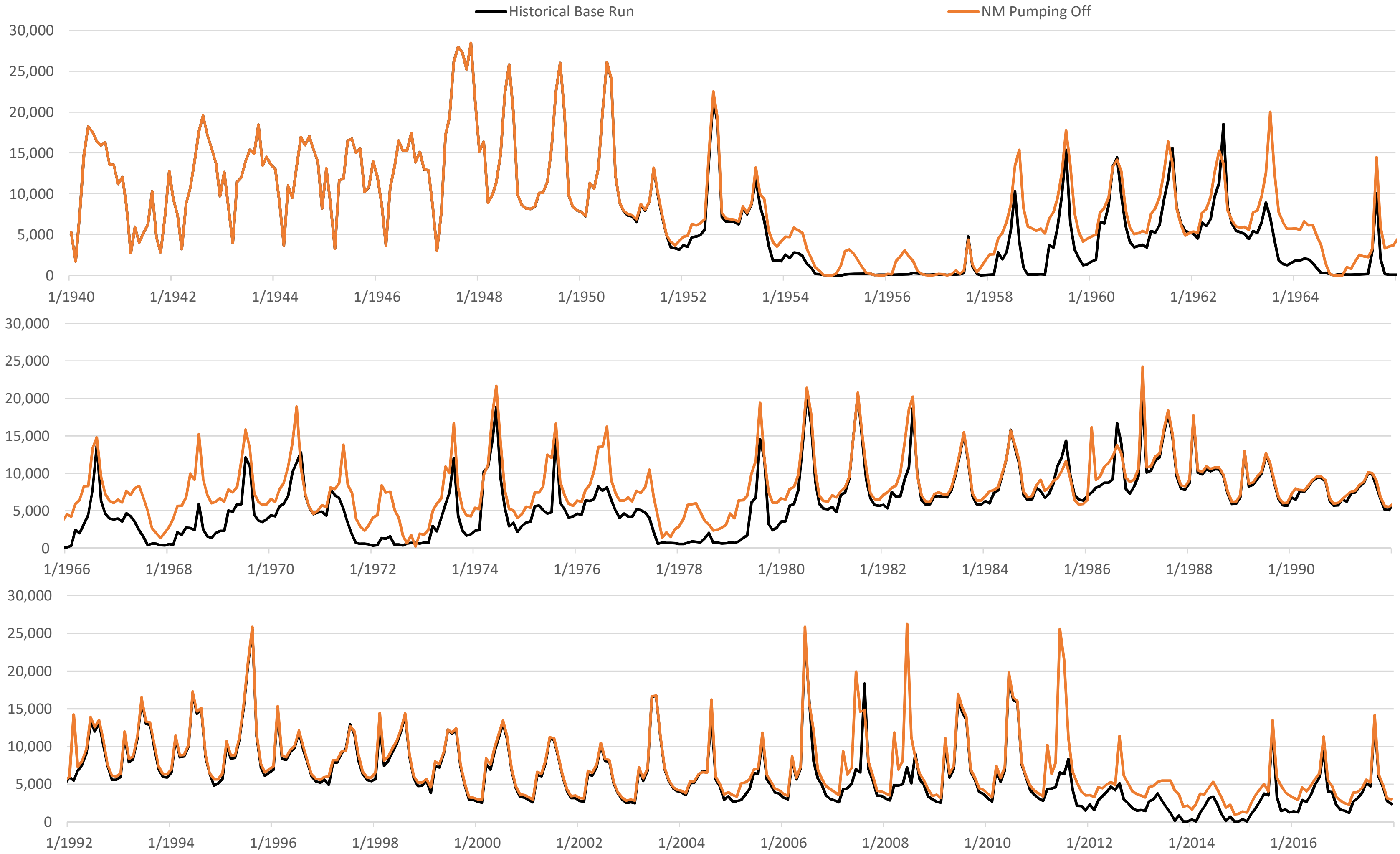


Figure 10B-8

NM Pumping Off v. Historical Base Run

Integrated LRG Model

Monthly FHG Deliveries

1940 - 2017 (acre-feet)

EBID Total

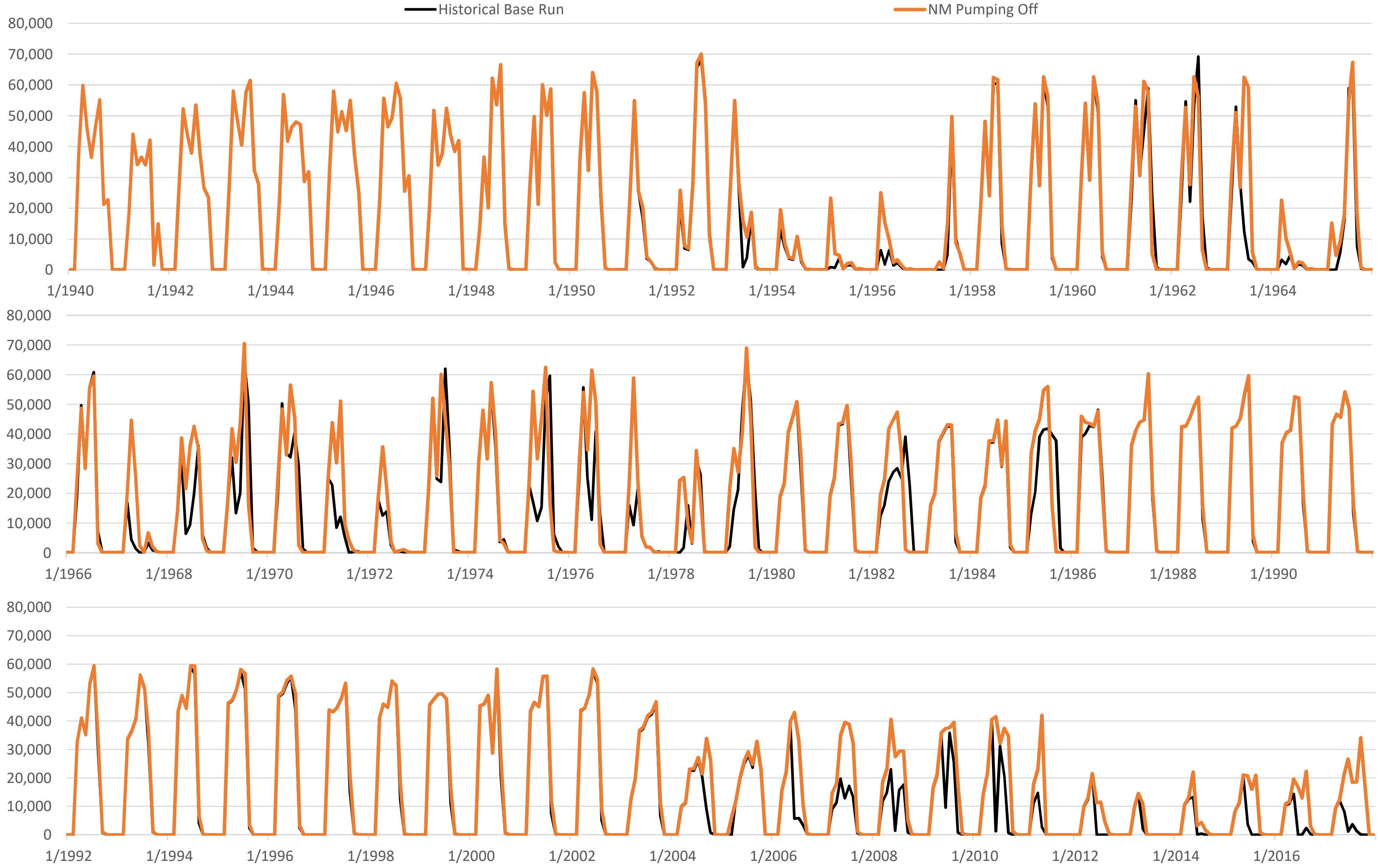


Figure 10B-9
NM Pumping Off v. Historical Base Run
Integrated LRG Model
Monthly FHG Deliveries
1940 - 2017 (acre-feet)

EPCWID Total

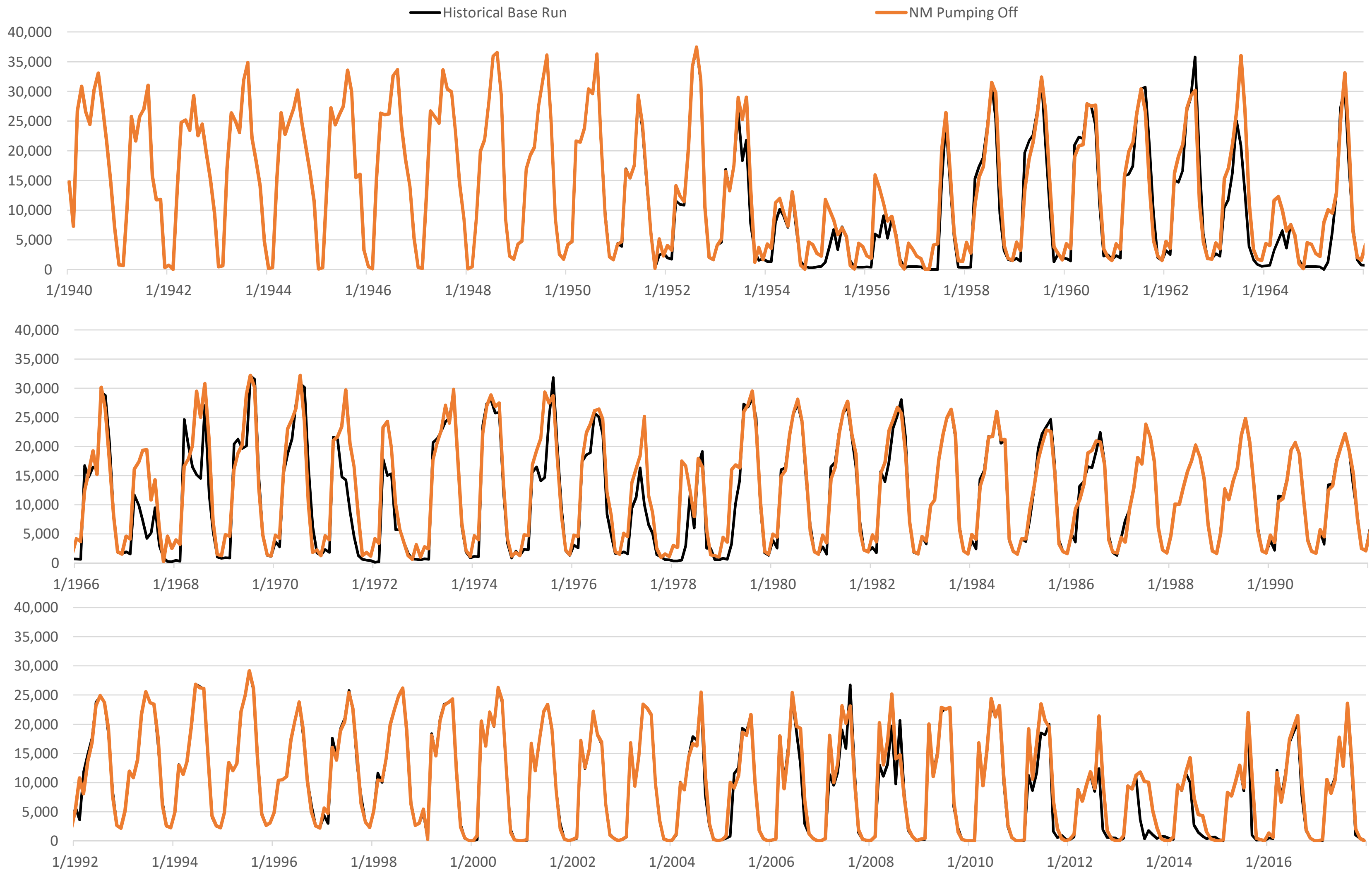


Figure 10B-10
NM Pumping Off v. Historical Base Run
Integrated LRG Model
Monthly FHG Deliveries
1940 - 2017 (acre-feet)
HCCRD Total

Figure 10B-11
NM Pumping Off v. Historical Base Run
Integrated LRG Model
Monthly Irrigation Supplemental Pumping
1940 - 2017 (acre-feet)
EBID Total

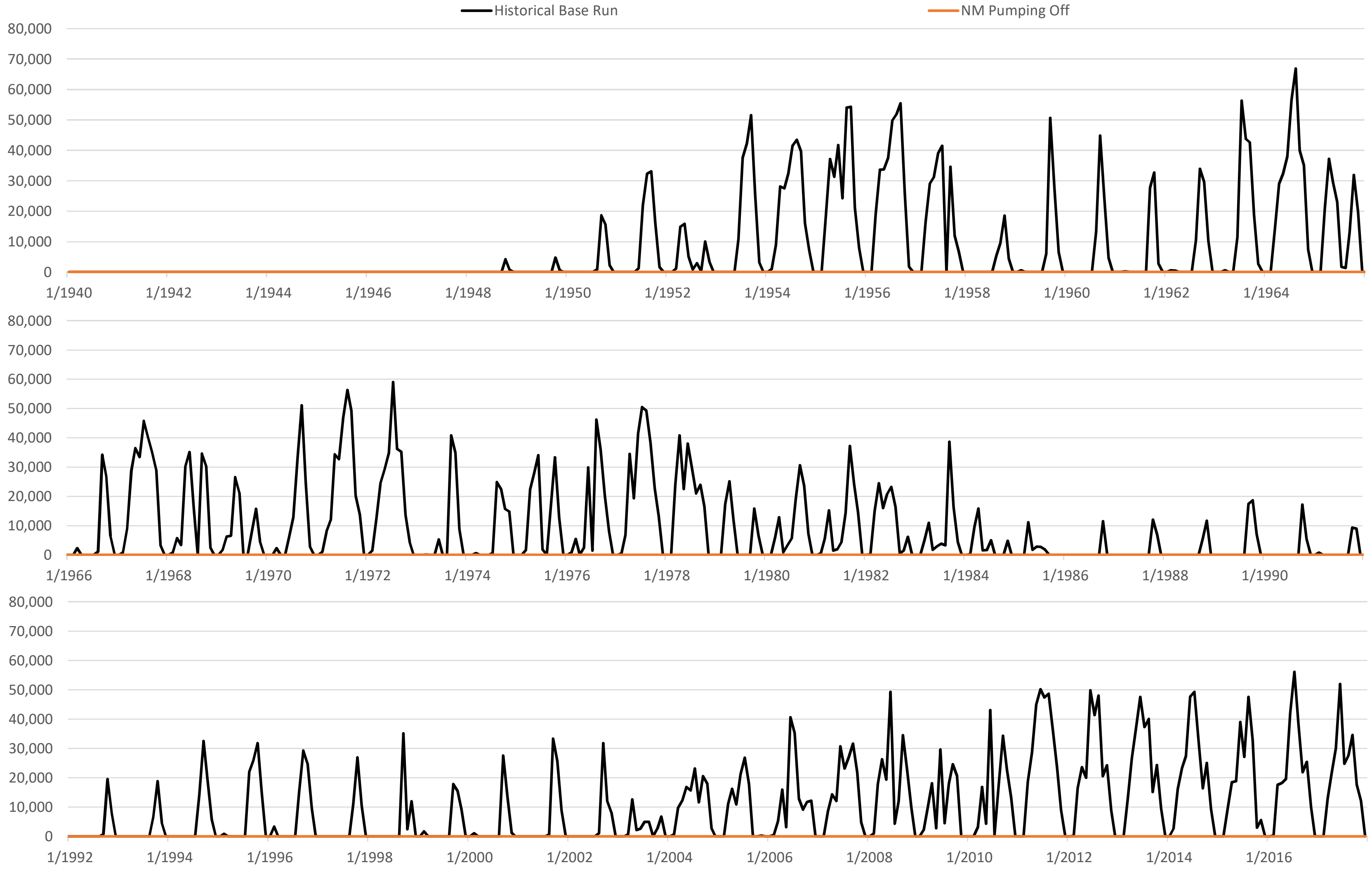


Figure 10B-12
NM Pumping Off v. Historical Base Run
Integrated LRG Model
Monthly Irrigation Supplemental Pumping
1940 - 2017 (acre-feet)

EPCWID Total

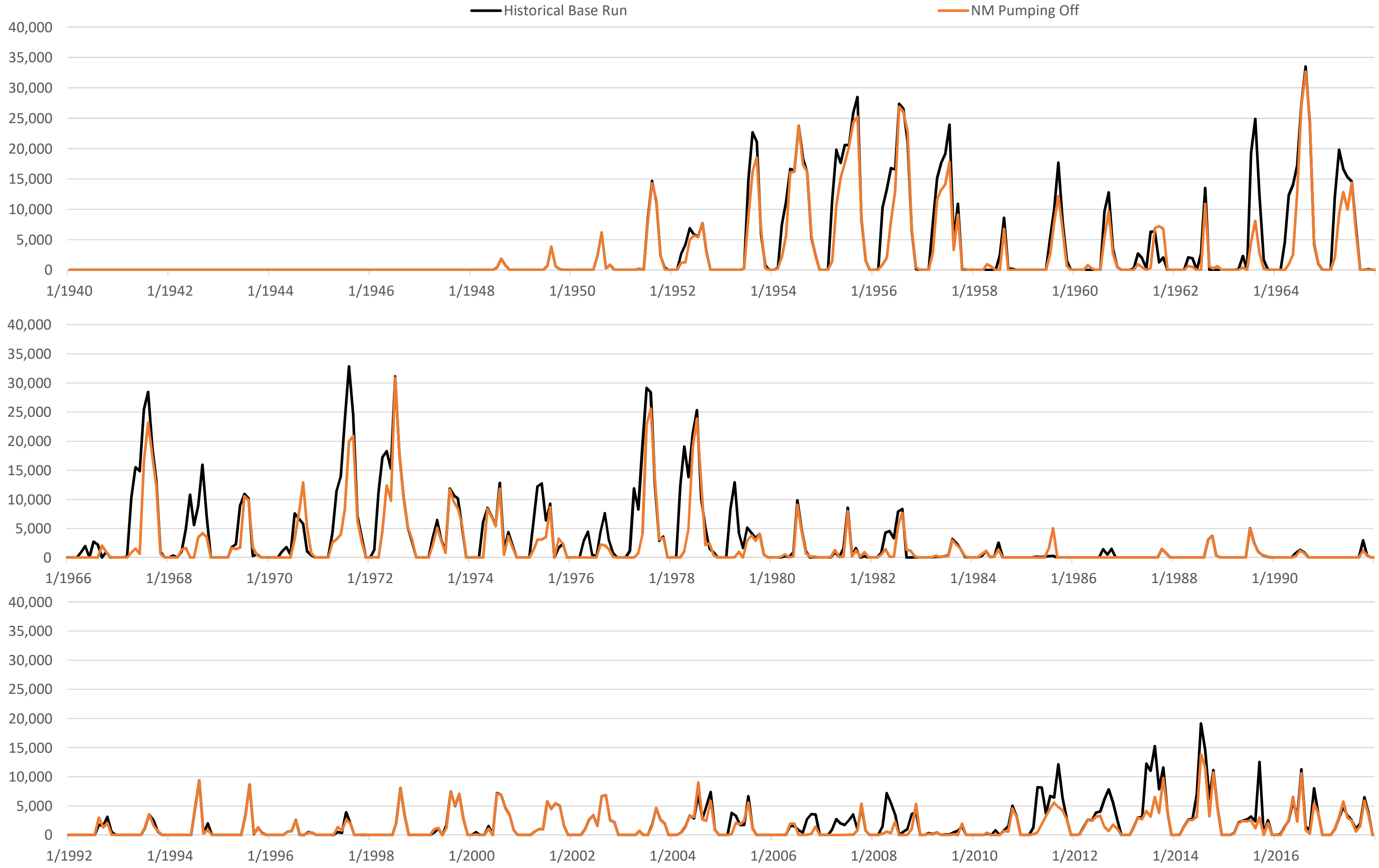


Figure 10B-13
NM Pumping Off v. Historical Base Run
Integrated LRG Model
Monthly Irrigation Supplemental Pumping
1940 - 2017 (acre-feet)
HCCRD Total

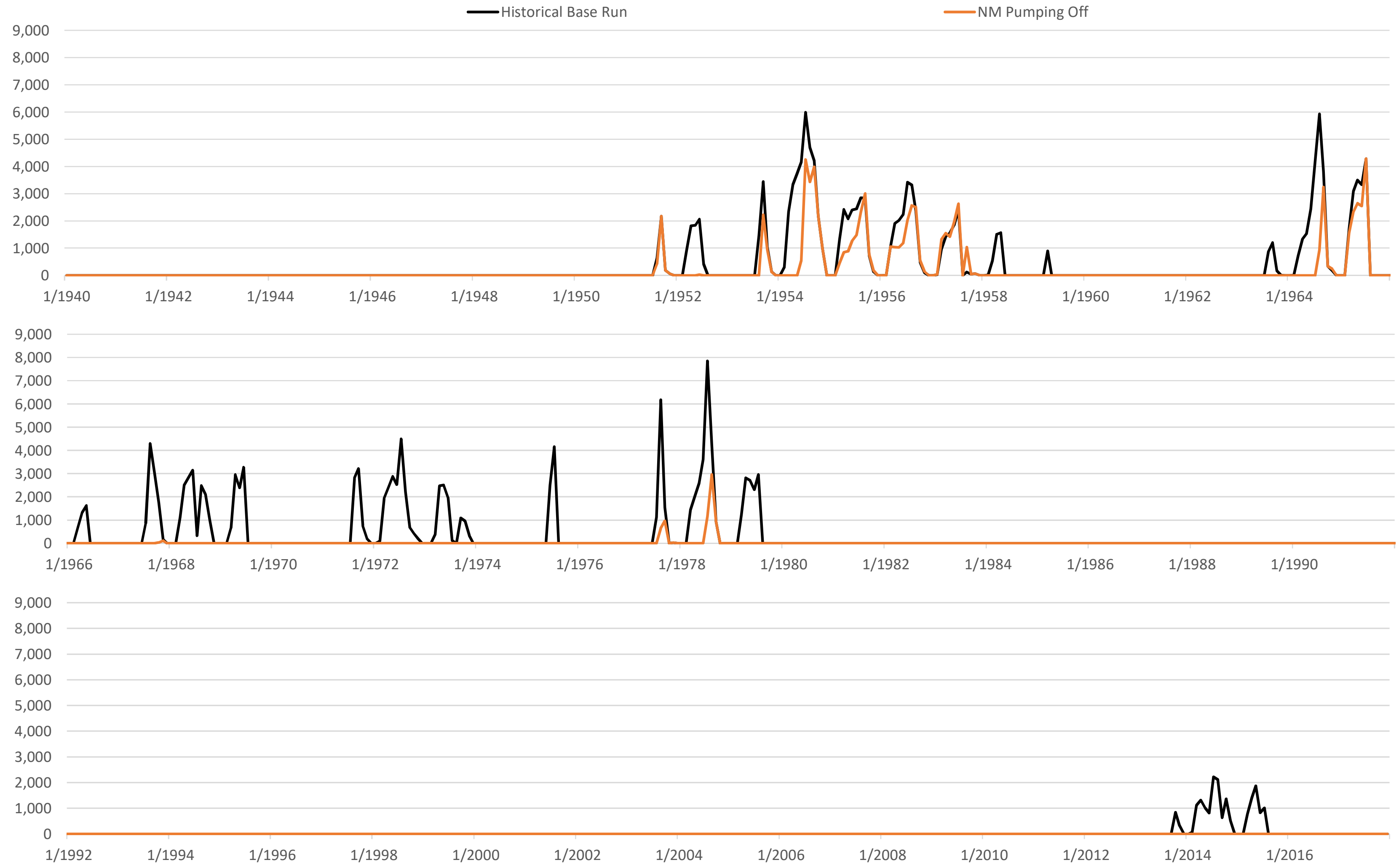


Figure 10B-14
NM Pumping Off v. Historical Base Run
Integrated LRG Model
End of Month Reservoir Storage (Elephant Butte + Caballo)
1940 - 2017 (acre-feet)

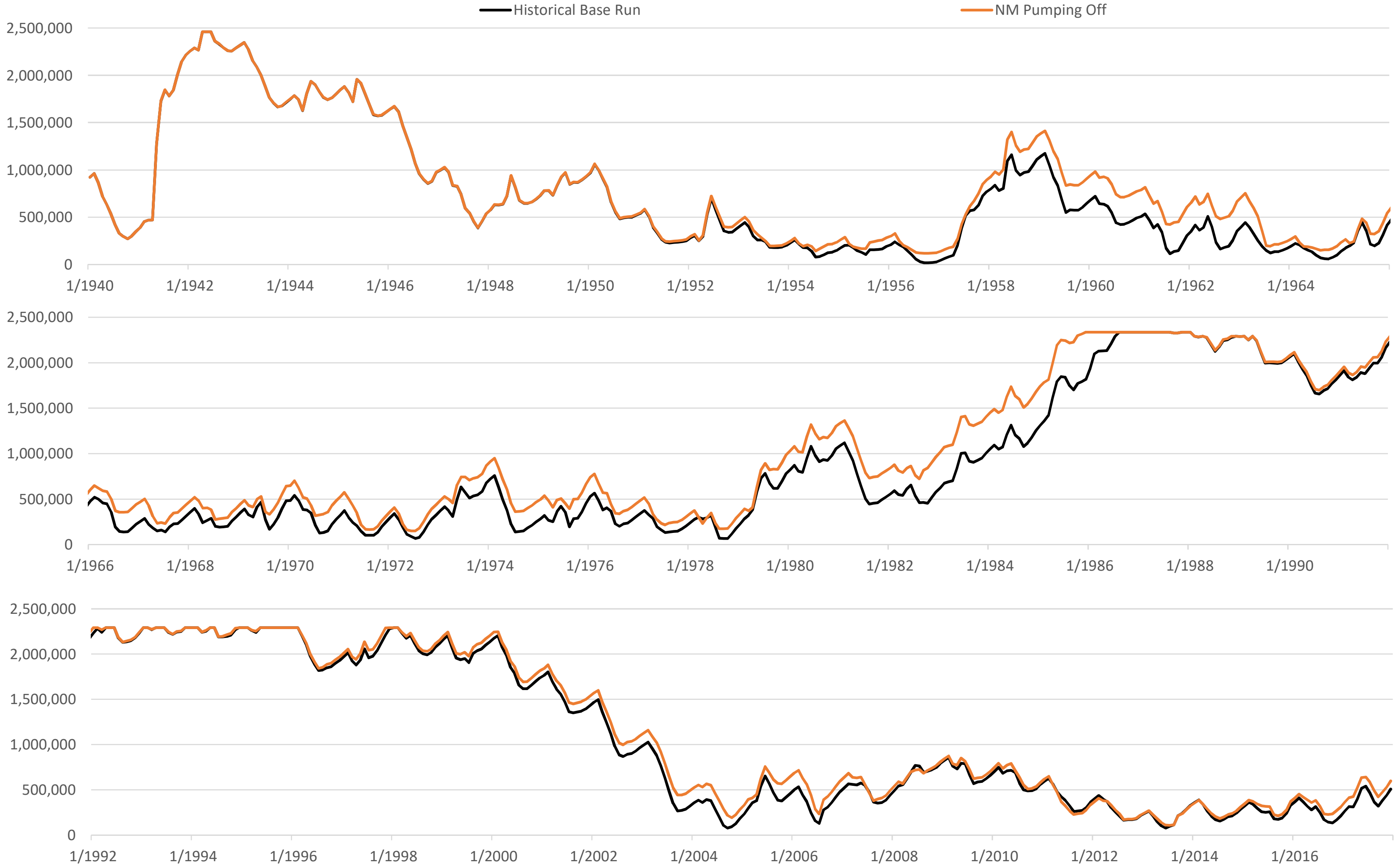


Figure 10B-15

NM Pumping Off v. Historical Base Run

Integrated LRG Model

Monthly Rio Grande Flow Below Caballo

1940 - 2017 (acre-feet)

Figure 10B-16

NM Pumping Off v. Historical Base Run

Integrated LRG Model

Monthly Rio Grande Flow at El Paso

1940 - 2017 (acre-feet)

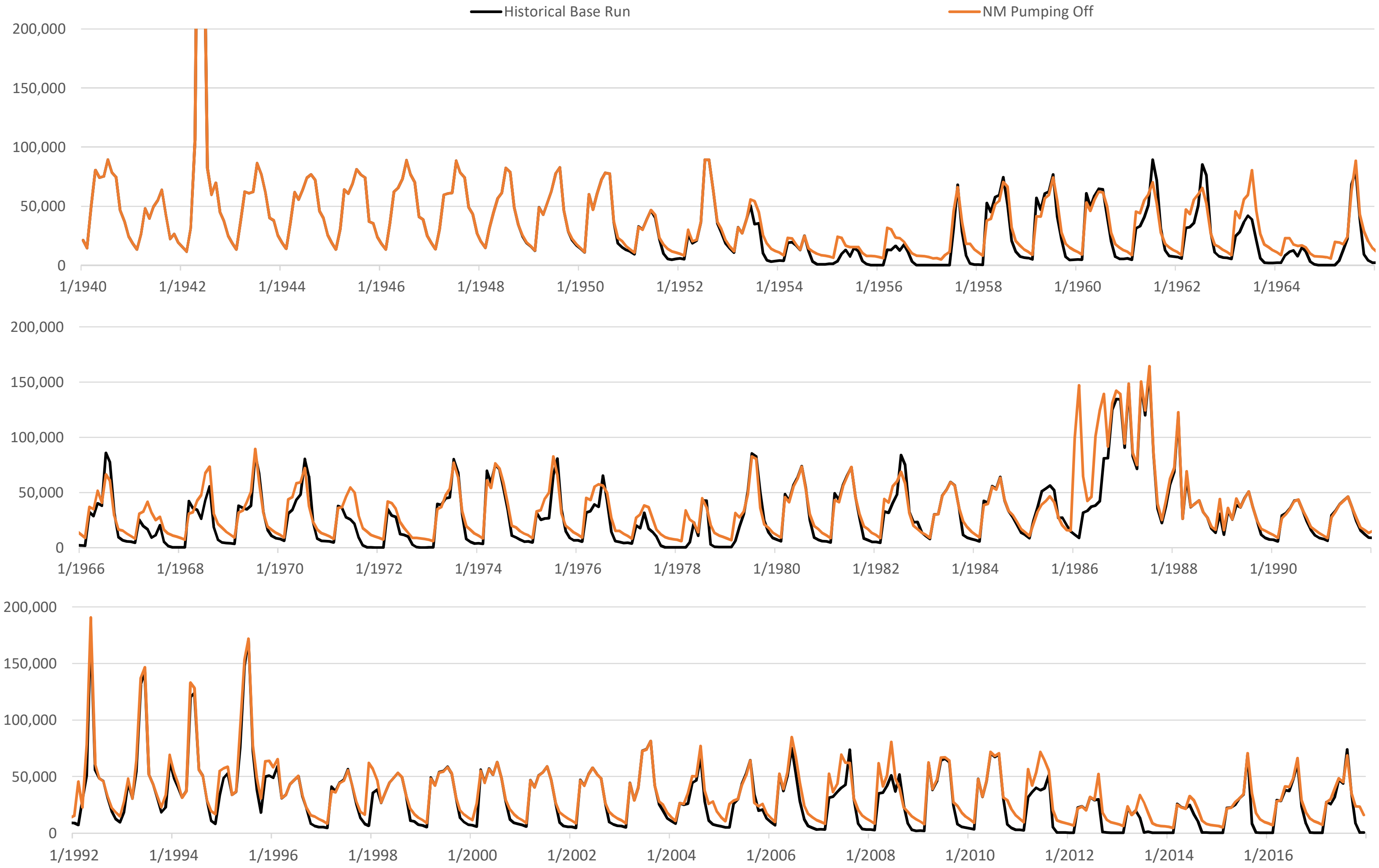
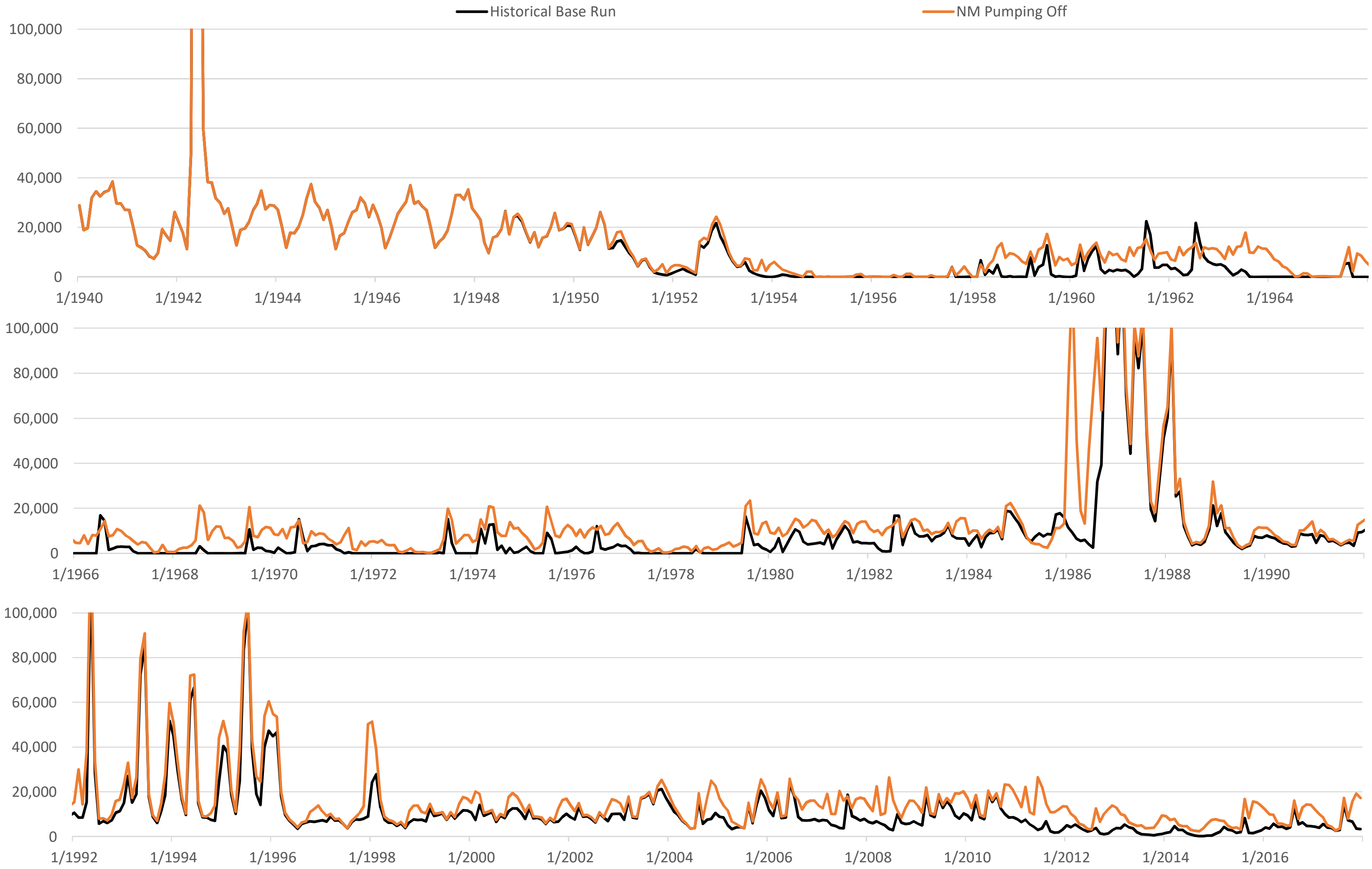


Figure 10B-17
NM Pumping Off v. Historical Base Run
Integrated LRG Model
Monthly Rio Grande Flow at Fort Quitman
1940 - 2017 (acre-feet)



No. 141, Original

IN THE
SUPREME COURT OF THE UNITED STATES
TEXAS V. NEW MEXICO AND COLORADO

REBUTTAL EXPERT REPORT OF GREGORY K. SULLIVAN, P.E. AND HEIDI M. WELSH

Second Edition

Prepared for:

STATE OF NEW MEXICO

Prepared by:

22620
9/15/20

Heidi Welsh

Gregory K. Sullivan, P.E.

Heidi M. Welsh

July 15, 2020
(Revised September 15, 2020)

TX v. NM # 141
New Mexico Exhibit
NM_EX-123

SWE Spronk Water Engineers, Inc.

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APPENDICES

LIST OF ABBREVIATIONS

2008 OA	2008 Operating Agreement
ACE	American Canal Extension
AF	Acre-feet
Reclamation	Bureau of Reclamation
BIAS	Mean Error
CFB Model	Canal and Farm Budget Model prepared by SWE
cfs	Cubic feet per second
CIR	Crop irrigation requirement
cms	Cubic meters per second
Compact	Rio Grande Compact
d	Index of Agreement
D1/D2	Procedure for allocating and accounting of Project water from 1979-2005 based on 1951-1978 Project operation data
D3	Procedure for allocating and accounting of Project water from 2006-present under the 2008 Operating Agreement
DCMI	Domestic, commercial, municipal, and industrial
DE	David's Engineering
DP	Deep percolation
EBID	Elephant Butte Irrigation District
EPA	Environmental Protection Agency
EPCWID	El Paso County Water Improvement District No. 1
EPW	El Paso Water
ET	Evapotranspiration
FHG	Farm headgate
Ft. Quitman	Fort Quitman, Texas
gpm	Gallons per minute
GPS	Global positioning system
HCCRD	Hudspeth County Conservation and Reclamation District No. 1
Hueco Model	Hueco Ground Water Model
Hydros	Hydros Consulting
IBWC	International Boundary and Water Commission
ILRG Model	Integrated Lower Rio Grande Model
JID	Juarez Irrigation District
JMAS	Junta Municipal de Aqua y Saneamiento (water utility for Ciudad Juarez)
Log-NSE	Logarithmic Nash-Sutcliffe Efficiency
LRG	Lower Rio Grande
LRG Area	Area of irrigation and non-irrigation water use in the Rincon, Mesilla, El Paso, and Juarez Valleys between Caballo Reservoir and Ft. Quitman Texas
M&A	Montgomery & Associates
M&I	Municipal and Industrial
MAD	Management allowable depletion

MAE	Mean Absolute Error
MFE	Maximum farm irrigation efficiency
MMA	McDonald-Morrisey Associates, LLC
MX-IBWC	Mexican section of the International Boundary and Water Commission
NMAGO	New Mexico Office of the Attorney General
NMISC	New Mexico Interstate Stream Commission
NMOSE	New Mexico Office of the State Engineer
NMR-M Model	New Mexico Rincon-Mesilla Ground Water Model
NPDES	National Pollutant Discharge Elimination System
NSE	Nash-Sutcliffe Efficiency
PBIAS	Percent Bias
PET	Potential evapotranspiration
PMAE	Percent Mean Absolute Error
QA/QC	Quality assurance and quality control
R^2	Coefficient of Determination
RGCC	Rio Grande Compact Commission
RGJI	Rio Grande Joint Investigation
RiverWare	RiverWare simulation model
RHG	River headgate
RMSE	Root Mean Squared Error
RSR	RMSE – Observed Standard Deviation Ratio
SSPA	S.S. Papadopulos & Associates
SWDataSet	Surface Water Dataset prepared by SWE
SWE	Spronk Water Engineers, Inc.
URGWOM	Upper Rio Grande Water Operations Model
USGS	United States Geological Survey
US-IBWC	United States section of the International Boundary and Water Commission
WDR	Water Distribution Report
WTP	Water Treatment Plant
WWTP	Wastewater Treatment Plant

17.0 SUMMARY OF OPINIONS

17.1 Introduction

The Case Management Order in Texas v. New Mexico and Colorado set forth a schedule for alternating the exchange of expert reports by parties to the case and the following reports have been submitted to date:

- Opening expert reports for Texas and the United States were submitted on May 31, 2019.
- Expert reports for New Mexico supporting the New Mexico counterclaims and responding to the original reports of Texas and the United States were submitted on October 31, 2019.
- Rebuttal expert reports for Texas and the United States responding to the New Mexico reports were submitted on December 30, 2019.
- Supplemental expert reports were submitted by several of the experts for Texas and United States after the deadlines in the case management orders. These included a May 2020 Coors Supplemental Report, a September 2019 Moran Supplemental Report, and a May 2020 Moran Second Supplemental Report. In addition, updated information and analysis was provided by certain of the Texas experts that was not documented in any expert reports.
- Rebuttal expert reports for New Mexico were originally scheduled for submittal on March 27, 2020, but this deadline was postponed to June 15, 2020 for non-modeling experts and July 15, 2020 for modeling experts as a result of the Covid-19 situation and other factors, including allowance of time to respond to the late-disclosed supplemental reports from Texas and the Unites States.
- Also, on July 15, 2020, the New Mexico experts submitted revised or second editions of their opening expert reports.

Among the opening New Mexico reports submitted on October 31, 2019 was the Expert Report of Gregory K. Sullivan, P.E., and Adelheid (Heidi) M. Welsh (“SWE Report”). The topics covered in the SWE Report generally consisted of the following:

- Hydrologic and Rio Grande Project data,
- Summaries of historical water supply and water uses,
- Canal and farm budget modeling,
- Review of the New Mexico Integrated LRG Model (“ILRG Model”),

- Results from ILRG Model simulations, and
- Responses to certain of the Texas expert reports.

This Rebuttal Expert Report by Gregory K. Sullivan, P.E. and Heidi M. Welsh was prepared to respond to certain of the rebuttal expert reports and supplemental expert reports submitted by the Texas and United States experts ("SWE Rebuttal Report").

Due to changes in the analyses performed by the Texas experts and updates to the ILRG Model runs, certain of the results that were reported in the text, tables, figures, and appendices in the SWE Report have changed. Revised figures and tables from the SWE Report are provided with this report. **Appendix 18** contains updates of the figures and tables for which the presentation format did not change. The format for certain of the figures, tables, and appendices that presented results of the ILRG Model have been updated. For these, rather than updating the original attachments in their original format, revised figures, tables, and appendices in the new format are attached to this rebuttal report and are described in Sections 28.0 – 30.0.

To avoid confusion with the numbering of the sections and attachments in the SWE Report, the section numbering in this rebuttal report picks up where the prior report left off with Section 17. All figures, tables, and appendices are identified with a prefix of the section number followed by numbers that are sequenced in the order described in the report text.

A second edition of the SWE Rebuttal Report was prepared to describe corrections and improvements that have been made to the ILRG Model, to report the results of the model re-tuning, and to present the results of the updated Base Run (Run 1) and alternative scenario runs (Runs 2 – 18). This second edition report also corrects typographical errors in the original SWE Rebuttal Report. A new Appendix 17 is attached that contains an errata list for Sections 17-29 and 31, a redline depiction of the changes to Section 30, and a list of the figures, tables, and appendices revised for this second edition.

17.2 Assignments

Our assignments for this rebuttal report were developed in discussions with legal counsel for the State of New Mexico. We were asked by legal counsel to develop analyses and expert opinions in the following areas:

- Review of rebuttal reports and supplemental report and supporting data, analyses, and modeling submitted by experts for the Texas and the United States,
- Updates to the CFB Models of the major irrigation users between Elephant Butte Reservoir and Fort Quitman Texas,

- Coordination of the updates to and use of the ILRG Model,
- Analysis of the effects of changes in Project operations and accounting in the El Paso Valley portion of EPCWID compared to those that existed in the past, and
- Evaluation of conjunctive use of ground water and surface water under alternative conditions, including limiting pumping to D1/D2 amounts, limiting M&I pumping to pre-compact levels, and/or limiting pumping to crop demands on authorized Project acres.

Summaries of the opinions that were developed by Ms. Welsh and Mr. Sullivan for this case follow. The numbering of the opinions picks up where the numbering in the SWE Report left off.

17.3 Summary of Opinions of Heidi M. Welsh

Ms. Welsh updated the SWDataSet as described in Section 26.0 and prepared an update to the annual CFB Model of the Hueco Bolson area that is described in Section 27.0. and summarized below. In addition, she continued to be involved in disseminating data for use in the New Mexico models, and in post-processing the model output files into summary tables and graphs.

<u>Section 26.0 – Lower Rio Grande Data</u>

47. Additional data for the Socorro WWTP and monthly drain water diverted at Fabens were added to the SWDataSet. The updated SWDataSet was used to supply data inputs to the revised ILRG Model.

<u>Section 27.0 – Lower Rio Grande Canal and Farm Budget Models</u>

48. The annual CFB Models that simulate irrigation operations in the portions of the Texas and Mexico irrigation districts that overlie the Hueco Bolson during 1903 - 1937 were revised to incorporate new FHG delivery data and to include a switch to turn off Juarez sewage discharge to canals when Mexico pumping is turned off. The revised CFB Model was used to prepare certain input data used in the early 1903 – 1939 annual warm-up simulation in the Hueco Model.

17.4 Summary of Opinions of Gregory K. Sullivan

Mr. Sullivan prepared Sections 18.0 – 25.0, and Sections 28.0 – 31.0 and is responsible for the opinions presented in those sections, which are summarized below.

Section 18.0 – Response to Revised Texas Analyses Submitted Without a Rebuttal Report

Based on review of the revised Texas analyses that were submitted without a rebuttal report, I developed the responses and opinions that are presented in Section 18.0, some of which are summarized below.

49. Corrections to the M&A Farm Budget analysis of EPCWID reduced the magnitude of the differences in results compared to the SWE CFB analysis, however substantial differences remain, including M&A's unrealistically high estimates of crop evapotranspiration and supplemental pumping.

50. Dr. Dorrance updated her analysis that translates impacts on Rio Grande at El Paso flow from New Mexico pumping computed by the Texas Model into estimated impacts on deliveries to Texas water users. The revised analysis remains flawed and inappropriate for the reasons described in the original SWE Report.

Section 19.0 – Response to Ferguson Rebuttal Report

Based on review of the rebuttal report by Dr. Ian Ferguson (U.S. expert), his backup files and references, and attending his deposition, I developed the responses and opinions that are presented in Section 19.0, some of which are summarized below.

51. Annual Texas Mesilla pumping occasionally exceeded 20% of the total pumping in the Rincon and Mesilla Valleys. (Figure 19-1). Simulated depletions of El Paso flow caused by Texas Mesilla pumping, on the other hand, were often much greater than 20% of the total depletions from all pumping in the Rincon and Mesilla Valleys. (Figure 19-2).

52. Pumping from the Hueco Bolson, including pumping by wells in Texas, depletes river flows, canal and lateral flows, and drain flows in and around the EPCWID service area. These depletions increase EPCWID calls for Project releases, reduce farm headgate deliveries of Project water, and reduce the surface flows leaving EPCWID that supply HCCRD. The impacts of Texas Hueco pumping on Project operations impact diversions and FHG deliveries of Project water to EBID. These impacts are reflected in the ILRG Model Runs that are discussed in Section 30.0.

53. The effects of Texas Hueco pumping have been partially offset by Texas WWTP discharges and urban deep percolation return flows. In order to minimize the impacts of Texas Hueco pumping, EPW WWTP discharges must continue to be a part of the irrigation supply used by EPCWID farmers. If EPW WWTP discharges were to become unavailable, the effects of Texas Hueco pumping on EBID would increase.

54. Total New Mexico pumping during 1979-2005, when the D1/D2 accounting was in use, averaged 109,600 AF/y, which is less than the total New Mexico pumping during the D1/D2 source data period of 1951-1978, when it averaged 179,100 AF/y. (Figure 19-5).

55. New Mexico Irrigation pumping since the 2008 OA has been in effect (2006-2017) is marginally greater than the average irrigation pumping during the 1951-1978 D1/D2 period. The increased recent pumping is due to severe drought conditions and the effect of the 2008 OA that has substantially reduced the allocation of Project water to EBID. (Figure 19-7).

56. New Mexico M&I pumping has increased by approximately 20,000 AF since the end of the D1/D2 period (1978), but a portion of the impacts of the increased pumping has been offset by urban return flows. (Figure 19-7).

57. Total beneficial consumptive use for irrigation and non-irrigation uses in New Mexico has increased relatively little over the last 60 years, with the 10-year average ending in 2017 only 20,000 AF greater than it was in 1960. (Figure 19-9).

58. EPCWID’s unused allocation has exceeded 50,000 AF in 20 years since 1978, more than half of all the years, and these years tend to correspond with years of little or no irrigation pumping to meet unmet demand, thus confirming that EPCWID’s unused allocation generally occurs in years when EPCWID irrigation demands are met (Figure 19-12).

59. Historical records show that annual EPWCID use of drain flows for irrigation declined from almost 30,000 AF in the late 1940s to zero in the early 1980s. Use of drain flows throughout the Project has been an integral part of Project operation throughout the history of the Project and the cessation of use of return flows arising within the EPCWID service area has impacted Project operations to the detriment of EBID. (Figure 19-16).

60. Analysis of historical records confirms that the increase in reported EPCWID waste that occurred after EPWCID took over distribution of water within its service area from the BOR in about 1980 was unreasonable compared to the more efficient operation that occurred prior to that time. (Figures 19-17 – Figure 19-20).

61. Analysis of historical records of Project operation clearly shows that releases from Project storage vary inversely with the amount of net gains between the Caballo Reservoir outlet and American Dam in order to meet Project water demands. Reservoir releases are higher in dry years with more losses and lower in years with

more gains. Since pumping affects Rio Grande gains and losses, changes in pumping result in changes in reservoir releases (Figure 19-23).

Section 20.0 - Response to George Rebuttal Report

Based on review of the rebuttal report by Mr. Jonathan D. George (Texas expert), his backup files and references, and reviewing his deposition transcript, I developed the responses and opinions that are presented in Section 20.0 and summarized below.

62. Increases in average crop evapotranspiration in the Rincon and Mesilla Valleys during 1985-2016 compared to 1938-1950 can be explained mostly by differences in weather and crop selection as opposed to well pumping. (Figure 20-1).

Section 21.0 - Response to Hornberger Rebuttal Report

Based on review of the rebuttal report by Dr. George M. Hornberger (Texas expert), his backup files and references, and viewing his deposition, I developed the responses and opinions that are presented in Section 21.0, some of which are summarized below.

63. The Texas Model fails to meet the stated Texas objective of showing how New Mexico pumping affects Rio Grande at El Paso flows because the Texas model (a) does not simulate the dynamic response of Project operations to changes in flows that would occur without pumping, (b) does not simulate the area downstream of the El Paso gage and thus cannot simulate the feedback response from those areas to changes in Project operations, and (c) uses annual stress periods that prevent distinguishing impacts that occur during the irrigation season from impacts that occur during the non-irrigation season.

64. The effects of pumping from the Hueco Bolson can propagate upstream of El Paso through Project operation mechanisms. Because the Project is operated as a unit, depletions of surface flows that affect deliveries to EPCWID users can result in increased releases of Project water to meet EPCWID demands, which in turn reduces the supply available for allocation to EBID. The impacts to EBID from Hueco Bolson pumping are magnified under the D3 accounting in the 2008 OA.

65. Simulation of Project operations is essential in modeling impacts of pumping on deliveries to LRG water users. The key aspects of Project operation are well understood and amenable to simulation, and there is a rich trove of historical data to validate the model simulation processes.

Section 22.0 - Response to Coors Rebuttal Report

Based on review of the rebuttal report by Mr. Adolph (Shane) Coors V (Texas expert), his backup files and references, and attending his deposition, I developed the responses and opinions that are presented in Section 22.0, one of which is summarized below.

66. Average deviations between simulated and observed data in the historical run of the ILRG Model do not represent uncertainty of the ILRG Model in simulating impacts of pumping or changes in operating practices. These impacts are quantified based on differences between model runs, and any model imperfections tend to cancel out when computing these differences.

Section 23.0 - Response to Coors Supplemental Report

Based on review of the supplemental report by Mr. Coors, his backup files and references, and viewing his deposition, I developed the responses and opinions that are presented in Section 23.0, some of which are summarized below.

67. Development and refinement of the ILRG Model by the New Mexico experts occurred over many years based on extensive discussion, testing, and evaluation of the simulated processes and model outputs. Additional simulation capabilities were added incrementally when they were shown to improve the functionality of the model and improve its performance. The result is a model that captures the essential elements of the reservoir and irrigation system operations in the LRG Basin. The robust and sophisticated operation of the ILRG Model is supported by the rich and extensive record of historical Project operation.

68. The complexity and detail included in the ILRG Model is consistent with the complexity of the Rio Grande Project and the LRG irrigation systems, and this complexity and detail is needed to answer and address the complex questions and issues raised in this case.

69. Project operation responses to impacts from pumping vary depending on several factors including the allocation procedure that is in effect (D1/D2 vs. D3+Carryover) and whether there is a full or partial allocation to the Districts. The Project operation responses that are simulated in the ILRG Model reflect the real-world responses to changes in surface water supply resulting from variations in pumping and other factors.

70. The monthly timestep of the ILRG Model is consistent with the monthly scale of the generally extensive historical data that document the historical Project operation,

and allow the model to importantly distinguish impacts on surface flows that occur within the irrigation season from those that occur during the non-irrigation season.

71. While there are numerous statistics and graphical methods that can be used to evaluate model calibration, there are no universally accepted guidelines for calibration assessment in the scientific community. Assessment of model calibration should be focused on how the model is being used.

72. The calibration statistics proposed by Mr. Coors for evaluation of model calibration are partially consistent with the statistics that were used by the New Mexico experts to evaluate performance of the ILRG Model. However, these statistics were computed using irrigation season or annual flows consistent with the temporal scale of the questions that the ILRG Model is being used to answer.

73. The statistics and graphical methods used to evaluate the calibration of the ILRG Model are based, in part, on performance measures and performance evaluation criteria recommended by Moriasi et.al. (2015) on behalf of the American Society of Agricultural and Biological Engineers (“ASABE”).

74. The Log NSE statistic proposed by Mr. Coors is inappropriate for use in evaluating the ILRG Model because of its emphasis on differences in low flows. The claims and counterclaims by the states implicate Project operations and deliveries at all levels of flows. In addition, the highly regulated nature of the Rio Grande Project insulates it from the extreme flow variations and extreme low flows that are typical of unregulated river basins that may be more suited to evaluation using the Log NSE statistic.

75. The locations selected by Mr. Coors for evaluation of the calibration of the ILRG Model reflect an indiscriminate selection based on available data rather than locations that are important to the essential model functions and intended uses of the model. The individual and aggregated locations selected by the New Mexico experts for evaluating model calibration reflect thoughtful consideration of the interaction of the simulated model components and the questions that the model is being used to answer in this case.

76. Calibration of the ILRG Model should not be assessed using statistics computed from monthly data for several reasons. First, Project water is allocated to the Districts and to farmers as irrigation season volumes that they can take delivery of at their discretion. Second, releases from Project storage can buffer the monthly variability of stream depletions caused by pumping. Third, the availability of wells to

supplement surface supplies can smooth out monthly water supply variations caused by the pumping of others.

77. There is no widespread consensus in the scientific community for excluding a portion of the historical data period for use in validating a simulation model calibrated using data from a different period. In this case, since the ILRG Model is being used mostly to analyze the past, it is logical to use the entire simulation period for calibration.

78. It is common in modeling alternative irrigation scenarios using historical data to leave the irrigated acreage and cropping pattern at the historical values. This is reasonable because when the water supply to a farm is reduced in the absence of supplemental pumping, consumptive use will be limited by the available surface water supply and the maximum irrigation efficiency rather than crop water demand.

79. The dynamics of the Rio Grande Project operation and management are evident in the extensive historical records that have been analyzed and used in developing and calibrating the ILRG Model. The remarkable calibration performance of the ILRG Model is clear evidence that the system can be reasonably simulated.

80. Quantification of impacts on streamflows, diversions, and deliveries is not dependent on precise replication of historical conditions in calibration. Indeed, no simulation models of heterogeneous real-world systems could meet such an impossible standard. Rather, good model simulations are ensured using a model with reasonable and rational simulation processes that is calibrated to reasonably match the magnitude and patterns of the historical data. In this case, since model results are largely being evaluated based on differences between model runs, the cancelling of errors that occurs when differencing model results further enhances the reliability of model results.

81. It is illogical and inappropriate to use the results of the All Pumping Off (Run 2) scenario of the ILRG Model to evaluate the impacts of New Mexico pumping on Project operations, surface water flows, and ground water storage because pumping in the Texas portion of the Mesilla Valley and all pumping from the Hueco Bolson is turned off. There is no way to distinguish the impacts of New Mexico pumping from the impacts caused by the other pumping.

82. Due to non-linearities in the ILRG Model, differences between results of the All Pumping Off (Run 2) and Rincon-Mesilla Pumping Off (Run 6) should not be used to assess the impacts of Hueco Bolson pumping on Project operations. These impacts can be assessed by turning off the Hueco pumping and the associated return flows

in isolation and simulating the results as was done in Run 14 and several variants that are described in Section 30.0.

Section 24.0 - Response to Moran Supplemental Report

Based on review of the supplemental report by Ms. Jean Moran (U.S. expert), her backup files and references, and reviewing her deposition transcript, I developed the responses and opinions that are presented in Section 24.0, some of which are summarized below.

83. The results of the simulations of impacts of New Mexico pumping performed by Ms. Moran using the Texas Model are unreliable because of the serious flaws in that model which include the lack of simulation of the dynamic response of Project facilities and irrigation systems to changes in supply, the coarse annual stress periods, and the limited model domain that ends at the El Paso gage.

84. The crude redistribution of simulated increases in flow at the El Paso gage that result from turning off New Mexico pumping performed through iterative post-processing by Ms. Moran fail to incorporate many essential processes that affect Project operations and deliveries and therefore the results of these analyses are unreliable. Notwithstanding, the redistribution that was attempted by Ms. Moran recognizes the crucial point that Project operations, including reservoir releases, diversions, and deliveries, would have been different if pumping had been reduced.

85. In addition to the limitations of the Texas Model and the crudeness of her redistribution attempt, the estimates of the impacts of New Mexico pumping that were simulated by Ms. Moran are inflated because (a) all pumping in the Rincon and Mesilla Valleys was turned off, including the irrigation and M&I pumping in the Texas portion of the Mesilla Valley, and (b) WWTP discharges were not turned off which precluded simulation of the offset these discharges provide to depletions from pumping.

Section 25.0 - Response to Moran Second Supplemental Report

Based on review of the second supplemental report by Ms. Moran, her backup files and references, and reviewing her deposition transcript, I developed the responses and opinions that are presented in Section 25.0, some of which are summarized below.

86. The differences in ILRG Model performance before and after 1985 are insignificant and have not been shown to affect the results of the ILRG Model simulations. The average percent differences between modeled and measured values of Caballo releases and Rio Grande at El Paso flows fall within the “Very Good” evaluation

criteria proposed by Moriasi et. al, (2015). The performance of the updated ILRG Model is improved compared to the version of the model evaluated by Ms. Moran.

87. The other criticisms of ILRG Model performance made by Ms. Moran are not significant in the context of the overall calibration performance that is described in detail in Section 28.0. Moreover, Ms. Moran has not analyzed whether the alleged imperfections in the ILRG Model simulation of the Historical Base Run would affect the differences in the simulated results of alternative scenarios, given the cancelling of errors that occurs with such comparisons.

88. The calibration of the Rio Grande at El Paso flow in the ILRG Model is very good. The purportedly perfect calibration of the Texas Model at El Paso is achieved through inappropriate overparameterizing of conductance values and canal spills to drains in every stress period.

89. The comparisons of ILRG Model results of Run 2 (All Pumping Off) with Run 6 (R-M Pumping Off) are not reliable indications for the effect of Hueco pumping for the same reasons described in the opinions for Section 23.0.

90. When evaluating the effects of New Mexico pumping, WWTP returns from use of Las Cruces' Jornada Wells should be turned off to compute an appropriate credit for water imported to the basin.

91. Differences between simulated impacts of Rincon-Mesilla pumping computed by the Texas Model compared to the ILRG Model have not been demonstrated by Ms. Moran to be within the range of uncertainty of the models. Moreover, as described at length in this report and the SWE Report, the ILRG Model is far superior to the Texas Model due to its more sophisticated and robust processes and first-rate calibration.

<u>Section 28.0 - Overview and Assessment of Updated ILRG Model</u>

92. Changes to the RiverWare operating rules along with updated tuning have improved the ILRG Model simulation of historical Project operations. Substantive changes included modifications to reservoir operations to improve model performance when Project storage is near full or spilling. In addition, refinements were made to EPCWID operations to more evenly distribute water within the EPCWID service area and to make the simulated RHG demands more responsive to changes in irrigation use of WWTP discharges and local drain flows.

93. The improvements to the ILRG Model are reflected in the updated and expanded calibration summaries that demonstrate the outstanding performance of the ILRG Model in replicating historical operation of the Project and the associated LRG irrigation systems.

94. A wide range of statistical performance measures were employed to characterize the statistical performance of the ILRG Model in simulating the reservoir operations, streamflows, RHG diversions, FHG deliveries, supplemental pumping, and drain flows in the study area. These included a standard regression measure (R^2), dimensionless statistics (NSE, d), and error indices (BIAS, PBIAS, MAE, PMAE, RMSE, RSR).

95. The statistical performance measures were evaluated in comparison to performance evaluation criteria recommended by the ASABE and contained in a peer-reviewed journal article by Moriasi et. al. (2015) based on synthesis and meta-data analysis of numerous published articles describing calibration performance of various watershed models.

96. In addition, graphical performance measures were utilized to visually assess the goodness of fit of ILRG Model results, including monthly and annual time series graphs, cumulative residual graphs, scatter plots, and flow duration curves.

97. All statistical performance measures and graphical performance depictions were applied to a set of individual and aggregated locations that were thoughtfully selected as representative of model performance in relation to the intended uses of the ILRG Model results to answer the questions posed in this case.

98. The results of the application of the statistical performance measures to the ILRG Model Historical Base Run (Run 1) are summarized in Table 28-1. The results demonstrate acceptable to remarkable performance of the ILRG model in simulating Project operations, diversions and deliveries to LRG water users, and Rio Grande streamflows.

99. Graphical depictions of the ILRG Model performance are presented in Figure 28-1 through Figure 28-21. The graphs confirm and illustrate the ability of the ILRG Model to reasonably replicate the monthly, seasonal, annual, and decadal variations in streamflows, RHG diversions, FHG deliveries, supplemental pumping and drain flows throughout the LRG Basin.

100. The calibration performance of the ILRG Model is generally excellent considering the complexity and scale of the Rio Grande Project, the associated irrigation systems,

and the M&I water uses in the LRG Basin. The model achieves this excellent performance by reasonable and rational simulation of the physical and management processes that control the movement and interaction of surface water and ground water throughout the study area.

Section 29.0 – Historical Base Run of ILRG Model

101. The revised ILRG Model (v116) was used to prepare a new Historical Base Run (Run 1) generally according to the procedures described in the original SWE Report. Project water allocations were simulated using the D1/D2 allocation procedure from 1950-2005, the D3 allocation procedure without carryover in 2006 and 2007, and the D3+Carryover procedure in the 2008 OA from 2008-2017. Irrigation pumping coverage in EBID, EPCWID, HCCRD, and JID Units 2 and 3 was specified to increase linearly from 0% in 1947 to 100% in 1955, and in JID Unit 1 from 0% in 1939 to 100% in 1954. Non-irrigation pumping and return flows were specified and simulated based on historical records and estimates.

102. In addition to the statistics and graphs illustrating the calibration of the Historical Base Run in Section 28.0, numerous graphs were prepared to illustrate Project reservoir water budgets, canal and farm water budgets, river water budgets, and river point flows over the 1940-2017 simulation period. These results demonstrate that the ILRG Model reasonably and sensibly simulates the operation of the Rio Grande Project over the range of hydrologic conditions that occurred during the historical study period.

103. The excellent calibration of the ILRG Model achieved using rules that facilitate dynamic response of the essential Project and irrigation system functions make the model the best available tool and a reliable tool for answering the complex questions presented in this case through simulation of alternative scenarios and computing the differences between model runs.

Section 30.0 - Alternative Runs of ILRG Model

104. The revised ILRG Model was used to simulate “what-if” scenarios over the historical period to assess the impacts on reservoir operations, reservoir releases, RHG diversions, FHG deliveries, and Rio Grande flows resulting from cessation or reduction in historical pumping and/or changes in operating practices. Changes in model inputs cause dynamic responses of all simulated processes as the changed conditions ripple spatially and temporally through the model, just as they would in the real world. For the most part, the results from the what-if scenarios were compared to the Historical Base Run (Run 1) and changes in model outputs were

computed and summarized using a consistent set of tables and graphs that facilitate comparison of results between the various model runs.

105. The thirteen original runs described in the original SWE Report were repeated using the revised ILRG Model. These include the previously described Historical Base Run (Run 1), nine no-pumping runs (Runs 2 - 10), and three alternative operations scenarios (Runs 11 - 13) (Table 30-1).

106. Fourteen new runs were made in response to issues raised by experts for Texas and United States in rebuttal and supplemental expert reports, and in response to issues raised by legal counsel for Texas and the United States in their questioning of the New Mexico experts in depositions. These included five scenarios of reduced pumping from the Hueco Bolson in Texas and Mexico (Runs 14 – 14d), four scenarios with EPCWID operations modified to be consistent with earlier practices (Runs 15 – 15c), and five alternative conjunctive use scenarios (Runs 16, 16a, 17, 17a, and 18) (Table 30-2).

107. In the no-pumping runs, all pumping or just non-irrigation pumping was turned off in all areas (Run 2) or in certain geographic areas (Runs 3 – 10, 14, 14a, 14b, 14d, 15c). When non-irrigation pumping was turned off or reduced, so were the associated wastewater treatment plant discharges and urban deep percolation (except 14d). Because the Project is operated as a single system, any effects of pumping on surface water supplies that occur upstream of points of water delivery affect Project operations. The model results show that pumping in Texas and Mexico affects Project water deliveries to EBID water users in New Mexico.

108. The updated results for the original no pumping scenarios (Runs 2-10) are generally similar to the results for these scenarios that were presented and described in the original SWE Report. Keep in mind that the updated results for Runs 2-10 report differences in net RHG diversions as opposed to the differences in gross RHG diversions that were presented in the results for the original simulations of these scenarios.

109. Several runs were made to analyze the effects of Hueco Bolson pumping on Project operations and water supplies. These included turning off all Hueco pumping (Run 14), Texas Hueco pumping (Run 14a), and Mexico Hueco pumping (Run 14b). To further analyze the effect of Texas Hueco pumping, two additional runs were made. A run was made in which the Texas Hueco pumping was turned off, but the return flows from Texas M&I pumping were left on (Run 14d), to show the effect of Texas Hueco pumping without M&I return flow offsets. Another run was made in which all discharges from Texas WWTPs were turned off (Run 14c). The results from these

simulations show that pumping from the Hueco Bolson affects Project operations including deliveries to EBID and EPCWID as well as the total supply of water available to HCCRD. The results also show that without the offsetting effects of Texas WWTP discharges, impacts from Hueco pumping would be greater.

110. The updated results for the original runs that were made to evaluate the effect of the 2008 OA on Project operations (Runs 11 and 12) are similar to the results presented in the original SWE Report. The updated results show that since the new Project water allocation procedures in the 2008 OA were enacted beginning in 2006, the new procedures have caused a profoundly negative impact on the allocation and delivery of Project water to EBID that far outweighs the impacts of New Mexico pumping. Comparison of Runs 11 and 12 over the 1951-2017 period show that the negative impacts of the 2008 OA on EBID allocations and deliveries during average and dry years when water is most needed far outweigh the increased allocations and deliveries in wet years when water supplies are more plentiful.

111. The updated simulation of Project operations in which operational waste in EBID and EPCWID is limited to no more than 10 percent of the simulated diversions (Run 13) results that are similar to the original run described in the original SWE expert report. Limiting Project operational waste would substantially increase allocations and deliveries of Project water to both EBID and EPCWID.

112. Four runs of the ILRG Model were made to evaluate the effects on Project operations that would result from a return to EPCWID operations that are consistent with how the Project operated in the past (Runs 15, 15a, 15b, and 15c). The simulated changes in EPCWID operations generally consisted of increased use of drain flows for irrigation and charging EPCWID for all of the water that it uses. The results of these runs show that EBID allocations and deliveries would increase in average and dry years.

113. Based on discussion with New Mexico representatives and legal counsel, several ILRG Model runs were made to simulate various conjunctive use scenarios (Runs 16, 16a, 17, 17a, and 18). The results for Runs 16 and 16a are described in detail in the supplemental rebuttal expert report of Ms. Barroll (2020b), and the results for Runs 17, 17a, and 18 are detailed in the supplemental rebuttal expert report of Mr. Lopez (2020b).

Section 31.0 - Sensitivity Analyses of ILRG Model

114. Alternative runs of the updated ILRG Model were made to test the sensitivity of the model results to changes in certain input parameters and input data. The

sensitivities of model results were evaluated based on differences in alternative simulations of Run 3 (No New Mexico Pumping) and Run 1 (Historical Base Run). The results of the sensitivity analyses showed the simulated effects of pumping were most sensitive to changes in crop irrigation requirements. The results showed moderate sensitivity to changes in canal bed conductance, and minor sensitivity to changes in river bed conductance, drain bed conductance, and alluvial aquifer hydraulic conductivity.

18.0 RESPONSE TO REVISED TEXAS ANALYSES SUBMITTED WITHOUT A REBUTTAL REPORT

Certain of the analyses prepared by Texas experts, M&A and Dr. Dorrance, were updated to address some of the criticisms of the New Mexico experts. Neither M&A nor Dr. Dorrance submitted a rebuttal report or a supplemental report describing their updated analyses. Rather, the revised analyses were submitted as part of the materials relied upon by Texas expert Dr. Sunding for his rebuttal report. Upon learning of these revised analyses, legal counsel requested backup for the analyses and provided this information to SWE.

The SWE Report contained comparisons of results from simulations of the ILRG Model performed by the New Mexico experts to runs of the Texas Model performed by Dr. Hutchison. While Dr. Hutchison did not submit any new runs of the Texas Model, it was necessary to revise the comparisons of the model results to incorporate the results of the simulations made using the updated ILRG Model that are described in Section 30.0.

Discussion of the revised M&A Farm Budget analysis for EPCWID (El Paso Valley), the revised Dorrance analysis, and the updates to the comparisons of the ILRG Model and Texas Model results is provided below, and updated figures and tables relevant to these topics are included in **Appendix 18**.

18.1 Revised M&A Farm Budget Analysis

The May 31, 2019 expert report from M&A included a water budget analysis of irrigation operations by EPCWID and HCCRD in the El Paso Valley that was used in analysis of alleged damages to Texas from water quality impacts caused by New Mexico pumping during the period from 1985 – 2016. A revision to the M&A water budget analysis of EPCWID (El Paso Valley) was used in the updated damages analysis by Dr. Sunding.

The Goldsim Model input and output files and associated Excel spreadsheets that comprised the revised M&A Farm Budget Model and output for the revised analysis of EPCWID operations in the El Paso Valley were provided to SWE for review. The following is a summary of the changes to the M&A farm budget analysis of EPCWID (El Paso Valley) and our responses.

- <u>On-Farm Conveyance Efficiency</u> – The on-farm conveyance loss in the revised M&A Farm Budget Model of EPCWID (El Paso Valley) was changed from 10% to 2%. The basis for the revised on-farm conveyance loss was not provided in the Texas rebuttal materials. Nor was any basis provided as to why it is appropriate to change the on-farm conveyance loss for EPCWID (El Paso Valley), but leave the on-farm conveyance loss in the other M&A Farm Budget Models of the Rincon basin, the Mesilla basin, and HCCRD at 10%. As a sensitivity analysis, the M&A Farm Budget Models for Rincon basin and Mesilla basin were rerun by adjusting the on-farm conveyance loss (FCE) in the M&A input file from 10% to 2%, and the average annual simulated supplemental pumping in the Rincon and Mesilla basins declined by a combined total of 12,500 AF during 1985 - 2016.

- 2010 FHG Delivery Data – As described in the SWE Report, it appeared that the BOR FHG delivery data used by M&A for EPCWID (El Paso Valley) in 2010 were in error. While this error was corrected in the revised M&A farm budget analysis, disagreement with the method that M&A used to estimate EPCWID (El Paso Valley) FHG deliveries after 2008 remains.

- EPCWID Irrigated Area – The New Mexico experts criticized the irrigated area data used in the original M&A Farm Budget Model of EPCWID (El Paso Valley) because prior to 2011 it appeared to include the irrigated area for the Texas portion of the Mesilla Valley. The pre-2011 irrigated area values in the revised M&A farm budget analysis for EPCWID (El Paso Valley) were reduced, but the basis for the reduced values was not described in the rebuttal materials provided by Texas, and it was not clear if the reduction was to correct for the apparent error or for other reasons.

The results for the M&A Farm Budget Model of EPCWID (El Paso Valley) were compared to the results from the SWE CFB Model in **Figure 12-12** – **Figure 12-14** of the SWE Report. Updated versions of these figures with the results from the revised M&A Farm Budget Model are provided in **Appendix 18**. The following are comparisons of the 1985-2016 annual averages from the SWE CFB Model to the outputs from original and revised M&A Farm Budget Models.

Comparison of 1985-2016 Annual Averages
SWE CFB Model vs. M&A Farm Budget Model
EPCWID (El Paso Valley)

Quantity	SWE	M&A Original	M&A Revised	M&A Rev minus SWE	% Diff
Irrigated Area (ac)	37,900	43,200	38,800	+900	+2.3%
FHG Deliveries (AF)	116,800	104,400	100,100	-16,700	-14.3%
Unit ET (ft)	2.48	3.18	3.17	+0.69	+28.0%
ET Volume (AF)	93,400	137,200	122,700	+29,300	+31.4%
Irrigation Pumping (AF)	14,300	78,900	58,000	+43,800	+306.9%

The corrections to the irrigated area closed the gap in average annual irrigated area, but the revised M&A value remains 2.3% greater than the SWE value.

The correction to the 2010 FHG deliveries further increased the difference in average annual FHG deliveries, with the M&A value being 14.3% less than the SWE value. As described in the SWE Report, the difference between the M&A and SWE FHG deliveries appears to be due to differences in how the reported total EPCWID FHG deliveries were disaggregated between the Texas Mesilla and the El Paso Valley, with the M&A method providing unrealistically low results for the El Paso Valley FHG deliveries in many years.

The change to the M&A weighted average unit ET was minimal, and it remains 28% greater than the weighted average value in the SWE farm budget during the 1985-2016 period. This difference is due to differences in ET values for individual crops and differences in the annual crop mix.

The difference in ET Volume has decreased, but the average in the M&A Farm Budget Model is 31.4% greater than in the SWE CFB Model of EPCWID (El Paso Valley).

The revisions to the irrigated area, FHG deliveries, and the on-farm loss narrowed the difference in the computed pumping in EPCWID (El Paso Valley). However, the average annual pumping in the M&A Farm Budget analysis of 58,000 AF is still much greater than the 14,300 AF average in the SWE CFB Model.

While the revisions to the M&A farm budget analysis have reduced the differences between the pumping for EPCWID (El Paso Valley) computed by M&A and SWE, the opinions and criticisms of the M&A farm budget analysis that were originally presented in the SWE Report remain valid, most notably the unrealistically high M&A estimates of consumptive use and pumping.

18.2 Revised Comparisons to Texas Model Results

Dr. Hutchison has not submitted additional or revised runs of the Texas Model. However, because of the updates to the ILRG Model and the revised ILRG Model runs described in Section 30.0, it was necessary to update **Figure 13-1** and **Figure 13-2** from the SWE Report to reflect the revised ILRG Model results. These updated figures are included **Appendix 18**. The revisions to these figures did not change the overall conclusions and opinions regarding the Hutchison Report that were presented in the SWE Report.

18.3 Revised Dorrance Analyses

The May 31, 2019 expert report from Dr. Dorrance included analyses that translated simulated changes in the annual flows for the Rio Grande at El Paso computed using the Texas Model into estimated changes in monthly surface water deliveries to EPCWID farmers, HCCRD farmers, and EPW municipal water users. The Dorrance Report also describes the effect that changes in the monthly surface water deliveries would have on the salinity of the mixed surface water and ground water supplies of farmers and municipal water users.

While Dr. Dorrance did not submit a rebuttal report on behalf of Texas, she did prepare a revised analysis to translate the depletions of the Rio Grande at El Paso caused by New Mexico pumping from the Texas Model into effects on deliveries to Texas farmers, HCCRD farmers, and to EPW for M&I use. The analysis was revised to incorporate the results of the updated farm budget analysis of EPCWID (El Paso Valley) that was prepared by M&A as described Section 18.1. An Excel spreadsheet containing the revised Dorrance analysis was provided to SWE for review.

The additional available flow from the simulated reduction in New Mexico pumping used by Dorrance did not change because there were no new runs of the Texas Model submitted with the Texas rebuttal reports. However, the increases in deliveries to Texas water users and reductions in simulated pumping computed by Dorrance did change as a result of the corrected 2010 FHG deliveries and the reduced pumping provided as part of the revised M&A farm budget analysis of EPCWID (El Paso Valley). Updated versions of

Figure 14-1 – **Figure 14-3** from the SWE Report reflecting the updated Dorrance analysis are provided in **Appendix 18**.

The results from the updated Dorrance analysis were also used to prepare revised comparisons between her estimates of the increased deliveries to Texas water users that would occur with a reduction in New Mexico pumping to the increased deliveries to Texas users in the ILRG Model simulation of no New Mexico pumping (Run 3). These updated comparisons are provided in the revised **Figure 14-4** – **Figure 14-7** that are included in **Appendix 18**.

The revisions to the Dorrance analysis described above do not change the overall conclusions and opinions regarding the Dorrance Report that were originally presented in the SWE Report.

18.4 Revised Sunding Analyses

The May 31, 2019 expert report from Dr. Sunding computed alleged damages to Texas resulting from the increased Texas pumping for irrigation and M&I uses due to the effects of pumping by New Mexico computed by the Texas experts. According to Dr. Sunding, the increased pumping in Texas caused by New Mexico pumping increased the salinity of the mixed surface water and ground water supply used in Texas for irrigation (in EPCWID and HCCRD) and M&I uses resulting in economic damages that were quantified during 1985 – 2016.

Dr. Sunding used the revised Dorrance analysis described above to recompute the damages to Texas generally in accordance with the procedures set forth in the original Sunding Report.

The responses to the Sunding Report contained in the SWE Report did not rely on ILRG Model runs or any other analyses by the New Mexico experts that were updated since the original expert reports were prepared. As a result, it was unnecessary to update any of the responses to the Sunding opinions, and all responses and associated data, information, summaries contained in Section 15.0 of the SWE Report remain valid.

19.0 RESPONSE TO FERGUSON REBUTTAL REPORT

Ian M. Ferguson, Ph.D., P.E. prepared a December 30, 2019 rebuttal expert report on behalf of the United States ("Ferguson Rebuttal Report") that describes his rebuttal opinions to expert reports prepared on behalf of New Mexico by Margaret Barroll, Estevan Lopez, Gregory K. Sullivan and Heidi M. Welsh (SWE Report), and John C. Carron and Steven T. Setzer.

SWE was asked by legal counsel for New Mexico to review the Ferguson Rebuttal Report and to prepare expert opinions to respond the opinions of Dr. Ferguson. A lack of response regarding a particular issue should not be interpreted as tacit agreement with the Ferguson opinions on that issue.

Ferguson Opinion 1 – *Estimates of groundwater pumping provided in the expert report of Sullivan and Welsh indicate that more than 80% of the total groundwater pumping in the Rincon and Mesilla Valleys occurs in New Mexico and less than 20% occurs in Texas; similar estimates are provided in the expert report of Hutchinson. While the relative amount of annual pumping in each state varies from year to year, these studies indicates that the relative amount of cumulative pumping has remained consistent since the late 1960s. (page 3).*

Response:

Contrary to Dr. Ferguson's assertion, the relative amounts of New Mexico and Texas annual pumping in the Rincon and Mesilla Valleys have not remained constant since the late 1960s. The upper chart in **Figure 19-1** shows that total annual New Mexico pumping (sum of irrigation and M&I pumping) as blue bars and the total annual Texas Mesilla pumping as orange bars from 1940 – 2017. The annual New Mexico and Texas pumping as percentages of the total pumping in the Rincon and Mesilla Valleys are shown as blue and orange lines, respectively in the lower chart in **Figure 19-1**. The graph shows that the Texas pumping percentage exceeded 20% in 16 years between 1974 and 2000.

As shown in **Figure 19-1**, the Texas pumping as a percentage of the total pumping in the Rincon and Mesilla Valleys has declined in recent years due to the increase in New Mexico pumping that has occurred in large part due to the effect of the 2008 OA that significantly reduced New Mexico's allocation of Project water, resulting in a significant increase in unmet irrigation demand that was met by pumping.

Ferguson Opinion 2 – *Model simulation results presented in the expert report of Sullivan and Welsh and the expert report of Hutchinson further suggest that the depletion of Project surface water supplies is roughly proportional to the cumulative amount of* *pumping, with approximately 80% of the total depletion of Project supplies in the Rincon and Mesilla Valleys resulting from groundwater pumping in New Mexico and approximately 20% resulting from groundwater pumping in Texas. (page 3).*

Response:

The relative impact of New Mexico pumping and Texas Mesilla pumping on Rio Grande at El Paso flows was computed using results from the ILRG Model runs described in Section 30.0. Annual depletions to El Paso flow were computed based on differences in simulated El Paso flow between no pumping runs and the Historical Base Run (Run 1). Annual depletions from 1950 - 2017 for New Mexico pumping (Run 3 minus Run 1), Texas Mesilla pumping (Run 7 minus Run 1), and all Rincon-Mesilla pumping (Run 6 minus Run 1) are shown in the upper chart in **Figure 19-2**.

Annual depletions from New Mexico pumping and Texas Mesilla pumping as percentages of the depletions from all Rincon-Mesilla pumping are shown in the lower chart in **Figure 19-2**. The relative effects of Texas Mesilla pumping on Rio Grande at El Paso flows are often much greater 20%.

Ferguson Opinion 3 *– With respect to groundwater pumping in the El Paso Valley (Hueco Bolson aquifer), model simulation results presented in the expert report of Sullivan and Welsh indicate that the effects of groundwater pumping in the El Paso Valley on historical Project diversions and deliveries to Elephant Butte Irrigation District ("EBID") are negligible. Groundwater pumping in El Paso Valley no longer impacts Project deliveries in El Paso Valley due to the construction of the American Canal Extension ("ACE"), which eliminates the effects of groundwater/surface-water interactions on Project deliveries in the El Paso Valley. (page 3).*

Response:

Prior to construction of the ACE, depletions of the Rio Grande upstream of Riverside Dam affected Project deliveries to the Riverside Canal, requiring more releases from Project storage to the Riverside Canal than would be necessary without pumping from the Hueco Bolson in the El Paso Valley ("Hueco").

Depletions to the Rio Grande downstream of American Dam affect deliveries of 1906 Treaty water to Mexico at the Acequia Madre. In addition, depletions to river flows downstream of American Dam would affect downstream diversions from the river (if any) by HCCRD at the structure that can supply the Hudspeth Feeder Canal.

Hueco pumping also increases seepage from EPCWID canals and laterals (MMA, 2019). The increased seepage losses in the EPCWID service area require additional Project releases to deliver orders for Project water to EPCWID farmers. The increased seepage losses also reduce the amount of waste and drain flows from EPCWID that can be delivered to the headgates of HCCRD farmers.

Finally, Hueco pumping also depletes EPCWID drain flows that accumulate in the Fabens Waste Drain and the Tornillo Drain. Historical BOR records show EPCWID diverted water from the Fabens Waste Drain until the early 1980s for irrigation in the Tornillo area. Therefore, Hueco pumping reduced the drain supply that comprised a portion of the irrigation supply delivered to Tornillo area farmers until the early 1980s, and would still be depleting that supply if EPCWID had not ceased diverting from the Fabens Waste Drain.

Depletions of drain flows that reach the Fabens Waste Drain as well as depletions of Tornillo Drain flows reduce the supply leaving the EPCWID service area that is the primary source of supply to HCCRD farmers. The effect of Texas Hueco irrigation pumping on drain flows is illustrated in **Figure 19-3** which compares the monthly net recharge from the SWE CFB Model (orange line; defined as canal seepage plus deep percolation minus irrigation pumping) to the sum of the Fabens Waste Drain and the Tornillo Drain (blue line). Comparison of the lines in **Figure 19-3** shows that the simulated drain flows fluctuate up and down with the fluctuation in net recharge. During extended drought periods such as the mid-1950s, the net recharge declined due in large part to pumping, becoming negative at times (pumping exceeded the sum of canal seepage and deep percolation), and this resulted in the drain flows declining substantially and even drying up. The accumulated effect of the negative recharge during the 1950s drought is seen in the slow recovery of the drains after the drought, when it took two or three years for the drains to recover.

The impacts of Hueco pumping on surface water flows are ongoing and are reflected in the ILRG Model results for Runs 4, 5, 8, 10, 14, 14a, and 15c that are discussed in Section 30.0.

While Hueco pumping has impacted and continues to impact EPCWID and HCCRD water supplies, these impacts have been partially offset by increases in EPW WWTP discharges from pumping. The offsetting effects of the EPW WWTP discharges from pumping are immediate and concentrated in the EPCWID service area as opposed to the depletive effects of Hueco pumping, particularly the M&I pumping by EPW and Juarez, that are significantly lagged in time and distributed geographically throughout the El Paso Valley.

The combined effect of Texas Hueco pumping and Texas WWTP offsets is reflected in Run 14a of the ILRG Model that is described in Section 30.0. In this run, all Texas Hueco irrigation and non-irrigation pumping was turned off as well as the WWTP returns and urban deep percolation returns from the non-irrigation pumping. Differencing the results from Run 14a and Run 1 (Historical Base Run) reflects the net effect of Texas Hueco pumping and Texas Hueco returns. The following is a summary of the differences in EBID diversions and FHG deliveries averaged over two periods of time:

Average Annual Change in EBID Supply
from Turning Off Texas Hueco Pumping and Return Flows
(Run 14a minus Run 1)
(acre-feet)

Output	1951-1978	2006-2017
Diversions	-600	-7,800
FHG Deliveries	-300	-4,000

The impacts of Texas Hueco pumping are relatively small due in part to the offsetting effect of the Texas WWTP discharges (although there are some years with larger impacts). To illustrate this, a Run of the ILRG Model was made in which all Texas Hueco pumping was turned off, but leaving on the Texas WWTP returns at the historical levels (Run 14d). Comparison of Run 14d to Run 1 shows the effect of Texas Hueco pumping without the Texas WWTP offset. The following is a summary of the average changes in EBID diversions and FHG deliveries that would be caused by Texas Hueco pumping without the Texas WWTP offset:

Average Annual Change in EBID Supply
from Turning Off Texas Hueco Pumping without WWTP Offset
(Run 14d minus Run 1)
(acre-feet)

Output	1951-1978	2006-2017
Diversions	8,200	3,400
FHG Deliveries	5,000	2,000

Another run of the ILRG Model was made to isolate the effect of the Texas WWTP offsets. In this run, all Texas WWTP discharges were turned off, but all of the Texas pumping (irrigation and EPW pumping) was left on (Run 14c). The results show that without the Texas WWTP offsets, EBID diversions and FHG deliveries would decrease by the following average volumes:

Average Annual Change in EBID Supply
from Turning Off Texas WWTP Discharges
(Run 14c minus Run 1)
(acre-feet)

Output	1951-1978	2006-2017
Diversions	-15,200	-25,000
FHG Deliveries	-8,200	-11,700

The above comparisons clearly show that Texas Hueco pumping would have a greater impact on deliveries to EBID without the offsetting effect of the Texas WWTP discharges. In order to minimize the effect of Texas Hueco pumping on Project operations going forward it is essential that the Texas WWTP offsets continue and are a part of a future EPCWID compliance requirement. This means that the EPW WWTP discharges to the EPCWID canal system must continue to be part of the irrigation supply that is used by EPCWID farmers. If EPW found another use for its WWTP discharges (e.g., nonpotable reuse or sale to others), the effects of Texas Hueco pumping on EBID would increase.

Ferguson Opinion 4 – *Estimates of groundwater pumping in the Rincon Valley and the New Mexico portion of the Mesilla Valley provided in the expert report of Sullivan and Welsh show that groundwater pumping in New Mexico increased from 1985 to 2002, despite full diversion allocations to EBID through this period. Pumping in New Mexico continued to increase from 2003 to 2005, prior to the implementation of the "D3 Method" allocation procedure. (page 5).*

Response:

Dr. Ferguson's observation about increases in EBID ground water pumping during the full allocation years of 1985 – 2002 ignores that pumping during this period was generally lower than the EBID pumping in the full allocation years of 1979 – 1984. The upper chart in **Figure 19-4** shows the simulated annual EBID supplemental irrigation pumping from 1948 – 2017. The lower chart in **Figure 19-4** shows the annual EBID supplemental irrigation pumping during 1979 – 2017 along with the reported annual EBID allocations and delivery charges.

The simulated annual volume of EBID supplemental ground water pumping varies based on the unmet demand which is a function of the irrigation demand and the surface water supply. The irrigation demand is affected by the irrigated area, crop mix, weather conditions, and irrigation efficiency. Surface water supply is affected by the Project water allocation and how much Project water is called for and delivered to the farms. Given all of the factors that contribute to variations in pumping to meet unmet demand, the simulated variability in supplemental pumping during the full supply years from 1979 – 2005 is not surprising, and it has not been shown to be indicative of any upward or downward trend in supplemental pumping. As described in the Barroll Rebuttal Report (2020a), over the long term, to the extent there has been a shift to higher water consuming crops in EBID, this has been offset by overall reductions in irrigated area.

Ferguson Opinion 5 *– Increases in groundwater pumping in New Mexico occurred prior to the OA due to increases in water demands for supplemental irrigation within EBID, increases in water demands for irrigation of groundwater-only lands outside of EBID, and increases in water demands for domestic, municipal, industrial, and commercial uses. Current demands within EBID exceed the historical full-supply delivery of 3.024 AF per acre. (page 5).*

Response:

Dr. Ferguson appears to assert that EBID pumping increased during the time that the D1/D2 allocation procedure was in effect from 1979 – 2005 before it was replaced by the 2008 OA accounting that commenced in 2006. **Figure 19-5** is a stacked bar chart showing the annual pumping in New Mexico comprised of supplemental pumping in EBID, primary ground water pumping outside of EBID, and total M&I pumping. **Figure 19-5** shows that the total pumping in New Mexico actually decreased from an average of 179,100 AF/y during 1951 – 1978 (period used to develop the D1 and D2 Curves) to an average of 109,600 AF/y in 1979 – 2005 (period of D1/D2 accounting).

The normal or full supply delivery of 3.024 AF/ac was computed by the BOR based on analysis of actual Project water deliveries during 1946 – 1950 (Friedkin and Resch 1956). This represents the water supply that the BOR determined was sufficient in the late 1940s to meet average annual irrigation water demands. This unit full supply delivery was multiplied by the authorized Project acres in EBID (90,640 acres) and EPCWID (69,010 acres) to compute the average annual full supply delivery volume for the authorized Project acres. The actual annual FHG delivery demands for EBID and EPCWID were computed as the crop-weighted CIR multiplied by the reported annual irrigated acres divided by the estimated farm irrigation efficiency used in the CFB Models (increased from 65% before 1950 to 75% after 1984). The historical EPW diversions were added to the computed EPCWID FHG demands.

Figure 19-6 compares the average annual full supply delivery determined by the BOR for the authorized Project acres (dashed lines) to the computed annual FHG delivery demands in EBID and EPCWID (solid lines) for the period from 1940 – 2017. This comparison shows that the EBID FHG delivery demand consistently exceeded the BOR estimate during most years from 1951-1978. Since that time, the demand has remained above the BOR estimate in most years, but as shown in the inset table in **Figure 19-6**, the average FHG demand has declined since the D1/D2 period by an average of 27,900 AF. The annual EPCWID FHG demand (plus EPW Project water deliveries) was above the BOR estimate in the 1940s and 1950s, fluctuated above and below the estimate during the 1960s and 1970s, and has been generally less than the BOR estimate since then.

Ferguson Opinion 6 *– Increased groundwater pumping to meet these demands, and the corresponding impacts on Project surface-water supplies, was a major driver in negotiation of the OA. The reduction in EBID's annual diversion allocation under the "D3 Method" was negotiated as a means to offset these impacts. Under the "D3 Method," EBID foregoes a portion of its annual diversion allocation to offset the impacts of groundwater pumping in New Mexico on Project allocations and deliveries to EPCWID. (page 5).*

Response:

As discussed in Section 11.0 of the SWE Report, the D1 and D2 curves implicitly grandfathered in the effects of pumping during 1951 – 1978 by New Mexico, Texas, and Mexico on Project performance and Project deliveries. Contrary to Dr. Ferguson's assertion, the 2008 OA does not include any explicit statements that its purpose was to address only increases in pumping impacts after the D1/D2 period.

Historical pumping data and information from the SWE CFB Models were compiled to characterize and compare surface water and ground water use during and after the 1951 – 1978 D1/D2 period. The results are presented in **Figure 19-7** through **Figure 19-11** which are described below.

Pumping

Figure 19-7 shows the annual New Mexico pumping from 1940 – 2017. The upper chart shows the EBID irrigation pumping (blue bars). The maximum annual pumping during the D1/D2 period is shown as a horizontal black line and the average annual pumping during that period is shown as a horizontal blue line. Since the D1/D2 period there has been only one year (2011) with irrigation pumping that exceeded the D1/D2 period maximum. The running 10-year average pumping (red line) has only exceeded the D1/D2 average during the dry years from 2012 – 2017 when the 2008 OA was in effect. Therefore, Dr. Ferguson is wrong to imply that implementation of the 2008 OA was to address increased irrigation pumping in New Mexico after the D1/D2 period.

The lower chart in **Figure 19-7** shows the New Mexico M&I pumping from 1940 – 2017. The maximum annual pumping during the D1/D2 period is shown as a horizontal black line and the average annual pumping during that period is shown as a horizontal blue line. The New Mexico M&I pumping steadily increased after the D1/D2 period through about 2000 and has since leveled off. The annual New Mexico M&I pumping following the D1/D2 period has been above the D1/D2 maximum during most years. However, a portion of the impacts of the New Mexico M&I pumping is offset by WWTP discharges and urban deep percolation return flows. As is shown in the results for Run 9 described in Section 30.0, the impacts of New Mexico M&I pumping on EPCWID FHG deliveries averaged less than 1,500 AF/y during 1985-2017.

Figure 19-8 shows the annual Texas pumping from 1940 – 2017. The upper chart shows the sum of EPCWID and HCCRD irrigation pumping from 1940 – 2017 in the same format as **Figure 19-7**. Since the D1/D2 period there have not been any years that the irrigation pumping exceeded the D1/D2 maximum. The running 10-year average pumping (red line) exceeded the D1/D2 average during 1979 and 1980.

The lower chart in **Figure 19-8** shows the Texas M&I pumping from 1940 – 2017 in the same format as **Figure 19-7**. The Texas M&I pumping increased steadily throughout the D1/D2 period, leveled out during the 1980s, and then declined through the 1990s and 2000s. The annual M&I pumping then rose during the 2010s and has declined again during recent years. The annual Texas M&I pumping since 1978 has not exceeded the maximum during the D1/D2 period, however the running 10-year average pumping exceeded the D1/D2 average until the 2008 and since that time it has hovered near the D1/D2 average.

Consumptive Use

Figure 19-9 shows the annual New Mexico consumptive use comprised of surface water (grey bars) and pumping (irrigation and M&I) (light blue bars). The annual average total consumptive use during the D1/D2 period is plotted as a horizontal blue line and the 10-year running average total consumptive use is plotted as a red line. The running 10-year average consumptive use has remained slightly above the D1/D2 average since until the mid-1990s, and is currently about 21,000 AF above the D1/D2 average.

Figure 19-10 shows the annual Texas consumptive use of surface water (orange bars) and pumping (irrigation and M&I) (yellow bars). The annual average total consumptive use during the D1/D2 period is plotted as a horizontal blue line and the 10-year running average total consumptive use is plotted as a red line. The running 10-year average consumptive use remained slightly above the D1/D2 average until the early 2000s, after which it declined and is currently about 30,000 AF below the D1/D2 average.

Figure 19-11 shows the annual Texas plus Mexico consumptive use comprised of Texas surface water (orange bars), Texas pumping (irrigation and M&I) (yellow bars), Mexico surface water (dark green bars), and Mexico pumping (irrigation and M&I) (light green bars). The annual average total consumptive use during the D1/D2 period is plotted as a horizontal blue line and the 10-year running average total consumptive use is plotted as a red line. The running 10-year average consumptive use rose steadily above the D1/D2 average until the early 2000s. Since that time, the 10-year average consumptive has declined, but currently remains about 44,000 AF above the D1/D2 average.

Ferguson Opinion 7 *– Model simulation results presented in the expert report of Sullivan and Welsh indicate that the effects of groundwater pumping in El Paso Valley, including pumping in Texas and Mexico, on historical Project deliveries is negligible. (page 11).*

Response:

See response to Ferguson Opinion 2.

Ferguson Opinion 8 *– Reclamation ensures that diversion allocations do not exceed the amount of water that can be physically delivered to Project diversion points and accounted for under Project water accounting procedures. Allocations are constrained by the available Project supply, including return flows, as accounted for under Project water accounting procedures. Water orders by EBID, EPCWID, and US-IBWC on behalf of Mexico are subsequently constrained by each entity's allocation. Reclamation will not allocate water that cannot be delivered, and will not accept a delivery order that cannot be met. Therefore, the fact that all delivery orders were met cannot be interpreted as all demands being met. (page 12).*

Response:

Figure 19-12 was prepared to summarize EPCWID's historical use of Project water, irrigation pumping to meet unmet demand determined in the CFB Model, and unused allocation from 1940 – 2017. The annual EPCWID FHG demand is shown as a black line and was computed as the EPCWID FHG deliveries plus EPCWID irrigation pumping plus the historical deliveries of Project water to EPW. The historical FHG deliveries of Project water for irrigation are depicted as grey bars, the historical deliveries of Project water to EPW are shown as light blue bars, and the pumping to meeting unmet irrigation demand is shown as dark blue bars. The unused allocation for EPCWID was computed for the period 1979 – 2017 as the final allocation minus the reported delivery charges and is shown as orange bars.

The summary in **Figure 19-12** shows that there was substantial unused allocation in many years during 1979 – 2017. The unused allocation exceeded 30,000 AF in 26 years (67%), 50,000 AF in 20 years (51%), and 70,000 AF in 14 years (36%). The years with substantial unused allocation generally coincide with years of little or no supplemental irrigation pumping, thus confirming that the unused EPCWID allocation generally occurs in years when the EPCWID irrigation demands are met.

Ferguson Opinion 9 *– Increased operational waste from EPCWID in El Paso Valley from 1979-2002 was primarily the result of extremely wet hydrologic conditions throughout this period. As shown in the expert report of Sullivan and Welsh, operational waste from El Paso Valley was generally greater than 15% of total diversions from 1938-1950, generally less than 10% from 1951-1978, and generally greater than 15% from 1979-2002. Fluctuation in operational waste are consistent with fluctuations in hydrologic conditions: the period 1938-1950 was dominated by extremely wet hydrologic conditions; the period from 1951-1978 was dominated by dry and normal conditions; and the period from 1979-2002 was again dominated by extremely wet conditions. Operational waste increased during wet hydrologic conditions due to increases in storm runoff and greater than anticipated bypass and return flows from the Rincon and Mesilla Valleys. In addition, operational waste during the 1980s and 1990s included large amounts of water ordered by EBID but not diverted. Increased operational waste during this period did not result from negligence or improper operations by EPCWID or Reclamation. (page 19).*

Response:

While operational waste can fluctuate based on water supply conditions with more waste in wet years and less waste in dry years, Project records show that there was an increase in EPCWID waste after EPCWID took over operation from the BOR in 1979 that cannot be attributed solely to changes in water supply conditions. Additional analysis of the available water supply in the El Paso Valley was performed to further assess the reported increases in operational waste that occurred in EPCWID after the BOR relinquished operation of the EPCWID system.

The Rio Grande Project was conceived and initially operated to use all available water supplies to meet Project water deliveries. This included use of all available return flows between the Caballo Reservoir outlet and the last diversion from the river at Tornillo that supplied the Tornillo Canal.

The Rio Grande Rectification project in the late 1930s changed the surface water plumbing in the El Paso Valley so that most of the flows were conveyed through the EPCWID service area to EPCWID farmers using the canal system (including the part of the Rio Grande that was converted to an extension of the Riverside Canal), and from EPWCID to the HCCRD more in drains and less in the relocated Rio Grande channel.

As a result of the replumbing of the system in the Fabens area, return flows that previously were conveyed in the river and diverted to supply the lower portion of the EPCWID service area in the river instead were conveyed using canals and drains. Regardless of the conveyance mechanism, WWTP discharges and drain flows in the Fabens area have always been a portion of the supply available for use within the EPCWID service area.

Consistent with the Project planning described in the RGJI, it is reasonable to expect that WWTP discharges and drain flows that arise within the EPCWID system should be efficiently used by EPCWID farmers in order to reduce unnecessary releases from Project storage that could be saved and conserved for subsequent allocation and use.

Historical records of flows available for use in the El Paso Valley portion of EPCWID were tabulated and analyzed to determine how efficiently the available flows have been used and whether the records provide additional information as to the reasons for the increases in reported EPCWID operational waste that were described in the SWE Report.

A schematic diagram prepared by MMA that illustrates the EPCWID water distribution and drainage system is provided in **Figure 19-13**. Canals and laterals are shown as blue lines, wasteways as black lines, and drains as red lines. Long-term flow measurement locations are depicted as triangles.

The surface water supply available for use in the El Paso Valley portion of EPCWID has historically been comprised of (a) Rio Grande diversions at American Canal, (b) drain flows, and (c) discharges from EPW WWTPs.

Discharges from EPW WWTPs have long been a part of the supply used by EPCWID farmers. These include discharges to the Riverside Canal from the Socorro WWTP (1967-1992) and later from the Bustamante WWTP (1991 – present), discharges to the Rio Grande upstream of the Riverside Canal heading from the Haskell WWTP (until 1999), and discharges to the ACE from the Haskell WWTP (1999-2017). A chart illustrating the WWTP discharges to EPCWID canals from 1967 – 2017 is shown in **Figure 19-14**. Total irrigation season discharges to the EPCWID canal system have increased from about 5,000 AF/y in the mid-1960s to approximately 30,000 AF/y in recent years. These WWTP discharges comingle with other supplies in the EPCWID distribution system and comprise a portion of the available irrigation supply.

Drain flows collected in the Fabens area are another supply that is available and has historically been used for irrigation by EPCWID farmers. There are daily records of diversions from the River Drain to the Riverside Canal Extension from 1945 – 1983. This is labeled as “Drain to Canal” in **Figure 19-13**. A chart summarizing the historical drain diversion data is provided in **Figure 19-15**. The blue line depicts the monthly average diverted flow and the orange line presents the daily maximum diversion in each month. The chart shows that monthly average drain flow diversions often exceeded 50 cfs in the 1940s and early 1950s while maximum diversions often exceeded 100 cfs. The maximum reported monthly diversion volume was 5,700 AF in July 1946.

Historical records of Fabens area irrigation season drain flows from 1940 – 2017 are summarized in **Figure 19-16**. Until 1983 the drain flow records include measurements at five drains that collected in the Fabens Waste Drain. The blue bars depict the flows of the River Drain and Middle Drain that flow into the River Drain upstream of the point where the diversions to the Riverside Canal Extension occurred until 1983. These are referred to as the “Usable Drains.” The other three bars represent flows in the Fabens Intercepting Drain, the Mesa Drain, and the Cuadrilla Drain that accrue to the Fabens Waste Drain downstream of where drain flows were diverted into the Riverside Canal Extension. These are referred to as the “Other Drains.”

Beginning in 1984, the Fabens area drain records are limited to measurements of the Fabens Waste Drain upstream of where it discharges into the Fabens Waste Channel. These records are plotted as the green bars in **Figure 19-16**. The drain flows measured at this location represent the accumulation of the flows contributed by all five drains that were separately measured until 1983. Therefore, the irrigation season totals depicted by the green bars from 1984 – 2017 are comparable to the sum of the flows of the five drains that were separately measured prior to 1984. On average during 1945 – 1983 when there are records of diversions from the River Drain to the Riverside Canal Extension, the average flow of the Usable Drains comprised approximately 70% of the total Fabens Drain flows during the irrigation season.

Figure 19-17 shows the total supply available to EPCWID users in the El Paso Valley from 1940 – 2017. The blue bars represent the historical EPCWID diversions[1] less the reported and estimated conveyance losses from the CFB Model, the yellow bars represent the total EPW discharges to the canal system, and the grey bars represent the usable Fabens drain flows[2]. The black line represents the total Project water deliveries to EPCWID users including deliveries to irrigation users and deliveries to EPW. The reported total supply to HCCRD is shown for comparison as the negative light blue bars. EPCWID flows in excess of EPCWID deliveries are represented by the portion of the stacked bars that project above the black line. These excess flows generally correspond to the total flows to HCCRD. The data presented in **Figure 19-17** shows that the EPCWID system was generally operated efficiently during most years from 1951 – 1979 with modest amounts of excess flow going to HCCRD.

Figure 19-18 presents a more detailed analysis of the excess flows (portion of bars above the black line) in **Figure 19-17**. Superimposed on the excess flow bars are lines depicting the unadjusted reported EPCWID waste in the WDR's (black line) and EPCWID waste adjusted to fill in missing data and to make other mass balance adjustments (red line). The data plotted in **Figure 19-18** show that the reported EPCWID waste generally corresponds with the sum of the excess EPCWID diversions and EPW WWTP discharges, but does not include the unused Fabens drain flows.

Additional insight on the flow exiting the EPCWID service is gained by analysis of the historical water supply for HCCRD. **Figure 19-19** is a stacked bar chart illustrating the historical irrigation season flows to HCCRD that are comprised of water tailing out of the Tornillo Canal at Alamo Alto (dark blue bars), the Tornillo Drain (grey bars) and the Hudspeth Feeder Canal (yellow bars). Also shown in **Figure 19-19** is a red line computed as 10% of the EPCWID diversions, which represents a reasonable upper limit of the waste that should be exiting the EPCWID service area. Comparison of the sum of the Tornillo Canal at Alamo Alto and non-drain flows in the Hudspeth Feeder Canal shows this sum is similar to the red line until 1980.

Table 19-1 contains a summary of the irrigation season totals depicted in **Figure 19-19**. The total waste exceeding a reasonable upper limit of 10% of the EPCWID supply is summarized in column 12. During 1980 – 2002, the waste to HCCRD in excess of 10% of the EPCWID supply averaged approximately 16,700 AF. Had the deliveries to EPCWID

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[1] Franklin Canal plus Riverside Canal minus Ascarate Wasteway plus EPW diversions.

[2] Sum of reported Middle Drain and River Drain flows from 1940 – 1983 and 70% of the reported Fabens Waste Drain flows from 1984 – 2017.

been managed more carefully to reduce the excess waste that flowed to HCCRD, additional water would have been conserved in Project storage that would have increased allocations to EBID and EPCWID in later years with less than full allocations.

The dramatic increase in supply to HCCRD that occurred after EPCWID took over operation is remarked upon in a report by Dr. Phillip King (2003) containing analyses of irrigation operations in the LRG Basin:

> *In his evaluation of the District Kirby (1978) presented a rather gloomy outlook for the District, understandable considering the 28 years of drought that preceded his investigation: "It would appear that the Hudspeth (sic) District may continue marginal agricultural operations at about current levels for perhaps another twenty years. At the end of that time, the district most probably will begin dissolution with only those few water users blessed with good soil drainage and reasonably good groundwater surviving as independent farmers."*
>
> *Ironically, the water supply began its wet cycle the very next year, and HCCRD has enjoyed three to nine feet of inflow per water righted acre ever since. If the current drought proves to be anything like the period of 1951-1978, Kirby (1978) may prove to be prophetic, but ahead of his time.*

Ferguson Opinion 10 *– Sullivan's and Welsh's use of correlation or regression analysis to fill missing data does not account for the effects of hydrologic conditions on Project operations. For example, operational waste from EPCWID in El Paso Valley was estimated based on correlations over the period 1951-2002. The early part of this period (1951-1978) is characterized by normal to extremely dry hydrologic conditions; the latter part of this period (1979-2002) is characterized by extremely wet hydrologic conditions. These conditions affect Project operations, including operational waste. Use of correlations based in part on extremely wet conditions (1979-2002) to estimate operational waste during recent years characterized by normal to extremely dry hydrologic conditions (2003-2018) results in a significant over estimation of recent operational waste. (page 21).*

Response:

Contrary to Dr. Ferguson's statement, the regression analyses that were used to fill missing data in the SWDataSet did account for variations in hydrologic conditions. The regression relationships were developed using the available historical data which typically included wet, average, and dry years. Note that there was significant missing data that needed to be estimated for the pre-1940 period for use in the Hueco ground water model. Considering the data needs and time period, these pre-1940 regressions were largely performed using data from the 1930s and 1940s that would have been more representative of the looser operational practices that existed before the BOR tightened up operations with the onset of the drought in the early 1950s.

Dr. Ferguson goes on to complain that estimates of operational waste from EPCWID in the El Paso Valley for 2003 – 2017 are too high because they were based on a regression analysis of historical data from 1951 – 2002 that included a wet period from 1979 – 2002. His comments imply that the 1979 – 2002 historical data should have been excluded from the regression analysis.

EPCWID operational waste estimates from 2003 – 2017 were computed using a correlation with the total flows to HCCRD using historical data from 1951 – 2002 (excluding spill years) that included dry, average, and wet years. The data from this period generally show that EPCWID operational waste and HCCRD total diversions are lower in dry years and higher in wet years.

In order to assess Dr. Ferguson's contention that the 1979 – 2002 data influenced the regression relationship, the historical irrigation season (March – October) EPCWID waste data from 1951 – 2002 that were used in the regression analysis were plotted against irrigation season Caballo Reservoir releases in the scatter diagram in **Figure 19-20**. The blue dots in represent data for 1951 – 1978 and the orange dots show data for 1979 – 2002. While comparison of the blue dots and the orange dots indicates that reservoir releases were generally lower during 1951 – 1978 than during 1979 – 2002, the data also show that EPCWID waste was significantly greater after 1978 for similar reservoir releases. Therefore, it would be inappropriate to exclude the 1979 – 2002 data from the regression relationship because only using the blue dots would result in a regression relationship that would ignore the apparent change in operational practices that resulted in increases in operational waste for similar hydrologic conditions. If anything, it may be more appropriate to use only the data after 1978 since it would reflect the change in operational practices that is apparent in the data.

***Ferguson Opinion 11** – As shown in Figures 5-10, 5-12, and 5-14, FHG deliveries of Project water were not "relatively steady from the 1950s-1970s." Rather, FHG deliveries during this period varied from less than 0.5 acre-feet per acre to more than 2.5 acre-feet per acre (Figures 5-12 and 5-14). In addition, it should be clarified that FHG deliveries declined in the early 2000s relative to the wet period during the 1980s and 1990s, not relative to the 1950s-1970s. Recent FHG deliveries since 2003 are comparable to FHG deliveries during the 1950s-1970s; FHG deliveries during both of these periods reflect severe drought conditions. (page 22).*

Response:

Dr. Ferguson implies that the SWE report mischaracterized the changes in EBID FHG deliveries. However, the partially quoted language from the SWE Report accurately stated that "average annual farm headgate deliveries remained relatively steady from the 1950s – 1970s." This is indicated by the running 10-year average line in Figure 5-10. Further, the decline in FHG deliveries during the recent drought is described as a decline "since then" with "then" referring to the "1980s and 1990s."

Ferguson Opinion 12 *– Figure 5-15 indicates that the total applied water in EBID during the period 2008-2016 is slightly greater than the total applied water during the period 1984-1993. Figure 5-19 indicates that the total applied water in EPCWID, including deliveries to EPW, declined slightly during the 1980s, increased during the 1990s, and has generally declined since 2003. (page 22).*

Response:

As shown in Figure 5-15 of the SWE Report, the 10-year average total applied water for EBID declined from approximately 300,000 AF in the early 1980s to about 270,000 AF in recent years

Ferguson Opinion 13 *– Operational waste in during the period 1979-2002 is greater than during the period 1951-1978 due to extremely wet hydrologic conditions during this period. Operational waste during this period includes large amounts of water diverted in excess of district water orders, including storm runoff, greater than anticipated bypass and return flows from the Rincon and Mesilla Valleys, and water ordered by EBID and not diverted. Operational waste during this period is consistent with operational waste during the 1940s, which were also characterized by extremely wet hydrologic conditions. (page 22).*

Response:

As described in the response to Ferguson Opinion 9 and as shown in **Figure 19-20**, the reported EPCWID waste is greater after 1978 than before that time for years of similar releases from Project storage.

Irrigation season operational waste during the 1940s (excluding the 1942 spill year) averaged 87,400 AF which is much greater than the average of 67,400 AF during 1979 – 2002 (excluding spill years 1986, 1987, and 1995).

Ferguson Opinion 14 *– In addition, as noted above, the correlation analysis used to estimate operational waste for the period 2003-2016 incorrectly over-estimates* *operational waste. Lack of accounting for hydrologic conditions in estimating recent operational waste contributes to the incorrect conclusion that operational waste from 2003-2016 is excessive compared to operational waste from 1951-1978. (page 23).*

Response:

See the response to Ferguson Opinion 9.

Ferguson Opinion 15 – *This conclusion incorrectly implies or assumes that metering of pumping results in reduction of pumping, or that lack of metering of pumping results in an increase in pumping. The fact that groundwater pumping in New Mexico is metered has no bearing on the fact that groundwater pumping in New Mexico depletes Project water supplies. In addition, this conclusion incorrectly implies that recent increases in groundwater pumping in New Mexico are the result of reduced allocations to EBID under the OA; to the contrary, increased groundwater pumping in New Mexico and corresponding impacts on Project water supplies began decades before the Operating Agreement was adopted. Lastly, this conclusion fails to acknowledge that increased groundwater pumping in New Mexico, and the corresponding impacts on Project surface-water supplies, was a major driver in negotiation of the OA and that the reduction in EBID's annual diversion allocation under the "D3 Method" was negotiated as a means to offset these impacts. (page 23).*

Response:

Dr. Ferguson's statement that metering has no effect on pumping is contrary to statements in a report by Texas expert, Dr. Phillip King (2003) that analyzed irrigation water use in the Rio Grande Project. In a section of that report describing Farm Delivery Metering, Dr. King states the following:

> *It has been noted by several researchers that the very act of metering reduces the amount of water people use, though it is difficult to prove because there is no pre-metering baseline to which metered water usage can be compared. Newly installed meters often show an initial drop in use with time as water users adjust their management practices in response to the new information provided by the meters. Fipps (1999) suggested that metering is a necessary part of a water conservation program. The fact that farmers have quantitative metrics to guide their management can, in itself, significantly reduce water use by as much as 20 percent. (p. 108).*

While Dr. King's report was referring to metering of farm deliveries of surface water, the same logic would apply to ground water pumping. It costs money to pump ground water. If farmers have knowledge of how much water their crops require and how much their surface water and ground water sources supply, they can employ management practices such as irrigation scheduling to optimize their water use, minimize their operational costs, and maximize their profits.

Dr. Ferguson's assertion that increased New Mexico pumping is not the result of reduced allocations to EBID under the 2008 OA is illogical. **Figure 19-21** is a scatter plot of annual EBID supplemental pumping from the SWE CFB Model versus the annual EBID Project water allocation for 1979 – 2017. The blue dots represent data for the years that EBID's allocation was determined using the D1/D2 procedure (1979 – 2005) and the orange dots are data for the years that the D3 procedure under the 2008 OA was in effect (2006 – 2017). The chart shows clearly that as the EBID allocation declines, EBID supplemental pumping increases. Since 1979, the lowest annual EBID allocations have occurred under the 2008 OA resulting in the greatest annual supplemental pumping in 2011.

Simulations of the ILRG Model demonstrate that EBID supplemental pumping is greater under the 2008 OA than under D1/D2 accounting. Annual EBID pumping under Run 11 with D1/D2 allocation simulated in all years starting in 1950 averages 129,600 AF during 1951 – 2017. This compares to an average of 154,200 AF during the same period under the D3 + Carryover accounting of the 2008 OA. The results for these ILRG Model runs are presented and discussed in Section 30.0.

***Ferguson Opinion 16** – This conclusion incorrectly implies that the impact of groundwater pumping on the Project is proportionate to the volume of pumping, without consideration as to the location where pumping occurs. Modeling results provided with the expert report of Sullivan and Welsh demonstrate that groundwater pumping in New Mexico results in significant depletion of Project deliveries to EBID and EPCWID. These modeling results also demonstrate that groundwater pumping in the Texas portion of the Mesilla Valley results in much smaller depletions of Project deliveries to EBID and EPCWID (less than 25% of the depletion caused by pumping in New Mexico). In addition, these modeling results demonstrate that groundwater pumping in the Conejos-Médanos Basin (i.e., the Mexican portion of the Mesilla Valley aquifer) and in the Hueco Bolson have negligible impact on Project deliveries to EBID and EPCWID. (page 24).*

Response:

The Rio Grande Project is operated as an integrated system. Releases from storage are made to deliver orders for Project water, and the release amounts are varied in consideration of the gains and losses in the river system and the canal system. For any particular aggregate Project water demand, when net downstream gains increase, storage releases are reduced to meet that demand. Conversely, when downstream gains decrease, storage releases must be increased to meet the same demand.

Historical monthly records of reservoir releases, diversions, and Rio Grande flows were analyzed to assess the relationship between reservoir releases and downstream gains. These records included the following:

- Caballo Reservoir releases
- Arrey Dam diversions (Rincon)
- Leasburg Dam diversions
- Mesilla Dam diversions
- American Dam diversions
- Rio Grande Below American Dam flows
- Acequia Madre diversions

Except during periods of high flow and spills, the flow past American Dam is generally limited to the flow necessary to deliver the Mexico order at the Acequia Madre including river conveyance losses. This is illustrated in the scatter plot in **Figure 19-22** that shows the monthly Rio Grande below American Dam flow vs. the monthly Acequia Madre diversions from 1940 – 2017.

The total gain/loss between the Caballo outlet and American Dam was computed as the sum of the Rio Grande below American Dam plus diversions at American Dam plus all upstream river diversions minus the Caballo releases. **Figure 19-23** shows the historical monthly releases from Project storage, the gains and losses, and the total diversions between the Caballo Dam and American Dam. The graphs on the left side of **Figure 19-23** show the monthly Caballo Dam to American Dam diversions (black line), the monthly release (blue bars) and the monthly gain (+) or loss (-) (orange bars).

On the right side of **Figure 19-23** is a plot of the normalized monthly gain (+) or loss (-) against the normalized monthly Caballo release (both values normalized by the sum of the monthly Caballo to American Dam diversions). The results, which all plot along a straight line, show empirically that as monthly gain increases the reservoir release needed to meet the diversion decreases, and as the monthly gain decreases the reservoir release increases.

There is no disagreement that pumping in the Rincon and Mesilla Valleys affects the gains and losses between the Caballo Outlet and American Dam. Therefore, by logical extension to the gain/loss – reservoir release relationship shown in **Figure 19-23**, pumping affects reservoir releases. When more water needs to be released from storage to meet demands, this leaves less water in storage for subsequent use, and thus creates or exacerbates shortages in non-full supply years. Return flows from irrigation pumping and M&I pumping within the Rincon and Mesilla Valleys offset a portion of the impacts of pumping.

As with the impacts of pumping in the Rincon and Mesilla Valleys, there is a similar relationship among pumping, gains/losses, and reservoir releases within EPCWID. The BOR should be operating the Project to release only enough water from storage to meet the EPWICD demands with a minimum of waste, and net of the gain/loss within the EPCWID system. Since Hueco pumping increases the losses between American Dam and Riverside Dam (before 1999), increases conveyances losses through the EPCWID distribution system, and reduces the drain flows available for irrigation use, this requires increased releases from Project storage to meet EPCWID demands. This is how Hueco pumping affects upstream Project operations.

Under current Project operation and accounting, discharges from EPW WWTPs to EPCWID canals provide an offset to the negative effects on Project operations caused by Hueco pumping. Just as Hueco pumping increases the reservoir releases needed to meet EPCWID demands, WWTP discharges to the EPCWID canal system that are used by EPCWID farmers reduce the reservoir releases needed to meet demands.

What is dissimilar between the WWTP offsets in the Rincon and Mesilla Valley versus the WWTP offsets in the El Paso Valley is that EPCWID either receives a credit or is not charged for its use of EPW WWTP discharges while EBID is charged for all water that it uses and receives no credit for New Mexico WWTP discharges.

20.0 RESPONSE TO GEORGE REBUTTAL REPORT

Jonathan D. George, P.E. prepared a December 30, 2019 rebuttal expert report on behalf of Texas ("George Rebuttal Report") that describes his rebuttal to opinions of the New Mexico experts related to crop consumptive use in the LRG Basin.

SWE was asked by legal counsel for New Mexico to review certain opinions in the George Rebuttal Report and to prepare expert opinions to respond those opinions of Mr. George.

***George Opinion 1** – [Based] on the October 2019 NM SWE Report, the SWE Farm Budget average actual evapotranspiration in the Rincon and Mesilla valleys increased from a pre-well development average of 188,830 acre-feet per year during the 1938 through 1950 period to a post-well development average of 236,916 acre-feet per year during the 1985-2016 period, an increase in average actual evapotranspiration of 48,085 acre-feet per year or 25.5%, and the M&A Farm Budget average actual evapotranspiration in the Rincon and Mesilla valleys increased from a pre-well development average of 201,183 acre-feet per year during the 1938 through 1950 period to a post-well development average of 257,364 acre-feet per year during the 1985-2016 period, an increase in average actual evapotranspiration of 56,181 acre-feet per year or 27.9%. The percentage increase in average actual evapotranspiration between the SWE Farm Budget and M&A Farm Budget (25.5% vs. 27.9%, respectively), as reported in the October 2019 NM SWE Report, are very similar and the increase can largely be attributed to use of wells. (p. 10).*

Response:

While it is true that a portion of the increase in consumptive use in the SWE Farm Budget analysis of the Rincon and Mesilla Valleys is due to the development of ground water pumping for irrigation, differences in weather conditions and changes in crops also are reasons that the consumptive use during 1985-2016 is greater than the consumptive use during 1938-1950.

The effect of weather and crop selection on consumptive use are integrated in the crop-weighted average CIR input to the SWE CFB Model. Therefore, differences in crop-weighted CIR between one period and another reflect differences in weather effects on Reference ET, difference in effective precipitation, and differences in crop selection between the two periods. Based on inputs to the SWE CFB Model, the crop-weighted average CIR in the Rincon and Mesilla Valleys was 2.74 and 2.78 inches per year ("in/yr") during 1985-2016, which is 116% and 117% greater than the average of 2.35 and 2.36 in/yr during 1938-1950.

In order to test the effect of differences in weather and crop selection on differences in the consumptive use in the Rincon and Mesilla Valleys between 1938-1950 and 1985-2016, a test run of the SWE CFB Model was made in which the crop-weighted average inputs to the model during 1985-2016 were scaled by the ratio of the 1938-1950 average CIR to the 1985-2016 average CIR (i.e., ratio for Rincon = 0.86). The results of this analysis showed that the annual consumptive use in the Rincon and Mesilla Valleys during 1985-2016 computed using the adjusted CIR values averaged 203,763 AF. This is an average of 33,153 AF/y less than the average of 236,916 AF/y computed with the original unadjusted CIR values. These results show that 69% of the 48,095 AF/y difference in average consumptive use in the SWE CFB Model for the Rincon and Mesilla Valleys between 1985-2016 and 1938-1950 can be explained by differences in weather and crop selection between the two periods.

The upper graph in **Figure 20-1** shows annual crop-weighted average CIR from 1938-2017, and averages for 1938-1950 and 1985-2016. The lower graph in **Figure 20-1** shows the annual consumptive use of applied water for the same period with annual average for 1938-1950 and 1985-2016. The 1985-2016 adjusted CIR and consumptive use volumes are also shown in the two graphs. This analysis shows that Mr. George is incorrect in his assertion that differences in average annual consumptive use in the Rincon and Mesilla Valleys between 1938-1950 and 1985-2016 "can largely be attributed to wells."

21.0 RESPONSE TO HORNBERGER REBUTTAL REPORT

George M. Hornberger, Ph.D. prepared a December 30, 2019 rebuttal expert report on behalf of Texas (“Hornberger Rebuttal Report”) that describes his rebuttal to opinions of the New Mexico modeling experts regarding the Texas Model.

SWE was asked by legal counsel for New Mexico to review the Hornberger Rebuttal Report and to prepare expert opinions to respond the opinions of Dr. Hornberger. A lack of response regarding a particular issue should not be interpreted as tacit agreement with the Hornberger opinions on that issue.

***Hornberger Opinion 1** - The critiques of the groundwater modeling approach (hereinafter Texas model”) taken by Hutchison (2019) from experts for New Mexico lack specificity. The Texas groundwater model focuses on modeling the impact of pumping groundwater in the Rincon and Mesilla Valleys on flow in the Rio Grande at El Paso using annual stress periods. In contrast, the models produced by New Mexico include a river flow routing model using RiverWare, include groundwater models of the Hueco Bolson in addition to the Rincon-Mesilla Valleys, use monthly stress periods, and use hypothetical reservoir releases in place of historical observations. The argument that these “improvements” to the model are necessary without presentation of any justification of what purpose is served by adding complexity, is completely opaque. Without justification in terms of the specific objectives stated for the model, such criticism is meaningless.*

Response:

The assertion by Dr. Hornberger that so-called “improvements” were made to the ILRG Model by the New Mexico experts without presentation of any justification for the purpose of the improvements is blatantly false, and confirms Dr. Hornberger’s statement in the Introduction section of his report that “he only scanned the reports produced by the experts for New Mexico.” During his deposition, Dr. Hornberger admitted to only spending two hours reviewing the New Mexico expert reports.

The New Mexico experts provided ample description and support for the monthly stress periods, spatial scale, and rule-based processes for simulating Project operations that are essential bedrock elements of the ILRG Model. This is discussed at length in the SWE Report, and in the responses to the Coors Supplemental Report in Section 23.0.

By comparison, the coarse annual stress periods, limited geographic scope, and absence of dynamic processes for simulating Project operations render the Texas Model woefully inadequate for analyzing the claims and counterclaims in this case.

Hornberger Opinion 2 *- The objectives set forth for the Texas model by Hutchison (2019) are stated clearly and are straightforward. The goal is to show how groundwater pumping in the Rincon and Mesilla Valleys affects the amount of water that flows to Texas at the gage at El Paso. This is the key issue that needs to be addressed both to demonstrate the impact of pumping in New Mexico on water deliveries to Texas and to provide a simple and straightforward method to explore counterfactuals related to what deliveries would have been if pumping had been curtailed over the period of record.*

Response:

The Texas Model fails to meet the stated Texas objective “to show how groundwater pumping in the Rincon and Mesilla Valleys affects the amount of water that flows to Texas at El Paso” for several reasons.

- The Texas Model lacks simulation of the dynamic responses of Project operations to changes in surface water flows that would occur under no pumping or reduced pumping scenarios.

- The limited geographic scope of the Texas Model from the Caballo Reservoir outlet to the Rio Grande at El Paso gage precludes simulation and analysis of the response of upstream reservoir operations to changes in pumping, and the effects of irrigation and non-irrigation pumping in the Hueco Bolson on deliveries to EBID, EPCWID, and HCCRD.

- The annual stress periods of the Texas Model are too coarse to distinguish the effects of pumping on surface water supplies and Project deliveries that occur within the irrigation season versus the effects on surface flows during the non-irrigation season.

In addition, the stated Texas objective is an incomplete statement of the questions that need to be answered to fully analyze the claims and counterclaims in this case. Other questions that need to be answered include how pumping throughout the Project affects Project deliveries to New Mexico and Texas water users, and how changes in Project operations (e.g., enactment of the 2008 OA) have affected deliveries.

Hornberger Opinion 3 *- The vast majority of Project deliveries to Texas are diverted at the American Dam, a short distance downstream from the El Paso gage. Because the clearly stated objective of the Texas model is to determine the impact of groundwater pumping on deliveries to Texas, the only possible reason to include the use of water between El Paso and Ft. Quitman in the model would be if pumping from the Hueco Bolson significantly influenced flow in the Rio Grande above El Paso. The only groundwater links between the*

Mesilla and the Hueco are at Fillmore Pass and at the Narrows. The connecting strata are thin, however, so the underflows from the Mesilla to the Hueco are quite limited (Slichter 1905). Hutchison's estimates of about 400 to 1200 AF/year (Hutchison 2019) are somewhat higher than other estimates (e.g., Heywood and Yager 2003) but nevertheless a small fraction of annual groundwater pumping by New Mexico above El Paso. Pumping from the Hueco aquifer can have very little effect on the Rio Grande flows at the El Paso gage and thus on deliveries to Texas; therefore, adding complexity to the Texas model on this account is unnecessary to address the objectives stated. The criticism leveled at the Texas model has no merit.

Response:

Due to an apparent lack of understanding of Project operations, Dr. Hornberger mistakenly assumes that the only way for impacts of Hueco pumping to propagate upstream is through changes in ground water flow either at Fillmore Pass or at the El Paso Narrows. Rather than through ground water flow changes, Hueco pumping impacts propagate upstream through changes in Project operations caused by such pumping.

The mechanism for Hueco pumping impacts to propagate upstream is rooted in the long-standing practice of operating the Rio Grande Project as a single unit, and that changes in flows anywhere within the system have the potential to affect deliveries to all Project water users, including users located upstream of where the pumping occurs. Upstream impacts from Hueco pumping occur when the pumping depletes delivery of Project water to EPCWID water users, thus necessitating increased releases of Project water to meet EPCWID demands. Depletions of Project water deliveries by Hueco pumping occur through mechanisms that vary based on the location:

- Prior to construction of the ACE, depletions of the Rio Grande upstream of Riverside Dam caused by Hueco pumping required increased releases from Project storage to meet demands for Riverside Canal users.
- Depletions to the Rio Grande downstream of American Dam caused by Hueco pumping increase the reservoir releases needed to deliver 1906 Treaty water to Mexico at the Acequia Madre.
- Hueco pumping also increases seepage from EPCWID canals and laterals (MMA, 2019). The increased seepage losses in the EPCWID service area require additional Project storage releases to deliver orders for Project water to EPCWID farmers.

Any of the above effects of Hueco pumping that require increases in Project storage releases reduce the unused supply of water left in Project storage at the end of the year.

Under the accounting that existed prior to the 2008 OA, these reductions in unused supply would have reduced the supply available for allocation to the Districts in the following year.

Under the 2008 OA, the above effects of Hueco pumping reduce the computed Diversion Ratio, and this negatively impacts deliveries of Project water to EBID in the current year in accordance with the D3 allocation procedure. In addition, the increased reservoir releases to deliver EPCWID orders for Project water increase the amount of "paper water" in EPCWID's carryover storage account that must be filled by inflows in the next year, thus reducing the supply available for allocation to EBID in the next year.

In addition to the effects on Project water deliveries described above, Hueco pumping also affects the supply of water to HCCRD through the following mechanisms:

- Hueco pumping depletes the Tornillo Canal at Alamo Alto and the flows of the Tornillo Drain and Fabens Waste Channel that comprise the HCCRD supply.
- Hueco pumping increases seepage losses in the HCCRD canals and laterals, reducing the supply available for delivery to the headgates of HCCRD farmers.

The ILRG Model is the only model in this case that is capable of analyzing and quantifying the effects of Hueco pumping on EBID, EPCWID, and HCCRD.

Hornberger Opinion 4 *- Hutchison (2019) stated no objective about exploring how management decisions in the future might affect Project deliveries. Rather, he focused on the physical response because that is the central question related to the Compact. Any institutional or management changes would involve several stakeholders to determine how much of a given flow increase would be retained in storage and how much would flow to the Narrows. Information about such management is unknowable before any negotiations are completed so any such simulation would be highly speculative and counterproductive given the objectives stated by Hutchison.*

Response:

It is naïve to state that impacts in this case would somehow be limited to impacts that manifest solely through physical processes. Given the dominant effect that Project operations have on the water supply of the LRG area, both directly and indirectly, virtually all impacts from pumping or other actions that affect the available water supply are likely to be filtered through the Project water allocation and delivery mechanisms. The key elements of the allocation and delivery processes are well established and well understood. For example, the water available for allocation in the current year is generally based on the water available in storage, and releases from storage are based on the aggregation of downstream demands adjusted for gains and losses between the reservoir outlet and the points of delivery.

The effects of pumping are implicit in the gains and losses to surface flows throughout the LRG area. During periods of high pumping, net surface water gains (gains minus losses) decrease and more water must be released to meet certain demands. Conversely, during periods of low pumping, net surface water gains increase and less water needs to be released to meet the same demands. The specific effects of pumping generally cannot be discerned by observation or measurement from other processes that affect the gains and losses. Nor do such pumping impacts need to be specifically discerned in order to determine reservoir releases that are needed to meet demands. Reservoir releases are made in consideration of the downstream gains and losses regardless of what causes those gains and losses.

It is not necessary to speculate how the Project would operate with reduced pumping because the records of operations during the 1940s, 1980s, and 1990s already provide ample empirical evidence.

Hornberger Opinion 5 *- The intent of the Hutchison report was to determine to what extent groundwater pumping by New Mexico depletes deliveries to Texas from the Rio Grande Project. This is the key question and the answer does not depend on a distinction between the irrigation and non- irrigation seasons. Changes in pumping over time influence short-term conditions near the well being pumped but impacts on river flow are manifested in the long term. The point is that at some distance from the river the effects of an intermittent or cyclic pumping pattern "become indistinguishable from a constant pumping pattern at a cycle (or long-term) average pumping rate" (Barlow and Leake 2012). The long-term impact of pumping and associated consumptive use of the water through irrigation on the regional water budget is captured by use of an annual stress period in calculations. The important question is not about potential monthly fluctuations but about long-term average impacts.*

Response:

As discussed in the response to the Coors Supplemental Report, responses of surface water flows (canals, drains, and Rio Grande) to irrigation pumping typically occur within months but can persist for longer durations during extended drought periods. See the response to Coors Opinion 6 for a detailed discussion of this subject.

The annual stress periods of the Texas Model are too coarse to evaluate the monthly and seasonal effects of pumping on LRG surface water supplies. Quantification of the portion of the surface water depletions caused by pumping is of significant importance because of the seasonal nature of Project operations and deliveries. Depletions to surface water flows during the non-irrigation season from pumping are less significant in this case than depletions during the irrigation season. Uses of surface water during the non-irrigation season are minimal, and none of the impacts claimed by Texas are due to depletions of non-irrigation season surface water flows caused by New Mexico pumping.

22.0 RESPONSE TO COORS REBUTTAL REPORT

Mr. Coors prepared a December 30, 2019 rebuttal expert report on behalf of Texas ("Coors Rebuttal Report") that describes his rebuttal opinions and criticisms of New Mexico's ILRG Model.

SWE was asked by legal counsel for New Mexico to review the Coors Rebuttal Report and to prepare expert opinions to respond to the opinions of Mr. Coors. A lack of response regarding a particular issue should not be interpreted as tacit agreement with the Coors opinions on that issue.

Although the deadline for Mr. Coors to submit his report was in December 2019, he much later substantially expanded on his initial rebuttal opinions and added new rebuttal opinions in a supplemental report that was submitted on May 5, 2020. In some instances, my responses to Mr. Coors' initial and supplemental opinions are consolidated in the responses to his supplemental report in Section 23.0. The opinion numbering system in the following discussion is independent of the opinion numbering in the Coors Rebuttal Report.

Coors Opinion 1 *- The Lower Rio Grande (LRG) system itself is complex and the data used to develop the models comprising the ILRG is limited, so determining if the model produces meaningful results is something that warrants further analysis. A sensitivity analysis of the ILRG system is in order to determine the reliability of the model results and the level of uncertainty present in them. There is no indication in the NM experts' reports that a sensitivity analysis of the ILRG was performed. (page 4).*

Response:

Sensitivity analyses of the ILRG Model were performed to test the sensitivity of the model results (differences between runs) to changes in selected input parameters and input data. The results of the sensitivity analyses are reported in Section 31.0.

Coors Opinion 2 *- The impacts on flows in the river at El Paso are determined by longer time scale effects that may not warrant the shorter timestep and highly uncertain modeling that has been performed by the NM experts on a monthly timestep. (page 5).*

Response:

See the responses to Mr. Coors' supplemental report.

Coors Opinion 3 *- The uncertainty present in the ILRG model due to insufficient data, unknowable historical practices in irrigation and Project operations may make the model results unreliable or require that the modeled domain be further aggregated either spatially or temporally in order to reduce the uncertainty present in the results to an acceptable level for quantifying impacts. (page 5).*

Response:

See the responses to Mr. Coors' supplemental report.

Coors Opinion 4 *- I also generated a timeseries of annual differences between the Run 1 and Run 0 variables. If the model was a perfect replica of the LRG system, each of the 78 annual difference values (1940-2017) for each variable would be zero acre-feet. The average deviation of each of these timeseries provides a simple measure of the level of uncertainty in values produced by the model for each variable. It is important to note that five of the six calculated impacts of pumping in New Mexico and Texas are smaller than this uncertainty metric in the model as indicated by the Run 1 to Run 0 comparison across the three modeled variables. This is further indication that a sensitivity analysis of the model is needed to determine if the level of uncertainty in the ILRG model results is problematic for answering the questions it is being used to answer.*

> *12.1 For Project water storage the average deviation of the Run 1 – Run 0 values is 152,156 acre-ft. The differences in the no New Mexico and no Texas pumping run combinations are 104,802 acre-ft and 9,386 acre-ft respectively.*
>
> *12.2 For the annual volume of flow at El Paso the average deviation of the Run 1 – Run 0 values is 121,572 acre-ft. The differences in the no New Mexico and no Texas pumping runs are 121,939 acre-ft and 30,850 acre-ft respectively.*
>
> *12.3 For the annual diversion at the American Canal, the average deviation of the Run 1 – Run 0 values is 110,040 acre-ft. The differences in the no New Mexico and no Texas pumping runs are 56,375 acre-ft and 20,419 acre-ft respectively. (page 6).*

Response:

Like all simulation models, the ILRG Model does not perfectly replicate historical observed flows in the Historical Base Run (Run 1). However, as is described in Section 28.0, the ILRG Model is well calibrated to give reliable results, and is the best model available for analyzing the claims and counterclaims in this case.

The analyses of the ILRG Model presented by Mr. Coors are not useful measures of the uncertainty of the ILRG Model in analysis of the impacts of pumping or other actions in this case. This is because such impacts are analyzed by differences between model runs. For example, the effects of New Mexico pumping can be assessed by comparing the result of Run 3 (No New Mexico Pumping) and Run 1 (Historical Base Run). When computing the differences between model runs, the model imperfections that are present in both runs cancel out. Therefore, differences between model runs can be more accurate than simulated values in a single model run. See additional discussion of canceling of errors in the responses to Coors' supplemental report and in Section 28.0.

Coors Opinion 5 *- It is my opinion that characterizing the results [based on differences between runs] is not necessarily accurate and that a more thorough model validation process would need to be conducted in order to make this claim. If the Run 1 model is not a sufficiently accurate representation of the basin and all of the water dynamics, then the differences between any of the Scenario Runs and Run 1 do not give a reliable approximation of what would have happened historically if pumping in any particular region of the basin did not occur. (page 7).*

Response:

See the response to Coors Opinion 4.

23.0 RESPONSE TO COORS SUPPLEMENTAL REPORT

Mr. Coors prepared a May 5, 2020 supplemental rebuttal expert report on behalf of Texas ("Coors Supplemental Report") that greatly expanded on and added to the rebuttal opinions provided in the Coors Rebuttal Report. The topic of both Coors reports is criticism of New Mexico's ILRG Model.

SWE was asked by legal counsel for New Mexico to review the Coors Supplemental Report and to prepare expert opinions to respond to the opinions of Mr. Coors. A lack of response regarding a particular issue should not be interpreted as tacit agreement with the Coors opinions on that issue.

The opinion numbering in this section picks up where the opinion numbering in the responses to the Coors Rebuttal Report left off.

Coors Opinion 6 *- So, the Compact was intended to fix the existing apportionment of the LRG water supply among the two states and Mexico at the time of the Compact, which included a recognition of the influence of groundwater on surface water. With this as one of the fundamental objectives of the Compact, in order to substantiate its Complaint, Texas developed the Texas Model to simply demonstrate that New Mexico's ongoing use of groundwater throughout the years since the signing of the Compact represents an inappropriate overuse of the original apportionment of the limited water supply to the Project. The Texas model was designed specifically to substantiate this claim and as was concluded by Dr. Hornberger in his report:*

> *"These questions supplied a clear purpose for developing a parsimonious model…I conclude that Hutchison (2019) indeed followed appropriate modeling guidelines and produced a model that meets the stated objectives, clearly showing the impacts of groundwater pumping by New Mexico on Rio Grande water deliveries to Texas." (Hornberger Rebuttal at p. 10.)*

New Mexico experts, Spronk Water Engineers (Spronk) and Hydros Consulting (Hydros) state repeatedly in their expert reports that the LRG system is highly complex and includes many dynamics that occur on a monthly scale, namely Project operations. While this is true it does not ipso facto justify a model that attempts to model all known dynamics in the system. A justification tied specifically to the Texas Complaint that drives the decision to include a very ambitious level of detail in on-farm processes throughout the project, a monthly timestep, and an attempt to capture in rules historical Project operations is not clearly given. (page 4).

Response:

The Supreme Court has essentially stated that the Rio Grande Project has been the mechanism for effecting the allocation of water under the Rio Grande Compact between New Mexico and Texas downstream of Elephant Butte Reservoir, and implicit in this recognition was the necessity to ensure successful operation of the Rio Grande Project (Lopez, 2019). Consistent with this, the BOR, New Mexico, and Texas encouraged the development of ground water pumping to supplement Project water deliveries in dry years when it became evident that the Project supply was inadequate to provide a full irrigation water supply (Barroll, 2019). Conjunctive use of surface water and ground water ensured the continued successful operation of the Rio Grande Project in all hydrologic conditions, including during extended drought periods, which had not been experienced in the LRG Basin between 1915, when Elephant Butte Reservoir began delivering Project water, and 1939, when the Compact was enacted.

Notwithstanding the encouragement and embrace of ground water pumping by the BOR, New Mexico, and Texas, Mr. Coors and Dr. Hornberger continue to support the overly simplistic Texas objective of the of the Texas Model to answer the question, “Did New Mexico’s pumping deplete streamflows at El Paso on an annual basis?” The scope of this case is not limited to this very simplistic question. Rather, to determine impacts to Project deliveries it is necessary to develop a simulation model that includes simulation of Project operations to answer the correct questions.

New Mexico and its experts understood from the outset that the issues in this case were more complex than portrayed by Mr. Coors and Dr. Hornberger. This case involves <u>quantifying</u> the amount and timing of impacts from pumping and changes in Project operations on deliveries to water users in New Mexico and Texas. Quantification of these impacts needs to consider how pumping and other actions affect the Project operations that dominate how the highly variable Rio Grande inflows to Project storage are managed and delivered to New Mexico and Texas water users.

As was described at length in the opening expert reports of the New Mexico experts and further expounded upon in their rebuttal reports, the Texas Model, with its limited geographic scope, coarse annual stress periods, and lack of dynamic simulation of Project operations, is woefully inadequate and inappropriate for answering the complex technical questions posed in this case, including the quantification of impacts from pumping and other actions.

The level of detail included in the ILRG Model developed by the New Mexico experts was developed over many years of model testing, evaluation, and refinement. The simulations of Project operations and on-farm processes were developed and refined to capture essential elements of these processes. Additional simulation capabilities were added when detailed review of model output revealed that simulation of historical conditions could be improved. Potential model improvements were identified, discussed, and tested in the model. Proposed model changes were implemented if (a) they reasonably reflected physical processes or rational operating procedures and (b) resulted in significant improvement in model performance. Proposed changes were not implemented and if they did not meet these criteria. The following are examples of improvements that were made to the ILRG Model through the years:

- Extension of the model south to Fort Quitman and incorporation of full simulations of irrigation operations in the El Paso Valley and Juarez Valley as well as M&I pumping and returns.
- Development of the Hueco Ground Water Model as a component of the ILRG.
- Subdivision of the spatial scale of the simulated water user and ground water components in the RiverWare Model into smaller subareas,
- Linking of the ground water models to the RiverWare Model to provide a dynamic exchange of data between the models, including the RiverWare inputs for canal seepage, riparian ET, and flux between the shallow and deep aquifers,
- Simulation of WWTP discharges and urban deep percolation from M&I pumping,
- Implementation of a soil moisture simulation algorithm in the farm budget kernel of the RiverWare model,
- Refinement of rules for allocating Project water under D1/D2 accounting and D3+Carryover accounting, and
- Refinement of operational rules for simulating farm headgate and river headgate demands considering crop water demands, conveyance losses, and other irrigation supplies (i.e., WWTP flows and drain flows).

Development of the ILRG Model employed the principle of parsimony in the sense that additional detail was added to the simulation processes only as necessary to capture essential elements of the system operation. The robust and sophisticated functionality of the ILRG Model is supported by the rich and extensive record of historical Project operations.

Coors Opinion 7 *- The ILRG model became a monumental undertaking that is not appropriate for, or successful in, refuting the Texas Complaint or supporting New Mexico's criticisms of the Texas Model for reasons surveyed in the remainder of this report. What is most interesting is that once the ILRG model was completed and a set of runs were made* *by New Mexico experts, the results support Texas's claims, confirm the Texas experts' findings both from modeling and historical analysis, and refute New Mexico's Counterclaim 1. (page 5).*

Response:

What Mr. Coors' portrays as a monumental undertaking was instead incremental and rational development of a model appropriate for simulating the complex Project operations, irrigation system operations, and ground water and surface interactions in the LRG Basin. The effort and care in developing the ILRG Model reflect the necessary attention that New Mexico and its experts are giving to this case.

The objectives for developing the ILRG Model were not limited to refuting the Texas complaint. Rather, the ILRG Model was also developed to gain insight into and understanding of the effects of various actions on Project operations and deliveries to the U.S. Districts and Mexico, and to analyze New Mexico's counterclaims. This includes identifying and quantifying how past or proposed changes in Project operations and water use practices have affected surface flows, reservoir storage, ground water storage, Project water allocations and deliveries, and consumptive use since the Compact became effective in 1939.

The Texas Model is wholly inadequate to meet the foregoing objectives because it does not extend downstream beyond the El Paso gage, it employs annual stress periods that cannot distinguish between Project operations during the irrigation season and non-Project operations during the non-irrigation season, and it does not simulate the Project operation and accounting that determine deliveries of surface water for irrigation and non-irrigation uses in the Project area.

Coors Opinion 8 *- The nature of Texas's Complaint against New Mexico is that groundwater pumping in New Mexico has resulted in New Mexico consistently using more than its share of water annually as defined by the Compact to the injury of the Texas water users. The effects of groundwater pumping are slow and are not realized within a single year. As Dr. Hornberger stated in his rebuttal report:*

"The long-term impact of pumping and associated consumptive use of the water through irrigation on the regional water budget is captured by use of an annual stress period in calculations. The important question is not about potential monthly fluctuations but about long-term average impacts." (Hornberger Rebuttal, Criticism 3 at p. 9.)

New Mexico experts describe the complexity of the effects of GW pumping within a given year. (See Spronk Report at pp. 71-72) The sequence of effects given in this section *qualitatively describe how the system would be affected by a reduction in pumping in the Project. While effects in this sequence might be accurate, this is put forth as one of the justifications for the ILRG model and its complex representation of the system. This sequence of effects generally takes place within a single year and does not describe the sequence of events (mechanism) that gives rise to the Texas Complaint. (page 5).*

Response:

The Compact has no explicit definition of how water delivered into Elephant Butte Reservoir is divided among downstream water users in New Mexico and Texas. Instead, the inflows are allocated and delivered to downstream water users in accordance with the operating practices of the Rio Grande Project, which have long incorporated the conjunctive use of ground water and surface water to ensure successful operation during drought periods.

Mr. Coors and Dr. Hornberger are wrong in their assertions that the effects of ground water pumping are slow and not realized within a single year. Irrigation wells in the LRG area are generally less than 250 feet deep and less than one-half mile from the drains that control the alluvial ground water levels. This results in a relatively rapid response (within months) of surface flows to pumping during non-drought periods when the ground water table is hydraulically connected to surface water flows (canals, drains, and the Rio Grande). During drought periods, the combination of a lack of recharge from surface water use and increased ground water pumping can cause the ground water table to become disconnected from the surface water flows in some areas. When this happens, the drains can cease flowing, and seepage from rivers and canals will stabilize and not be affected by short-term variation in pumping. Therefore, the effects of pumping during drought periods can persist for longer periods than during non-drought periods.

The rapid response of the LRG area drains is illustrated in **Figure 23-1** for the Rincon Valley and **Figure 23-2** for the Mesilla Valley for 1938 - 2005[3]. Each graph compares the monthly net recharge (orange line; defined as canal seepage plus deep percolation minus irrigation pumping) to the aggregate recorded monthly drain flows (blue line). Close inspection of the Rincon Valley and Mesilla Valley graphs shows that the drain flows respond rapidly and typically lag the net recharge by only one to three months.

During drought periods such as the mid-1950s, net recharge declined, becoming negative at times (pumping exceeded the sum of canal seepage and deep percolation), and this

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[3] Some drain data are not available from 1984-2005, and limited drain data are available after 2005.

resulted in the drain flows declining substantially and even drying up. The accumulated effect of the negative recharge during the drought is seen in the slow recovery of the drains after the drought, when it took two or three years for the drains to recover.

The ILRG Model, with its monthly stress periods, is capable of simulating the monthly, seasonal, and long-term responses of surface water flows to pumping as well as the Project operation responses to the changing surface flows. While the ILRG Model results reported by New Mexico generally rely on seasonal stress periods, the granularity of monthly stress periods is helpful in simulation of the following processes:

- Monthly inflows to Project storage and the resulting increases in Project water allocations through the early portions of the irrigation season (typically through July) and reserving later inflows for carryover to the next year.
- Characteristic monthly variability in LRG irrigation operations including planting dates, crop irrigation demands, diversions and deliveries, soil moisture carryover, and irrigation pumping,
- Monthly or sub-seasonal lagged impacts from recharge and pumping on surface flows (e.g., canal, drain, and river flows),
- Monthly M&I pumping volumes and WWTP returns based on historical monthly data, and associated estimates of monthly urban deep percolation,
- Bunching of reservoir releases into shorter delivery periods during non-full supply years.

The Texas Model, with its annual stress periods and lack of Project operating rules, is incapable of simulating many of the real-world responses described in Section 7.0 of the SWE Report (2019), including their monthly and seasonal variability.

Coors Opinion 9 *- When there is not a full allocation, Project operations do not provide a mechanism to compensate for the reduced flows that occur at El Paso due to pumping in New Mexico. Then, in subsequent years of full allocation, the groundwater elevation remains lower than it would have been without New Mexico pumping. So even if Texas receives a full allocation in a full allocation year, the depleted groundwater condition in New Mexico continues depleting additional water from the river and the injury to Texas continues. (page 6).*

Response:

The description of the Project response to the impacts of pumping described by Mr. Coors is overly simplistic and incomplete. Under D1/D2 accounting, pumping impacts during a year with less than a full allocation can potentially result in (a) more water having to be released from storage to deliver the allocations or (b) insufficient water being available to deliver the allocations. In the latter case, pumping can reduce deliveries in the current year. In both cases, the supply available for allocation in the next year can be reduced. In a full supply year, the effects of pumping can result in more water needing to be released to deliver the orders for irrigation water, which can result in less water available for allocation in the next year.

Under the D3 accounting in the 2008 OA, mechanisms for pumping to impact deliveries to EPCWID are generally similar to the mechanisms described above for the D1/D2 accounting. However, pumping (or other actions) can also affect EBID in the current year due to changes in the diversion ratio.

The ILRG Model, with its dynamic rules for simulating Project operations, is capable of reasonably simulating the foregoing real-world responses to changes in surface water supply caused by pumping in New Mexico and Texas in full supply and non-full supply years as well as the effects on future Project water allocations and deliveries.

Coors Opinion 10 *- The ILRG runs on a monthly timestep. For the questions raised by the Texas Complaint and New Mexico's Counterclaim, the most appropriate timestep is an annual one. By selecting a monthly timestep, simulating Project operations, including on-farm processes, reservoir operations, and canal operations and drain flows becomes significantly more complex and uncertain. Data needs to support modeling at this time scale also become greater. Due to a lack of much important historical data, a significant data development effort needed to be undertaken that introduces significant uncertainty to the model. Just because there are dynamics in the Project that occur on a monthly or seasonal level, does not mean that a monthly timestep is the appropriate one. The objective of the model is better served by an annual timestep which reduces the uncertainty present in the model results and more effectively captures the effects of a depleted groundwater condition on the surface water in the Rio Grande and in the Project over the course of years. (page 7).*

Response:

Contrary to Mr. Coors' statements, simulating the monthly operations of the Rio Grande Project and the LRG irrigation systems is not significantly more complex than simulating these operations using an annual timestep. Most of the LRG data needed for modeling are recorded and tabulated as monthly if not daily values. There is no significant "lack of important historical data" that limits the monthly simulation of the ILRG Model as asserted by Mr. Coors, and he did not specifically identify any data alleged to be lacking.

The monthly time-step of the ILRG Model allows it to simulate and distinguish the effects of pumping and other actions on Project water deliveries during the irrigation season from less important impacts on surface flows during the non-irrigation season. This capability is extremely important for analysis of the issues in this case.

Coors Opinion 11 *- Hydros applied three statistical metrics to quantify the effectiveness of the calibration of the Historical Base Run. For a short list of locations, they analyzed all the differences between the Run 1 simulated values and the observed values. The difference between an observed value and a modeled value is called the residual. Residuals from the Historical Base Run were analyzed by the following three statistics:*

1. *Monthly Mean Error*
2. *Mean Error as Percentage of Monthly Average*
3. *Nash-Sutcliffe Efficiency.*

The statistical methods selected are inadequate and inappropriate, and the locations at which they were applied are inadequate for determining the quality of the calibration of the Historical Base Run. (page 8).

Response:

While use of calibration statistics to evaluate the calibration of hydrologic models is commonplace, there are no universally accepted guidelines for calibration assessment in the scientific community (Moriasi et al., 2012). There are numerous statistical performance measures that have been developed to assess the goodness of fit of modeled values to measured values, and the choice of statistics is generally left in the hands of the modeler based on professional judgment. In addition, there are numerous graphical performance measures to evaluate model calibration, and most modelers use some combination of statistical and graphical performance measures to assess calibration of hydrologic models.

Coors Opinion 12 *- The third statistical parameter reported in the New Mexico experts' reports is the Nash Sutcliffe Efficiency (NSE) parameter, Eq (2). This parameter characterizes the goodness-of-fit between a modeled quantity and the observed. The value ranges from - ∞ to 1.0. A value of 1.0 represents a perfect fit. Negative values indicate the observed mean is a better representation of the timeseries than the model results. "Performance Evaluation of Hydrological Models: Statistical Significance for Reducing Subjectivity in Goodness-of-Fit Assessments" by Ritter, Axel, and Rafael Muñoz-Carpena (2013) provides performance ratings for NSE values. This performance rating system is given in Table 1. (page 9).*

NSE Category	*Value Range*
Unsatisfactory	*< 0.65*
Acceptable	*0.65 – 0.80*
Good	*0.80 – 0.90*
Very Good	*0.90 – 1.00*

Response:

The NSE has become a widely used statistic for evaluating the calibration of hydrologic models because it more appropriately measures the goodness of fit than does the coefficient of determination (R^2) statistic that previously was the standard regression statistic used to evaluate model performance (Harmel et al., 2010; Legates, 1999; Moriasi et al., 2007). However, there are no universally accepted performance criteria in the scientific community for evaluating NSE scores, and performance criteria used by Mr. Coors are proposed criteria included in Ritter (2013).

A widely cited journal article by Moriasi et al. (2007) included performance evaluation criteria for the NSE statistic that are less stringent than the criteria advocated by Mr. Coors. A subsequent article by Moriasi et al. (2015) describes an in-depth review and analysis of statistical and graphical performance measures and performance evaluation criteria in the hydrologic modeling literature. The following criteria were recommended for the NSE, coefficient of determination (R^2), Index of Agreement (d), and the Percent Bias (PBIAS) by Moriasi et al. (2015) on behalf of the American Society of Agricultural and Biological Engineers ("ASABE"):

Recommended Performance Evaluation Criteria
ASABE (2015)

Performance Evaluation Criteria	Nash-Sutcliff Efficiency (NSE)	Coefficient of Determination (R^2)	Index of Agreement (d)	Percent Bias (PBIAS)
Very Good	> 0.80	> 0.85	> 0.90	< 5%
Good	0.70 – 0.80	0.75 – 0.85	0.85 – 0.90	±5% – ±10%
Satisfactory	0.50 – 0.70	0.60 – 0.75	0.75 – 0.85	±10% – ±15%
Unsatisfactory	0.0 - 0.50	0.18 - 0.60	0.60 - 0.75	±15% - ±30%
Unacceptable	≤ 0.0	≤ 0.18	≤ 0.60	≥ ±30%

Note also that the NSE equation presented in the Coors Report on page 9 is incorrect. The opening parentheses in the numerator and denominator should be placed after, rather than before, the summation character.

Coors Opinion 13 – *[T]he NSE methodology fails to accurately evaluate model calibration across the whole range of values in the dataset. Krause, et al. (2005) asserts,*

> *"the Nash-Sutcliffe is not very sensitive to systematic model over- or underprediction especially during low flow periods."*

The NSE metric overemphasizes a model's ability to match higher values and underemphasizes the ability to match lower values. For model output intended to represent the surface water conditions of the Rio Grande Project, matching low flows is particularly important as it is during the low flow times when surface water is limited that the impacts of groundwater pumping are realized. It is more important that the model be effective at capturing the low flow periods to address the issues at hand. The NSE is more a measure of how well a model represents the higher values than the lower ones, which is not appropriate for determining the effectiveness of the ILRG model in replicating Project operations. (page 9).

Response:

The criticism by Mr. Coors of use of the NSE methodology for evaluating calibration of the ILRG Model because it underemphasizes low flows is misplaced for several reasons. First, the LRG system is different from more typical unregulated flow systems. Except for rare spills from Project storage, the irrigation season surface water flows in the LRG area are highly regulated by Project operations, resulting in streamflow and diversion rates that generally fall within a relatively narrow range of flows. This is much different than unregulated basins in the West in which streamflows may routinely vary widely between snowmelt or rainfall runoff in the spring and baseflows in the fall.

Second, reported monthly flow volumes (streamflows and diversions) in the LRG area are often very low in shoulder season months because the Caballo Reservoir releases commence late in a spring month or cease early in a fall month. These low flow volumes should not be treated in the statistics as if they are significant extreme values when they represent typical regulated flow rates occurring over a limited number of days in the month. Zero flows are typically rare in unregulated watersheds and of great interest to engineers and planners. However, zero flows in the LRG Basin are routine because of reservoir and canal operations.

Finally, the claims and counterclaims in this case need to be evaluated at all levels of flow conditions and not just in low flow years.

Coors Opinion 14 *- There are three additional metrics that are needed for a more complete assessment of the quality of the Run 1 calibration (tuning). The first is the Mean Absolute Error (MAE), shown in Eq (3). By taking the absolute value of the residual before applying the average, positive and negative residuals do not cancel each other out and the formula produces a statistic that meaningfully quantifies the predictive capability of a model. Note this metric does not have a "squared" term in its formulation which prevents large deviations from dominating the calculation. In hydrology, large flows generally exhibit larger deviations and so, unlike the NSE, this metric characterizes the model's ability to represent a full range of flows, not just high flows which are not nearly as important for the questions being addressed in this case. Additionally, this metric has units of flow and provides an intuitive value that simply represents the average absolute size of the model residual. (page 10).*

Response:

The MAE is a commonly used statistic for evaluating the range of the differences between simulated and observed values without the cancelation of positive and negative differences that occurs in the mean error statistic. The New Mexico experts informally reviewed the MAE in calibrating their models but did not publish this statistic in their prior reports. The MAE statistic is included in the calibration and tuning results for the ILRG Model that are presented in Section 28.0.

Mr. Coors again misplaces his criticism of the NSE statistic. Unlike other hydrologic models that may be focused more exclusively on drought periods, the modeling required for the LRG area needs to more equally consider and weigh conditions in dry, wet, and average periods because the claims and counterclaims in this case have the potential to affect Project operations in all types of hydrologic conditions.

Coors Opinion 15 *- The second is simply the MAE divided by the observed monthly mean. This calculates the relative size of the MAE to the mean of the observed quantity through the run period. (page 10).*

Response:

The MAE divided by the observed mean ("PMAE") statistic is included in the calibration and tuning results for the ILRG Model that are presented in Section 28.0. As with any relative statistic, care must be given in reviewing the computed values of the PMAE and PBIAS statistics because a simulated output with small mean can result in deceivingly high computed values for these statistics (i.e., a large percentage of a small value).

Coors Opinion 16 *- The third additional metric to apply is the Log NSE. Applying a log transformation to values in the NSE formula, shown in Eq (4), reduces parameter sensitivity to extreme high values and increases sensitivity to low flow conditions. (page10).*

Response:

As discussed in the response to Coors Opinions 13 and 14, the LRG modeling in this case should not be focused on drought conditions or low flow conditions because the claims and counterclaims by the states implicate Project operations and deliveries at all levels of supply, and in any event, the low monthly streamflows and diversions are typically the result of (a) normal partial month operations rather than dry conditions, or (b) months with no reservoir releases, typically in the non-irrigation season. In addition, the highly regulated nature of the Rio Grande Project insulates it from the more extreme flow variations that typically characterize unregulated river basins in the west. While the Log NSE can be useful in emphasizing the match of low flows, this is not necessary and indeed is undesirable in evaluating the LRG modeling for the aforementioned reasons.

In reviewing the implementation of the Log NSE statistic in the backup spreadsheets disclosed by Mr. Coors, it was discovered that he did not adjust his computations to consider a common issue associated with log transforming very small numbers. The equation for computing the Log NSE is shown below.

$$Log\ NSE = 1 - \frac{\sum_{i=1}^{n}(logx_{io} - logx_i)^2}{\sum_{i=1}^{n}(logx_{io} - log\bar{x}_o)^2}$$

n = number of stress periods
$x_i = modeled\ value$
$x_{io} = observed\ value$
$\bar{x}_o = mean\ of\ observed\ values$

The numerator of the above equation computes the sum of the squared differences between the log of the observed value and the log of the modeled value. The log of zero is negative infinity and the log of a small number approaching zero becomes a very large negative number. Therefore, the computed value of the numerator in the Log NSE equation can become inappropriately dominated by a few very small flows. This is what happens in Mr. Coors' application of the Log NSE equation to the simulated results of Run 1 of the ILRG Model. The RiverWare Model, like other computer models, sometimes computes a very small number for what is effectively a zero flow. When the log of that very small number is computed in the Coors spreadsheet, the result is a relatively large negative number that dominates the numerator in the Log NSE equation when squared[4]. In order to avoid this issue, it is typical in computing log transformed values to either (a) exclude flows lower than a certain threshold from the computations, or (b) to add a nominal amount to all flows (e.g., 100 AF) to avoid the computational issues described above. As described above, Mr. Coors did not make this important adjustment when computing the Log NSE statistics that he presented in his report.

It was also noted that the Log NSE equation presented in the Coors Report is incorrect. As shown in the above equation, the opening parentheses in the numerator and denominator should be placed after, rather than before, the summation character.

Coors Opinion 17 *- The three metrics used by the New Mexico experts and the three additional metrics described above are applied at 26 locations in the model. These provide*

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[4] For example, the flow computed by the RiverWare Model in Run 1 (v106) for the Acequia Madre in October 1956 is 2.095 x 10^{-29}. The log of this value is approximately -29 and when squared, the result is 841.

a much more robust and representative set of locations to assess how well the model represents Project operations throughout the basin on a monthly basis. (page 11).

Response:

An important consideration for determining the locations for evaluating model calibration is whether the simulated flows at those distinct locations are important to the functioning and proposed uses of the model. In reviewing the locations selected by Mr. Coors for evaluating the calibration of the ILRG Model, it appears that many of the locations were selected just because there were historical data available to compare to the modeled values. In particular, eleven of the locations selected by Mr. Coors are drain flow sites. Drains are important features in the ILRG Model because they are significant areas for the interaction of ground water and surface water. The effects of surface water irrigation and ground water pumping are realized, in part, in the model by impacts on drain flows that in turn affect Rio Grande flows. However, when evaluating the drain flows from a particular area (for example the Mesilla Valley) it is more important to assess the combined flow of all drains rather than the flow of the individual drains. As long as the combined drain flow is reasonably simulated, it is not so important that one drain is simulated too high and another is simulated too low. By evaluating the calibration of flows at individual drains, Mr. Coors' calibration statistics give the appearance of very poor drain flow calibration. The calibration performance improves when the drain flows are reasonably aggregated.

In addition, the flows at several of the Rio Grande gages evaluated by Mr. Coors are relatively unimportant to the model functioning and uses. These include the flows at the gages below Leasburg Dam and below Mesilla Dam. The streamflows at these two gages typically are not a limitation on diversions because of the additional flows that are being delivered past the gages downstream to Texas and Mexico. Also, the Rio Grande at Island Station gage is not of great importance because the flow at this gage does not limit any of the simulated water uses. Most of the surface water in this area is moving through the irrigation systems of EPCWID and JID and not in the Rio Grande.

Finally, the spatial scale of the data for use in modeling the LRG Basin is also important. **Table 23-1** summarizes the spatial scale of the major input data for the ILRG Model.

After reviewing the list of 26 locations evaluated by Mr. Coors and considering the model processes and intended model uses, the following individual and combined locations for evaluating the calibration and tuning of the updated ILRG Model were used:

River Gages
Caballo Reservoir Outflow
Rio Grande at El Paso
Rio Grande at Fort Quitman

Drains
Rincon Valley Drains
Mesilla Valley Drains
El Paso Valley Drains

FHG Deliveries and Pumping
EBID
EPCWID
HCCRD

Diversions
Rincon Dam
Leasburg Dam
Eastside Canal
Westside Canal
American Canal
Riverside Canal
Franklin Canal
Acequia Madre
Total HCCRD Supply

The above individual and aggregated locations represent thoughtful consideration of the extent to which historical and simulated flows are effectively aggregated in their simulated interactions, as summarized below:

- Rio Grande Flows – Releases from Caballo Reservoir and the flows at the El Paso and Fort Quitman gages are most important. The flows at the Rio Grande gages between the Caballo outlet and El Paso are less important because the river typically does not dry up at these locations, and therefore the simulated flow at these gages does not limit diversions of Project water. The flow at the Rio Grande gages between El Paso and Ft. Quitman is of less significance because most of the surface water is delivered through EPCWID and JID irrigation systems rather than the Rio Grande in this area.
- Diversions – Diversions are assessed at each of the major river headgates in the study area and at the Franklin and Riverside Canal gages in EPCWID.
- FHG Deliveries and Pumping – FHG deliveries are assessed for each District, consistent with the scale that the historical FHG delivery data are available. Because pumping is simulated to meet unmet demands after the FHG deliveries, pumping is also evaluated on a consistent District-wide basis. Note that irrigation pumping data is not available in the LRG Basin except for pumping in New Mexico starting in 2009. As result, simulated pumping in the Historical Base Run (Run 1) was compared to the simulated pumping in the Historical Calibration Run (Run 0).
- Drains – The flow of individual drains is generally less important than the aggregate flow of drains that collect flow from the major valleys. It is the aggregate total drain flow that contributes flow to the downstream users, and the

> particular drain in which the flow arises is of little importance to the model simulation. Aggregated drain flows were assessed for the Rincon Valley, the Mesilla Valley, and the El Paso Valley.

The claim by Mr. Coors that the ILRG Model is poorly calibrated is based on his assessment of calibration using statistics that compare monthly modeled and observed data. This assessment does not consider whether matching of monthly flows is necessary given how the Project operates and how the results from ILRG Model will be used in this case.

Project water is allocated to the Districts and allotted to the farmers as irrigation season volumes that they can take delivery at their discretion. In general, it is reasonable to assume that water users took delivery of water to meet the needs of their crops, but they also likely considered bunching releases to minimize transit losses, prioritizing irrigation of certain crops at the expense of other crops, whether late season reservoir inflows were better saved for use in the next year, and other factors. It is generally not possible to develop simulation rules that exactly match the variable water ordering and reservoir release practices that existed during the simulation period. Fortunately, accurate matching of historical monthly releases and deliveries is not necessary in the ILRG Model because simulating too much delivery early and not enough delivery late, or vice-versa, just redistributes a similar seasonal volume of deliveries and similarly redistributes a similar seasonal volume of pumping to meet unmet demand.

The existence of stored Project water in Elephant Butte and Caballo Reservoirs is another important consideration in assessing the need for close matching of modeled and observed values on a monthly basis in the ILRG Model. This stored water is by far the largest source of surface water supply in the LRG Basin. The availability of stored water to the Project users has a buffering effect on the impacts of pumping and other actions on Project water supplies. This means, for example, that monthly depletions to surface flows from pumping can be buffered in the short-term by greater releases from storage to meet delivery demands until the available storage supply is exhausted (either the physical supply or the annual allocations). It would be unreasonable to use the model to compute injurious impacts on a monthly basis without consideration of whether water remained in the water user’s account. The availability of supplemental wells can buffer the effect of monthly variations in Project supply

The foregoing considerations invite use of the ILRG Model to evaluate impacts on a seasonal basis rather than a monthly basis. This recognizes the important fungible nature of the timing of Project water use within the irrigation season. While aggregation of monthly model results to irrigation season totals is appropriate for analysis of impacts from pumping or other actions, aggregating model results into annual totals is generally not appropriate for evaluating diversions and deliveries of irrigation water supplies. Less usable flows occurring during the non-irrigation season are not a substitute for more useable flows during the irrigation season. This is consistent with Project accounting that is based on irrigation season allocations and deliveries, and water used outside of the irrigation season when the reservoir is not releasing is not considered or charged as Project water.

Given how the Project operates based on seasonal allocations, allotments, and releases as described above, it is appropriate to evaluate the ILRG Model calibration of diversions, FHG deliveries, and pumping using irrigation season totals. Reasonable matching of diversions goes hand in hand with reasonable simulation of river flows during the irrigation season. If there is not enough water is in the river, then the diversions can't be met, and if there is too much water in the river, then there will be too much water passing the American and International Dams. Therefore, the calibration of river flows was evaluated using annual totals to verify the model was reasonably matching the entire volume of the simulated flows that typically includes both reservoir releases and return flows in the irrigation season and return flows only during the non-irrigation season. Drain flows were also evaluated using annual totals.

Coors Opinion 18 *- It would be ideal to include model locations that were not used as calibration targets to assess the quality of the calibration process, but all of the locations that have observation data were used as calibration targets. It would have been more appropriate for the New Mexico experts to either leave some portion of every location's data for validation or some portion of the locations for validation, but this does not appear to have been done. (page 11).*

Response:

There is no broad consensus in the scientific community for excluding a portion of the historical study period from the model calibration, and to use the excluded data to validate the calibration. Some advocate that validation is useful and a good test of a model. Others argue that using all available information for calibration produces a better model (Konikow and Bredehoeft, 1992).

In this case, the ILRG Model is being used mostly to analyze the past, so it makes sense to use all available historical data to calibrate the model. Further, the historical data contain a representative variety of hydrologic conditions ranging from full supply years with relatively little pumping demand to low supply drought periods requiring large pumping volumes. The range of conditions during the historical calibration period generally encompasses the range of conditions that would be expected to occur in any of the conditions that are simulated in alternative scenarios. Therefore, it is reasonable to use all available data to calibrate the ILRG Model.

Coors Opinion 19 *- The results from the statistical analysis demonstrate that the Historical Base Run fails to accurately model historic Rio Grande Project conditions throughout the basin. The more robust and appropriate statistical parameters and list of locations introduced in this report provide a more accurate assessment of the quality of the Run 1 calibration process, and how well Run 1 simulates historical Project operations. (page 12).*

Response:

For the reasons described above, including the use of monthly calibration statistics applied to needlessly disaggregated locations, the calibration assessment presented by Mr. Coors is not appropriate for evaluating the utility of the ILRG Model for assessing the claims and counterclaims in this case.

The calibration and tuning assessment presented in Section 28.0, which includes calibration statistics computed using irrigation season and annual flows, and visual comparisons of simulated and observed values, is more representative of the capabilities of the ILRG Model in simulating conditions during the historical study period than the assessment presented by Mr. Coors. The calibration evaluation described in Section 28.0 provides confidence that the ILRG Model simulations of alternative scenarios are reasonable and can be relied upon in analyzing the claims and counterclaims in this case.

Coors Opinion 20 *- The ME parameter and the ME as Percent of Monthly Mean values reported by New Mexico experts give the appearance of a good fit. However, this metric only characterizes bias in modeled values at calibration target locations. When this metric is applied to a more comprehensive and representative set of locations, a significant bias in modeled values is shown. The average absolute value for the ME as Percent of Monthly Mean is 19% with values for four drains being nearly 50% and higher. The Rio Grande at Island Station gage shows a 55.1% value. This indicates an unacceptable level of bias throughout the model. (page 12).*

Response:

As discussed in more detail in Section 28.0 and shown in **Table 28-1**, the Mean Error and PBIAS statistics applied to a more representative set of locations or aggregated locations using irrigation season and annual totals demonstrate much better performance of the ILRG Model than indicated by the assessment presented by Mr. Coors. The PBIAS is less than 5% at the Caballo outlet and the Rio Grande at El Paso (very good), less than 10% at the canal gages (good to very good), and 16% or less for the aggregated drains (not satisfactory to very good).

Coors Opinion 21 *- The MAE parameter indicates significant uncertainty in the modeled values. The MAE as Percent of Monthly Mean values range from 28% to 121% of the observed monthly mean at the analyzed locations. The average value of this quantity for all 26 locations is 52.7%. This means that on average across all of these locations in the model, the monthly modeled values are over 50% off from observed values at these locations. This indicates an unacceptably high level of uncertainty in the monthly values across the whole model. (page 12).*

Response:

The MAE and PMAE statistics for locations selected by the New Mexico experts show better model performance when computed using irrigation season and annual totals rather than the monthly values used by Mr. Coors. The PMAE for most locations ranges from 6% to 36% with most values less than approximately 20%. This represents reasonable model performance given the size and complexity of the Rio Grande Project and irrigation systems in the LRG Basin. In addition, the graphs in **Figure 28-1** through **Figure 28-21** that are discussed in Section 28.0, demonstrate satisfactory to excellent performance in reproducing the monthly, seasonal, and long-term patterns of the historical data.

Coors Opinion 22 *- According to the NSE rating criteria created by Ritter, Axel, and Rafael Muñoz-Carpena (2013) three of the 26 locations analyzed perform at a satisfactory level. The average NSE value across all locations is 0.41 which is unsatisfactory. There is one location that has a NSE value that is negative. This means that the historical mean value is a better representation than what the model simulates. This also indicates an unacceptably high level of uncertainty in the monthly values across the whole model. (page 12).*

Response:

As discussed in the response to Coors Opinion 12, there is no consensus in the scientific community for what for what constitutes a satisfactory NSE value. However, according to the criteria proposed by the ASABE contained in Moriasi et al. (2015), an NSE greater than 0.50 is considered satisfactory. All but one of the 21 seasonal or annual NSE values shown in **Table 28-1** for the ILRG Model exceed 0.50, and all but seven exceed the 0.65 threshold advocated by Mr. Coors.

The only NSE value less than 0.50 is for the aggregated Rincon Valley drain flows which on average after 1950 flowed less than 15,000 AF/y.

Coors Opinion 23 *- Applying the same performance criteria to the Log NSE parameters only three of the 26 locations perform satisfactorily. Because the Rio Grande at El Paso is one of the calibration targets used during the operational tuning, this location and its associated calibration metrics have limited value in characterizing the quality of the calibration of the model. There are seven locations that have a Log NSE value that is negative including Caballo Reservoir Outflow which is discussed further in section 6.1.2.1, below. This is a clear indication of an unacceptable amount of uncertainty in the model. The fact that the log NSE indicates worse performance than the NSE says that the model does a particularly poor job of representing lower flow values. (page 13).*

Response:

See the response to Coors Opinion 16. While the Log NSE statistic is generally inappropriate for evaluating the ILRG Model performance because there is no need to emphasize performance at low flows, the Log NSE statistics computed for seasonal and annual values shown in **Table 28-1** show satisfactory to good performance for most locations.

Coors Opinion 24 *- Figures showing the calibration results graphically as scatter plots for all locations are found at the end of the report (see Section 9). (page 13).*

Response:

Mr. Coors included residual plots and scatter plots for the 26 locations that he selected for evaluating the calibration of the ILRG Model in Section 9 of his report. However, Mr. Coors did not offer any opinions regarding these graphs and therefore there are no opinions regarding these charts to rebut.

The presentation of the calibration and tuning results for the updated ILRG Model in Section 28.0 includes numerous graphs comparing modeled results against historical observed data. These charts, which are described in Section 28.0, are further evidence of the overall excellent performance of the updated ILRG Model.

Coors Opinion 25 *- The Caballo Outflow calibration metrics are particularly problematic. Caballo releases are arguably the most important Rio Grande Project operation that the model needs to replicate in the Historical Base Run (page 13).*

Response:

The calibration statistics in **Table 28-1** for the Caballo Outflows in the updated LRG Model show a small PBIAS of 0.1% and an excellent NSE value of 0.93. The monthly and annual graphs of modeled and observed values in **Figure 28-1** demonstrate that the simulated releases reasonably match the amounts and patterns in the historical data. This is evidence of excellent functioning of the RiverWare Model rules that simulate historical Project allocations and releases.

Coors Opinion 26 *- For New Mexico's claim that Project operations are reasonably simulated in the model to be true, the model must demonstrate the ability to, with rules, simulate releases of Project water that are a good representation of how the Project is actually operated. The ability of the ILRG model to meaningfully represent Project operations determines its capability to model hypotheticals, which in turn determines its ability to determine impacts. The Log NSE for this parameter is a problem at -.07. A negative Log NSE value means that the historical (observed) mean for the entire run period would be a better representation of monthly releases from Caballo than what RiverWare produced with its rules (Krause, P., et al). The unacceptable performance of the Caballo Outflow parameter in RiverWare means that the "operationally tuned" RiverWare model is not a reliable simulator of Project operations on a monthly scale and cannot be relied upon to provide accurate what-if analyses of hypothetical scenarios. (page 13).*

Response:

As discussed in the response to Coors Opinion 25, the ILRG Model performance in simulating Caballo Outflows is excellent. While the Log NSE statistic is generally inappropriate for evaluating the ILRG Model for the reasons discussed in the response to Coors Opinion 16, the Log NSE statistic was included among the performance measures presented in **Table 28-1** for comparison to the calibration statistics presented in the Coors Supplemental Report. When computed using simulated and observed annual Caballo releases, the Log NSE performance score for Caballo Outflows is very good at 0.93.

Coors Opinion 27 *- Though this figure (and the others like it) is never referenced by Hydros in the Tech Memo 4, presumably it is being presented to demonstrate that EBID project river diversions are being captured adequately by the rules. This is incomplete. These values have been aggregated significantly, both temporally and spatially. The model is monthly and the New Mexico experts assert that the system must be modeled monthly to be viable. The values in the plot are annual. (page 14).*

Response:

As discussed in the response to Coors Opinion 8, while it is important to model the system using monthly stress periods, the performance of the ILRG Model should be assessed primarily based on the degree that it reasonably simulates Project operations, irrigation operations, and surface water flows using irrigation season or annual totals. Visual comparison of model results on a monthly basis confirms that the simulated flows generally follow the monthly patterns in the observed data, particularly during the irrigation season.

Thoughtful spatial aggregation of ILRG model results for assessment of ILRG calibration is appropriate in consideration of how the Rio Grande Project operates and how water is delivered for use. For example, there is little sense in criticizing the model calibration of individual drains when those drain flows join together before the next downstream diversion.

In addition, calibration assessment should also consider the spatial scale of the input data to the ILRG Model. For example, while the model separately simulates the irrigation operations in the EBID subareas of Rincon, Leasburg, Eastside Mesilla, and Westside Mesilla, it is appropriate to evaluate the model performance for certain aspects of EBID using District totals. This is because portions of the EBID data used in the modeling are reported only as EBID totals. Care must be given in judging model results at a spatial scale that is finer than the spatial scale of the input data. A summary of the spatial scale of selected input data for the ILRG Model is shown in **Table 23-1** and discussed in Section 23.0.

Coors Opinion 28 *- A second important indicator of a well calibrated model is low operational bias. The cumulative residual between the modeled values and observed values is an indicator of model bias and should not exhibit noticeable patterns or trends in a well calibrated model. If the model is replicating history (Project operations in this case) objectively the absolute residual should appear random and cumulative residual should display no distinct multiannual trends indicated by significant departures from the zero line. Analysis of the bias in the same 26 locations exhibits the opposite, and the flaw is evident when viewing the residual and cumulative residual trends of the Rio Grande at El Paso, Figure 2. (page 15).*

Response:

The cumulative residual described by Mr. Coors is not the same as operational bias. Operational bias, also known as mean error, is defined as the difference between the computed mean of a simulated output and the computed mean of the observed data over all or a portion of the simulation period. The cumulative residual shows how differences between modeled and observed values accumulate through time during the simulation period. Virtually all models of complex systems will show cumulative residuals of model outputs trending in positive and negative directions over short time periods such as are shown for the Rio Grande at El Paso in Figure 2 of the Coors Supplemental Report. The suggestion by Mr. Coors that the cumulative residual represented by the heavy blue line should hover very closely around zero is an ideal that is rarely achieved in hydrologic modeling of complex systems.

In addition, Figure 2 in the Coors Supplemental Report does not provide context for the amount of the residuals and cumulative residuals. The middle right graph in **Figure 28-2** shows the cumulative residual for the Rio Grande at El Paso gage as a percentage of the cumulative El Paso flow over the 1940 – 2017 study period. This puts the cumulative residual error at the El Paso gage in proper perspective. The maximum cumulative residual ranges from -1.8% to +0.6% which is excellent.

Coors Opinion 29 *- The New Mexico experts fail to create accurate representations of no pumping conditions in their hypothetical scenarios. The hypothetical runs (Runs 2, 3, 4, 5, and 6) simulate scenarios in which groundwater pumping is turned off for regional and basin-wide combinations of water users. New Mexico experts modeled the hypothetical scenarios by simply setting groundwater pumping to zero in the no-pumping areas. Modeling the no-pumping condition in this way fails to adequately represent changes that would occur in on-farm processes resulting from the unavailability of groundwater supply. While the irrigated acreage on the primary groundwater users is properly reduced to zero, the irrigated acreage of supplemental groundwater users is not reduced in response to decreased water supply. The irrigated acreage would decrease or a crop requiring less water would be produced to respond to the decrease in available water, as shown in Eq (6). ILRG modelers selected RiverWare methods on the RiverWare "Water User" objects requiring irrigated acreage and the evapotranspiration (ET) rate be entered as inputs. Historical irrigated acreages and ET rates are also used in all the hypotheticals. Not allowing irrigated acreages or ET rates to change (reduce) for scenarios in which water supply significantly decreases results in unrealistic results because the modeling of monthly on-farm processes through the irrigation season are unreasonable. (page 16).*

Response:

In my experience, it is common in modeling alternative scenarios of historical irrigation to leave the irrigated acreage and cropping pattern at the historical values in simulations of alternative scenarios, including no pumping or reduced pumping scenarios. This is how reduced pumping scenarios were simulated using the H-I Model of the Arkansas River for the Kansas v. Colorado litigation. This procedure is also similar to how engineers in Colorado analyze historical use for changes in irrigation water rights in the Colorado water courts. In these analyses, the irrigated area is typically simulated at the maximum irrigable acres evident in aerial photographs. In each year of the historical simulation, the upper limit of the crop consumptive use is based on the crop-weighted CIR multiplied by the simulated irrigated area. During water short years, the actual crop consumptive use is limited to the historical farm headgate deliveries multiplied by the maximum on-farm irrigation efficiency.

In the no pumping or reduced pumping runs of the ILRG Model, the simulated irrigation supply delivered to the farms will often be less than the irrigation water demand for the historical irrigated area and cropping pattern resulting in irrigation water shortages. In these water short conditions, the simulated irrigation consumptive use is limited to the available supply times the maximum on-farm irrigation efficiency.

While it is true that in the real-world farmers without access to wells may reduce the irrigated area and change their crops to conform to the expected limited surface water supply, it is reasonable to assume that the limited supply would be consumed at the same maximum irrigation efficiency resulting in the same consumptive use of applied surface water. In other words, even if the acres and assumed crops were changed in the alternative runs, the consumptive use would still be the result of the available supply times maximum on-farm irrigation efficiency.

If the simulated consumptive use is the same whether or not the simulated acreage is reduced and the crops are changed, then there is little to be gained by speculating how the farmers would respond to the reduced irrigation supply in terms of the modeling results. Note also that Dr. Hutchison did not reduce the irrigated area is his simulation of reduced pumping scenarios.

Coors Opinion 30 *- This is a standard method to develop reservoir local inflows. However, because estimated evaporation and measurement error are part of the calculated mass balance equation, and bank storage and reservoir seepage are elements in the actual water balance of the reservoir and is not included in the calculated water balance, there are numerous months for which a negative value is calculated for this quantity. This is a common result from a mass-balance approach to developing reservoir inflows. It causes problems for modeling the hypothetical scenarios as the inflow to Caballo Reservoir would be different in the different hypothetical scenarios that have a significant difference in Caballo storage throughout the run, as bank storage and seepage are dependent on reservoir storage levels. The NM experts did not consider that there would be difference in bank storage effects in alternative runs. (page 18).*

Response:

Caballo Reservoir is an operational reservoir that helps to regulate releases for power production from Elephant Butte Reservoir for subsequent downstream delivery to meet Project water demands. It is not expected that the function of Caballo Reservoir as a regulating reservoir would be materially different in alternative scenarios compared to the historical operation over the long term, and therefore any differences in bank storage effects would be positive and negative and largely cancel each other out.

Coors Opinion 31 *- There is a second, more significant problem with this quantity. The RiverWare model introduces erroneous (non-historical) water to the system here by means of an inappropriate "method" being employed on this object. When during the course of a model run, the simulated releases from Elephant Butte are not large enough to compensate for the negative inflows input to the system at the "RGabvCaballo" reach, a negative outflow would result from the reach. This is problematic for the model and must be addressed. Hydros' solution to the problem was to select the "Negative Outflow Unidentified Loss" method which adds any additional flow to the reach necessary to make the outflow zero. This added water is not part of the historical inflow development process and represents water erroneously added to the system at Caballo. (page 18).*

Response:

This issue was described by Mr. Coors in his first deposition in February 2020. The New Mexico experts reviewed this matter and added a rule to the RiverWare simulation of Elephant Butte Reservoir that computes a minimum monthly release equal to the computed unmeasured negative inflow (loss) between Elephant Butte Reservoir and Caballo Reservoir. This additional rule corrected the mass balance issue that was identified by Mr. Coors.

Coors Opinion 32 *- Creating management rules and tuning a set of simplistic operational parameters to accurately simulate the complexity of real historic operations of the Project at a monthly scale is an overly ambitious goal. Physical processes are governed by physical laws that behave consistently. Given the same set of initial conditions, the dynamics of water in a physical system governed by physical laws will always be the same. The same is not true of management processes; management processes like Rio Grande Project operations are governed by legal structures, historical practice, and subjective decision making. Given the same set of initial conditions the dynamics of water governed by management process can vary significantly for a variety of reasons including the political climate, current system operator, one-off conditions, and any number of other factors. This fact makes characterizing historical Project operations with a sufficient degree of accuracy to support impacts analysis using hypotheticals an impossibility. (page 21).*

Response:

I disagree that the dynamics of the Rio Grande Project management processes cannot be modeled with sufficient accuracy. The historical procedures for allocating water and operating the Project reservoirs to release sufficient water to meet water orders are generally well established, understood, and amenable to modeling. The excellent calibration statistics for Caballo Outflows summarized in **Table 28-1** and the graphical comparison of simulated and observed releases shown in **Figure 28-1** are evidence of the efficacy of the RiverWare rules in simulating Project operations.

Coors Opinion 33 *- These unanticipated deviations make "tuning" the model to simulate management processes a highly uncertain exercise with only modest success even possible. When the quantification of pumping impacts is dependent on the model replicating historical conditions precisely, tuning a few simple model parameters to attempt to closes match the intricacies of real-world management processes to a degree suitable for closely matching historical operations is unattainable. (page 21).*

Response:

While there were occasional ad hoc historical deviations from standard Project operating practices, the RiverWare simulation rules produce a well-calibrated model as evidenced by the calibration statistics and graphical comparisons of predicted and observed flows presented in Section 28.0.

The statement that quantification of pumping impacts depends on <u>precise</u> model replication of historical conditions by Mr. Coors is not realistic and sets an impossible standard. A model need not be perfect to be useful and reliable. As discussed in the response to Coors Opinion 34, <u>differences</u> in model outputs from simulated scenarios (e.g., a no pumping run vs. the Historical Base Run) can be more accurate than the model predictions of the individual scenarios because of the cancelling of similar errors that are present in both scenarios.

In order for the differences between scenarios simulated in this case to be reasonable and accurate, the simulation model needs to (a) simulate the entire area from Elephant Butte Reservoir to Fort Quitman, (b) use monthly stress periods that facilitate analysis of the relatively rapid temporal response and interaction between the surface water features and the shallow alluvial aquifers, (c) simulate Project and irrigation system operations using rules that facilitate dynamic response to changing conditions in alternative scenarios, and (d) be calibrated to show a reasonable match between modeled and observed historical flows on a seasonal or annual basis. The updated ILRG Model succeeds in all of these areas.

The relatively simple tuning of the operational rules that produces a good model calibration without overparameterizing the model as demonstrated in tables and charts in Section 28.0.

Coors Opinion 34 *- [Deposition testimony of Michel Estrada-Lopez] characterizes precisely what is described above as a management process. This process is a fundamental aspect of Project operations that are purportedly "well represented" by rules and operational tuning factors. Her description of how the process of determining the annual allocation for the Project actually takes place certainly highlights the subjective and evolutionary nature of this operation. These characteristics make capturing historical Project operations with rules and simple tuning parameters essentially impossible. The failing calibration analysis and operational bias analysis presented above demonstrate what would be expected from a model that attempts to capture with static logic a real-world historical operational process like annual Project allocation as described by Ms. Estrada-Lopez. (page 22).*

Response:

The deposition testimony of Ms. Estrada-Lopez cited by Mr. Coors details the annual process involved in Project accounting. For modeling purposes, it is not necessary to simulate every detail of the Project accounting in order for the model to be reliable in analyzing the claims and counterclaims in this case. Application of the ILRG Model in this case will typically involve computing differences between model runs (e.g., a no pumping run minus the Historical Base Run). When computing these differences, model error resulting from insignificant fine accounting details that are not incorporated in the simulation rules will tend to be present in both of the model runs, and therefore this error will tend to cancel out when the runs are differenced. A consistent set of simulation rules is applied in the ILRG Model simulations of the Historical Base Run and alternative scenarios and this allows the changes in input data or assumptions for different runs to be reflected in the computed differences in model outputs.

This is analogous to ground water models that do not and cannot represent all of the real-world spatial heterogeneity of the simulated ground water system. Instead, ground water modelers represent the aquifer hydrogeology using hydraulic conductivity and storage coefficients that are spatially smoothed and approximate representations of real-world variability. When the ground water models are calibrated to reasonably replicate historical conditions, they are judged ready for use in simulating alternative scenarios.

Ms. Estrada-Lopez's testimony also describes the process for reviewing and potentially updating the Operating Agreement Manual and/or the accounting spreadsheet. The ILRG Model reasonably simulates the processes set forth in the Operations Manual and in the Accounting Spreadsheet. To the extent that the manual or spreadsheet are revised to a substantive degree, relevant ILRG Model rules can be modified accordingly to simulate those changes beginning in the year they are implemented. Historically, most of the accounting refinements that have been implemented are in the category of fine accounting details that need not be represented in the ILRG Model rules. As described above, to the extent the absence of these details contributes to model error, this error will tend to cancel out when differencing model runs.

Coors Opinion 35 *- It is my opinion that based on the calibration results for Run 1 the idealized monthly Project operations in the RiverWare model do not represent historical monthly Project operations to an acceptable degree to model non-historical hypothetical scenarios and how Project operations would change under hypothetical, non-historical conditions on a monthly basis. (page 22).*

Response:

As shown in the tables and figures in Section 28.0, the ILRG Model is well calibrated on a seasonal and annual basis and also generally matches the patterns of the monthly flows during the irrigation season and non-irrigation season. Because the robust performance of the ILRG Model is achieved with rules that facilitate dynamic response to changing conditions, it is my opinion that ILRG Model produces reasonable and reliable results in simulating alternative scenarios.

Coors Opinion 36 *- When results from the New Mexico experts' model runs are temporally aggregated to annual averages and spatially aggregated into large project areas (Rincon, Leasburg, and Mesilla), the uncertainty in the results is reduced. The simplest way to limit uncertainty in data, especially in the case of modeling the LRG system would be to aggregate. When data is aggregated spatially and/or temporally, the uncertainty in its values decreases. (page 22).*

Response:

There is agreement that aggregating results temporally and spatially reduces uncertainty in the ILRG Model results. Such aggregation is reasonable and appropriate in assessing the model calibration, interpreting the model results, and in using the model to evaluate the claims and counterclaims in this case.

Coors Opinion 37 *- Table 5 shows the same set of calibration results as were presented in Section 6.1.1, but model results are aggregated to an annual timestep. When comparing Table 5 to Table 2 (Section 6.1.2, above) it is apparent that the performance improves. Further improvement would be expected by spatially aggregating within the ILRG model as well. The results still show significant problems with the calibration of the model even at the annual level, and thus specific quantitative annual results from the ILRG model are informative, but still not reliable. (page 23).*

Response:

As discussed extensively above, it is reasonable and appropriate to aggregate and assess the ILRG Model results primarily using irrigation season totals. There is also some utility in assessing the model performance in simulating the Rio Grande flows at the El Paso and Fort Quitman gages on the basis of annual totals from an overall mass balance perspective because the simulated flows at these gages integrate all upstream operations.

The annual results presented in Table 5 of the Coors Supplemental Report and all other annual totals presented in the report and in backup spreadsheets are plagued with an arithmetic error. All of the annual totals were computed by Excel formulas based on the sum of the monthly values from one December through the next December. In other words, all annual totals reflect the sum of 13 monthly values. For example, the annual flow for 2010 was computed as the sum of the monthly flows from December 2009 through December 2010.

Coors Opinion 38 *- Considering Run 2 as the baseline or 1938 Compact condition and Run 1 as the historical deviation from the 1938 Compact condition, comparing results from the two runs at an appropriate spatial and temporal scale shows the impacts of groundwater pumping throughout the basin as all other processes that might affect the dynamics of water in the system are the same. Comparing results from these two scenarios isolates the impacts of groundwater pumping on surface water conditions, groundwater conditions, and Project operations. The results clearly substantiate Texas's primary claim. (page 24).*

Response:

It is illogical and inappropriate to use the results from Run 2 of the ILRG Model when all pumping is turned off (New Mexico, Texas, and Mexico) to attempt to substantiate the Texas claim that New Mexico pumping has reduced the supply to Texas. Run 2 does not isolate the effects of New Mexico's pumping on deliveries to Texas. The impacts of pumping by Texas in the Mesilla basin and the Hueco basin contribute to computed differences in the ILRG Model results for Run 2 and Run 1.

Coors Opinion 39 *- Dry periods such as the mid-1950's when pumping in New Mexico was prevalent are evident by the depleted groundwater condition. It is evident too that the duration of depleted groundwater conditions is multiple years, and that the groundwater condition remains somewhat depleted for the remainder of the run after 1950. This is consistent with the Texas claims and illustrates why Texas chose to develop a model with an annual stress period. (page 26).*

Response:

The fact that the ILRG Model simulates multi-year impacts to ground water elevations during dry periods does not mean that a model with annual stress periods is appropriate for use in analyzing the Texas complaint. While impacts to ground water storage are of interest in this case, the impacts to Project surface water supplies are the primary focus. As has been clearly demonstrated through analyses of historical data and through the simulations using the ILRG Model, impacts of pumping, changes in irrigation practices, and changes in Project operations affect surface water deliveries on a monthly or seasonal basis. The typical rapid response of drains to pumping and irrigation recharge is illustrated in **Figure 23-1** and **Figure 23-2** that are discussed in the response to Coors Opinion 8.

Coors Opinion 40 *- Clearly, the seepage out of the Rio Grande in these service areas in New Mexico is significantly greater in the historic scenario, Run 1, than in the no pumping baseline scenario, Run 2. (page 28).*

Response:

It is not appropriate to evaluate the effects on river seepage caused by New Mexico pumping using Run 2 (All Pumping Off). See the response to Coors Opinion 38.

Coors Opinion 41 *- Finally, New Mexico's RiverWare model simulates an idealized version of the determination of the annual allocation for EPCWID for each year of the run. Results show that the EPCWID allocation is negatively impacted by the historical pumping represented in Run 1 compared to the no pumping condition of Run 2. (page 28).*

Response:

It is not appropriate to evaluate the effects on Texas allocations caused by New Mexico pumping using Run 2 (All Pumping Off). See the response to Coors Opinion 38. As discussed in Section 30, New Mexico pumping impacts irrigation season deliveries to EPCWID by an average of 17,800 AF during 2006-2017. This is much less than the impact of the 2008 OA on New Mexico computed in Run 11 that averaged 54,600 AF during the same period.

Coors Opinion 42 *- A comparison of the flows in the river at El Paso between Run 2 and Run 1 of New Mexico's ILRG model clearly indicates that pumping in New Mexico has negatively impacted flows at El Paso. (page 29).*

Response:

It is not appropriate to evaluate the effects on Rio Grande at El Paso flows caused by New Mexico pumping using Run 2 (All Pumping Off). See the response to Coors Opinion 38. In any event, the El Paso gage is not a Compact delivery point and changes in El Paso flows caused by New Mexico pumping are not an appropriate measure of impacts to Texas.

Coors Opinion 43 - *Comparing Run 1 and Run 2 and their results for El Paso flows provides an answer from New Mexico's own model to Spronk and Hydros' repeated contentions that the Texas analysis in general, and Brandes's analysis in particular, is "overly-simplistic" and that the depleted El Paso flows issue is actually much more complex with many possible explanations. Run 1 and Run 2 are formulated to isolate the effects of pumping with <u>all else equal</u>. The Run 2 scenario as conceived by New Mexico experts is very similar in concept to a 1938 Compact condition of the basin. It simulates a condition in which there is no pumping throughout the LRG basin, as was the case during the 1930-1950 period. It is striking how similar the 1930-1950 double mass analysis data and extended trend line from Brandes' report are to the same double mass curve generated from the ILRG model Run 2 results. (page 30).*

Response:

Mr. Coors is incorrect in stating that there was no pumping in the LRG Basin during the 1930-1950 period. Large scale development of supplemental irrigation wells commenced in the late 1940s, and non-irrigation Irrigation pumping for M&I and other uses started earlier, most notably in the El Paso and Juarez areas.

The general long-term agreement between change in El Paso flow shown in the Brandes double-mass curve (as revised by Coors) and the ILRG Model (Run 2 vs. Run 1) is a validation of the efficacy of the ILRG Model.

Figure 15 in the Coors Supplemental Report compares cumulative <u>annual</u> El Paso flows from the revised Brandes double-mass curve analysis against the ILRG Model results. These comparisons of annual flows do not distinguish changes in flows during the irrigation season from changes in flows during the non-irrigation season. As described above, it is the changes in irrigation season flows that are most important in this case, with changes in irrigation season deliveries to the end users being the relevant measure of impacts, not changes in flow at the El Paso gage.

When all of the pumping in the Rincon and Mesilla Valleys is turned off in the Texas Model, far too much water shows up at El Paso, more than shown by the Brandes double-mass curve analysis because of the lack of re-operation in the Texas Model. This is clear evidence of the failure of the Texas Model to produce reasonable and believable results.

Coors Opinion 44 - *The New Mexico models corroborate that the observed decrease in flows at El Paso from the time when groundwater pumping began in New Mexico appears to be rightly attributed to this pumping. (page 32).*

Response:

The results from Run 2 cannot be used to attribute the effects of New Mexico pumping because all pumping is turned off in Run 2, including pumping by Texas and Mexico in the Mesilla and Hueco basins. See the response to Coors Opinion 38.

Coors Opinion 45 - *Modeling monthly Project reservoir operations is not necessary to demonstrate the impact of New Mexico groundwater pumping on deliveries to Texas water users, as has been substantiated throughout this report and is demonstrated convincingly in Dr. Hutchinson's report describing the Texas model. However, referencing these results from the New Mexico experts' runs of their own model further refines the narrative of how New Mexico's pumping impacts on Texas water users. (page 32).*

Response:

As discussed extensively in the SWE Report, the Texas Model is unreliable because it includes no capability for dynamic simulation of Project operations. In order to approximately match the historical change in El Paso flow evident in the Brandes double-mass curve analysis, Dr. Hutchison turns off only 60% of the pumping by New Mexico and Texas in the Rincon and Mesilla basins. Because of the lack of reoperation in the Texas Model, turning off all of the pumping in the Rincon and Mesilla basins causes too much water to flow out the bottom of the Texas Model at El Paso.

Notwithstanding the lack of reoperation, the Texas Model runs performed by Dr. Hutchison are not appropriate for attribution of impacts caused by New Mexico pumping because these runs also reflect the effects of pumping by Texas wells in the Mesilla basin.

Coors Opinion 46 - *Table 7 shows that during this 1950-1956 drought period, as a result of groundwater pumping, the impact to groundwater elevations grows, the impact to seepage increases and the allocation to EPCWID is negatively impacted as well. These values are bordered in orange in Table 7. (page 33).*

Response:

The results from Run 2 cannot be used to attribute effect of New Mexico pumping because all pumping is turned off in Run 2, including pumping by Texas and Mexico in the Mesilla and Hueco basins. See the response to Coors Opinion 38.

Coors Opinion 47 *- What is important about this first sequence of years is that it shows that the negative impacts of groundwater pumping continue to accrue even when the basin is no longer in drought and allocations return to full. (page 34).*

Response:

Impacts to ground water storage can reasonably persist even when full supply conditions return. That the ILRG Model simulates this phenomenon shows that the ILRG Model is robust and can simulate both short-term and long-term impacts from pumping. Mr. Coors has not shown how impacts to ground water storage in New Mexico are injurious to Texas.

Coors Opinion 48 *- While there is no realized impact to the allocation during these years, there is a growing deficit in stored water in the reservoirs. This storage differential can be characterized as a growing potential impact to Texas. (page 34).*

Response:

The results from Run 2 cannot be used to attribute effects of New Mexico pumping because all pumping is turned off in Run 2, including pumping by Texas and Mexico in the Mesilla and Hueco basins. See the response to Coors Opinion 38.

Potential impacts are not the same as actual impacts. Depletions to reservoir storage do not translate into impacts on Project deliveries until the storage account(s) empty. Impacts from pumping can accumulate in storage during full allocation years during which time portions of the accumulated impacts are lost to evaporation and seepage. Reservoir spills will also cancel out accumulated storage impacts.

Coors Opinion 49 *- When New Mexico pumps groundwater, it effectively and inappropriately borrows Project water from the future. Some of this borrowed water ends up impacting New Mexico by the same mechanism described above. But because New Mexico water users receive the benefit of the water when it is pumped from the ground, the impact does not represent an injury. They effectively borrowed from their own future water. There is an injury to Texas water users, however, because a significant portion of the Project water New Mexico borrowed through pumping belongs to the Texas as defined* *in the 1938 Rio Grande Compact. This is the essence of the complaint and the source of the injury to Texas water users. (page 35).*

Response:

The results from Run 2 cannot be used to attribute effects of New Mexico pumping because all pumping is turned off in Run 2, including pumping by Texas and Mexico in the Mesilla and Hueco basins. See the response to Coors Opinion 38.

Mr. Coors' assertions about future impacts caused by New Mexico pumping also apply to Texas pumping. The extent to which New Mexico or Texas pumping impacts Project water deliveries in the future depends on whether such pumping causes depletions of surface water flow that when translated through lens of Project operations results in material reductions in deliveries of Project water to the end users in Texas and/or New Mexico. The only way to evaluate such impacts is using the ILRG Model with its capability for dynamic reoperation response to changes to ground water and surface water flows caused by pumping. The Texas Model is incapable of such analysis.

Coors Opinion 50 *- Rather ILRG model results indicate that pumping in the Hueco has no significant impact on releases from Caballo Reservoir or Rio Grande flows at El Paso. (page 35).*

Response:

As described in the response to Ferguson Opinion 3. Hueco pumping does impact upstream Project operations, including Caballo Reservoir releases and El Paso flows. However, in many years some, but not all, of these impacts are offset by EPW WWTP discharges.

Coors Opinion 51 *- The appropriate conclusion from this simple comparison (Run 6 vs. Run 2) is that pumping in the Hueco Bolson basin has essentially no impact on Project operations or flows in the river at El Paso. Pumping in the Hueco Bolson resulted in differences in the releases from Caballo and the flows at El Paso by less than 1% on an absolute basis, and the changes were essentially unbiased, meaning that they were equally often increased as decreased. (page 37).*

Response:

Differencing the results between Run 2 (All Pumping Off) and Run 6 (Rincon-Mesilla Pumping Off) to compute the effects of pumping in the Hueco basin assumes that the ILRG Model is linear, which it is not. A more appropriate way to evaluate the effects of Hueco pumping is to make a run of the ILRG Model with the Hueco pumping turned off and compare the results to Run 1 (All Pumping On). This run and several variants are described in Section 31.0 (Runs 14, 14a, 14b, 14c, and 14d) and also in the response to Ferguson Opinion 3.

Coors Opinion 52 *- In order to make a comparison with Run 1 that isolates Hueco Bolson pumping, Texas legal counsel directed Precision to develop and conduct a run of the ILRG model that was not included in the set of runs disclosed by the New Mexico experts. Precision designed a scenario in which all groundwater pumping in the Hueco Bolson groundwater basin is turned off. This run of the ILRG model is titled "Run A". Comparing Run A back to New Mexico Run 1 provides an estimate of the impact of turning historical Hueco Bolson pumping off while maintaining historical pumping in the Rincon and Mesilla basins. (page 37).*

Response:

While Mr. Coors said that he turned off all ground water pumping in the Hueco in his "Run A" of the ILRG Model, review of the input and output files that he disclosed for this run shows this was not the case. The following are among the errors that were discovered in the configuration of Run A:

- Supplemental irrigation pumping and M&I pumping in Mexico were left on,
- M&I pumping in Texas by entities other than EPW was left on,
- All WWTP discharges (Haskell, Bustamante, Socorro, Juarez, and Fabens) were left on, and
- All urban deep percolation was left on.

Because of these errors, the results from the Run A made by Mr. Coors are not usable.

Coors Opinion 53 *- My conclusion from this comparison, much the same as the first one, is that according to the ILRG model, pumping in the Hueco Bolson basin has virtually no impact on Project operations or flows in the river at El Paso. (page 39).*

Response:

Because of the errors with how Run A was configured, the results from this run are not a reliable indication of the effects of Hueco pumping.

24.0 RESPONSE TO MORAN SUPPLEMENTAL REPORT

Ms. Jean Moran of Stetson Engineers, Inc. prepared a September 17, 2019 supplemental expert report on behalf of the United States ("Moran Supplemental Report") that described further review and analysis using the Texas Model and included two new model runs.

SWE was asked by legal counsel for New Mexico to review the Moran Supplemental Report and to prepare expert opinions to respond the opinions of Ms. Moran. A lack of response regarding a particular issue should not be interpreted as tacit agreement with the Moran opinions on that issue.

All of the criticisms of the Texas Model structure and inputs that are described in the SWE Report and elsewhere in the SWE Rebuttal Report also apply to the Texas Model runs described in the Moran Supplemental Report. The responses described below do not restate these criticisms but rather focus on particulars of the Texas Model runs performed by Ms. Moran.

Moran Opinion 1 *- To assess the impacts of pumping on surface water supplies, the Historical model run3 was modified to account for no pumping in an iterative process. First the MODFLOW WEL package was adjusted to eliminate irrigation, urban, and domestic pumping; in addition, deep infiltration attributed in the Texas Model to groundwater used for irrigation and urban supply was also eliminated. The Texas Model was rerun using these no pumping conditions. The No Pumping model run was compared to the Historical model run to evaluate and quantify changes (increases) in annual streamflow in the Rio Grande at El Paso Narrows that would have been available in the absence of groundwater pumping in New Mexico. These new No Pumping model run results with the final Texas Model update and confirm the model results described in our May 31, 2019 report.*

Response:

The first step in Moran's no-pumping run of the Texas Model was to turn off the irrigation pumping, non-irrigation pumping (urban and domestic), deep percolation from irrigation pumping, and deep percolation from urban pumping. Critically absent from this list of changes was turning off the WWTP discharges from the urban pumping. Without turning off these WWTP discharges, the Moran run does not simulate the offset from WWTP discharges when the results from this run are compared to the historical run. This error inflates the simulated impacts from pumping.

In the Moran no pumping run, all pumping in the Texas Model was turned off, including irrigation and non-irrigation pumping in the Texas portion of the Mesilla Valley. Therefore, the computed differences between the historical run and the no-pumping run reflect impacts caused by New Mexico pumping <u>and Texas pumping</u>.

Moran Opinion 2 *- The analysis for this supplemental report attempts to reasonably distribute the additional surface water made available by eliminating pumping in order to evaluate the sensitivity of the Texas Model to show the effect of no pumping on the surface water supplies for the Project. To make this analysis, adjustments were made to the MODFLOW Stream Flow Routing (SFR) package to distribute the increases in Rio Grande streamflow at El Paso Narrows calculated in the No Pumping model run to upstream diversions and farm deliveries based on historical distribution. The Texas Model was iteratively rerun to account for Project water deliveries and Rio Grande streamflow at El Paso Narrows gage.*

Response:

As has been discussed at length by the New Mexico experts, one of the fundamental flaws of the Texas Model is the absence of mechanisms for simulating the water allocation and delivery processes of the Rio Grande Project. The absence of such mechanisms causes the results from Texas Model runs that were presented in the Hutchison Report to be generally of little use because there is no simulated response of the Project operation to the changes simulated in alternative scenarios (e.g., reduced pumping scenarios). In the alternative scenario runs of the Texas Model runs that were presented by Dr. Hutchison, the reservoir releases and diversions are fixed at historical levels in all runs. Therefore, simulated changes in surface flows simply flow downstream and out of the model domain at the Rio Grande at El Paso gage.

Ms. Moran has attempted to remedy the severe shortcomings of the Texas Model by developing a crude iterative redistribution procedure that redistributes a portion of simulated changes in flow at El Paso to upstream diversions. This is tacit acknowledgement of the shortcomings caused by the lack of reoperation in the Texas Model.

While the redistribution mechanism implemented by Ms. Moran represents some improvement to the Texas Model, it has substantial shortcomings that create unrealistic results, especially in comparison to the more realistic reoperation capability that is inherent in the ILRG Model. The Moran process redistributes on average 84% of the simulated additional annual flow at El Paso to upstream river diversions at the Arrey, Leasburg, Eastside, and Westside Canals in proportion to relative historical annual diversions. The additional flow allocated to each canal is then distributed to terminal diversions (FHG deliveries) within each canal in proportion to the simulated values in the calibration run. This simple proportional redistribution of the additional El Paso flow to the upstream canals assumes a linear redistribution of the additional flow to the upstream canals in a highly nonlinear system. The simplified redistribution process used by Ms. Moran does not consider the following factors that would affect the distribution of additional river flow in no pumping or reduced pumping scenarios.

- Monthly and seasonal distribution of the additional annual El Paso flow,
- Changes in releases from Caballo Reservoir,
- Limits on canal capacity,
- Whether EBID or EPCWID had already used their annual allocations,
- Whether EBID or EPCWID already had sufficient supply to meet their irrigation demand, and
- Effects of the 2008 OA on how pumping impacts are distributed.

A comparison of the results of the crude redistribution performed by Ms. Moran to the results from the ILRG Model for the no Rincon-Mesilla pumping run (Run 6) is included in Section 30.0, and demonstrates the severe limitations of the crude Moran approach.

Moran Opinion 3 *- A second analysis using the Texas Model was made to evaluate the effects of a 60% reduction in total pumping (40% of the amount of pumping contained in the Texas Model's Historical model run) on Rio Grande flow and Project diversions. ("40% Pumping model run"). This model run was conducted with water budget and model files that were not available at the time of Stetson's May 31, 2019 report. The 40% Pumping model run further examines the Texas Model performance by making modifications to the WEL and SFR files, and comparing these results with the Historical and No Pumping model runs. The same methodology of model iterations performed for the No Pumping model run were applied to the 40% Pumping model run.*

Response:

Ms. Moran applied her crude redistribution process to the 40% pumping run of the Texas Model in which pumping was reduced by 60%. All of the criticisms described above for the No Pumping Run also apply to the 40% Pumping Run.

It is also important to point out the conceptual inconsistencies in the results of the 40% Pumping Run presented by Ms. Moran and the 40% Pumping Run presented by Dr. Hutchison.

Dr. Hutchison presented numerous simulations of alternative scenarios using the Texas Model in his May 2019 expert report. Among those runs was the 60% reduced pumping run (i.e., 40% Pumping Run). Dr. Hutchison identified this as a key run because it produced an average of 73,000 AF/y of Rio Grande flow at El Paso during 1951 – 2016 which he claimed was similar to the result of the double-mass curve analysis performed by Dr. Brandes that showed that the Rio Grande at El Paso flow had changed by an average of 79,000 AF/y during the same 1951-2016 period.

When Ms. Moran made a 40% Pumping Run of the Texas Model, she reported that it showed an average increase in Rio Grande flow at El Paso of 61,700 AF/y during 1951 – 2016, which is about 15% less than what Dr. Hutchison presented in his report. Then, when Ms. Moran applied her crude redistribution procedure to the 40% Pumping Run, the revised average annual increase in El Paso flow averaged only 26,800 AF/y. This is 63% less than the result presented by Dr. Hutchison, and 66% less than the result from the Brandes double-mass curve analysis. Notwithstanding all of the flaws in the crude redistribution by Ms. Moran described above, the results of her re-operated 40% Pumping Run appear to undercut the modeling results presented in the Hutchison expert report.

25.0 RESPONSE TO MORAN SECOND SUPPLEMENTAL REPORT

Ms. Jean Moran of Stetson Engineers, Inc. prepare a May 5, 2020 supplemental expert report on behalf of the United States ("Moran Second Supplemental Report") that included analyses and comparisons of the New Mexico ILRG Model and the Texas Model.

SWE was asked by legal counsel for New Mexico to review the Moran Second Supplemental Report and to prepare expert opinions to respond the opinions of Ms. Moran. A lack of response regarding a particular issue should not be interpreted as tacit agreement with the Moran opinions on that issue.

All of the criticisms of the Texas Model structure and inputs that are described in the SWE Report and elsewhere in the SWE Rebuttal Report also apply to the Texas Model runs described in the Moran Second Supplemental Report. The responses described below do not restate these criticisms but rather focus on particulars of the Texas Model runs performed by Ms. Moran.

The opinion numbering in this section picks up where the opinion numbering in the responses to the Moran Supplemental Report left off.

Moran Opinion 4 - *The ILRGM assumptions for the Baseline Run 1 appear to introduce noticeable differences (i.e. a pre/post 1985 bias) when compared to the Calibration Run 0 and gaged data. The assumptions that are part of the 'operational tuning' process should be reviewed to evaluate what causes these differences, and make the necessary improvements to either fix the observed differences or quantify the uncertainty that is introduced. (page 1).*

Response:

Ms. Moran points out differences in the performance of the ILRG Model before and after 1985. In particular, she highlights differences in simulated Caballo Reservoir releases (pre-1985: +2.5%; post-1985 -3.9%) and simulated El Paso flows (pre-1985: +3.6%; post-1985 -2.1%. Her summaries are based on comparison of model bias during 1940-1984 (pre-1985) and 1985-2017 (post-1985).

It is common for simulation models of complex system to vary in performance throughout a long study period. The bias (average % difference between modeled and measured values) for simulated Caballo releases and El Paso flows before and after 1985 fall within the within the "Very Good" performance evaluation criteria for PBIAS that are presented in Moriasi et al. (2015). These criteria are described in more detail in Section 28.0. Moreover, Ms. Moran presented no information or analysis to quantify the impact on model predictions that results from the small differences in average percent error before and after 1985.

Also noteworthy is that the differences between the pre- and post-1985 bias in the ILRG Model have narrowed for the Caballo releases and the Rio Grande at El Paso flows as summarized below.

Comparison of Pre- and Post-1985 PBIAS
Original (v106) and Updated (v116) ILRG Models

Output	ILRG Model (v106)	ILRG Model (v116)
Caballo Release		
Pre-1985 (1940-1984)	+2.5%	-0.9%
Post-1985 (1985-2017)	-3.9%	-0.7%
Total	-0.2%	-0.8%
Rio Grande at El Paso		
Pre-1985 (1940-1984)	+3.6%	-3.0%
Post-1985 (1985-2017)	-2.1%	2.3%
Total	1.2%	-0.6%

***Moran Opinion 5** - The mean absolute error ("MAE") for the annual differences in gaged and Baseline Run 1 simulated releases is 82,160 acre-feet/year (14% of average annual gaged releases). The root mean square error ("RMSE") for Caballo Dam gaged releases and Baseline Run 1 is larger, 110,900 acre-feet/year (18% error), because extra weight is given to larger differences. Both MAE and RMSE average errors indicate that some elements of the system are not captured correctly in the tuning process from Calibration Run 0 to Baseline Run 1. Further evaluation is warranted to determine the effects and uncertainties that are being introduced by the tuning process developed by the New Mexico experts for their Baseline Run 1. (page 7).*

Response:

As summarized in Section 28.0, the MAE and RMSE for annual Caballo releases in the updated ILRG Model are 47,600 AF/y and 58,100 AF/y, respectively. These values are significantly lower than the value that Ms. Moran computed for the prior version of the ILRG Model (version 106). All rule-based simulation models of complex system will produce results that do not exactly match historical values. The excellent overall performance of the updated ILRG Model is discussed at length in Section 28.0.

Moran Opinion 6 *- The RW Model manages the Caballo Reservoir more evenly than historical practices resulting in more spills in the late-1980s to mid-1990s indicated by the upper maximum reached on the monthly graph during this time period. The 'tuned' reservoir management does not appear to capture the historical variations that took place, and may contribute to the differences seen in the Caballo Dam releases (discussed in the previous paragraph). (page 8).*

Response:

Rules were added in the updated ILRG Model to increase reservoir releases and canal diversions in spill years. This improved the model performance during the wetter-than-average period of the 1980s and 1990s.

Moran Opinion 7 *- A comparison of the main canal diversions simulated in Baseline Run 1 (bottom graph, Figure 5) to the Calibration Run 0 (top graph, Figure 5) shows an average annual decrease of about 3% in diversions from 1951 to 2016, a period that coincides with increased groundwater pumping. The RW Model Baseline Run 1 shows an average of 11,800 acre-feet/year lower and the NMR-M Model shows an average of 13,200 acre-feet/year lower than the Calibration Run 0 for canal diversions. The RW Model estimates relatively consistent year-to-year canal diversions from 1984 through 2003 in the Baseline Run 1 that do not capture the variability observed during that same historical Calibration Run 0 time period. The Baseline Run 1 also underestimates the recent canal diversions in 2007-2008 and 2015-2017. The RW Model's 'tuned' Baseline Run 1 manages the canal diversions more evenly than historical practices (Calibration Run 0) resulting in overall decreased canal diversions compared with historical conditions that introduce some uncertainty into the predicted model results. The rule-based Baseline Run 1 underprediction of diversions from the river for the Rincon Mesilla Basins should be evaluated by the New Mexico experts to see if this introduces a bias in the proportioning of available Project water. (page 9).*

Response:

The average under-prediction of Rincon-Mesilla diversions by 11,800 AF/y in the ILRG Model described by Ms. Moran represents 3.0% of the Rincon-Mesilla diversions that average 400,000 AF/y. A 3.0% PBIAS qualifies as Very Good model performance under the criteria presented in Moriasi et al. (2015).

Moran Opinion 8 *- For the Baseline Run 1, on-farm surface water and groundwater required for meeting irrigation water demands are calculated by the RW Model for the ILRGM based on the 'tuned' rule-set developed to simulate historical conditions (Carron* *and Setzer, 2019). On average, the Baseline Run 1 FHG deliveries simulated by the RW Model (Table 4, Attachment B) are within 2,700 acre-feet/year of the FHG deliveries simulated in the Calibration Run 0 for the period 1951-2016. About 17% of the time (13 years),19 there is more than a 25% difference (± 45,000 acre-feet) in FHG deliveries between the Baseline Run 1 and the Calibration Run 0 (Figure 6 bottom graph). The MAE and RMSE for the annual differences between Calibration Run 0 and Baseline Run 1 FHG deliveries are 28,700 and 43,100 acre-feet/year, respectively, corresponding to 14% and 22% of the average annual historical FHG deliveries of 179,700 acre-feet/year. Both MAE and RMSE average errors indicate that that some elements of the system are not captured correctly in the tuning process from Calibration Run 0 to Baseline Run 1. Further evaluation should be undertaken by the New Mexico experts to determine the effects and uncertainties that are being introduced by the tuning process developed for their Baseline Run 1. (page 11).*

Response:

The simulated FHG deliveries in the ILRG Model represent the integration of the simulated Project operations, river operations, and canal system operations. Simulation of seasonal FHG deliveries are bound to be greater than measured in some years and less than measured in other years. The average underprediction in the simulated EBID and EPCWID FHG deliveries in the updated ILRG Model is less than 5% as shown in the results presented in Section 28.0. This qualifies as “Very Good” performance based on the PBIAS criteria presented in Moriasi et al. (2015).

Moran Opinion 9 *- Supplemental groundwater pumping for irrigation was initially estimated by Sullivan and Welsh (2019) for the ILRGM Calibration Run 0. The RW Model simulates about 7.3% (10,300 acre-feet/year) more irrigation pumping than the TX-RG Model (Table 5) during 1951 to 2016. The upper graph of Figure 7 shows the annual FHG deliveries of surface water and the supplemental pumping that make up the applied water simulated by the RW Model Calibration Run 0 and the TX-RG Model Calibration Run. Both the ILRGM and the TX-RG Model develop applied water based on crop irrigation requirements and on-farm efficiency assumptions. Figure 7 (upper graph) shows the annual differences in the two models – the RW Model calculates higher applied water than the TX-RG Model pre-1985, and lower applied water after 1985. (page 12).*

Response:

The pumping in the calibration run (Run 0) of the ILRG Model is computed by the on-farm simulation algorithm in the RiverWare Model. The results are very similar to but not exactly the same as the pumping computed in the SWE CFB Model and reported in the SWE Report.

Differences in the simulated Rincon-Mesilla pumping between the ILRG Model and the Texas Model are due to differences in (a) irrigated area, (b) crop irrigation water requirements, and (c) farm headgate deliveries. These differences are described in Section 12.0 of the SWE Report.

Moran Opinion 10 *- For the Calibration Run 0, the RW Model and NMR-M Model simulate streamflow out of the Mesilla Basin at the USGS streamflow gage 08364000 for Rio Grande at El Paso Narrows (Figure 1). When compared with the USGS gage 08362500 for Rio Grande below Caballo Dam, this streamflow data represents the net effect from hydrologic conditions, Rio Grande Project releases, canal diversions, seepage gains/losses, and return flows to the river within the Rincon and Mesilla Basins. The annual gaged and simulated data for these two USGS gages from 1940 to 2017 (model period) are shown in Figure 2 upper graph. For the Calibration Run 0, the RW Model simulates the long-term average Rio Grande gaged flows at El Paso Narrows almost exactly, and the NMR-M Model matches closely, within 300 acre-feet/year. The annual differences of Rio Grande flow at El Paso Narrows simulated by the RW Model compared with gaged data are shown on the upper graph of Figure 2, ranging from -74,600 acre-feet in 1979 to 96,300 acre-feet in 1948. The TX-RG Model was calibrated to the Rio Grande gaged flows at El Paso Narrows, and matches almost exactly as shown on Figure 2 upper graph. (page 15).*

Response:

The simulated flows in the updated ILRG Model for the Rio Grande at El Paso reasonably match the historical flows. This is reflected in the calibration statistics presented in **Table 28-1**. The exact match of the simulated and observed flows at the El Paso gage in the Texas Model is the result of inappropriate calibration techniques employed by Dr. Hutchison to adjust river bed conductance values and canal spills to drains in every stress-period to reproduce the historical gage flows (Barth, 2019).

Moran Opinion 11 *- New Mexico applied the ILRGM to ten different no-pumping scenarios by turning off groundwater production within different geographical areas (basins, states, country) or different entities (irrigation district, DCMI). The Rio Grande Project's operational criteria and farm processes developed for the Baseline Run 1 were applied to* *these different no-pumping conditions. In the absence of pumping, groundwater levels are higher, there are more gaining reaches in the river (and less river seepage (loss) to the aquifer), canals, and drains. This additional water in the river system becomes available for Project deliveries, affecting canal diversions and Caballo releases. The RW Model accounts for changes and feedback in Project operations and provides a new estimate of the surface water operations for assessing the impacts of pumping on Project supplies. The ILRGM's project re-operation was used to evaluate no-pumping scenarios where additional streamflow in the Rio Grande was allocated to both EBID in New Mexico and EPCWID in New Mexico and Texas based on the operational rules established in Baseline Run 1. (page 16).*

Response:

The changes and feedback in Project operations described by Ms. Moran in simulations of no-pumping scenarios and other scenarios are essential elements of the ILRG Model that simulate the real-world response of the Project operations to changes in conditions. This is one of many reasons that the ILRG Model is superior to Texas Model.

Moran Opinion 12 - *Two of the ILRGM model scenarios addressed no pumping in the Rincon and Mesilla Basins: Run 2 simulated no groundwater pumping in the Rincon, Mesilla, and Hueco Basins; and Run 6 simulated no groundwater pumping in the Rincon and Mesilla Basins with continued pumping in the Hueco Basin. This section of the supplemental report summarizes the effects of pumping in the Rincon and Mesilla Basins; compares the differences between the existing Run 2 and Run 6 simulated by the ILRGM (that also included linking the Hueco Model23); and compares these results with the TX-RG Model no-pumping results. Comparing the differences in Run 2 and Run 6 developed by New Mexico would show the effect of pumping in Hueco Basin on the conditions in the Rincon-Mesilla Basin. (page 16).*

Response:

Because of the non-linearities in the ILRG Model, it is not appropriate to compute the differences between Run 2 (All Pumping Off) and Run 6 (R-M Pumping Off) as a representation of the effects of pumping in the Hueco Bolson. The effects of Hueco pumping are more reasonably and accurately determined in a scenario in which the Hueco pumping is turned off by itself rather than differencing other model runs. See the discussion of the ILRG Model runs in Section 30.0

Moran Opinion 13 *- Stetson conducted an additional analysis using the RW Model and the NMR-M Model to evaluate the predicted effects of 40% pumping (60% reduction in Baseline Run 1 pumping) in the Rincon and Mesilla Basins in order to compare the RW Model predictions with a similar model run by Stetson using the TX-RG Model (Moran, 2019). The 40% R-M Pumping Run further evaluates the performance of the linked models and the ability to predict changes to Rio Grande Project operations (e.g. releases, diversions, deliveries) resulting from reduced pumping in the Rincon and Mesilla Basins. In addition, the changes to Rio Grande streamflow at El Paso Narrows and groundwater in storage are compared with the Baseline Run 1 and the TX-RG Model. (page 18).*

Response:

As discussed in the response to Moran Opinion 3, the 40% Pumping Run performed by Ms. Moran illuminate inconsistencies with the Texas Model runs presented in the Hutchison Report. Based on these inconsistencies, it is unclear what the purpose of the 40% Pumping Run is.

Moran Opinion 14 *- The RW Model input variables for No R-M Pumping Run 6 were adjusted for the 40% R-M Pumping Run. Agricultural and DCMI groundwater pumping variables were adjusted to account for 40% of the Baseline Run 1 pumping in the Rincon and Mesilla Basins. The corresponding variables for urban return flows to groundwater30 and wastewater treatment plan (WWTP) return flow to surface water were also adjusted to evaluate a 60% reduction in groundwater pumping used for the Baseline Run 1. There was one exception, the Las Cruces municipal WWTP return flow was adjusted to account for no changes to 10% of its water supply imported from outside of the basin. (page 19).*

Response:

When evaluating the effects of New Mexico pumping in the Rincon and Mesilla basins, WWTP returns that result from water imported from outside the basin should be turned off in order to compute an appropriate offset from that imported supply against the impacts of in-basin pumping. This includes turning off the return flows from Las Cruces use of imported water from its Jornada wells.

Moran Opinion 15 *- For the 40% R-M Pumping Run, the RW Model and NMR-M Model show about 9,200 acre-feet/year (1.5%) decrease in Project releases from Caballo Dam (Table 3) under reduced pumping conditions (Table 8). The RW Model and NMR-M Model simulated an average increase of Rio Grande streamflow at El Paso Narrows from 1951-2016 of 49,500 acre-feet/year and 49,700 acre-feet/year, respectively. The RW Model predicts a 7.6% (29,400 acre-feet/year) increase in canal diversions and an 11.2% (20,400* *acre-feet/year) increase in FHG deliveries under 40% Pumping Run conditions compared to Baseline Run 1 for 1951 through 2016. Figure 8 upper graph shows the cumulative change in groundwater storage, averaging -8,200 acre-feet/year (Table 9) under 40% pumping conditions. The Rio Grande streamflow at El Paso Narrows for the 40% Pumping Run shows a partial recovery over historical conditions (bottom graph of Figure 10). Stetson was not able to make any adjustments to Caballo releases in the TX-RG Model described in the first supplemental report (September 2019) – resulting in an increase of surface water for the Project. The proportioning method used by Stetson with the TX-RG Model estimated more canal diversions and farm deliveries, resulting in 26,800 acre-feet/year of streamflow at El Paso Narrows (Table 8). (page 21).*

Response:

The inability to adjust the releases from Caballo Reservoir in the 40% R-M Pumping Run of the Texas Model represents a fatal flaw in that model and a serious shortcoming in the crude proportioning method developed and applied by Ms. Moran to reallocate simulated increase in El Paso flows to upstream diversions in the Texas Model.

Moran Opinion 16 *- Both models are able to make predictions and show that pumping in the Rincon and Mesilla Basins impact the Project. Neither New Mexico nor Texas provided an error analyses for their models to give a range of uncertainty of the results. The differences between the models is likely within the uncertainty of the models. Both the New Mexico and Texas models are numerical tools showing that pumping impacts the Project and cutting back pumping would improve Project performance. Both models have uncertainties. (page 23).*

Response:

While both the ILRG Model and the Texas Model can be operated to simulate impacts from pumping in the Rincon and Mesilla Basins, shortcomings in the Texas Model that include (a) use of overly coarse annual stress periods, (b) a limited geographic scope that excludes simulation of the area between El Paso and Fort Quitman, and (c) no ability to reasonably re-operate the Rio Grande Project in response to changes in water supplies in alternative scenarios results in the Texas Model being far inferior to the ILRG Model.

26.0 LOWER RIO GRANDE DATA

26.1 Hydrologic Data

All hydrologic data opinions provided in Section 3.0 (Lower Rio Grande Hydrologic Data) of the SWE Report remain valid.

New Mexico has received limited additional hydrologic and water use data from Texas, the United States, and others since the SWE Report was submitted. These data include annual Socorro WWTP discharge data from 1967-1984 and monthly volumes of drain water diverted at Fabens to Tornillo Canal via the Riverside Canal Extension from 1945-1983. These additional data were added to the SWDataSet. Backup for these additional data are provided with this disclosure. An updated summary of the estimated data in the SWDataSet reflecting replacement of the previously estimated Socorro WWTP discharges with actual data is provided in **Table 26-1.**

The records for Socorro WWTP discharges and drain water diverted at Fabens were used as inputs to the updated ILRG Model.

26.2 Rio Grande Project Data

All Rio Grande Project accounting data, information, summaries, and opinions provided in Section 4.0 (Rio Grande Project Accounting Data) of the SWE Report remain valid.

New Mexico has received limited additional Project accounting data from the United States since the original SWE Report was submitted. These data, which include monthly accounting records 2008 – 2019 and Project allocation records for 2019, are currently under review.

27.0 LOWER RIO GRANDE CANAL AND FARM BUDGET MODELS

All data, information, and summaries provided in Section 6.0 (Lower River Grande Canal and Farm Budget Models) of the SWE Report remain valid, with the exception of the CFB Models for the Hueco area from 1903 – 1937 that were revised and updated. This included the CFB Models for the following geographic areas:

- EPCWID (El Paso Valley),
- HCCRD,
- JID Unit 1,
- JID Unit 2, and
- JID Unit 3.

The revisions to the annual CFB Models of the Hueco area are summarized below, and more detailed descriptions are provided in **Appendix 27**.

- The Water Distribution Report records of diversions and FHG deliveries for the El Paso Valley were used for the years they are available (1920, 1921, 1923, 1927, 1931, 1933, 1934, 1936, and 1937).
- A switch was added to turn off Juarez sewage discharge to canals when the Mexico pumping is turned off.

The revised annual CFB Models for the Hueco area were provided to MMA for generating the FHG delivery and on-farm deep percolation inputs to the Hueco GW Model.

28.0 OVERVIEW AND ASSESSMENT OF UPDATED ILRG MODEL

Several modifications were made by Hydros to improve the RiverWare Model (Hydros 2020). A summary of modifications is provided in Section 28.1 below. The assessments of the ILRG Model in Section 8.0 of the SWE Report remain valid except as modified by the descriptions in Section 28.2.

28.1 Revisions to RiverWare Model (v116)

Hydros made several revisions to the RiverWare Model to correct or improve the model functioning in operational mode when rules are used to simulate operation of the Project and the LRG irrigation systems. Many of the improvements result from responses to comments from the United States and Texas experts, questions during depositions, and further model review prompted by the United States and Texas comments. The following is a brief summary of the revisions:

<u>Model Changes</u>

- <u>Project Allocation Period</u> – Revise the pre-allocation period to end in 1949 and start the pre-D1/D2 period (during which the D1/D2 Rules are simulated) in 1950. While the Project Histories report that 1951 was the first year that an annual allotment was in effect for the entire irrigation season, allotments were issued in prior years that were lifted before the end of the season. Simulating annual allocations beginning in 1950 improved model tuning.

- <u>Maximum Annual Allocations to U.S Districts</u> – Compute time-series inputs of the maximum annual allocations for EBID and EP1 in full supply years using the D2 Curve, the maximum annual Project releases that were previously determined for 1955 – 1993, and a full supply allocation to Mexico of 60,000 AF. Compute the annual allocations to EBID and EP1 in RiverWare during 1955 – 1993 based on the D1/D2 procedure with allocations limited to maximum annual allocations. The annual allocation to Mexico is computed using the D1 Curve and the usable water in Project storage.
- <u>Final Annual Allocation</u> – Compute a final allocation to EBID and EPCWID in October for purposes of computing the amount of carryover when the D3 + Carryover rules are in effect.

- <u>Mexico Allocation</u> – Correct the computation of the annual allocation to Mexico during 1951 – 2017 as 11.3486% of the amount determined from the D1 Curve.

- Diversion Charge when One District Is Diverting – When only one District is diverting Project water, charge that District the maximum of its canal heading diversions or the Caballo Reservoir release minus the diversion by Mexico at the Acequia Madre.

- Project Water Split – Revise the split of Project water to be 57% for EBID and 43% for EPCWID during the period from 1955-1979 rather than the 60%/40% split that was previously used.

- Reservoir Threshold Elevations – Revise the elevations in Elephant Butte Reservoir and Caballo Reservoir above which spills and flood control operations are simulated.

- Reservoir Operations in Spill Years – Increase the EBID and EPCWID waste percentages during reservoir spill years. The added waste is routed through the EBID and EPCWID systems without being charged against their allocations.

- Net Losses in Elephant Butte Reservoir to Caballo Reservoir Reach – Release water from Elephant Butte Reservoir to cover net losses in the Elephant Butte Reservoir to Caballo Reservoir reach.

- Reservoir Evaporation Estimate for D1/D2 Allocation – Revise the estimated monthly evaporation values for Elephant Butte and Caballo Reservoirs used in computing the total usable water in D1/D2 allocation to be the average of years when Project storage is at or below a full supply of approximately 790,000 acre-feet.

- Pre-1950 Caballo Reservoir Winter Releases – Simulate releases from Caballo Reservoir during the winter months before 1950 consistent with historical operation.

- ACE Credit – Revise the application of the ACE credit to be simulated only in the years that it was historically applied.

- EP1 Use of Fabens Drain Flows – Simulate historical use of Fabens drain flows by EP1 based on historical records (1945 - 1983) in historical Base Run and all alternative scenarios (except scenarios with increased use of Fabens drain flows).

- EPCWID Orders – Adjust EPCWID Orders for EPW WWTP discharges and use of Fabens drain flows. Revise the equation for computing EPCWID orders of Project water at American Dam by subtracting the EPW WWTP discharges to canals (Haskell, Bustamante, and Socorro) and the use of Fabens drain flows.

- EPCWID Waste – Revise EPCWID waste to be computed as specified percentages of canal heading diversions rather than bypass of a portion of the deliveries to certain EPCWID subareas.

- EPCWID Diversion Charges – Add the simulated canal loss in the Texas Mesilla from the NMR-M Model to the EP1 Mesilla diversion charges rather than charging EBID for all Mesilla canal losses. Credit EBID for 1.15 x revised EP1 Westside Canal diversion charges and 1.20 x revised Eastside Canal diversion charges.

- EPCWID Diversion Charges Option – Add an option to charge EPCWID for use of drain flows and WWTP discharges. This option is enacted in several of the new alternative scenario runs described in Section 30.0.

- Distribution of Irrigation Water in EPCWID – Improve the distribution of water to EPCWID subareas to be more proportionate to irrigated area instead of distributing water top to bottom based with specified bypass percentages.

- Riverside Waste to Tornillo Drain – Add a rule to compute waste discharge from the Riverside Canal to the Tornillo drain based on monthly percentages computed from historical records.

- Hudspeth Feeder Canal Diversions – Add two rules to manage flows in the Hudspeth Feeder Canal. The first rule routes Fabens Waste Channel flows in excess of the historical Hudspeth Feeder Canal diversions to the Rio Grande. The second rule diverts water from the Rio Grande to the extent the Fabens Waste Channel flows are less than the historical Hudspeth Feeder Canal diversions.

- River Headgate Demand - Rearrange the equation that computes the river headgate demands so that the tuning factor is only applied to the crop, soil moisture, and EPW demands, and not to the conveyance losses and EPCWID use of WWTP discharges and drain flows.

- EPCWID Allocation Limit - Adjust the rule that limits EPCWID diversions when the EPCWID has less remaining allocation than demand.

- EPCWID FHG Deliveries – Add river seepage as an independent term in the equation that computes the EPCWID farm headgate deliveries.

- ACE Credit – Revise the rule that computes the ACE Credit to use the equation that has historically been most frequently used in the Project accounting.

Data Changes

- Haskell WWTP Discharges – Specify the Haskell WWTP discharges to the Franklin Canal and the Rio Grande based on historical records.

- Socorro WWTP Discharges – Use historical Socorro WWTP discharge data that was recently provided by Texas and the United States instead of the estimates of WWTP discharge that were used.

- Hueco WWTP Return Flows Attributed to Project Water – Set the time series input of WWTP discharges attributed to Project water to zero during the non-irrigation season. This avoids simulating WWTP discharges of Project water during the non-irrigation season when Project water deliveries are not simulated.

- EPW Hueco WTP Diversions – Compute monthly EPW water treatment plant diversions computed by multiplying the simulated monthly EPCWID allocations by a time series of monthly percentages input to the model. The monthly time-series percentages were recomputed as historical monthly EPW WTP diversions divided by the simulated monthly EPCWID allocations in Run 1 of the ILRG Model.

- Rincon and Mesilla Valley Canal Capacities – Reduce the simulated capacity of the Rincon, Leasburg, Eastside, and Westside canals to limit the simulated maximum monthly diversions consistent with historical diversion records.

The revisions to the RiverWare Model rules and data described above resulted in some minor changes to the Calibration Run (Run 0), but not enough to require the model to be recalibrated. However, the model changes did necessitate that the model be retuned so that the simulated reservoir operations and deliveries of Project water in the Historical Base Run (Run 1) reasonably matched historical records or in some cases, simulated values in the historical Calibration Run (Run 0) (e.g., simulated irrigation pumping). Comparisons of the revised Historical Base Run (Run 1) against historical data and simulated results from the Historical Calibration Run (Run 0) are presented in the figures and tables that are described below. As evidenced in these figures and tables, the revisions to the RiverWare Model rules and input data described above and the subsequent retuning have improved the ILRG Model and the correspondence between simulated flows in the Historical Base Run (Run 1) and the historical observed data (and in some cases to the simulated outputs from Run 0). This is particularly evident in the simulated reservoir storage, reservoir releases, Project water diversions and FHG deliveries, and El Paso flows. Based on these model enhancements and improved model performance, the revised ILRG Model continues to be the best available tool to simulate the effects of pumping and changes in Project operations on the supplies available to LRG water users.

28.2 Summary of Updated ILRG Model Tuning

In response to criticisms in the rebuttal and supplement expert reports by Texas experts Shane Coors and George Hornberger, additional charts and tables were prepared to present and summarize the calibration and tuning of the updated ILRG Model.

As discussed in the SWE Report, development of the ILRG Model included a physical calibration process in which monthly Caballo releases, diversions, and FHG deliveries were set to historical records (and estimates), and physical parameters in the models including aquifer hydraulic conductivity, river bed conductance, canal bed conductance, and drain bed conductance were adjusted to improve the match between modeled outputs, and observed data for river flows, drain flows, and ground water levels.

After the physical calibration of the ILRG Model, the historical records specifying the Caballo releases, diversions, and FHG deliveries were replaced by operational rules that operate the Project and LRG irrigation systems. The operational rules were tuned to match simulated reservoir releases, diversions, and FHG deliveries to the historical data. The match of historical drain flows and river flows was also reviewed during the tuning process.

After making the changes to the ILRG Model that are discussed in Section 28.0, it was necessary to retune the model. The tuning of the model was evaluated using various statistical and graphical performance measures recommended for use in assessing calibration of hydrological models. Unless otherwise specified, the term “calibration” as used below refers to the goodness of fit between the simulated outputs of the calibrated and tuned ILRG Model and the historical data.

While there is no universal consensus in the scientific community for evaluating the calibration of hydrologic models, a recent article by Moriasi et al. (2015) contains proposed guidelines for model performance evaluation based on meta-data analysis of hydrologic models reported in numerous peer-reviewed journal articles since 1990. This article synthesizes the recent state of the art of model calibration assessment and was used as a general guide for selection of the performance measures used for evaluating the calibration of the updated ILRG Model. The following subsections describe and present these statistical and graphical performance measures.

28.2.1 Statistical Performance Measures

Statistical performance measures provide an objective and reproducible process for evaluating model calibration. Moriasi et al. (2015) recommends use of the following statistics to assess the model calibration performance each of which have advantages and disadvantages, but together provide a reasonable and comprehensive picture of model calibration.

- Coefficient of Determination (R2) – Degree of collinearity between modeled and measured data.
- Nash-Sutcliff Efficiency (NSE, E2) – Relative magnitude of the residual variance compared to the measured data variance.
- Index of Agreement (d2) – Ratio between the mean square error and the potential error represented by the largest value that the squared difference of each measured and observed data pair can attain.
- Root-Mean Squared Error (RMSE) – Square root of the mean square error.
- RMSE-Observed Standard Deviation Ratio (RSR) – RMSE normalized using the standard deviation of the observed data.
- Mean Error or Bias (BIAS) – Average of the positive and negative differences between the modeled and measured data.
- Percent Bias (PBIAS) – Mean error expressed as a percentage of the average of the observed values.
- Mean Absolute Error (MAE) – Average of the absolute value of the differences between modeled and observed values.
- Percent MAE (PMAE) – Mean absolute error expressed as a percentage of the average of the observed values.

Descriptions of the equations, range of possible values, optimal values, and advantages and disadvantages of the above statistics is provided in Table 5 of the Moriasi et al. (2015) article which is included in **Appendix 28**.

In addition to the statistics listed above, **Table 28-1** also includes results for the Log NSE statistic that was advocated by Mr. Coors. As discussed in Section 23.0, the Log NSE statistic is inappropriate for evaluating the calibration of the ILRG Model because of how it inappropriately weights differences in low flows. Nevertheless, the Log NSE statistic is included in **Table 28-1** for comparison to the results presented in the Coors Supplemental Report.

The spatial and temporal scales of the input data, calibration data, model processes, model outputs, and the intended model uses need to be considered in determining how to apply the calibration statistics to the model output. To achieve meaningful results, model performance assessment must focus on the processes and model outputs that are relevant to the model purpose using methods that reflect variation at the appropriate temporal and spatial scales (Baffaut, 2015).

Most of the inputs, outputs, and simulation processes of the ILRG Model are monthly, consistent with the monthly stress periods of the model. However, the model results should generally be assessed as irrigation season or annual totals. For example, when comparing the results of a no pumping run against the Historical Base Run (Run 1), differences between model outputs can be computed at monthly or longer time intervals. However, it makes little sense to evaluate simulated changes in Project water deliveries at monthly intervals because water users generally have wide latitude for ordering and receiving delivery of water most anytime within the irrigation season (subject of course to orders being bunched in water short years to minimize transit losses). Of more significance are the differences between model runs of diversions and deliveries over the entire irrigation season. Consistent with this, it is appropriate that the calibration of the ILRG Model also be evaluated based on irrigation season totals rather than monthly totals.

The spatial resolution of the model calibration assessment should be consistent with the resolution of the input data, calibration targets, modelled processes, and model linkages. As shown in **Table 23-1** in the response to the Coors Supplemental Report in Section 23.0, the spatial resolution of LRG data that are either used in the model or available for calibration assessment include point, valley, district, and basin scale information. The coarse nature of some of the input data (valley, district, basin) result in some level of smoothing of model inputs. Therefore, while farm budget calculations in the model are performed at a sub-area scale to spatially distribute model processes, it is not reasonable to assess certain of the model outputs on a fine spatial scale that is inconsistent with the model inputs. A prime example is the assessment of drain flow calibration. While drain flow data (measurements and estimates) are reported for some individual canals, it is unrealistic to expect the model to calibrate well to individual drains. Further, since the flow of many drains return flows that comingle upstream of where the next downstream diversion occurs it is reasonable to aggregate the flow of such drains for calibration assessment.

The simulation period of the ILRG Model extends from 1940 – 2017. However, widespread irrigation pumping did not commence until the late 1940s and early 1950s. In addition, the 1940s were characterized by greater than average inflows to Elephant Butte Reservoir and plentiful Project storage resulting in little restriction on use of Project water, and water users generally had sufficient supplies to meet demands. Therefore, consistent with the prior calibration and tuning described in the original reports of the New Mexico experts, calibration of the updated ILRG Model was evaluated primarily for the period from 1951 – 2017. The beginning of the calibration assessment period generally coincides with initiation of widespread irrigation pumping in the LRG area and also overlaps the 1951 – 1978 period from which data were used to develop the D1 and D2 curves that were subsequently used for allocation of Project water to the U.S Districts and Mexico.

Statistics summarizing calibration of the ILRG Model over the 1951 – 2017 period are tabulated in **Table 28-1**. Certain of these statistics were evaluated against Performance Evaluation Criteria presented in Moriasi et al. (2015) for R2, NSE, d, and PBIAS. These criteria characterize the model performance based on the value of the computed statistic relative to numerical ranges that define performance as Very Good, Good, Satisfactory, Not Satisfactory, and Unacceptable. The performance ranges for each statistic are listed in the color-coded legend at the bottom of **Table 28-1**. Note that no criteria were reported in Moriasi et al. (2015) for RMSE, RSR, and PMAE.

The ILRG Model performance summarized in **Table 28-1** ranges from satisfactory to very good for most of the calibration statistics when the results are appropriately evaluated using irrigation season totals. The improvements and re-tuning have generally elevated the statistical performance of the updated ILRG Model over that of the ILRG Model (v. 106) that was presented in the original reports of the New Mexico experts.

28.2.2 Graphical Performance Measures

Performance of the ILRG Model in simulating historical conditions was also evaluated using various graphical performance measures including monthly and annual time series plots, cumulative plots, scatter diagrams, and flow duration curves. These graphs facilitate qualitative assessment of the model capability to reproduce historical patterns and trends in the model output in a manner that the statistical measures do not. **Figure 28-1** through **Figure 28-21** present the graphs for each of the individual and aggregated locations for which calibration statistics are presented in **Table 28-1**.

The monthly and yearly time-series graphs show that the ILRG Model generally performs well in matching the monthly, seasonal, annual, and decadal patterns and variability present in the historical data.

- Caballo Release (Figure 28-1) – Monthly and annual releases match very well throughout the study period as evidenced by the monthly and annual time-series plot and the cumulative residual graph. Modeled annual releases match the historical records throughout the range of simulated values as indicated in the scatter plot and flow duration curve.

- Rio Grande at El Paso (Figure 28-2) – Monthly and annual flows match very well throughout the study period as shown in the monthly and annual time-series plot and the cumulative residual graph. The peaks and troughs of the simulated flows agree in most years indicating the supplies delivered during the irrigation season and return flows in the non-irrigation season are well simulated. Modeled annual flows match the historical records throughout the range of simulated values as indicated in the scatter plot and flow duration curve.

- Rio Grande at Fort Quitman (Figure 28-3) – Differences in simulated and measured flows at Fort Quitman represent the accumulation of all imperfections in the model simulation. While the variability of the monthly flows is not well matched, the annual and multi-year trends in flow are well simulated. The cumulative residual graph shows a general overprediction of flows in the 1940s and an underprediction of flows in the 1970s and 1980s. The horizontal slope of the cumulative residual line from about 1950-1970 and after 1990 shows the model replicates the annual flows reasonably well during these periods.

- Rincon and Mesilla Valley Diversions (Figures 28-4 – 28-7) – Irrigation season diversions are generally simulated well throughout the study period, aside from some overprediction for the smaller Rincon and Eastside Canals in the 1940s. The good match is evidenced in the irrigation season time-series graphs and the cumulative residual graphs that are relatively flat after the 1940s. The monthly diversion patterns are reasonably replicated in most years although there is some tendency to overpredict peak month diversions in full supply years.

- El Paso Valley Diversions (Figures 28-8 – 28-12) – Diversions at American Dam, Acequia Madre, Riverside Canal Gage, Franklin Canal Gage, and Total HCCRD Supply are generally simulated well after some underprediction in the 1940s as indicated in the monthly and annual time-series graphs. The cumulative residual graphs show no unreasonable long-term over- or under-predictions of diversions. The patterns of monthly diversions are simulated well, including monthly peak diversions.

- EBID FHG Deliveries (Figure 28-13) – Deliveries are typically simulated well, matching the yearly variability and long-term trends. Peak monthly flows tend to be overpredicted in full supply years, but the overall monthly patterns of deliveries match well.

- EPCWID FHG Deliveries (Figure 28-14) – There is a slight tendency toward underprediction of deliveries, particularly in wet years. The monthly pattern of deliveries is well matched.

- HCCRD FHG Deliveries (Figure 28-15) – The yearly and long-term trends in deliveries are satisfactorily simulated. The cumulative residual charts demonstrate a tendency toward overprediction of deliveries before 1980 and underprediction of deliveries after 1980.

- EBID Pumping (Figure 28-16) – Accurate simulation of supplemental pumping in the ILRG Model reflects a culmination of the successful simulation of the physical and operational processes that ultimately deliver inflows to Project storage to the end users. Given the complex interaction of all of the modeled processes, the replication of the pumping volumes in the yearly time-series plot is outstanding. As is the relatively lack of wavering in the cumulative residual chart and the degree of agreement throughout the range of pumping in the flow duration curve.

- EPCWID Pumping (Figure 28-17) – Supplemental pumping is simulated almost as well as for EBID with some underprediction late in the study period. The flow duration curve demonstrates pumping is generally well matched in all hydrologic conditions.

- HCCRD Pumping (Figure 28-18) – Supplemental pumping tends to be underpredicted in most years.

- Rincon Valley Drains (Figure 28-19) – Good simulation of drain flows is difficult because it requires reasonable simulation of ground water elevations (and surface water elevations) and the processes that conduct and attenuate the drain flow responses to the simulated elevation differences. Given these challenges, the ILRG Model simulates acceptable responses of the Rincon Valley Drains throughout the study period with some underprediction of flows until about 1980. The amplitude of the monthly variations in the simulated drain flows is satisfactory. The historical data for the Rincon drains are substantially incomplete after 2002 and therefore there is no observed data shown in the graphs after that time.

- Mesilla Valley Drains (Figure 28-20) – The Mesilla Valley drains, which transmit roughly five times as much flow as the Rincon Valley Drains are simulated very well in the ILRG Model. The annual flows are well matched throughout the study period as shown in the annual time-series plot, the cumulative residual plot, and the flow duration plot. The seasonal amplitude of the monthly flows is also well matched during most years. The historical data for the Mesilla Valley drains are substantially incomplete after 2013 and therefore there is no observed data shown in the graphs after that time.

- El Paso Valley Drains (Figure 28-21) – El Paso Valley drains are simulated generally well as shown in the annual time-series and cumulative residual plots, except for some underprediction of flows from 1960-1980. The amplitude of the monthly flow variations tends to be underpredicted in most years before 1990, but well matched thereafter.

28.2.3 Summary and Conclusions

Given the complexity of the Rio Grande Project area and the need to simulate the mix of physical and management processes that characterize the Project operations, the overall calibration performance of the ILRG Model is remarkable. In my opinion the superior calibration performance of the ILRG Model that is achieved using rational process-based rules clearly demonstrates that the updated ILRG Model is suitable for use in evaluating the claims and counterclaims in this case.

While the overall calibration performance of the ILRG Model is excellent for a system as complex as the Rio Grande Project and the associated portions of the LRG Basin, the model performance in matching the historical flows in the Historical Base Run (Run 1) is not perfect. It is important to understand that the imperfections in the Historical Base Run do not carry over into computed differences between the Historical Base Run and alternative scenario runs. This is due to the cancelling of errors that occurs when differencing model runs. For example, when the flow at El Paso or the diversion at the American Canal are overpredicted in a particular month in the Historical Base Run, that error will tend to also be present in the alternative run. Therefore, when the differences between model runs are computed, these errors will cancel out. The resulting computed differences then reflect the change in stress or operating rules between the two runs.

Canceling of errors is clearly evident in careful review of the differences between model runs. The simulated changes in flows such as streamflows, diversions and deliveries are reasonable and consistent with differences in the model inputs for the two runs and the simulated processes in the ILRG Model. In detailed review of the model results, there have been no identified differences between runs that could not be attributed to the rational functioning of the model rules. The cancelling of errors is why even relatively small differences between runs are reasonable and rational and are not lost in the noise of random errors that do not cancel out.

The ILRG Model is clearly more capable than the Texas Model of simulating the response of Project operations to changes in conditions simulated in alternative scenarios than is the Texas Model. The serious shortcomings of the Texas Model, which include rudimentary annual stress periods that foreclose the model from distinguishing between irrigation season and non-irrigation season flows, absence of dynamic simulation of Project operations that can respond to changes in flows and stresses in alternative scenarios, and limited geographical scope that excludes simulation of Project operations and water use downstream of the El Paso gage, render the Texas Model of limited or no utility in analyzing the complex issues that are presented in this case.

29.0 HISTORICAL BASE RUN OF ILRG MODEL

As described in Section 28.0, a number of revisions were made to the RiverWare Model to refine the simulated Project operations and water distribution. After these revisions were made the model was retuned and iterated with the ground water models to closure to produce a revised Historical Base Run (Run 1). Various water budget summaries and other outputs for the original Run 1 were presented in figures discussed in Section 9.0 of the SWE Report. Updated versions of those figures for the new Run 1 are included as **Figure 29-1** through **Figure 29-10** and a new **Figure 29-11** as listed below:

- Annual Reservoir Budget Summaries (**Figure 29-1**)
- Annual Project Allocations and Charges (**Figure 29-2**)
- Annual Canal and Farm Budget Summaries (**Figure 29-3** – **Figure 29-6**)
- Annual River Budget Summaries (**Figure 29-7** – **Figure 29-8**)
- Rio Grande Flow Summaries (**Figure 29-9** – **Figure 29-11**)

The illustrations of the Historical Base Run (Run 1) outputs provided **Figure 29-1** – **Figure 29-10** are similar to the comparable figures in Section 9.0 of the SWE Report. The detailed discussions of the Section 9.0 figures in the SWE Report also are applicable to the updated figures in this report. These summaries of the Historical Base Run along with the calibration results described in Section 28.0 show that the ILRG Model reasonably simulates the operations of the Rio Grande Project and the irrigation systems of the LRG Basin.

30.0 ALTERNATIVE RUNS OF ILRG MODEL

The updated ILRG Model (v116) was used to re-run the no-pumping scenarios and operations scenarios that were presented in the SWE Report (Runs 2 – 13). A list of the original model runs is provided in **Table 30-1**.

In addition to re-running the original 13 scenarios, the updated ILRG Model was used to simulate additional no-pumping scenarios and operations scenarios. These included Run 14 and several variants that simulate the effects of pumping in the Hueco and Run 15 and several variants that simulate early EPCWID operations prior to changes in water use practices. In addition, five other scenarios were simulated (Runs 16, 16a, 17, 17a, and 18) to analyze conjunctive use of surface water and ground water. These conjunctive use scenarios are based on either a D1/D2 level of supplemental pumping or a supplemental pumping level up to the crop demands on the authorized Project acres, and were developed in consultation with representatives and legal counsel for New Mexico. A list of the additional model runs is provided in **Table 30-2**. Additional specifications for the model runs are provided in **Appendix 30-A** including details for Runs 15-18 and details for the WWTP discharges and urban deep percolation returns that are turned off or reduced in certain of the alternative scenarios.

The results from the re-running of the original scenarios and simulation of the new scenarios are presented in a consistent format in the tables and graphs in **Appendix 30**. These include tabular and graphical results similar to those presented in the SWE Report as well as several additional tables and graphs. Unless otherwise noted, all of the results presented in **Appendix 30** are comparisons between an alternative scenario and the Historical Base Run (Run 1). There are 22 pages of tables and graphs included in the run comparisons for each scenario. An overview of the format and content of each of these tables and graphs follows:

- <u>Cover Page (p. 1)</u> – Selected input specifications for the two runs being compared.

- <u>Comparison of ILRG Model Runs (p. 2-3)</u> – This two-page table provides a high-level overview of how the ILRG Model distributes the change in inputs (e.g., change in pumping stress or change in operating rules) into changes in model outputs. The first five rows of values are the average annual pumping stresses in each run, which consist of the irrigation pumping that is on in Run 1 and off in the alternative run, and the total non-irrigation pumping and non-irrigation pumping return flows (WWTP discharges and urban deep percolation). The Total Stress is computed as the sum of the irrigation and non-irrigation pumping less the non-irrigation returns flows. The third column of numbers shows the difference in stress between the two runs being compared. The remainder of the table reports the annual averages for selected ILRG Model outputs and the differences in outputs between the two runs. The fourth and fifth columns of numbers express the average annual output differences as percentages of the change in Total Stress and as percentages of the Base Run values. For the alternative runs that simulate differences in operating rules (i.e. Runs 11-13, 15-18), there are no rows in the table listing the stresses, nor is there a column listing the % Change Stress.

- Annual Differences in ILRG Model Outputs (p. 4-5) – This two-page table lists the differences in model outputs for selected model outputs. These include the differences in irrigation season and annual net RHG Diversions and FHG Deliveries, and differences in annual river flows at the Caballo outlet, El Paso, and Fort Quitman. Net RHG Diversions are defined as the simulated gross diversions less the historical El Paso carriage water that was delivered through the Rincon and Mesilla Valley canals and less the simulated flood control releases that were run through the canals in spill years. Reporting of differences in net RHG Diversions in the model results represents a change from the reporting of differences in gross RHG diversions that were presented in model results described in the SWE Report.

- Simulated Differences in ILRG Model Outputs (p. 6-9) – These four pages of graphs and tables show differences in model outputs expressed as either annual or irrigation season totals. There is a bar chart with the yearly differences in model output, an inset line chart showing the annual outputs that are differenced in the bar chart, and a table summarizing the yearly average differences (annual or irrigation season totals). The differences in net RHG diversions and FHG deliveries are shown in line graphs rather than bar charts.

- Annual Allocation and Charges (p. 10) – This chart summarizes for the two compared runs the simulated annual allocation and delivery charges for EBID and EPCWID, as well as the simulated annual Diversion Ratio computed as the sum of the annual diversion charges for EBID, EPCWID, and Mexico divided by the annual Caballo Reservoir releases.

- Annual Summary of Project Storage and Rio Grande Flows (p. 11) – This chart summarizes for the two compared runs the total year-end project storage in Elephant Butte and Caballo Reservoirs and the annual Rio Grande flow at the Caballo Reservoir outlet, at El Paso, and at Fort Quitman.

- Irrigation Season Summary of Irrigation Operations (p. 12-14) – These three pages of charts summarize for the two compared runs the net RHG diversions, FHG deliveries, irrigation pumping, and RHG diversions minus FHG deliveries (conveyance losses). There are separate pages for EBID, EPCWID, and HCCRD.

- Cumulative Change in Ground Water Storage (p. 15) – This chart summarizes for the two compared runs the cumulative year-end change in ground water storage in the alluvial and non-alluvial aquifers in the Rincon and Mesilla valleys and in the Hueco.

- Monthly Net RHG Diversions (p. 16-18) – These three pages of charts show for the two compared runs the simulated monthly net RHG diversions. There are charts showing the total EBID diversions, total EPCWID diversion, and the total flow to HCCRD.

- End of Month Reservoir Storage (Elephant Butte + Caballo) (p. 19) – This chart shows for the two compared runs the combined end-of-month Project storage in Elephant Butte and Caballo Reservoirs. This doesn't include storage of non-Project water.

- Monthly Rio Grande Flows (p. 20-22) – These three pages of charts show for the two compared runs the simulated monthly Rio Grande flows at the Caballo Reservoir outlet, at El Paso, and at Fort Quitman.

Narrative summaries of the ILRG Model simulations of alternative scenarios are provided below to highlight and explain some of the more significant results shown in the tabular and graphical summaries presented in **Appendix 30**. The tables in **Appendix 30** include annual and irrigation season differences in model outputs for all run comparisons. Averages are computed for the following noteworthy ranges of years:

1951-2017:	Period with irrigation pumping development commencing with the beginning of the D1/D2 data period (57/43 allocation until 2006).
1951-1978:	D1/D2 data period (57/43 allocation).
1979-2005:	Post D1/D2 data period prior to the 2008 OA allocation and accounting that commenced in 2006 (57/43 allocation).
2006-2017:	Period when the 2008 OA allocation and accounting was in effect (D3 allocation for 2006 and 2007, D3 allocation plus carryover for 2008-2017).
1985-2017:	Period for which alleged damages were computed by Texas (1985-2016) plus the last year of the study period (2017).

1985-2005: Portion of the Texas damages period prior to commencement of the 2008 OA allocation and accounting.

Averages for other portions of the study periods can be computed from the data in the run comparison spreadsheets that are being disclosed with this report.

30.1 All Pumping Off (Run 2)

In Run 2, all irrigation and non-irrigation pumping in the study area is turned off, and all non-irrigation returns, including WWTP discharges and urban deep percolation returns, are also turned off. The changes in irrigation returns that result from turning off the irrigation pumping are simulated by the farm budget processes included in the model.

The ILRG Model re-operates the Project and all of the simulated irrigation systems in the absence of pumping. Turning off pumping increases drain flows and reduces river seepage in most years. During full allocation years, this results in water accumulating in storage as less water needs to be released to meet demands. Accumulating water in storage increases allocations and Caballo Reservoir releases in subsequent dry years (e.g., several years in the 1960s, 1970s, and 2000s). Spills are also larger due to the accumulated water in storage.

The increased allocations result in increased diversions and FHG deliveries to EBID in dry years between 1950 and 1978. During the full allocation years from 1979 – 2002, there is little change in EBID diversions, however FHG deliveries increase modestly due to reductions in the simulated canal conveyance losses in the no-pumping run that allowed more of the water that is diverted to be delivered to the farms. When dry conditions return, EBID diversions and FHG deliveries increase again in 2003 and 2004. EBID diversions increase substantially beginning in 2006 due to the effects that pumping has when the 2008 OA is in effect. As is discussed in Barroll (2019), EBID's allocation under the 2008 OA is sensitive to the diversion ratio. When pumping is turned off, the diversion ratio increases resulting in increased allocations and increased deliveries to EBID. On average from 2006 – 2017, EBID's diversions increase by 148,700 AF and FHG deliveries increase by 92,700 AF.

The increase in Project water allocations also results in increased diversions and FHG deliveries to EPCWID in many dry years in the 1950s – 1970s. There are also modest increases in EPCWID diversions during many full allocation years in the 1980s and 1990s because the reduction in EPW WWTP discharges to EPCWID canals results in EPCWID requiring more reservoir releases to meet its demands. Increases in deliveries also occur in several dry years in the 2000s – 2010s although the increases are not near as large under the 2008 OA after 2005 as they are for EBID.

Turning off pumping and the resulting effects on Project operations and deliveries results in increased Rio Grande at El Paso flow in most years averaging 79,000 AF annually during 1951 – 2017. Of this amount, an average of only 33,100 AF occurs during the irrigation season (Mar-Oct) and the remaining 45,900 AF occurs during the non-irrigation season (Nov-Feb) or during reservoirs spill. During the 1985-2005 period, the increase in irrigation season flows, excluding spills, averages 15,700 AF. A portion of the increase is attributable to turning off New Mexico pumping and a portion is due to turning off Texas pumping. Cessation of pumping also produces substantial increases in flow at Fort Quitman averaging 100,300 AF annually during 1951-2017.

30.2 NM Pumping Off (Run 3)

In Run 3, all irrigation pumping and all non-irrigation pumping and returns in New Mexico is turned off. This includes all EBID supplemental irrigation pumping, all primary irrigation pumping in the Rincon Valley and Mesilla Valley, and all non-irrigation pumping and associated WWTP discharges and deep percolation returns in New Mexico.

Many of the simulated effects of turning off New Mexico pumping are similar to but smaller than the effects of turning off all pumping in Run 2. There is a similar pattern of accumulations in Project storage that are released in dry years when the simulated Project allocations increase. The accumulated storage again leads to larger spills.

EBID diversions increase by an average of 46,300 AF during 1951-2017, while FHG deliveries increase by an average of 31,200 AF. When the 2008 OA is in effect during 2006-2017, turning off New Mexico pumping increases EBID diversions by an average of 137,500 AF, and FHG deliveries increase by an average of 83,900 AF.

The impacts of New Mexico pumping on EPCWID supply are less than the impacts on EBID. From 1951 – 2017, EPCWID irrigation season diversions increase by an average of 18,500 AF and FHG deliveries increase by an average of 11,700 AF. After 1984 when Texas is claiming damages, New Mexico pumping impacts EPCWID irrigation season diversions by an average of 17,200 AF and irrigation season FHG deliveries by an average of 9,700 AF (1985-2017). During 1985-2005, prior to implementation of the 2008 OA, EPCWID irrigation season diversions increase by an average of 10,900 AF and irrigation season FHG deliveries increase by an average of 5,100 AF.

Simulated flows in the Rio Grande at El Paso increase when New Mexico pumping is turned off by an average of 61,100 AF annually during 1951-2017, of which an average of 22,900 AF occurs during the irrigation season and 38,200 AF occurs during the non-irrigation season or during spills. Average annual flows at Fort Quitman during 1951-2017 increase by an average of 49,000 AF due largely to return flows from increased surface water deliveries and reduced surface water depletions from pumping. This run shows that the Texas Model without reoperation greatly exaggerates the impacts of New Mexico pumping on El Paso flows.

30.3 TX Pumping Off (Run 4)

In Run 4, all supplemental irrigation pumping in EPCWID and HCCRD is turned off, as is all non-irrigation pumping and associated returns in the Texas portion of the Mesilla Valley and in the El Paso Valley. Deliveries of Project water to EPW and the associated return flows continue to be simulated in Run 4.

When Texas pumping is turned off, annual EBID diversions increase by an average of 5,400 AF/y during 1951-1978, and by an average of 15,500 AF during 2006-2017 when the 2008 OA is in effect. The impacts of Texas pumping are magnified by the sensitivity of changes in the diversion ratio on EBID allocations. The pattern of impacts on EBID FHG deliveries is similar with impacts to diversions that average 4,300 AF during 1951-1978 and 9,600 AF during 2006-2017.

Texas pumping also impacts Project water deliveries to EPCWID. The net effect on EPCWID supply depends on the relative positive effect of reducing depletions from pumping compared to the negative effect of turning off Texas WWTP discharges. During 1951-1978, EPCWID diversions increase by an average of 200 AF, but FHG deliveries increase by an average of 2,600 AF. During the mostly full supply years of 1979-2005, EPCWID diversions increase by an average of 10,200 AF to replace the significant reduction in WWTP discharges to the EPCWID canal system.

The reduction in the Texas WWTP discharges due to turning off the non-irrigation pumping and the concurrent increased deliveries of Project water to EPCWID, along with the reduction in stream depletions caused by Texas Mesilla irrigation pumping results in increased Rio Grande at El Paso flow in many years, particularly in the 1980s and 1990s. During 1985-2005, El Paso flows increase by an average of 27,800 AF during the irrigation season, excluding spills.

30.4 MX Pumping Off (Run 5)

In Run 5, all supplemental pumping in JID and all municipal pumping and associated WWTP discharges in Ciudad Juarez is turned off. Turning off pumping in Mexico has much less effect on Project operations than turning off pumping in New Mexico or Texas.

Turning off Mexico pumping reduces the river and conveyance system losses in delivering Project water to EPCWID farmers. As a result, in full supply years, less water needs to be released from storage to meet EPCWID demands. This results in an accumulation of water in storage that increases allocations and deliveries in later non-full supply years. This is seen in the increased reservoir releases and deliveries in 1955, 1964, 1967, 1977, 1978 and several other years after 2000.

EBID FHG deliveries increase by an average of 2,400 AF during 1951-1978, and 2,400 AF during 2006-2017. EPCWID FHG deliveries increase by similar amounts averaging 1,500 AF during 1951-1978 and 2,100 AF during 2006-2017. The impact of Mexico pumping on the HCCRD supply is larger than on EBID or EPCWID, with the total irrigation season supply to HCCRD increasing by an average of 3,900 AF during 1951-2007.

Mexico pumping also has a large impact on ground water storage in the Hueco. From 1951-2017, Hueco ground water storage is depleted by an average of 59,500 AF/y. The effect of Juarez pumping from the new Conejos-Medanos wellfield is evident in the recent changes in Rincon-Mesilla ground water storage.

30.5 R-M Pumping Off (Run 6)

In Run 6, all irrigation pumping and non-irrigation pumping and associated returns in the Rincon and Mesilla basins is turned off. This includes turning off irrigation and non-irrigation pumping in the Texas portion of the Mesilla basin. The purpose of this run is to simulate a scenario that is directly comparable to the 100% reduced pumping run of the Texas Model described in the Hutchison Report.

As expected, the effect of turning off all Rincon-Mesilla pumping in Run 6 has a larger effect than turning off New Mexico pumping in Run 3, but with a similar pattern. Turning off R-M pumping increases the Project delivery efficiency by increasing drain flows, reducing river losses, and reducing canal seepage. In full allocation years, releases from storage can be reduced while still delivering full allocations to EBID and EPCWID. This accumulates water in storage leading to increased allocations and deliveries in dry years, and greater spills in very wet years.

As discussed in Section 18.0, the comparisons of simulated changes in El Paso flow between the ILRG Model and the Texas Model that were presented in the SWE Report were revised with results from the updated ILRG Model. The revised results are shown in revised **Figures 13-1** and **13-2** in **Appendix 18**.

Additional comparisons of the R-M Pumping Off results to comparable runs of the Texas Model presented in the Hutchison Report and the Second Supplemental Moran Report are presented in **Table 30-3**. These include comparisons of 1951-2016 averages for selected model outputs for the updated ILRG Model (Run 6), the Texas Model without reoperation (Hutchison; 100% R-M Pumping Off), and the Texas Model with crude redistribution (Moran; 100% R-M Pumping Off). The updated ILRG Model results are summarized as annual averages and irrigation season averages. The Texas Model results are annual averages consistent with the annual stress periods in the Texas Model. The table entries for the Texas Model shown as "n/a" and shaded grey indicate outputs that are not simulated in the Texas Model.

Table 30-3 highlights many of the processes simulated in the ILRG Model that are not simulated in the Texas Model. It also contrasts long-term average differences between the models as to simulated changes in Rincon-Mesilla diversions and FHG deliveries, and El Paso flows. During 1951-2016, the average annual change in El Paso flow in the Texas Model is 124,700 AF without reoperation (Hutchison) and 51,700 AF with crude redistribution (Moran). These results compare to the change in flow in the ILRG Model that averages 79,800 AF year-around, and 33,200 AF during the irrigation season, excluding spills. The change in flow goes down to 12,900 AF during the irrigation season from 1985-2005.

30.6 TX Mesilla Pumping Off (Run 7)

In Run 7, all supplemental irrigation pumping and non-irrigation pumping in the Texas portion of the Mesilla basin is turned off. This includes turning off the EPW Canutillo wells and associated M&I return flows. The results of this run show that turning off Texas-Mesilla pumping has, on average over the whole study period, more impact on Project operations than does turning off all Texas pumping in Run 4. This is due to significant WWTP offsets that occur in Run 4.

Similar to many of the runs described above, turning off Texas-Mesilla pumping and returns increases the Project delivery efficiency due to increased drain flows, reduced river seepage, and reduced canal seepage. In turn, this reduces reservoir releases needed to deliver full supply allocations in wet years and the resulting storage accumulations increase allocations and deliveries in dry years.

Turning off Texas-Mesilla pumping causes EBID diversions to increase by an average of 7,200 AF during 1951-1978 and 21,300 AF during 2006-2017. EBID FHG deliveries increase in a similar pattern with average increases of 5,800 AF in 1951-1978 and 12,500 AF in 2006-2017. Impacts during recent years are magnified by the effect of the 2008 OA on EBID allocations.

EPCWID operations are also impacted by Texas-Mesilla pumping. Average irrigation season diversions by EPCWID increase by an average of 4,100 AF during 1951-1978 and 2,600 AF during 2006-2017. EPCWID FHG deliveries during 1951-1978 increase by an average of 2,600 AF and during 2006-2017 by an average of 400 AF.

30.7 TX Non-Irrigation Pumping Off (Run 8)

In Run 8, all Texas non-irrigation pumping and associated urban return flows are turned off. This includes pumping by EPW and other minor pumpers from the Hueco and pumping from EPW's Canutillo wellfield in the Mesilla Valley. Discharges from EPW's WWTPs are turned off except for amounts attributed to EPW's use of Project water which continue to be simulated. All urban deep percolation is also similarly eliminated or reduced.

Turning off the non-irrigation pumping and returns in Texas results in EPCWID ordering more Project water to replace the loss in WWTP discharge supply. This reduces the supply available for allocation in some dry years resulting in reduced diversions and/or deliveries to EBID and EPCWID.

EBID diversions decrease by an average of 2,900 AF during 1951-1978. After the 2008 OA becomes effective, the increases in Project water diversions by EPCWID to replace the reduced WWTP discharge supply increases the computed diversion ratio resulting in EBID diversions increasing by an average of 12,100 AF during 2006-2017. EBID FHG deliveries change by corresponding amounts with an average decrease of 1,000 AF from 1951-1978 and an average increase of 7,600 AF from 2006-2017.

Turning off Texas non-irrigation pumping causes EPCWID to order more Project water to replace the lost WWTP returns. There is a modest increase in diversions during 1951-1978 averaging 2,500 AF/y, which is followed by a much larger increase in diversions during 1979-2005 averaging 14,300 AF/y.

30.8 NM Non-Irrigation Pumping Off (Run 9)

In this scenario, all non-irrigation pumping in New Mexico along with the associated WWTP discharges and urban deep percolation are turned off. The effects are similar in pattern, but much smaller than the effects of turning off all New Mexico pumping in Run 3.

The familiar pattern of accumulated water in Project storage in wet years followed by increases in allocation and releases in dry years is repeated in Run 9. EBID diversions increase by averages of 2,500 AF during 1951-1978 and 23,400 AF during 2006-2017 when the effects of pumping are elevated by interaction with the revised allocation procedure under the 2008 OA. EBID FHG deliveries increase proportionally by an average of 2,000 AF/y during 1951-1978 and 14,100 AF/y during 2006-2017.

EPCWID diversions and FHG deliveries increase by small amounts when the non-irrigation pumping in New Mexico is turned off. On average, irrigation season diversions for

EPCWID increase by 900 AF during 1951-1978 and 4,500 AF during 1985-2017. Irrigation season FHG deliveries to EPCWID increase by 800 AF from 1951-1978 and 2,000 AF during 1985-2017.

The increases in Rio Grande at El Paso flow during the irrigation season are generally limited to times of increased deliveries to EPCWID, and these average 4,000 AF during 1951-2017. The increases in El Paso flow during the non-irrigation season and during spills average 2,100 AF during 1951-2017.

30.9 MX Non-Irrigation Pumping Off (Run 10)

In this scenario, all non-irrigation pumping for Ciudad Juarez in Mexico along with the associated sewage/WWTP returns are turned off. Mexico non-irrigation pumping has a relatively minor effect on Project operations and deliveries to EBID and EPCWID. For the analysis of all Mexico groundwater pumping off, refer to Run 5 in section 30.4 above.

Mexico irrigation pumping increases due to loss of Juarez WWTP discharges. This in turn increases EPCWID conveyance losses resulting in EPCWID having to increase diversions to deliver similar amounts to the farms. EPCWID irrigation season diversions increase by an average of 700 AF/y during 1951-2017, and FHG deliveries increase by an average of 200 AF over the same period. The increase in EBID diversions and FHG over 1951-2017 is minimal averaging 300 AF.

30.10 2008 Operating Agreement Scenarios (Runs 11 and 12)

Two runs of the ILRG Model were made to evaluate the effect of the D3+Carryover accounting in the 2008 OA on Project operations and LRG water supplies. In Run 11, the D1/D2 allocation procedure is simulated to allocate Project water during the entire period from 1950 - 2017 period, and in Run 12 the D3+Carryover accounting is simulated during this 68-year period[5]. Otherwise, both runs employ the same RiverWare simulation rules that are used in the Historical Base Run. Irrigation pumping is computed based on the unmet irrigation demand and the non-irrigation pumping and associated return flows are set at historical levels.

Comparison of the results of Run 11 to Run 1 show the effects of the 2008 OA on Project operations in Run 1 compared to what would have happened had the 2008 OA not been implemented and the D1/D2 allocation procedure been left in place.

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[5] The RiverWare rules do not simulate annual allocations during the wet period from 1940 – 1949.

When the D1/D2 allocation procedure is left in place during 2006-2017, the annual allocations to EBID increase substantially in most years during this period resulting in large increases in EBID diversions averaging 94,200 AF and in EBID FHG deliveries averaging 54,600 AF. These impacts on EBID from the 2008 OA are far greater than the impacts of New Mexico pumping on EPCWID irrigation season FHG deliveries that average 17,800 AF during 2006-2017 as shown in the Run 3 results.

Conversely EPCWID diversions decline by an average of 23,000 AF and FHG deliveries decline by an average of 17,200 AF during 2006-2007. The reason for the decline in EPCWID supply is primarily due to the limited amount of Project water in storage. The increases in EBID's allocations and deliveries result in smaller amounts of Project water to allocate between the districts in subsequent years. Another factor is the absence of carryover for the individual districts and this results in more water allocated to EBID and less water available for EPCWID to use.

Comparison of the results of Run 12 to Run 11 allows differences between the D1/D2 and D3+Carryover allocation procedures to be evaluated over the entire 1950-2017 period. The differences between these runs are computed based on Run 12 (D3+CO) minus Run 11 (D1/D2) and therefore reflect the impacts of going from the D1/D2 allocation procedure to the D3+CO allocation procedure.

Comparison of Run 12 and Run 11 shows clearly the effect of the 2008 OA on EBID varies depending on the type of year. In wet years with a relatively high diversion ratio, the annual EBID allocation is greater under the D3+CO method than under D1/D2 method and this results in increased diversions and FHG deliveries during 26 of the 67 years between 1951-2017 period (1951-1952, 1959-1962, 1982-2001). EBID diversions and FHG deliveries were lower in the other 41 years which were generally years of average and below average water supply. On average during 1951-2017, EBID diversions declined by 34,400 AF and FHG deliveries declined by 19,800 AF.

Conversely, the 2008 OA has a positive effect on EPCWID allocations, diversions, and FHG deliveries in most years. During the irrigation season, diversions increased by an average of 13,100 AF and FHG deliveries increased by an average of 8,200 AF. The average increase in EPCWID supply is much less that the average decrease in EBID supply.

The following is a summary of the average annual effect on EBID and EPCWID FHG deliveries in dry, wet, and all years during the 1951-2017 period.

Cumulative Volume Impact of 2008 Operating Agreement
on March - October FHG Deliveries
In Wet and Dry Periods
1951-2017

Condition	Years	EBID	EPCWID
Dry	1953-1958, 1963-1981, 2002-2017	-2.47 MAF	+0.37 MAF
Wet	1951-1952, 1959-1962, 1982-2001	+1.14 MAF	+0.17 MAF
All	1951-2017	-1.33 MAF	+0.55 MAF

The results in the above table show that the 2008 OA takes away critical surface water in the dry years when EBID has a greater need for water (2.47 MAF) than it gives back to EBID in wet years when the need is less (1.14 MAF) As a result, the 2008 OA forces EBID to pump more ground water in dry years to make up for the reduction in surface water supplies. The increased EBID pumping negatively affects the diversion ratio which contributes to the reduction in water allocated and delivered to EBID in dry years. This was termed a “vicious cycle” by Dr. Barroll (2019, 2020a).

30.11 Reduced Waste (Run 13)

As was described in Section 5.0 of the SWE Report, beginning with the 1950s drought and continuing through the 1970s, Reclamation was able to operate the Project with reported operational waste below 10% during most years. In a few years during the wet periods of the mid-1980s and mid-1990s, the EBID waste increased to approximately 20%. The situation in EPCWID was markedly different than in EBID from the 1980s through the 2000s (after EPCWID took over operations) with the operational waste consistently in the range of 20% to 30%.

A run of the ILRG Model was made to evaluate the benefit to the Project from reducing the operational waste. The RiverWare operational rules were modified so that the operational waste was limited to the lesser of the historical amounts or 10% of the simulated diversions.

Limiting operational waste in both Districts to no more than 10 percent reduces releases from Project storage in full allocation years resulting in increased allocations and deliveries in dry years with less than full allocations. As a result of the more efficient Project operation, FHG deliveries to EBID and EPCWID increase in many years during the

1950s – 1970s, and again after 2002. Increases in FHG deliveries to EBID average 35,300 AF during 1951-1978 and 57,300 AF during 2006-2017. Increases in FHG deliveries to EPCWID average 17,800 AF during 1951-1978 and 18,500 AF during 2006-2017.

30.12 Hueco Pumping Off (Runs 14, 14a, 14b, 14c, and 14d)

In response to questions from Texas legal counsel during depositions of the New Mexico experts, and in response to opinions from Texas and U.S. experts, several runs of the ILRG Model were made in which all or a portion of the pumping in the Hueco was turned off, as well as runs in which pumping was turned off without turning off WWTP discharges and vice-versa. The results from these runs are useful in assessing the effects of the Hueco pumping in isolation from pumping in other areas of the LRG basin and the effect of WWTP discharges in offsetting impacts from Hueco pumping.

The No Hueco Pumping Scenarios is simulated in the same manner as the other no pumping scenarios. The supplemental irrigation pumping from the Hueco in Texas and/or Mexico is turned off. In addition, the non-irrigation pumping in these areas and the corresponding WWTP and urban deep percolation return flows are also turned off. Specifications and summaries of the results of the No Hueco Pumping Scenarios are presented below. Runs 14a, 14b, 14c, and 14d were made to test various components of Run 14.

- <u>All Hueco Pumping Off (Run 14)</u> – In Run 14, all supplemental irrigation pumping and non-irrigation pumping in the Hueco in Texas and Mexico is turned off. In addition, the WWTP discharges by EPW and Ciudad Juarez from their Hueco pumping are turned off, as is the urban deep percolation from EPW[6].

  There are opposing effects within EPCWID from turning off Hueco pumping. Turning off Hueco pumping reduces canal and lateral losses in EPCWID and reduces river seepage between American Dam and Riverside Dam before the ACE was constructed in 1999. These changes can result in reduced Project water orders to deliver the same amount of water to EPCWID farm headgates. On the other hand, the reduction in WWTP discharges to the EPCWID canal system when M&I pumping is turned off reduces the irrigation supply available to deliver to EPCWID farm headgates and increases RHG demands for Project water. These opposing effects can result in net increases or decreases in annual EPCWID FHG deliveries.

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[6] No urban deep percolation is simulated for Mexico in the historical Base Run.

The effects within EPCWID from turning off Hueco pumping can propagate upstream and impact reservoir operations and deliveries to EBID depending on whether it is a full allocation year or non-full allocation year. In full allocation years, there is little effect on EBID FHG deliveries because EBID's allocation does not change. In non-full allocation years, accumulated changes in reservoir storage resulting from changes in EPCWID orders of Project water can result in changes in EBID allocations and deliveries.

When Hueco pumping is turned off in Run 14, there are some increases and decreases in EBID FHG deliveries that average to a 1,500 AF increase during 1951-2017 with the increases occurring in dry years.

Turning off Hueco pumping increases EPCWID FHG deliveries by an average of 800 AF during 1951-2017. Turning off Hueco pumping results in a substantial increase in the total HCCRD supply (RHG diversions) averaging 7,500 AF during 1951-2017.

- Texas Hueco Pumping Off (Run 14a) – In Run 14a, all supplemental irrigation pumping and non-irrigation pumping by Texas in the El Paso Valley is turned off, along with the WWTP discharges and urban deep percolation from the EPW Hueco pumping.

  Turning off Texas Hueco pumping reduces EBID FHG deliveries by an average of 1,000 AF during 1951-2017. EBID FHG deliveries decrease by an average of 4,000 AF during 2006-2017 when the 2008 OA is in effect.

  During 1985-2017, Texas Hueco pumping reduces EPCWID FHG deliveries during the irrigation season by an average of 1,400 AF and increases the total flow to HCCRD an average of 2,100 AF.

  Contrary to the claims of the Texas and U.S. experts, the impacts of Texas Hueco pumping on Project operations and surface water supplies to EBID, EPCWID, and HCCRD are not negligible.

- Mexico Hueco Pumping Off (Run 14b) – In Run 14b, all supplemental irrigation pumping and non-irrigation pumping in the Mexico portion of the Hueco is turned off, along with the WWTP discharges from Ciudad Juarez pumping.

  Turning off Mexico pumping reduces canal seepage and river seepage in EPCWID causing reduced Project orders at EPCWID canal headings. This results in accumulation of water in Project storage that increases Project water deliveries to EBID in years with less than a full Project water allocation. Simulated increases in

EBID FHG deliveries average 1,700 AF during 1951-2017, and 3,200 AF during 2006-2017, with increases exceeding 5,000 AF in several years and 10,000 AF in 2010.

Turning off Mexico Hueco pumping has similar effects on EPCWID with FHG deliveries increasing by an average of 1,500 AF during 1951-2017. The increase in total HCCRD supply is greater averaging 3,900 AF during 1951-2017.

- Texas WWTP Discharges Off (Run 14c) – In Run 14c, all discharges from Texas WWTPs are turned off. This includes turning off discharges from the EPW's Northwest, Haskell, Socorro, and Bustamante WWTPs, as well as discharges from the Anthony TX WWTP and the Fabens WWTP. The purpose of this run is to quantify the benefit to the Project operations and LRG water users from the Texas WWTP discharges. Without these discharges, the impacts of Texas Hueco pumping would be much larger.

  When the Texas WWTP returns are turned off, EBID FHG deliveries decrease markedly in numerous years with less than full allocations. This shows the interconnected nature of the Project and how changes in supply at the bottom of the Project area can ripple through the Project and affect operations hundreds of miles upstream. On average during 1951-2017 the reduction in diversions averages 14,600 AF and the reduction in FHG deliveries averages 6,600 AF.

  Turning off Texas WWTP discharges results in increased Project releases and diversions to EPCWID to replace the reduction in irrigation supply to EPCWID farmers from the WWTP discharges. This results in large increases in El Paso flows to deliver additional Project water to EPCWID, particularly during the wet period in the 1980s and 1990s. The increase in El Paso flows during the irrigation season, excluding spills, average 38,300 AF during 1985-2005.

  Without the Texas WWTP discharges, the simulated impacts from Texas pumping would be much larger than the impacts shown in Runs 4, 7, 8, 14, and 14a. The results for Run 14c show the effect of Texas WWTP discharges have in offsetting the impacts of Texas pumping. Without these discharges (for example if EPW reused its WWTP discharges for non-potable uses), the effects of Texas pumping on Project operations, including deliveries to EBID would be much greater.

- Texas Hueco Pumping Off without WWTP Discharges Off (Run 14d) – In Run 14d, Texas Hueco pumping is turned off without turning off the associated Texas WWTP discharges and urban deep percolation. This test run simulates the effect of Texas Hueco pumping without the offsets from Texas M&I return flows.

When the Texas Hueco pumping is turned off without turning off the M&I returns, the simulated impacts on Project operations increase. EBID FHG deliveries increase by an average of 5,000 AF during 1951-1978 and 2,000 AF during 2006-2017. FHG deliveries to EPCWID increase by 4,600 AF during 1951-1978 and 2,000 AF during 2006-2017. Total flows to HCCRD increase by 7,100 AF during 1951-1978 and 3,700 AF during 2006-2017.

30.13 Early EPCWID Ops (Runs 15, 15a, 15b, 15c)

Four scenarios were simulated using the ILRG Model to evaluate the effects on Project operations that would result from a return to EPCWID operations consistent with how the Project was operated in the past. These include simulating increased irrigation use of drain flows in the Fabens area and charging EPCWID for all water that it uses. Runs 15a, 15b, and 15c were made to test various components of Run 15. Descriptions of the four Early EPCWID Ops scenarios are provided below along with the scenario results.

- <u>Early EPCWID Ops (WWTP & Fabens Drains) (Run 15)</u> – In Run 15, simulation of EPCWID operations in the El Paso Valley are modified to simulate irrigation use of all available supplies consistent with how the Project was originally operated in the El Paso Valley. This includes simulation of irrigation use of the usable Fabens drain flows, which are estimated as 70% of the total Fabens drain flows limited to a monthly volume of 6,000 AF, based on available historical data (see response to Ferguson Opinion 9 for more information). In addition, EPCWID is charged for all use of drain flows and WWTP flows, and the ACE Credit and Haskell WWTP discharge credits are disabled. These changes reflect operations consistent with the original concept and implementation of the Project which was to use all available supplies to minimize the amount of storage releases needed to meet Project water demands. Further, since EPCWID is charged for all of its water use including the water that arises within the EPCWID system, it has less unused allocation in many years and uses its entire allocation in more years than in the Historical Base Run (Run 1). The increased use of water arising within the EPCWID system reduces the releases from Project storage to meet EPCWID demands and the accumulated Project storage increases the supply available for allocation and use in subsequent years. When accounting under 2008 OA commences, EPCWID has less unused allocation to carryover to subsequent years. The following is a summary of the effects of the foregoing changes in EPCWID operations:
    - <u>EBID</u> – FHG deliveries increase modestly by an average of 4,300 AF during 1951-1978 and by a much larger amount, averaging 41,900 AF during 2006-2017. The large increases during the recent period result from significant increases in the diversion ratio that result from EPCWID being

charged for all water that it uses, and the positive feedback of increases in the diversion ratio on EBID allocations under D3 accounting.

  - EPCWID – FHG deliveries increase by an average of 1,400 AF during 1951-2017. Simulated EPCWID RHG diversions decrease by an average of 15,100 AF during 1951-2017 as diversions of Project water from the river are eschewed in favor of the supplies arising within EPCWID.

  - HCCRD – The changes in EPCWID operations result in minor reductions in the water flowing to HCCRD. Annual total flow to HCCRD decreases by an average of 3,100 AF during 1951-2017.

- Early EPCWID Ops (WWTP) (Run 15a) – In Run 15a, EPCWID is charged for irrigation use of WWTP flows, and the ACE Credit and Haskell WWTP discharge credits are disabled. However, the simulated use of drain flows is left at the historical levels simulated in Run 1, and EPCWID is not charged for the historical use of the drain flows. The results are similar in pattern to the Run 15 results but smaller in magnitude as follows:

  - EBID – FHG deliveries increase modestly by an average of only 200 AF during 1951-1978, but by much larger amounts averaging 27,200 AF during 2006-2017. Similar to Run 15, the large increases during the recent period result from the effect of an increase in the diversion ratio on EBID allocations under the 2008 OA.

  - EPCWID – FHG deliveries decrease by an average of 1,900 AF during 1951-2017. Simulated EPCWID RHG diversions decrease by an average of 2,900 AF during 1951-2017 with the increased use and charge for supplies arising within EPCWID.

  - HCCRD – Charging EPCWID for use of WWTP flows and elimination of credits against charges reduces the total flow to HCCRD by an average of 500 AF during 1979-2005 and 2,200 AF during 2006-2017

- Early EPCWID Ops (Fabens Drains) (Run 15b) – In Run 15b, the model simulates and charges EPCWID for use of the usable Fabens drain flows as described above in Run 15. However, EPCWID is not charged for use of WWTP flows and is credited for Haskell WWTP discharges and the ACE Credit. The results are similar in pattern to the Run 15 results as follows:

  - EBID – FHG deliveries increase modestly by an average of 4,300 AF during 1951-1978, and by an average of 21,800 AF during 2006-2017. Similar to Run 15, the large increases during the recent period result from the effect of an increase in the diversion ratio on EBID allocations under the 2008 OA.

  - EPCWID – FHG deliveries increase by an average of 3,100 AF during 1951-2017. Simulated EPCWID RHG diversions decrease by an average of 12,900 AF during 1951-2017 with the simulated increased use and charge for drain flows arising within EPCWID.

  - HCCRD – The increased use of drain flows in EPCWID results in a reduction in the total flow to HCCRD averaging 2,600 AF.

- Early EPCWID Ops (TX Hueco Pumping Off) (Run 15c) – In this scenario, the changes to EPCWID operations and accounting from Run 15 were simulated with the Texas Hueco pumping turned off. The effects of Texas Hueco pumping with the modified EPCWID operation were assessed by comparing the results of Run 15c and Run 15. The effects of the Texas Hueco pumping on EBID are mixed due to the opposing effects on EPCWID from pumping and WWTP discharges from pumping.

30.14 Conj Use 1: Hist All Acres D1/D2 (Runs 16 and 16a)

Two scenarios are simulated to evaluate conjunctive use of surface water and ground water within the Rio Grande Project under the D1/D2 allocation procedure with the historical irrigated area that evolved over time (including irrigation of the primary ground water only acres in New Mexico), and with the early EPCWID operations that are simulated in Run 15. In both scenarios, irrigation pumping in EBID and EPCWID is limited based on the irrigation pumping that existed during the 1951-1978 D1/D2 data period. This is implemented by not allowing the 10-year running average pumping after 1978 to exceed the 1951-1978 historical average annual pumping.

- Conj Use 1: Hist All Acres D1/D2 (Hist M&I) (Run 16) – Run 16 essentially combines the early EPCWID operations from Run 15 with the Run 11 continuation of D1/D2 allocation of Project water after 2005 along with a limit on irrigation pumping after 1978. In Run 16, the M&I pumping and returns are set at the historical amounts simulated in Run 1. The results for Run 16 are very similar to Run 15 until 2005. After that time, the differences from Run 1 represent the combination of the early EPCWID operations and continuation of D1/D2 accounting. The following are summaries of the differences between Run 16 and Run 1 after 2005:

  - EBID – FHG deliveries increase by an average 69,000 AF during 2006 -2017 which is much greater than the increase of 41,900 AF in Run 15.
  - EPCWID – FHG deliveries decrease by an average of 14,500 AF during 2006 -2017 with the D1/D2 accounting compared to an average increase of 700 AF in Run 15.
  - HCCRD – Total flows to HCCRD decline by an average of 9,500 AF during 2006-2017, compared to an average decline of 3,800 AF during this same period in Run 15.

- Conj Use 1: Hist All Acres D1/D2 (1978 M&I) (Run 16a) – The conditions simulated in Run 16a are the same as Run 16 except that M&I pumping in New Mexico and Texas after 1978 is limited to the levels that existed in 1978 at the end of the D1/D2 period. This limit has minimal effect on Texas M&I pumping because it exceeded the 1978 amount by only small amounts in a few years after 1978. When the M&I pumping is limited by the 1978 amount, the simulated M&I returns are scaled down proportionally. The results of Run 16a are very similar to Run 16 which reinforces that New Mexico M&I pumping has relatively little impact on Project operations.
  - EBID – FHG deliveries increase by an average of 72,400 AF during 2006-2017 compared to an average increase of 69,000 AF in Run 16.
  - EPCWID – FHG deliveries decrease by an average of 12,600 AF during 2006-2017 compared to a decrease of 14,500 AF in Run 16.
  - HCCRD – Total supply to HCCRD from 2006-2017 decreases by 9,200 AF compared to an average decrease of 9,500 AF in Run 16.

30.15 Conj Use 2: Hist Proj Acres (Runs 17 and 17a)

A second set of conjunctive use scenarios are simulated in Run 17 and Runs 17a under the D1/D2 allocation procedure with irrigation limited to the historical Project acres and no irrigation of the non-Project primary (ground water only) acres in New Mexico. The early EPCWID operations from Run 15 are also a part of these conjunctive use scenarios.

- Conj Use 2: Hist Proj Acres (Hist M&I) (Run 17) – In Run 17, the M&I pumping and returns are set at the historical amounts simulated in Run 1. The results from Run 17 are similar to the results from Run 16 and the differences largely reflect the effect of ground water pumping on primary acres in New Mexico.

  - EBID – Annual FHG deliveries increase by an average of 7,500 AF during 1951-1978, and by a much larger average of 75,600 AF following the change to D1/D2 after 2005.
  - EPCWID – Annual FHG deliveries increase by an average 5,100 AF during 1951-1978, and decline by 10,700 AF during 2006-2017 due to the change in allocation method from D3 to D1/D2 starting in 2006.
  - HCCRD – Total flows to HCCRD decrease by an average of 8,600 AF during 2006-2017.

- Conj Use 2: Hist Proj Acres (Pre-Comp M&I) (Run 17a) – The conditions simulated in Run 17a are the same as Run 17 except that M&I pumping in New Mexico and Texas is set at the pre-Compact amounts that existed in 1938 (736 AF/y in New Mexico and 13,744 AF/y in Texas). M&I returns are scaled down proportionally consistent with the pre-Compact pumping volumes. The differences between Run 17 and Run 17a reflect the effects of the post-compact increases in total M&I pumping throughout the study area on simulated surface water supplies.
  - EBID – Annual FHG deliveries increase by an average of 9,500 AF from 1951 – 1978 and 87,900 AF from 2006-2017. These compare to an increase of 7,500 AF and an increase of 75,600 AF in Run 17, respectively.
  - EPCWID – Annual FHG deliveries increase by an average 6,100 AF during 1951-1978, and decrease by 4,300 AF during 2006-2017 due to the change in allocation method to D1/D2. These compare to a 1951-1978 increase of 5,100 AF and 2006-2017 decrease of 10,700 AF in Run 17.
  - HCCRD – Total supply to HCCRD increases by an average of 1,100 AF during 1951-2017 compared to an average decrease of 2,800 AF in Run 17.

30.16 Conj Use 3: Auth Proj Acres (Pre-Comp M&I) (Run 18)

A third conjunctive use scenario is simulated in Run 18 under the D1/D2 allocation procedure with irrigation of the original authorized Project acres simulated in every year from 1940-2017 (88,000 acres in EBID and 67,000 acres in EPCWID). The irrigated area in HCCRD is set at the reported maximum historical amount of 17,750 acres that occurred in 1951, and the irrigated area in JID is set at historical levels. M&I pumping and returns are limited to the pre-Compact amounts as in Run 17a. The early EPCWID operations are also simulated as in the other conjunctive use scenarios. Finally, because the authorized EPCWID acres are simulated as irrigated in every year, there is no simulation of EPW use of Project water.

- EBID – Annual FHG deliveries decrease by an average of 1,800 AF during 1951-1978, and increase by 51,500 AF during 2006-2017 under D1/D2.

- EPCWID – Annual FHG deliveries increase by an average of 5,600 AF during 1951-1978 and decrease by an average of 35,700 AF during 2006-2017 when allocations revert back to the D1/D2 method.

- HCCRD – Total supply to HCCRD increases by 500 AF during 1951-1978 and decreases by an average of 13,500 AF during 2006-2017.

31.0 SENSITIVITY ANALYSES OF ILRG MODEL

Alternative runs of the ILRG Model were made to test the sensitivity of the results to changes in certain input parameters and input data. Since ILRG Model results are assessed primarily based on differences between runs, the results of the sensitivity runs were also tabulated based on run differences. The No New Mexico Pumping scenario (Run 3) was selected for the sensitivity analysis, along with the differences in model output compared to the Historical Base Run scenario (Run 1).

The following inputs were selected for sensitivity analysis based on discussions among the New Mexico experts:

- Alluvial Aquifer Hydraulic Conductivity
- River Bed Conductance
- Canal Bed Conductance
- Drain Bed Conductance
- Crop Irrigation Requirement (CIR)

Each of the above inputs was separately perturbated by +10% for the sensitivity runs. Since each of the above inputs are represented in the model as spatially varying values, the 10% perturbation involved applying a scaler of 1.1 to each spatially distributed value. Then, fully iterated runs of the ILRG Model were made to closure for Run 3 and Run 1 (identified as Run 3* and Run 1* in the results summaries). The model inputs being tested were perturbated by 10% in both the RiverWare Model and the two ground water models, except for the CIR which is not an input to the ground water models and canal bed conductance which is perturbed only in the ground water models since canal loss is computed in the ground water models and passed to the RiverWare Model.

The model outputs tabulated and compared for the sensitivity analyses are the same outputs that are summarized in the run comparisons for the alternative model runs described in Section 30.0. The differences in outputs between Run 3* and Run 1* are compared to the differences between the original Run 3 and Run 1, and these comparisons are tabulated in several figures and tables for each input that was tested.

Graphs illustrating the sensitivity analysis results are provided in the bar charts in **Figure 31-1** through **Figure 31-5**. The black bars represent the average Run 3 minus Run 1 differences for the original ILRG Model Runs. As described in more detail in Section 30.0

turning off New Mexico pumping generally results in increased Project storage, decreased Caballo releases, increased diversions and FHG deliveries to EBID, EPCWID, and HCCRD, increased Rio Grande flows at El Paso and Fort Quitman, and increased ground water storage. The orange bars depict the average Run 3* minus Run 1* differences for the sensitivity runs of the ILRG Model. Differences between the black and orange bars reflect the sensitivity of the model outputs to the 10% perturbations of the specified inputs. These differences are summarized as average volumes and average percent changes in **Table 31-1** for each of the five inputs that were tested. The sensitivities of each input are summarized below.

- <u>Alluvial Aquifer Hydraulic Conductivity</u> – Increasing the alluvial aquifer hydraulic conductivity by 10% causes relatively small changes in diversions, FHG deliveries, river flows, and storage (4% or less). These changes generally reflect slight speeding of the surface flow responses to pumping and recharge.

- <u>River Bed Conductance</u> – Increasing the river bed conductance by 10% increases the river gain and loss responses to changes in aquifer heads in hydraulically connected reaches. This in turn slightly increases the surface water response to the cessation of New Mexico pumping in Run 3. More of the pumping effects are expressed as changes in surface water flows and less to changes in ground water storage.

- <u>Canal Bed Conductance</u> – Increasing the canal bed conductance by 10% increases the canal seepage response to changes in pumping and recharge. As a result, turning off pumping in New Mexico results in a modest increase in the effects on diversions and FHG deliveries of the districts (0% - 7%). There are also positive changes in the increases in reservoir and ground water storage (3% - 5%) as well as the increases in river flows from turning off New Mexico pumping (3% - 6%).

- <u>Drain Bed Conductance</u> – Increasing the drain bed conductance by 10% has little effect on the model outputs. The effect on the changes in diversions is only 2% or less, and the effect on reservoir and ground water storage changes is less than 1%.

- <u>Crop Irrigation Requirement (CIR)</u> – Increasing the CIR by 10% has a greater effect on model outputs than any of the other inputs that were tested. This is not surprising because an increase in the CIR has a greater effect on the water budget. Increasing the CIR results in an increase in the unmet demand after the surface water deliveries which in turn increases the simulated pumping in Run 1*. Therefore, when New Mexico pumping is turned off in Run 3*, there are larger computed impacts of pumping on surface water flows than in the base runs. The effect of pumping on diversions and FHG deliveries by the U.S. districts increases by 15% - 43%. The effects of pumping on reservoir storage, river flows, and ground water storage are also significantly affected.

The results of the sensitivity analyses demonstrate that the ILRG Model is most sensitive to changes in CIR because of its substantial effect on the water budget and the unmet irrigation demand that is satisfied by pumping. The other tested parameters mainly affect the timing of ground water flow and the interaction of ground water and surface water interaction as opposed to directly affecting the water budget.

32.0 LIST OF REFERENCES

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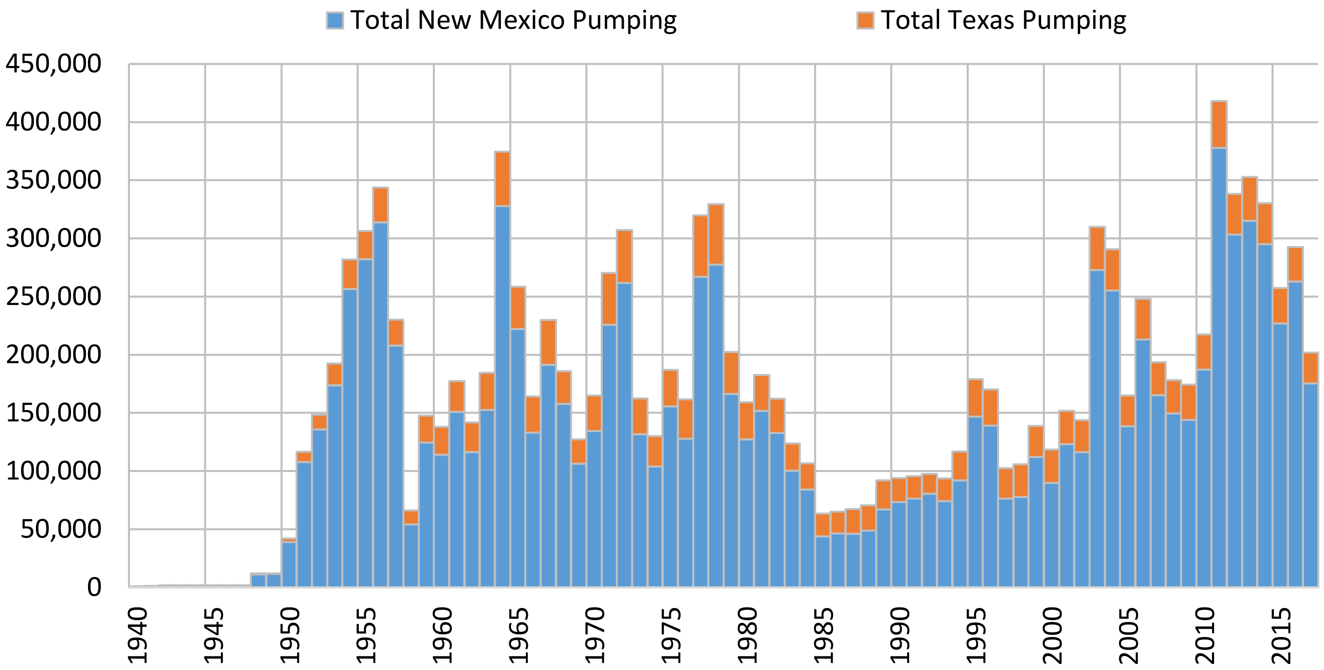
FIGURES

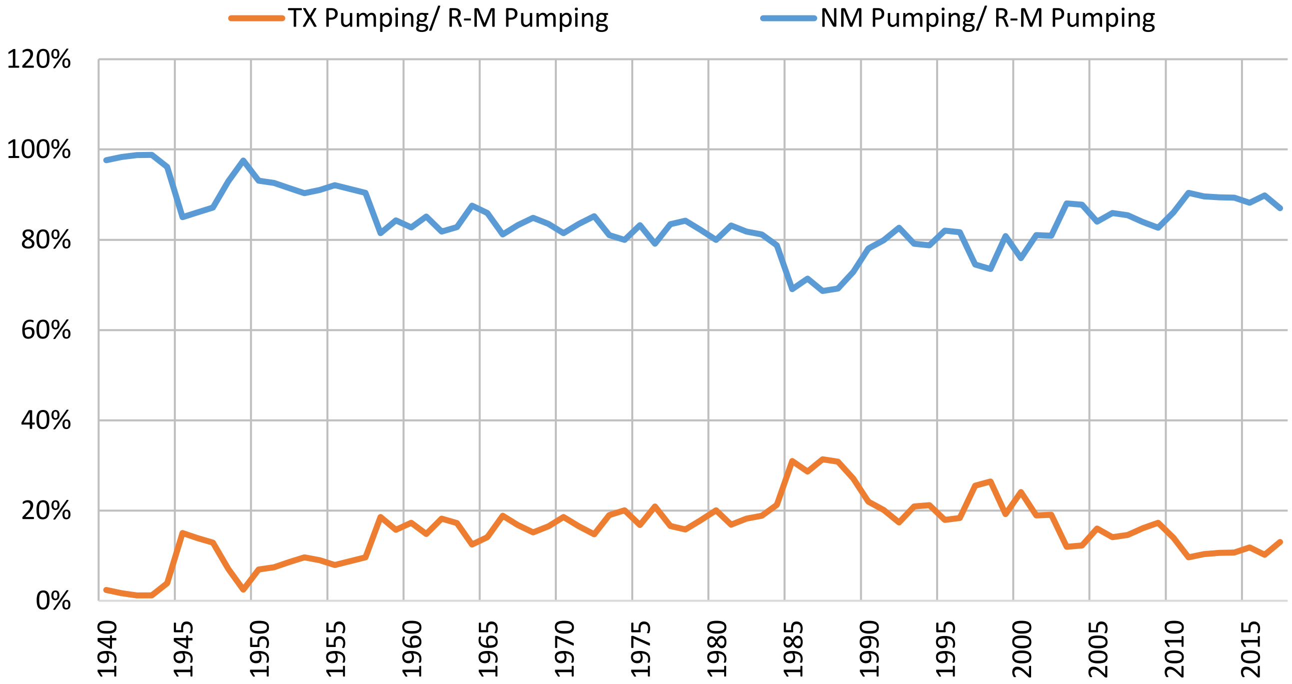
Figure 19-1

Historical Pumping in the Rincon and Mesilla Valleys
1940 - 2017

Annual Pumping (acre-feet)



% Total Rincon and Mesilla Valley Pumping



Notes:

(1) All pumping amounts include irrigation (primary and supplemental) plus M&I pumping.

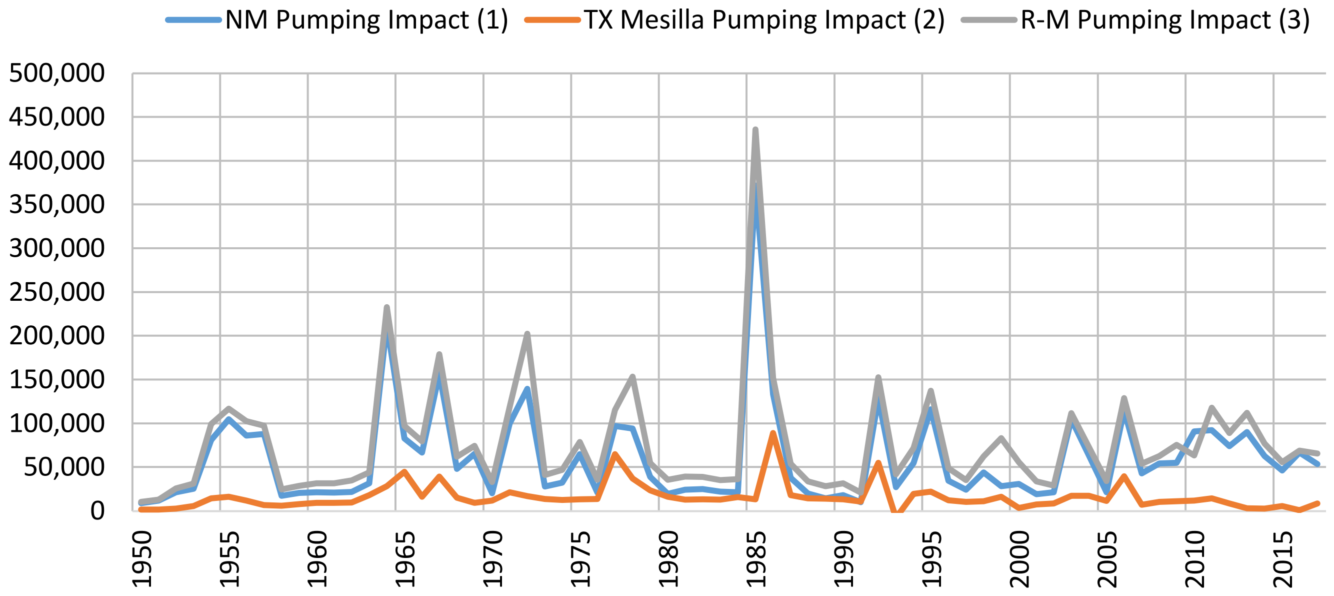
(2) Irrigation pumping amounts from SWE CFB Model.

(3) M&I pumping from the NMR-M Model.

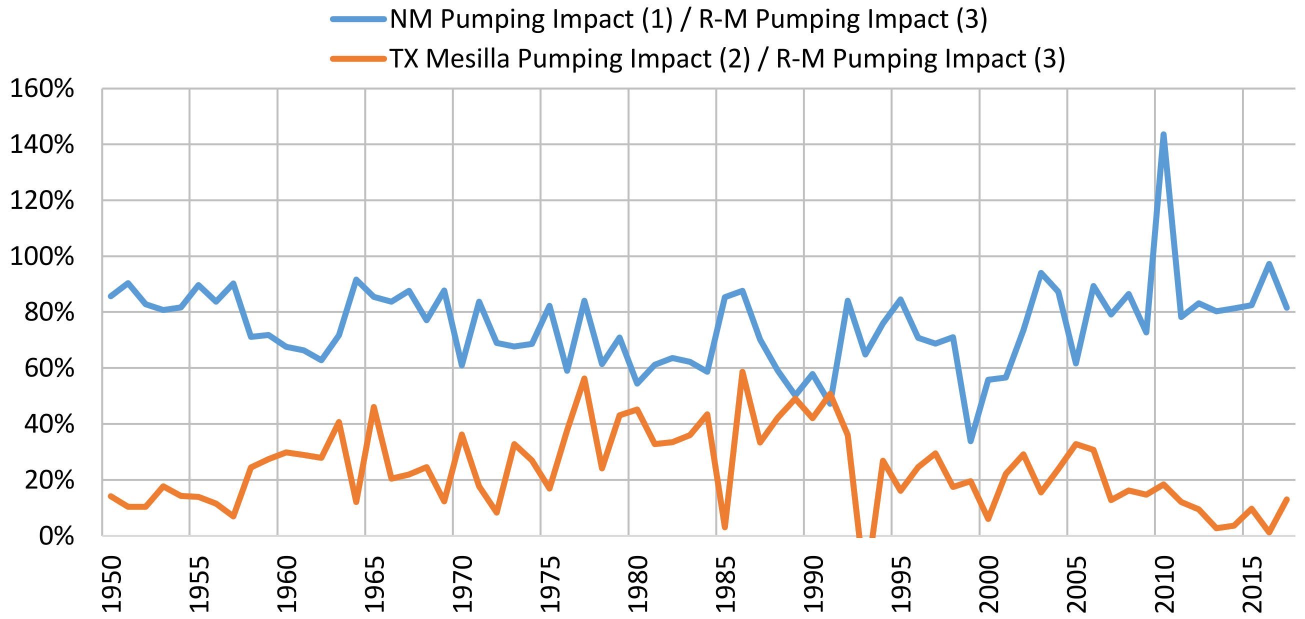
Figure 19-2

Depletion to Rio Grande at El Paso Flow from Pumping in the Rincon and Mesilla Valleys
ILRG Model
1950 - 2017

Annual Pumping Impacts on Rio Grande at El Paso Flow (acre-feet)



% Total Rincon - Mesilla Pumping Impacts



Notes:

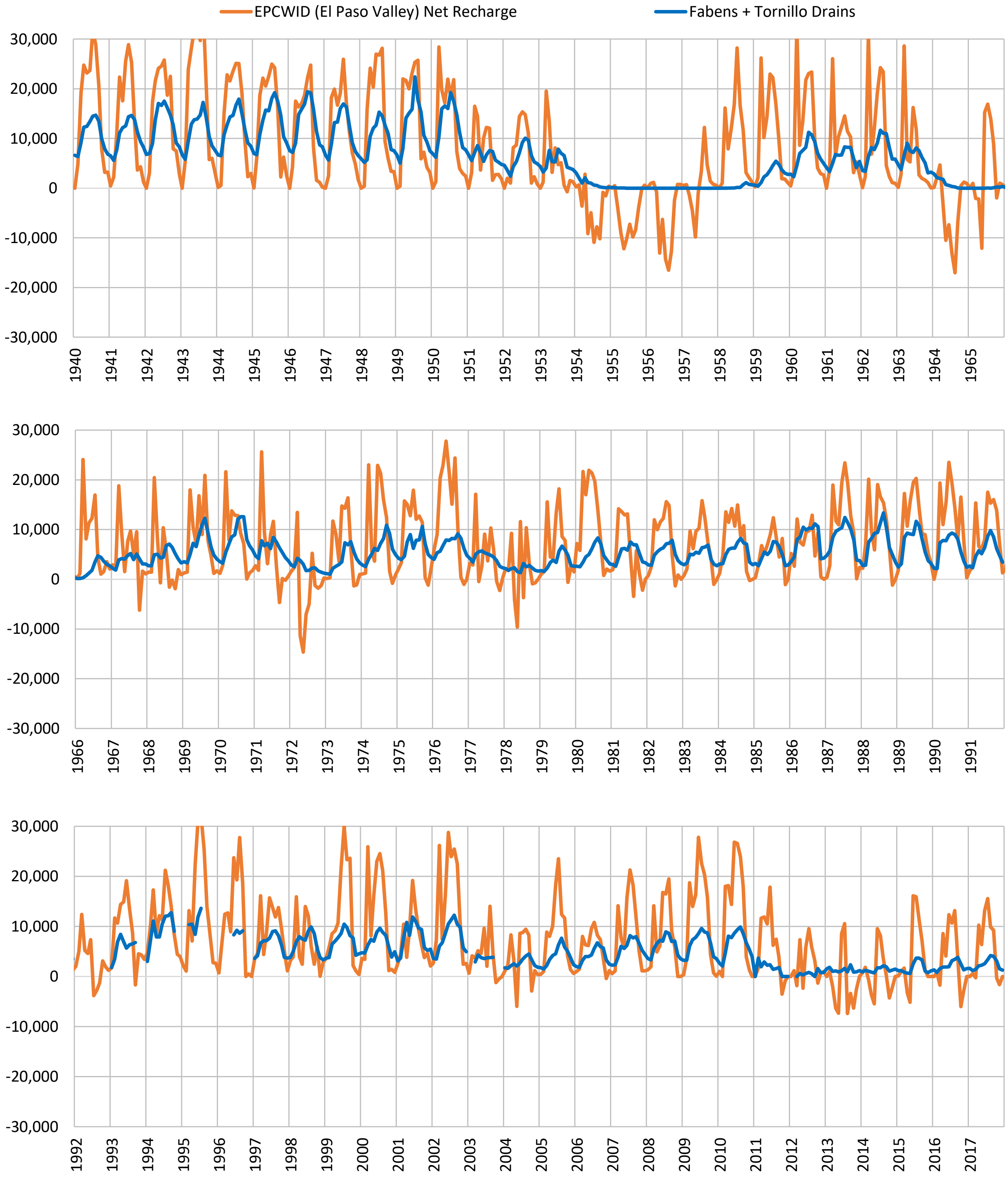
(1) NM Pumping Impact computed as El Paso Flow plus Northwest WWTP discharge in Run 3 minus Run 1.

(2) TX Mesilla Pumping Impact computed as El Paso Flow plus Northwest WWTP discharge in Run 7 minus Run 1.

(3) R-M Pumping Impact computed as El Paso Flow plus Northwest WWTP discharge in Run 6 minus Run 1.

Figure 19-3

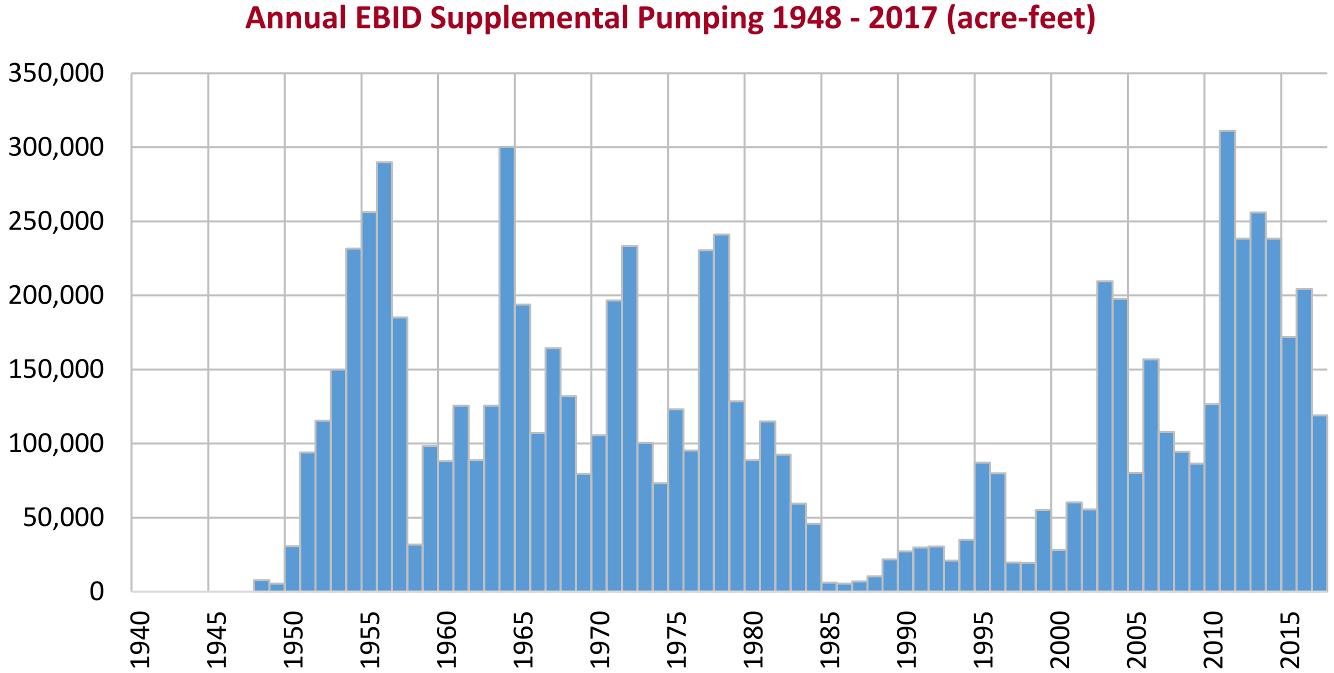
Monthly Net Recharge vs. Drain Flow
EPCWID (El Paso Valley)
1940 - 2017 (acre-feet)

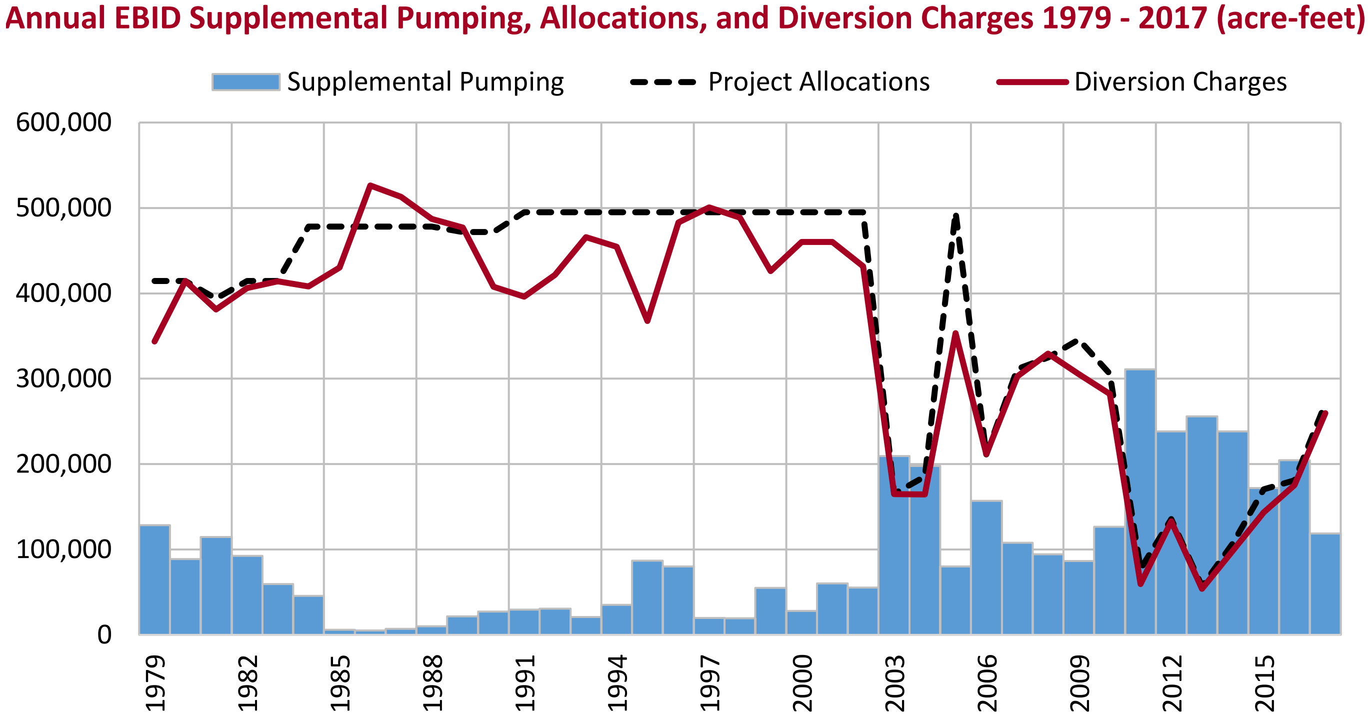


Notes: Net recharge computed as canal seepage plus on farm deep percolation minus pumping from the CFB Model.
Drain flows from SWE SWDataSet. Computed as Tornillo Drain plus Fabens Waste Drain. Fabens Waste Drain flows estimated 1940-1983 as sum of River, Middle, Cuadrilla, Mesa, and Fabens Intercepting drains. Missing Fabens Intercepting Drain flows 1972 - 1983. Missing Fabens Waste Drain flows in 1992, and in certain months in 1993-1996, 2003, and 2012.

Figure 19-4

EBID Pumping, Allocations, and Charges

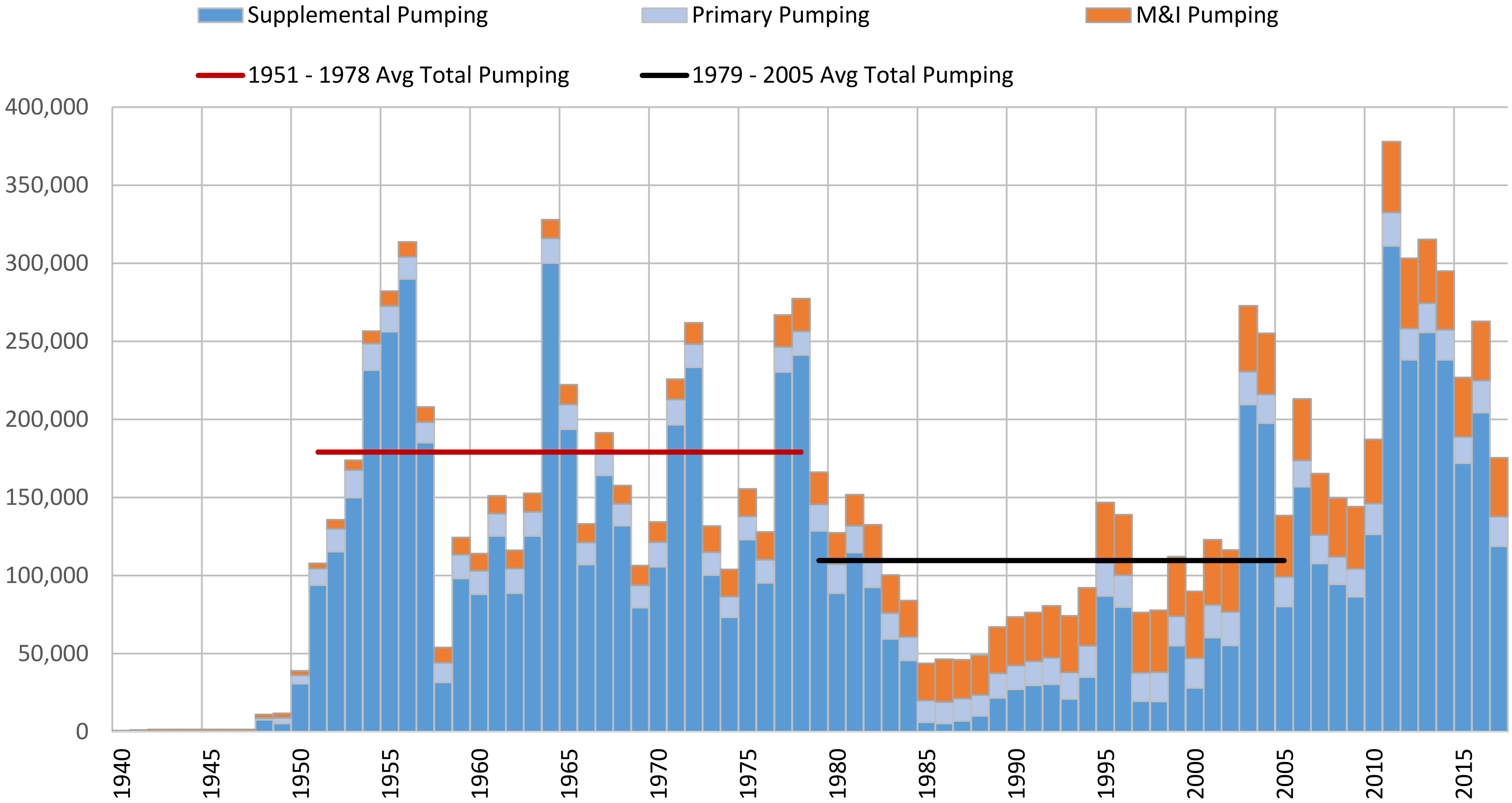




Notes:
(1) Supplemental irrigation pumping from SWE CFB Model.
(2) Annual allocations and diversion charges from SWE Accounting DataSet.

Figure 19-5

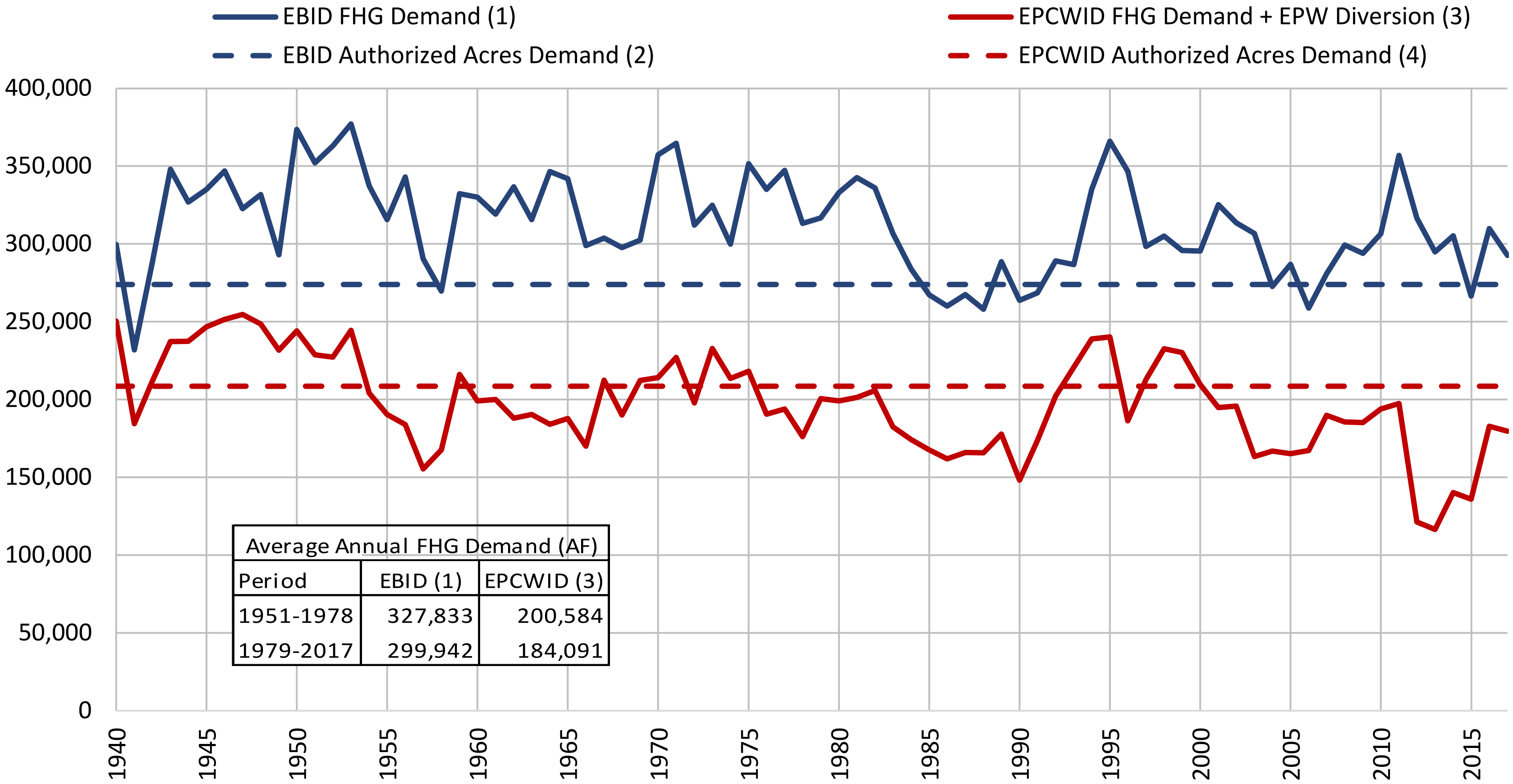
New Mexico Annual Pumping in the Rincon and Mesilla Valleys
1940 - 2017 (acre-feet)



Notes:
(1) New Mexico irrigation pumping from SWE CFB Model.
(2) New Mexico M&I pumping from the NMR-M Model.

Figure 19-6

EBID and EPCWID Annual Farm Headgate Demand
1940 - 2017 (acre-feet)



Average Annual FHG Demand (AF)		
Period	EBID (1)	EPCWID (3)
1951-1978	327,833	200,584
1979-2017	299,942	184,091

Notes:

(1) EBID FHG Demand from SWE CFB Model and computed as weighted supplemental CIR (feet) x irrigated acres /on-farm irrigation efficiency.

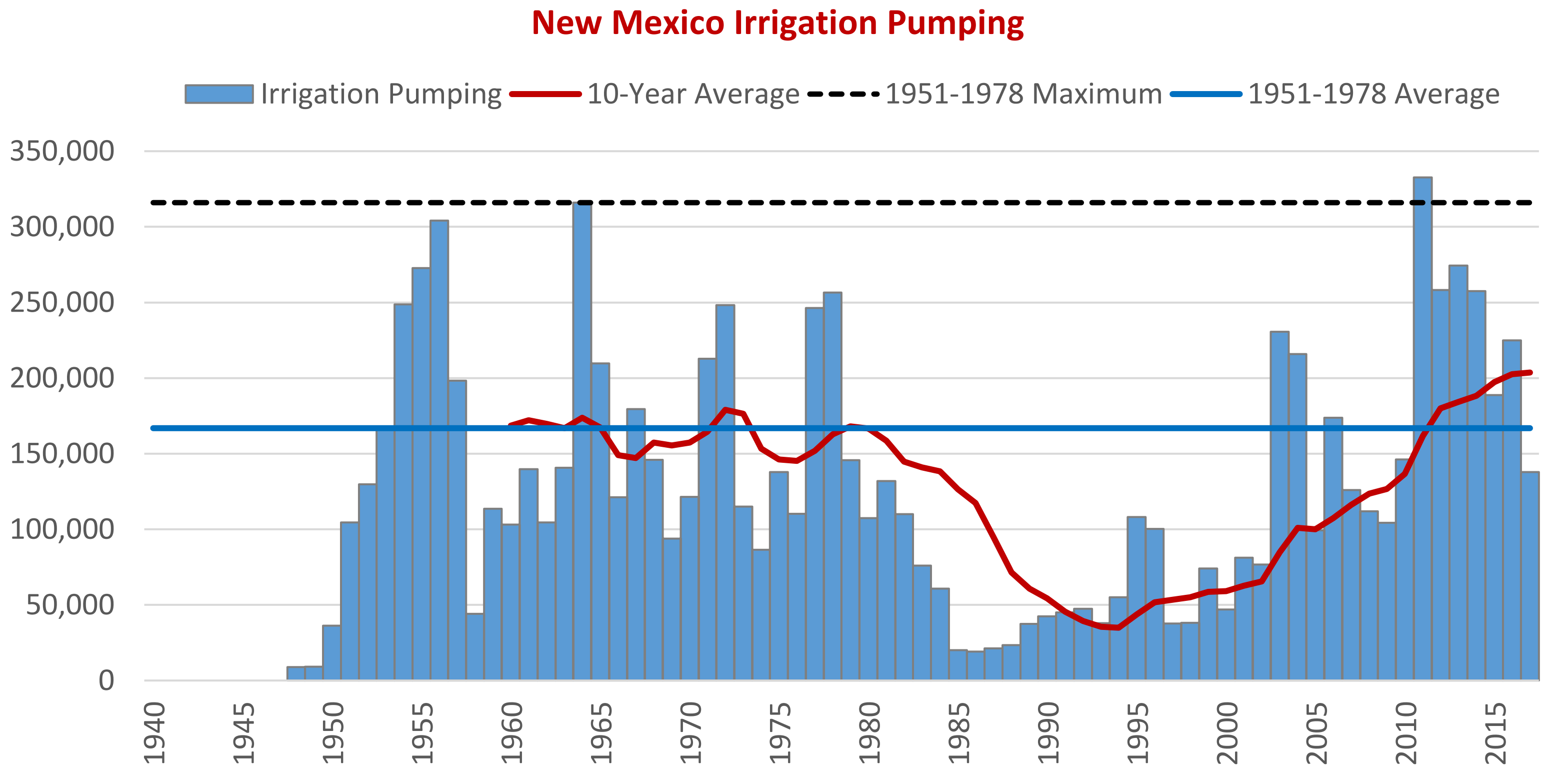
(2) EBID Authorized Acres Demand computed as 3.024 AF/acre x EBID authorized acres (90,640).

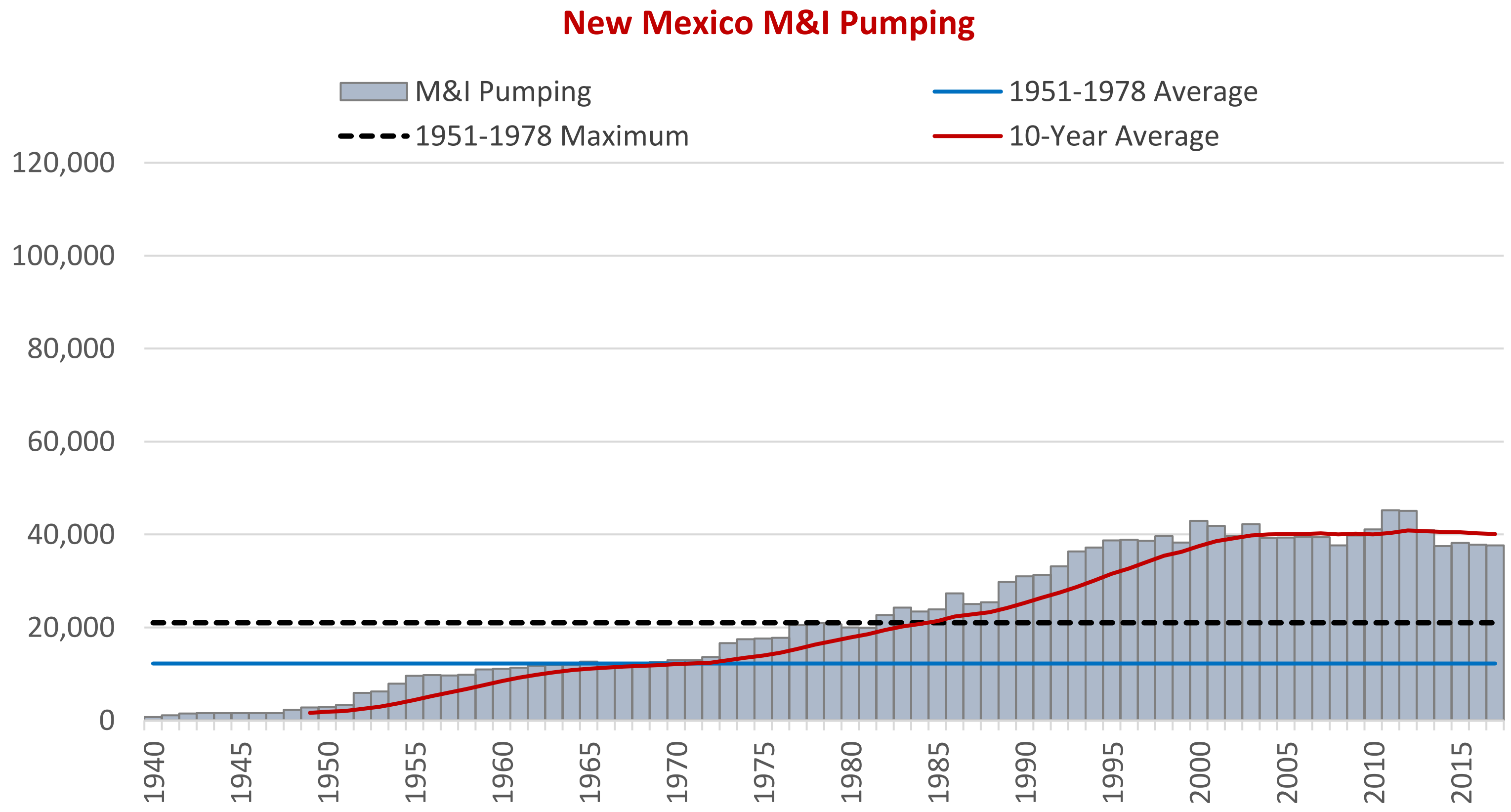
(3) EPCWID FHG Demand from SWE CFB Model and computed as weighted CIR (feet) x irrigated acres /on-farm irrigation efficiency.
EPW Diversion from SWE SWDataSet.

(4) EPCWID Authorized Acres Demand computed as 3.024 AF/acre x EPCWID authorized acres (69,010).

Figure 19-7

Annual New Mexico Pumping
1940 - 2017 (acre-feet)





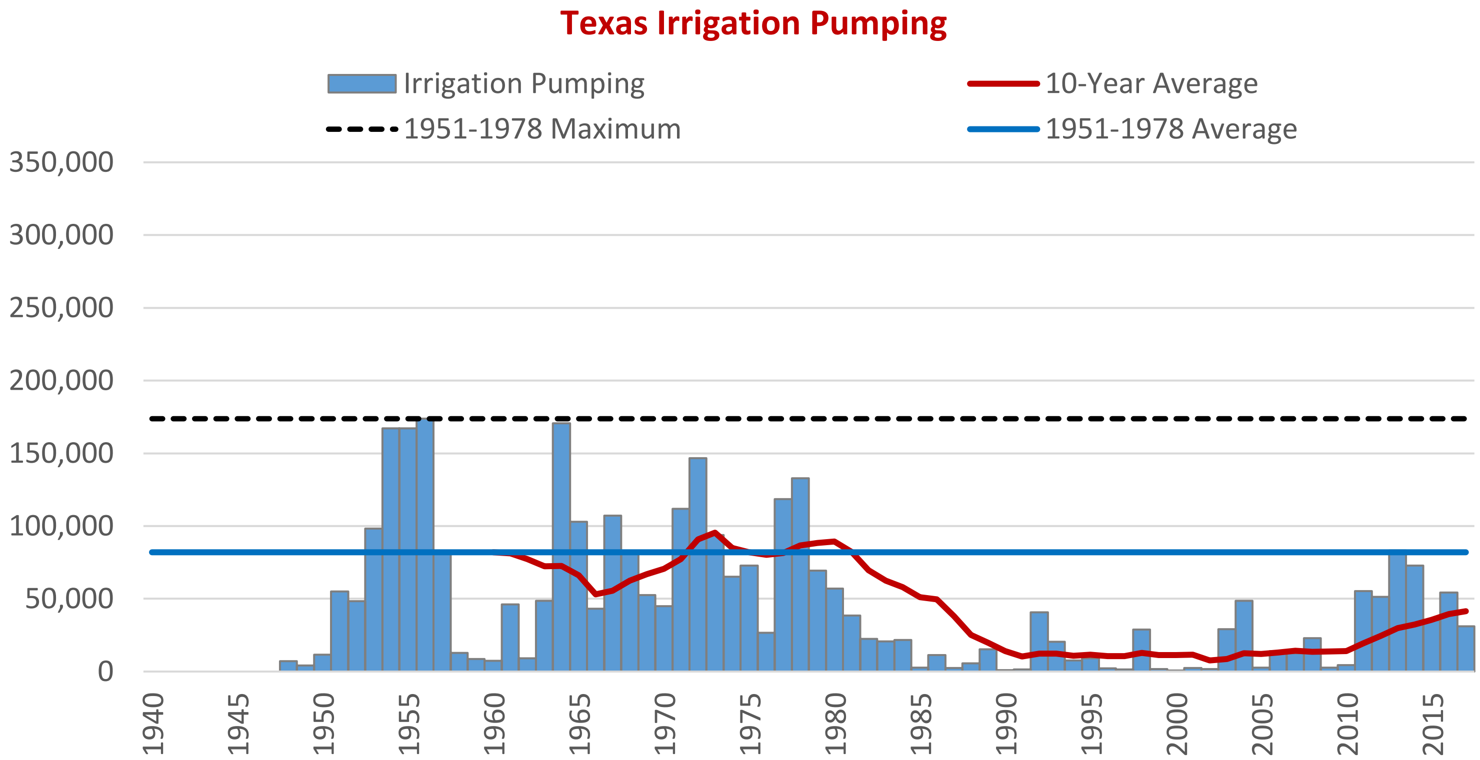
Notes:

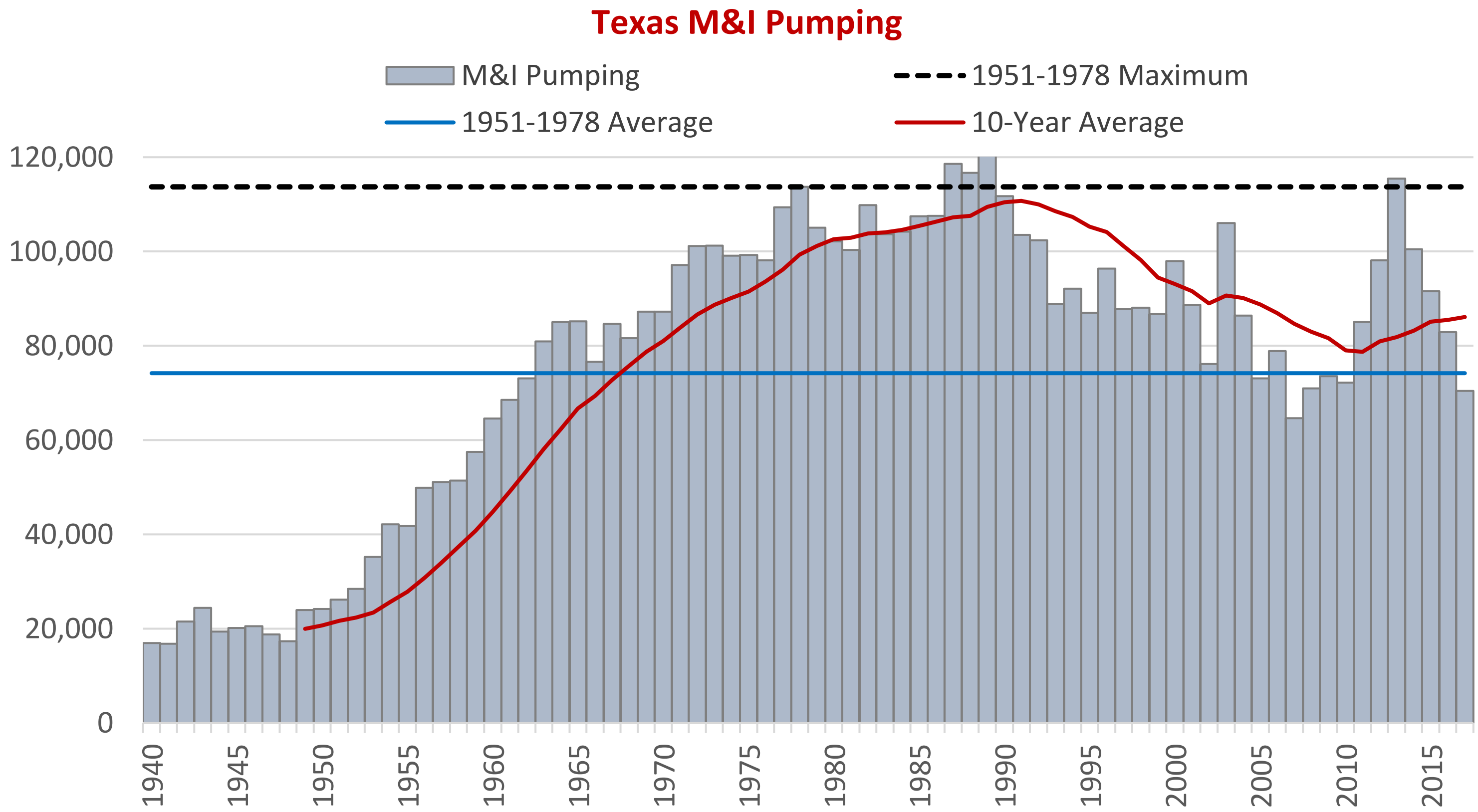
(1) New Mexico irrigation pumping includes EBID supplemental and primary pumping from SWE CFB Model.

(2) New Mexico M&I pumping from NMR-M Model.

Figure 19-8

Annual Texas Pumping
1940 - 2017 (acre-feet)





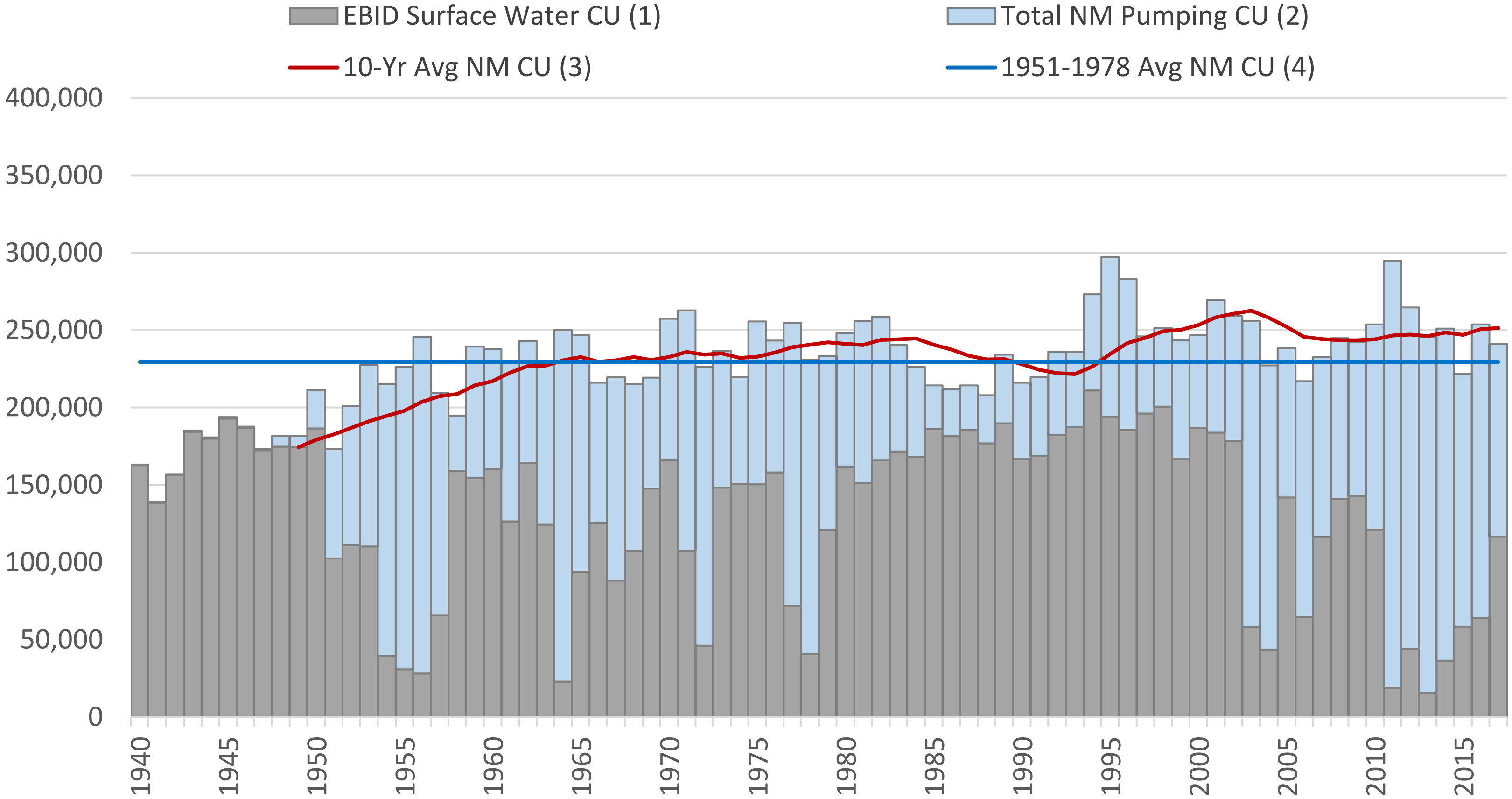
Notes:

(1) Texas irrigation pumping includes EPCWID and HCCRD pumping from SWE CFB Model.

(2) Texas M&I pumping includes EPW and other Texas M&I pumping from NMR-M Model and Hueco Model.

Figure 19-9

Annual Irrigation and M&I Consumptive Use
New Mexico
1940 - 2017 (acre-feet)



Notes:

(1) EBID surface water irrigation consumptive use from SWE CFB Model.

(2) EBID irrigation pumping CU (incl. primary ground water lands) from SWE CFB Model plus New Mexico M&I pumping from NMR-M Model and Hueco Model minus return flows from NMR-M Model and Hueco Model inputs.

(3) 10-year running average of total irrigation and M&I consumptive use (1, 2).

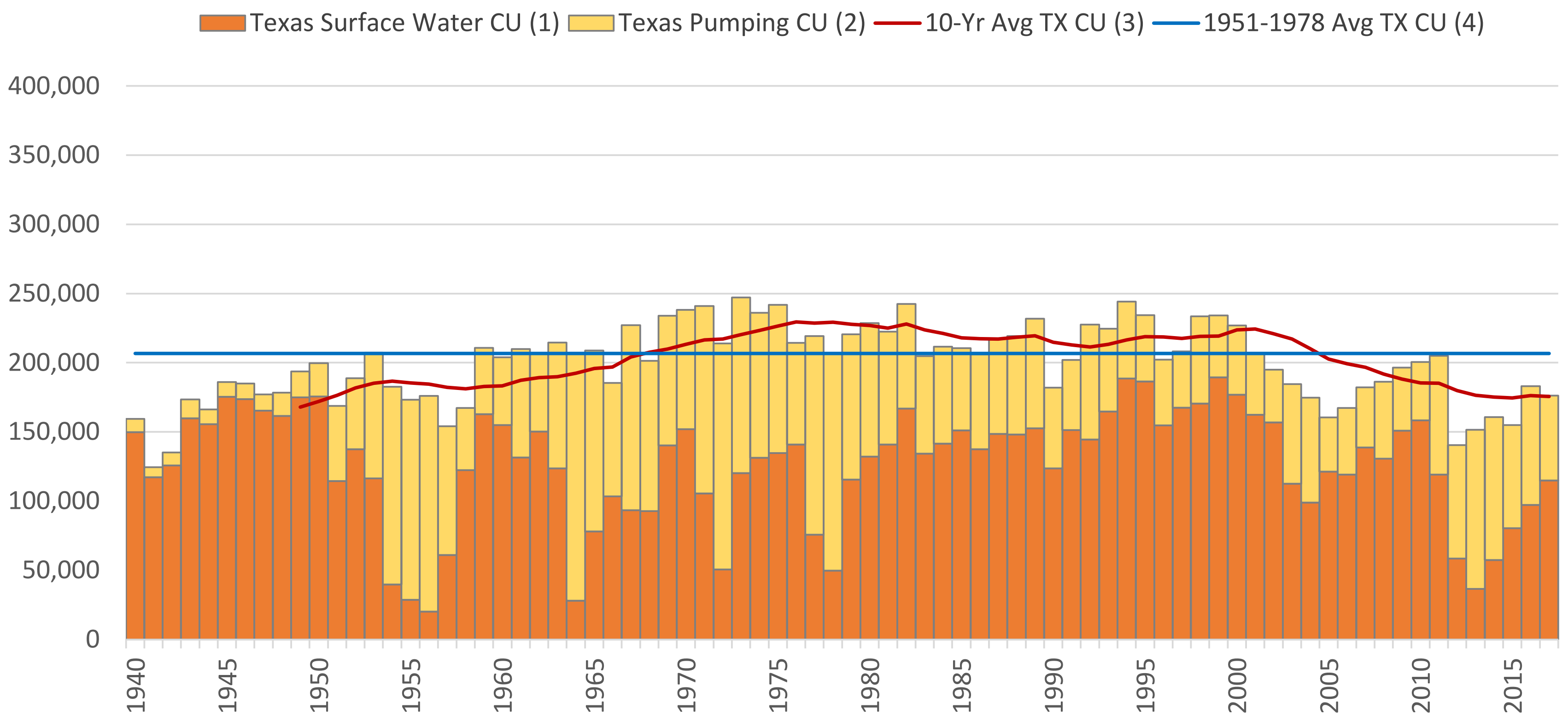
(4) 1951 - 1978 average of total irrigation and M&I consumptive use (1, 2).

Figure 19-10

Annual Irrigation and M&I Consumptive Use

Texas

1940 - 2017 (acre-feet)



Notes:

(1) Sum of EPCWID and HCCRD surface water irrigation consumptive use from SWE CFB Model plus EPW surface water diversions from SWE SWDataSet minus pro-rata return flows based on EPW total use minus total returns. EPW pumping and returns from NMR-M Model and Hueco Model.

(2) Sum of EPCWID and HCCRD irrigation pumping CU from SWE CFB Model plus Texas M&I pumping from NMR-M Model and Hueco Model minus return flows from NMR-M Model and Hueco Model inputs.

(3) 10-year running average of total irrigation and M&I consumptive use (1, 2).

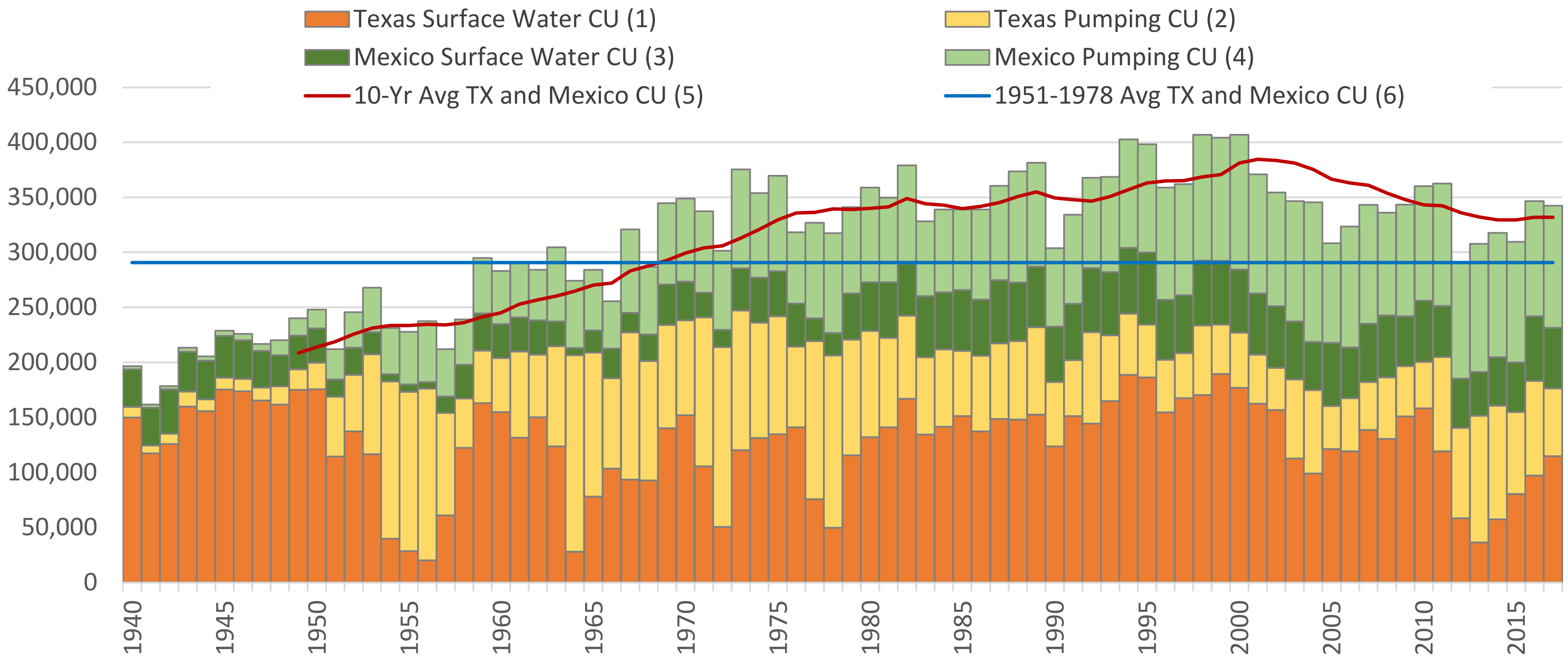
(4) 1951 - 1978 average of total irrigation and M&I consumptive use (1, 2).

Figure 19-11

Annual Irrigation and M&I Consumptive Use

Texas and Mexico

1940 - 2017 (acre-feet)



Notes:

(1) Sum of EPCWID and HCCRD surface water irrigation consumptive use from SWE CFB Model plus EPW surface water diversions from SWE SWDataSet minus pro-rata return flows based on EPW total use minus total returns. EPW pumping and returns from NMR-M Model and Hueco Model.

(2) Sum of EPCWID and HCCRD irrigation pumping CU from SWE CFB Model plus Texas M&I pumping from NMR-M Model and Hueco Model minus return flows from NMR-M Model and Hueco Model inputs.

(3) JID irrigation surface water consumptive use from SWE CFB Model.

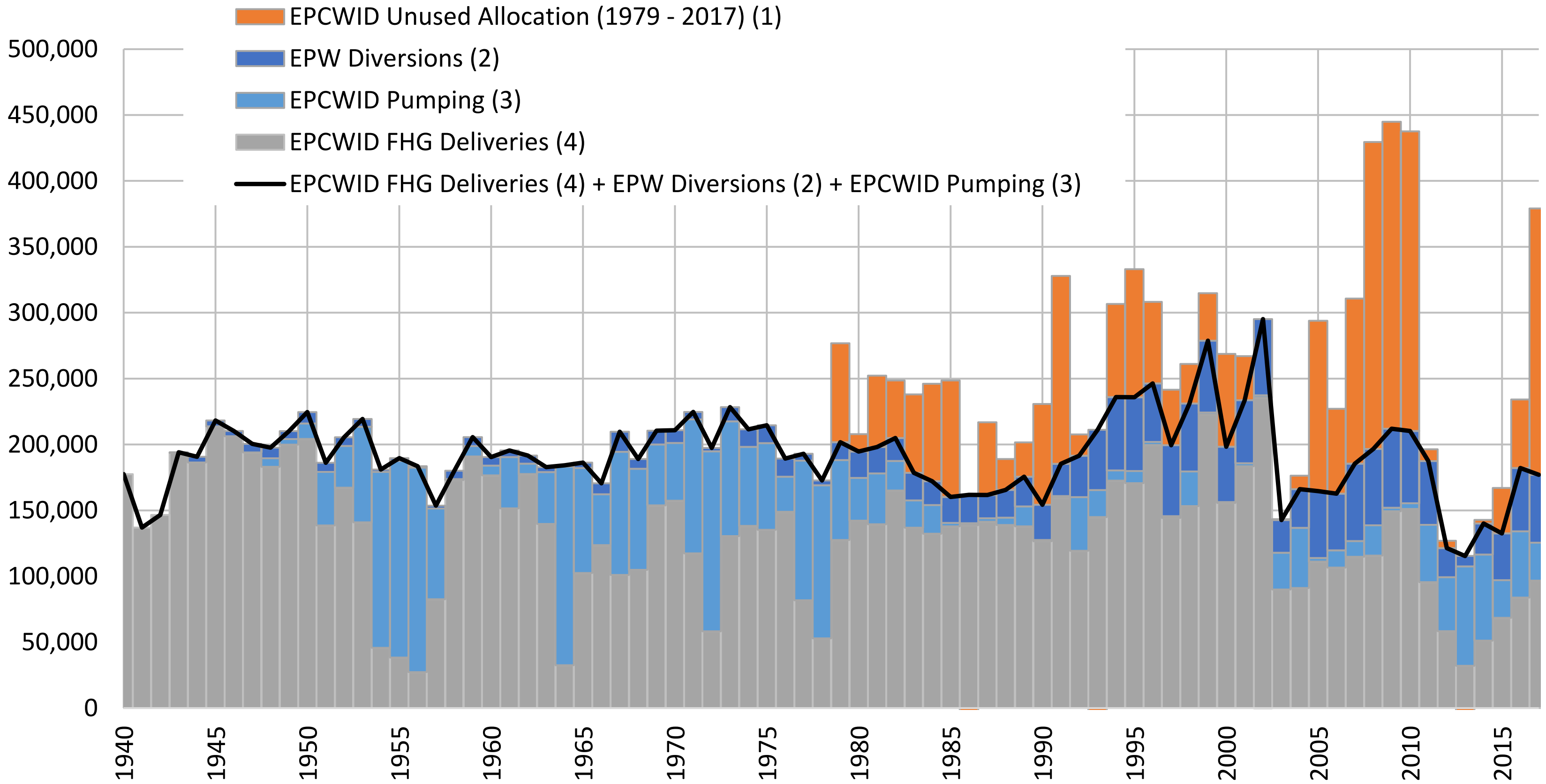
(4) Sum of JID irrigation pumping CU from SWE CFB Model and Ciudad Juarez M&I pumping (not including Conejos-Medanos M&I pumping) minus return flows from Hueco Model.

(5) 10-year running average of total Texas and Mexico consumptive use (1,2,3,4).

(6) 1951 - 1978 average of total Texas and Mexico consumptive use (1,2,3,4).

Figure 19-12

Annual EPCWID FHG Deliveries, Pumping, and Unused Allocation 1940 - 2017 (acre-feet)

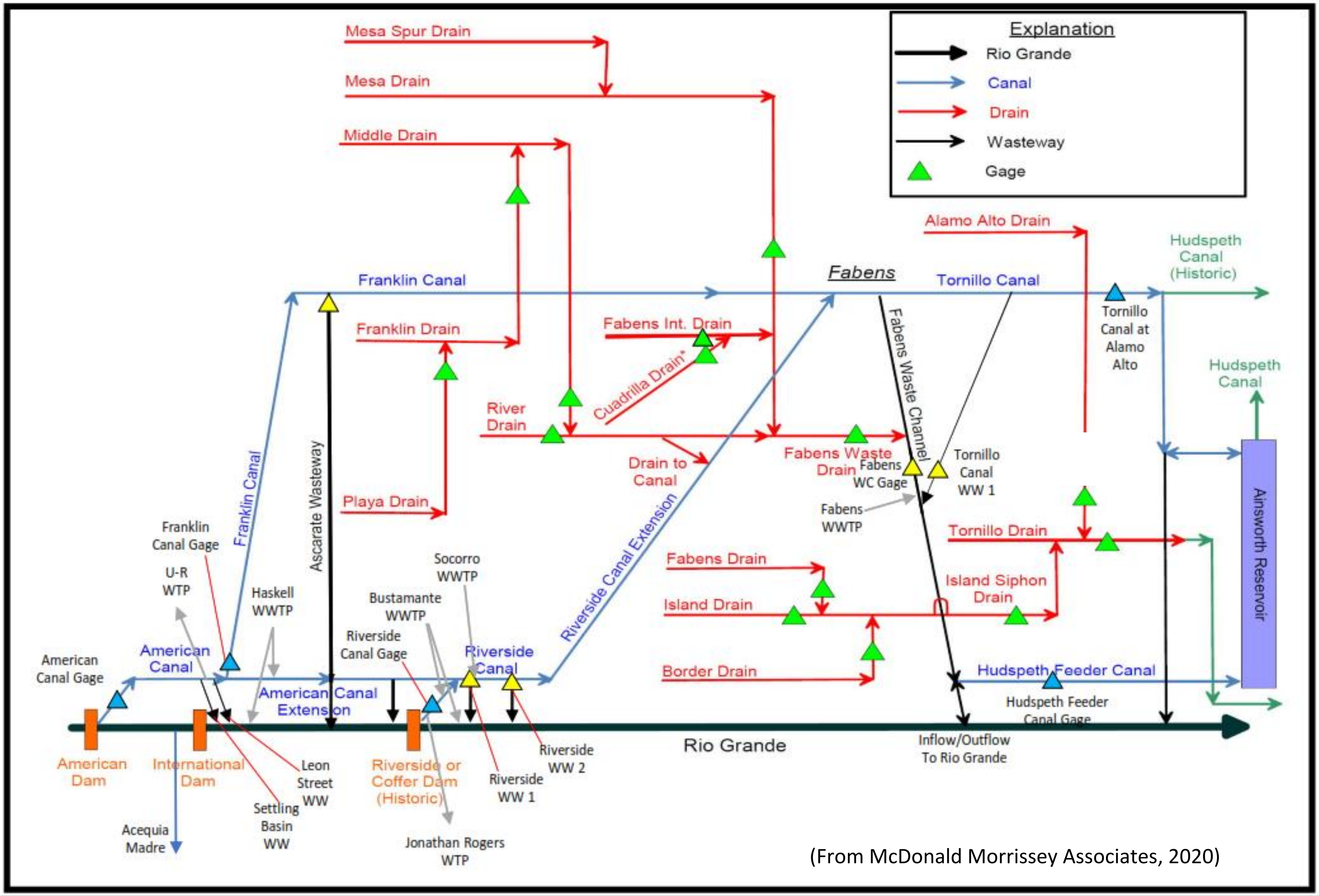


Notes:

(1) EPCWID unused allocation from SWE Accounting Dataset and computed as allocations minus diversion charge.
(2) EPW diversions from SWE SWDataSet.
(3) EPCWID pumping from SWE CFB Model.
(4) EPCWID FHG deliveries from SWE CFB Model.

Figure 19-13

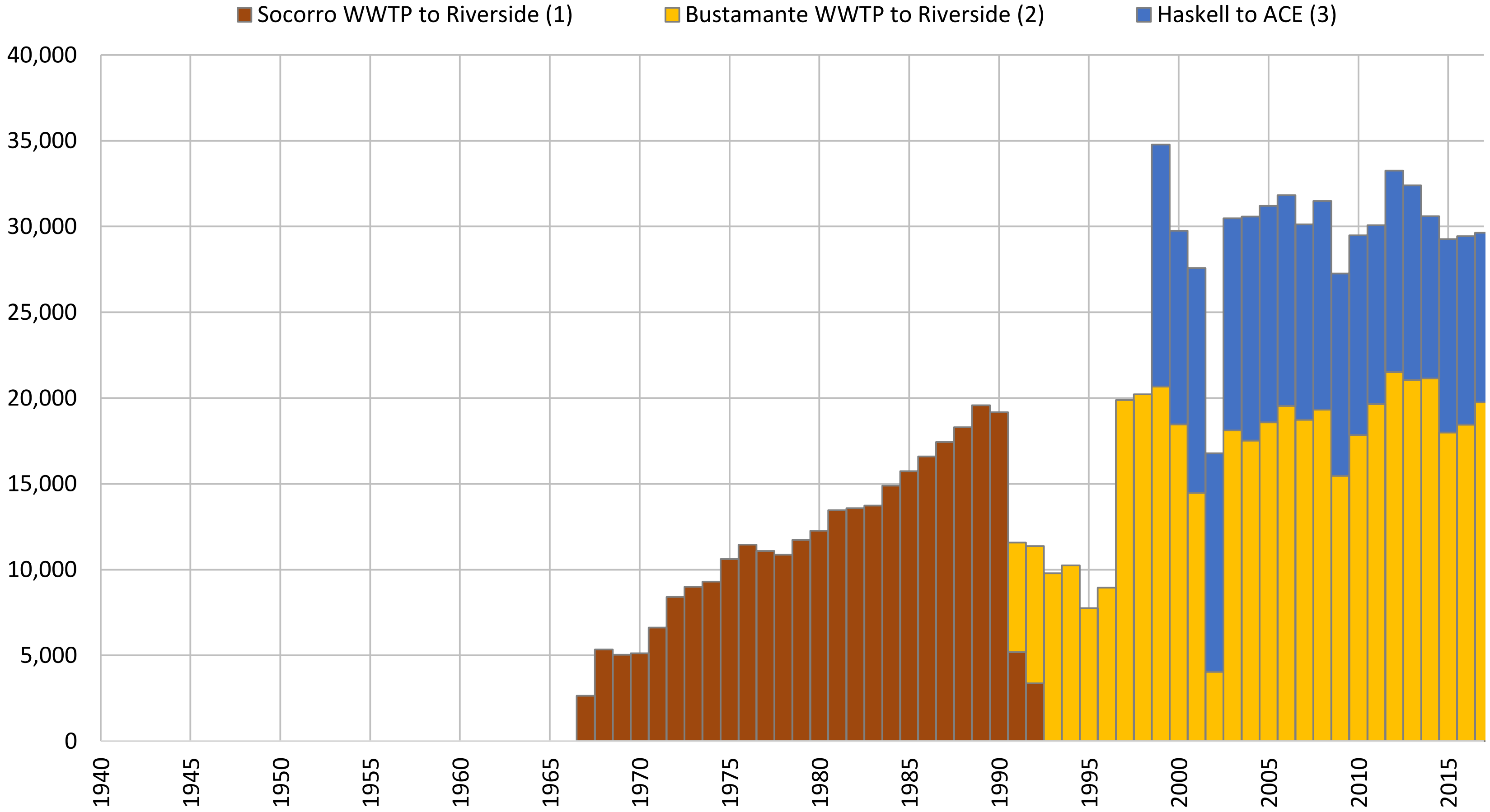
Schematic Diagram
EPCWID Distribution and Drainage System and Gages



(From McDonald Morrissey Associates, 2020)

Figure 19-14

WWTP Discharges to Canals (Irrigation Season)
EPCWID (El Paso Valley)
1967 - 2017 (acre-feet)



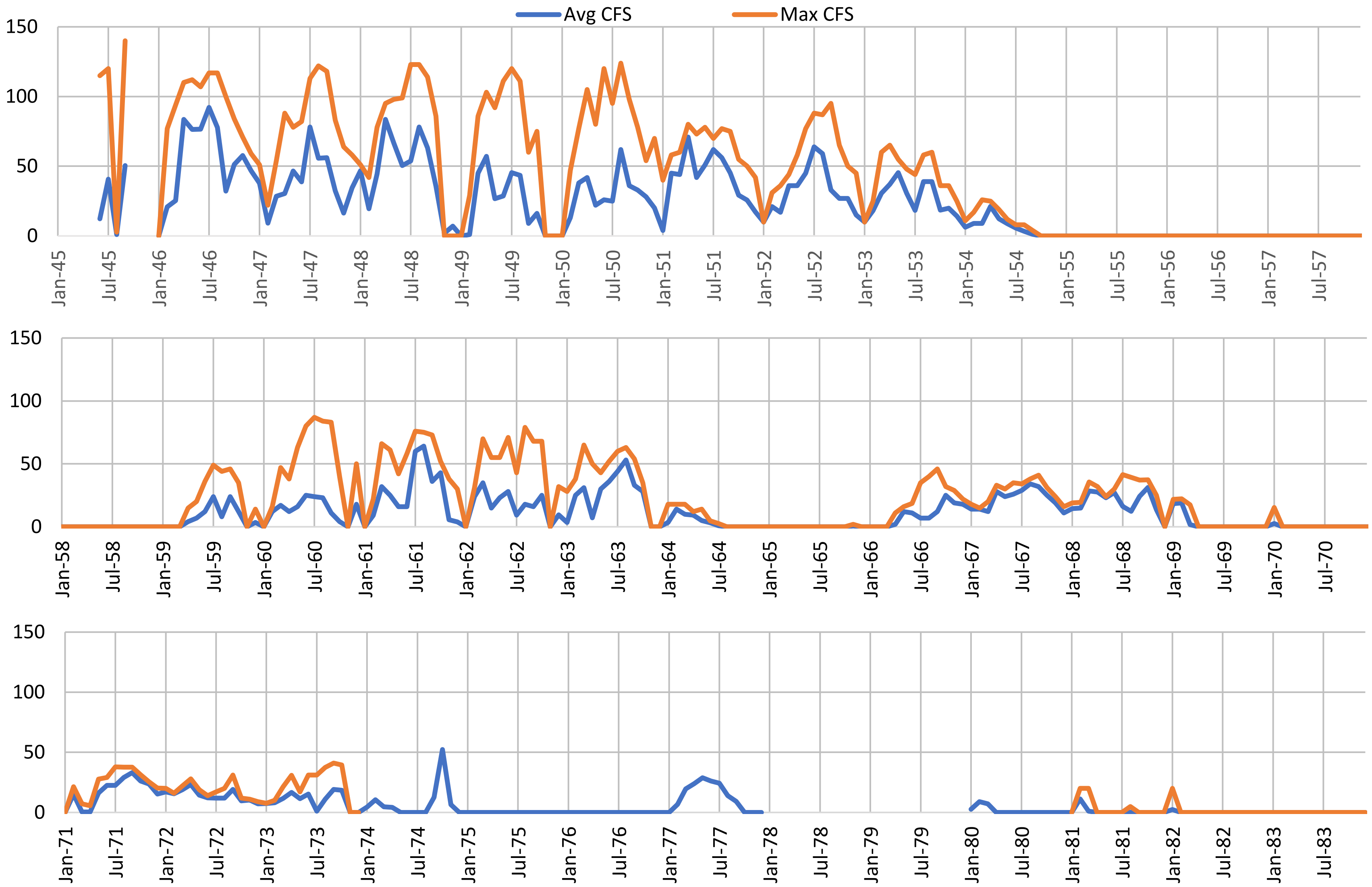
Notes:

(1) Monthly Socorro WWTP discharges estimated 1967 - 1988 from SWE SWDataSet (annual data only 1967 - 1984).
(2) Bustamante WWTP discharges to Riverside Canal estimated 1991 - 1994 from SWE SWDataSet.
(3) Haskell WWTP discharges to the American Canal Extension ("ACE") are included in Riverside Canal gaged flows from SWE SWDataSet.

Figure 19-15

Monthly Drain Flows Pumped at Fabens to Canal

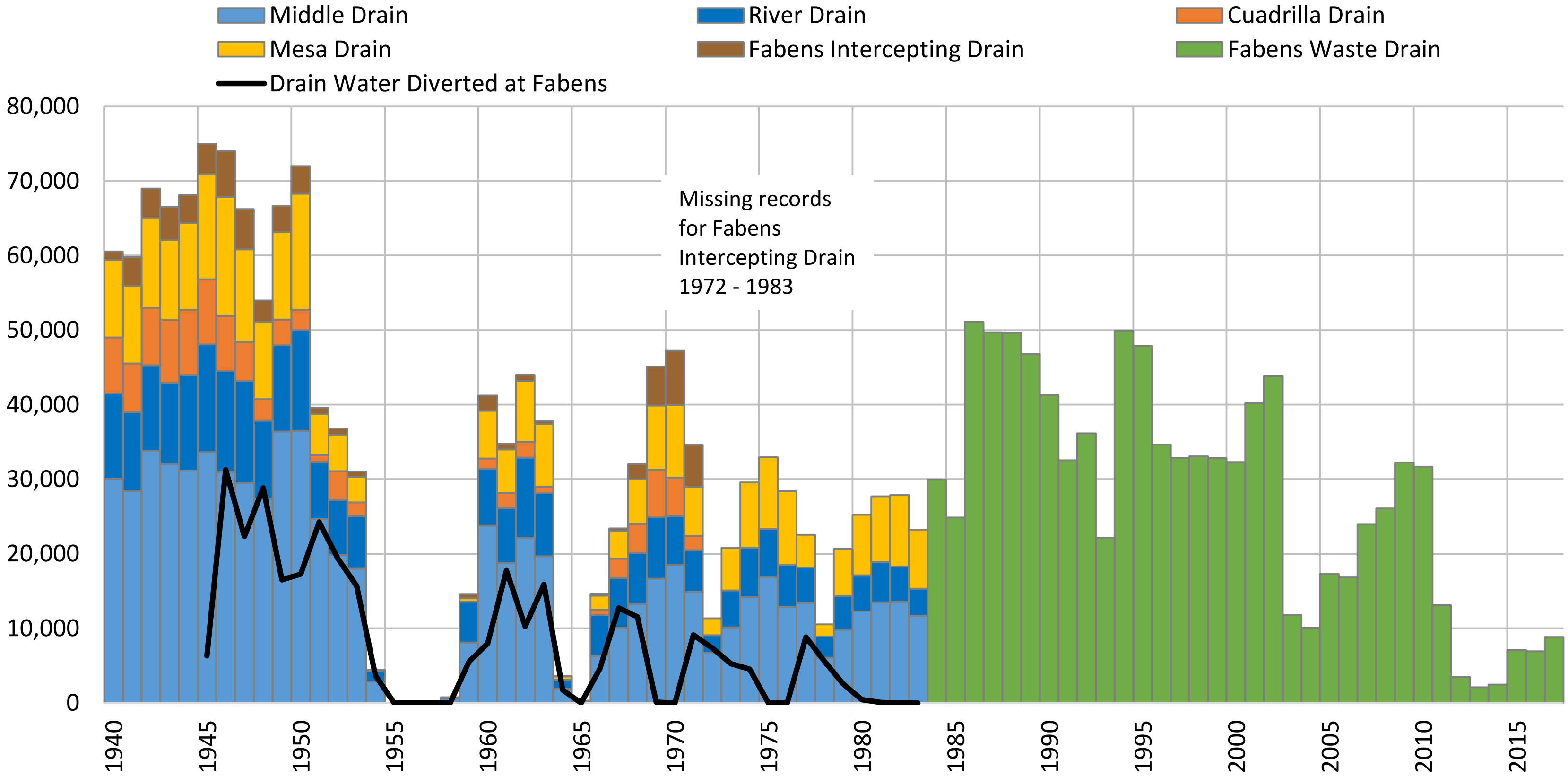
1945 - 1983 (CFS)



Note:
(1) Monthly average and maximum daily values from USBR daily records ("USBR-Scan-Drain to Canal").

Figure 19-16

Irrigation Season Drain Flows at Fabens
EPCWID (El Paso Valley)
1940 - 2017 (acre-feet)



Notes:

(1) Water pumped from the River Drain and Middle Drain for EPCWID irrigation use.

(2) The Mesa Drain, Cuadrilla Drain, and Fabens Intercepting Drain reportedly were reportedly not used for EPCWID irrigation use.
These drain flows accrue to the Fabens Waste Channel and become part of the HCCRD supply along with unused River and Middle Drain flows.

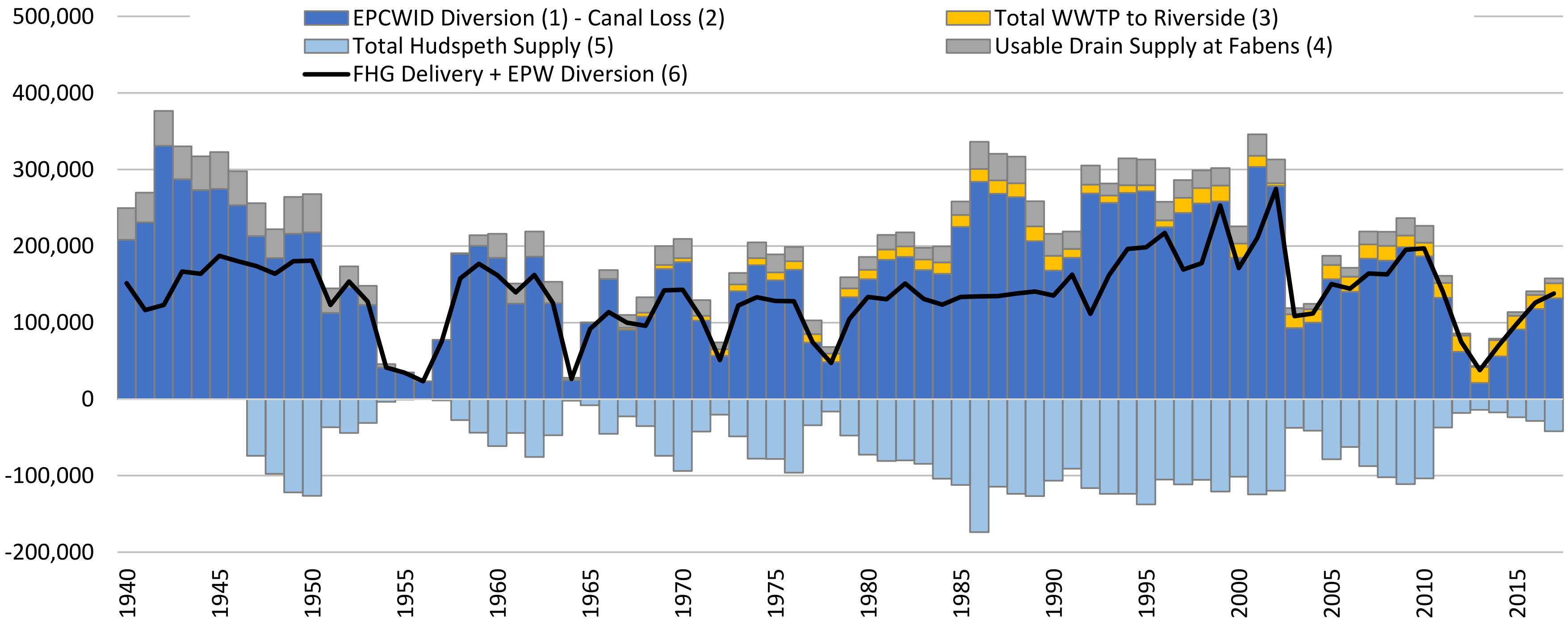
(3) The Fabens Waste Drain collects flow from the River Drain, Middle Drain, Mesa Drain, Cuadrilla Drain, and Fabens Intercepting Drain for delivery into the Fabens Waste Channel.

(4) A schematic diagram illustrating EPCWID drain system is provided in **Figure 19-13**.

(5) Fabens Waste Drain flows were estimated in 1992 and some months in 1993 - 1996, 2003, and 2012.

Figure 19-17

Available FHG Supply vs. FHG Delivery (Irrigation Season)
EPCWID (El Paso Valley)
1940 - 2017 (acre-feet)



Notes:

All data from SWE SWDataSet unless otherwise noted.

(1) EPCWID (El Paso Valley) Diversions computed as the sum of the Franklin Canal plus Riverside Canal plus EPW diversions minus Ascarate Wasteway.

(2) Canal Loss from SWE CFB Model and are based on records and estimates for years with no records.

(3) Total WWTP to Riverside includes Socorro WWTP and Bustamante WWTP. Flows are estimated for Socorro WWTP from 1985 - 1988 and for Bustamante WWTP from 1991 - 1994.

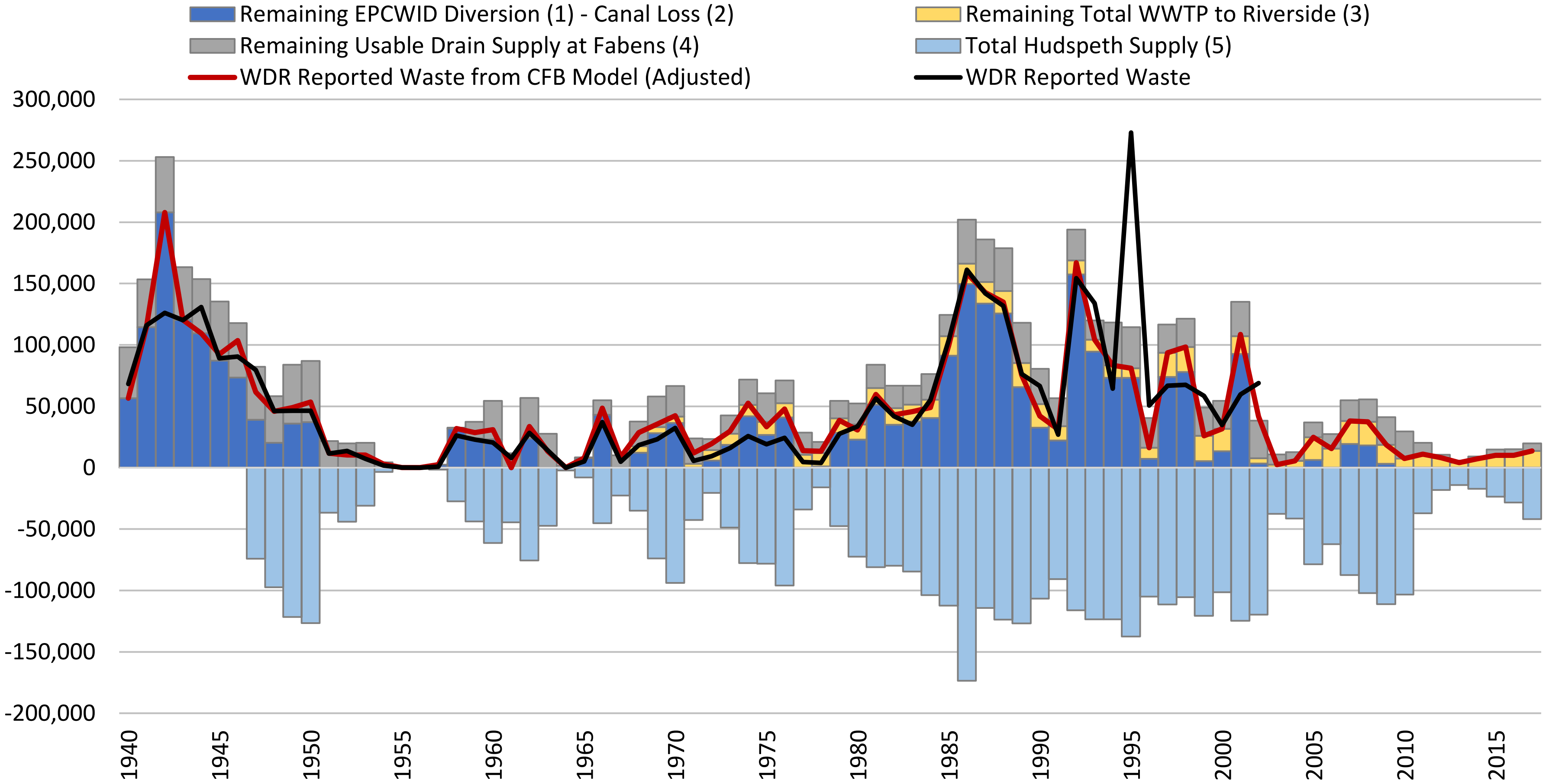
(4) Usable Drain Supply at Fabens computed as the sum of the River Drain plus Middle Drain (1940 - 1983) and 70% of Fabens Waste Drain (1984 - 2017). Fabens Waste Drain flows were estimated in 1992 and some months in 1993 - 1996, 2003, and 2012.

(5) Total Hudspeth Supply is the sum of Tornillo Drain plus Tornillo Canal at Alamo Alto plus Hudspeth Feeder Canal. Missing records for Tornillo. Canal at Alamo Alto in 1995 - 1996 and Hudspeth Feeder Canal in 2011 - 2012 were estimated. Missing records for Tornillo Drain in 2011 - 2012 were not estimated. Total Hudspeth Supply shown as negative for presentation purposes.

(6) FHG Delivery from SWE CFB Model based on records and estimates for years with no records plus EPW Diversions.

Figure 19-18

Waste Comparison (Irrigation Season)
EPCWID (El Paso Valley)
1940 - 2017 (acre-feet)



Notes:

(1,2,3) The positive bars represent the portion of the available EPCWID supply in excess of the historical EPCWID FHG deliveries (see Figure 19-17).

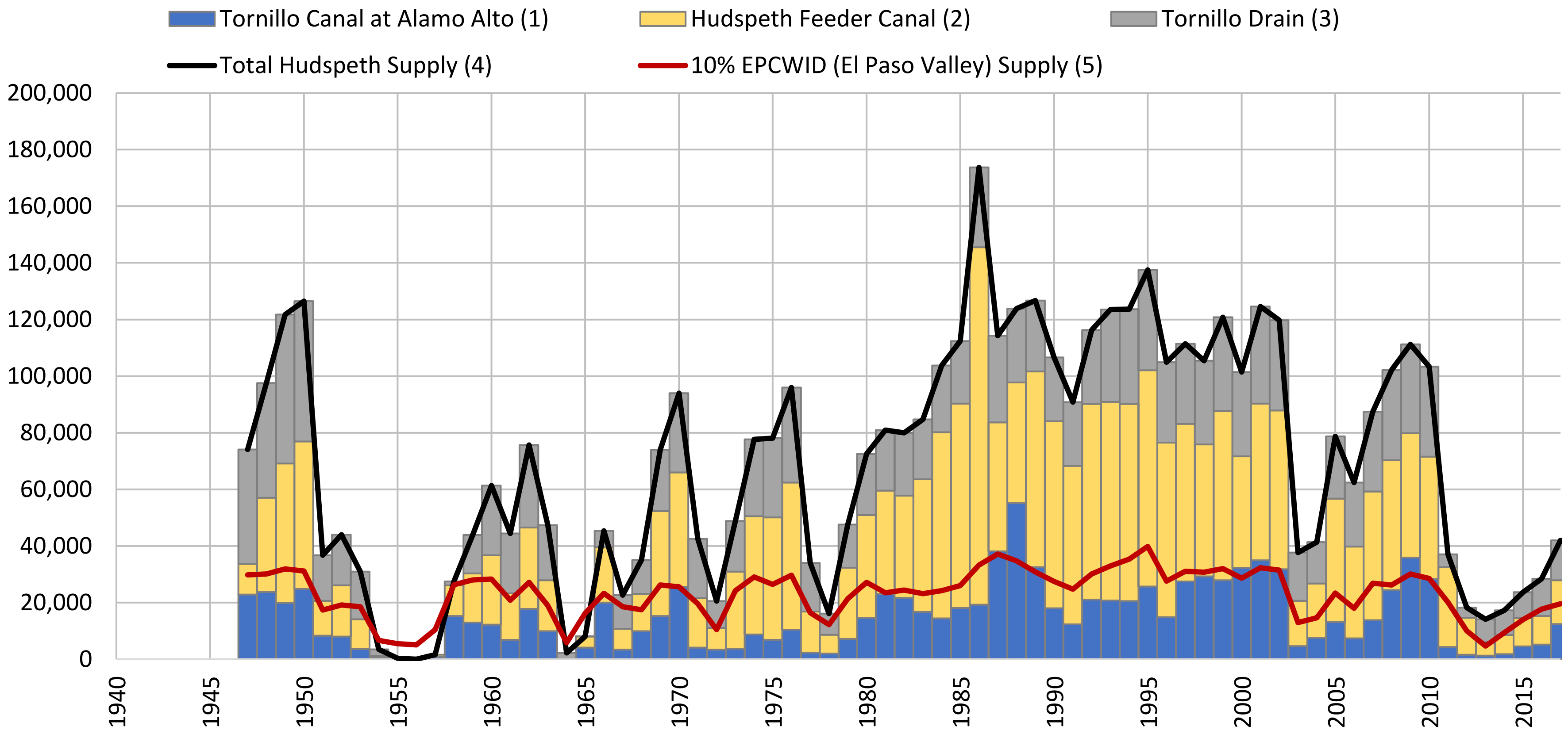
(4) Total Hudspeth Supply is the sum of Tornillo Drain plus Tornillo Canal at Alamo Alto plus Hudspeth Feeder Canal (data from 1947 - 2017 only).

(5) Adjusted WDR Reported Waste is the historical reported waste from the WDRs with mass balance adjustments and estimates of missing data from SWE CFB Models.

(6) WDR Reported Waste (Unadjusted) is the historical reported waste from the SWE Accounting DataSet.

Figure 19-19

Total Water Supply (Irrigation Season)
HCCRD
1947 - 2017 (acre-feet)



Notes:

Prior to 1947, the Hudspeth Feeder Canal did not exist and there was no Tornillo Canal at Alamo Alto gage.

(1) Tornillo Canal at Alamo Alto flows include estimates for certain months in 1995 and 1996; data and estimates from SWE SWDataSet.

(2) Hudspeth Feeder Canal flows include estimates for certain months in 2011 and 2012; data and estimates from SWE SWDataSet.

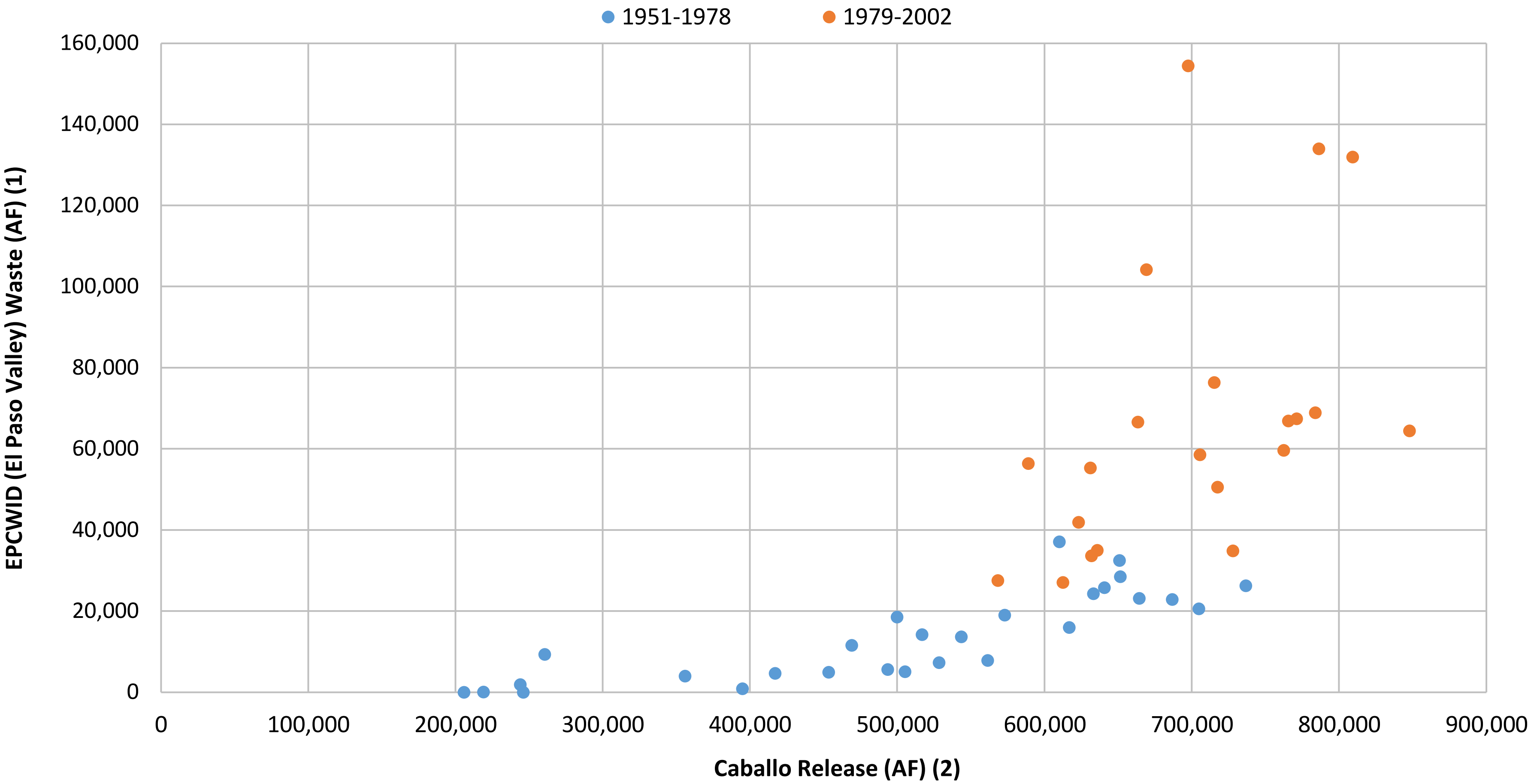
(3) Tornillo Drain flows are incomplete for 2011 and 2012; data from SWE SWDataSet and estimates from the SWE CFB Model.

(4) Total Hudspeth Supply is the sum of Tornillo Canal at Alamo Alto (1) plus Hudspeth Feeder Canal (2) plus Tornillo Drain (3) flows.

(5) EPCWID (El Paso Valley) Supply computed as the sum of the Franklin Canal plus Riverside Canal flows plus EPW surface water diversions minus Ascarate Wasteway flows; flows from SWE SWDataSet.

Figure 19-20

Waste vs. Caballo Release (Irrigation Season)
EPCWID (El Paso Valley)
1951 - 2002 (acre-feet)



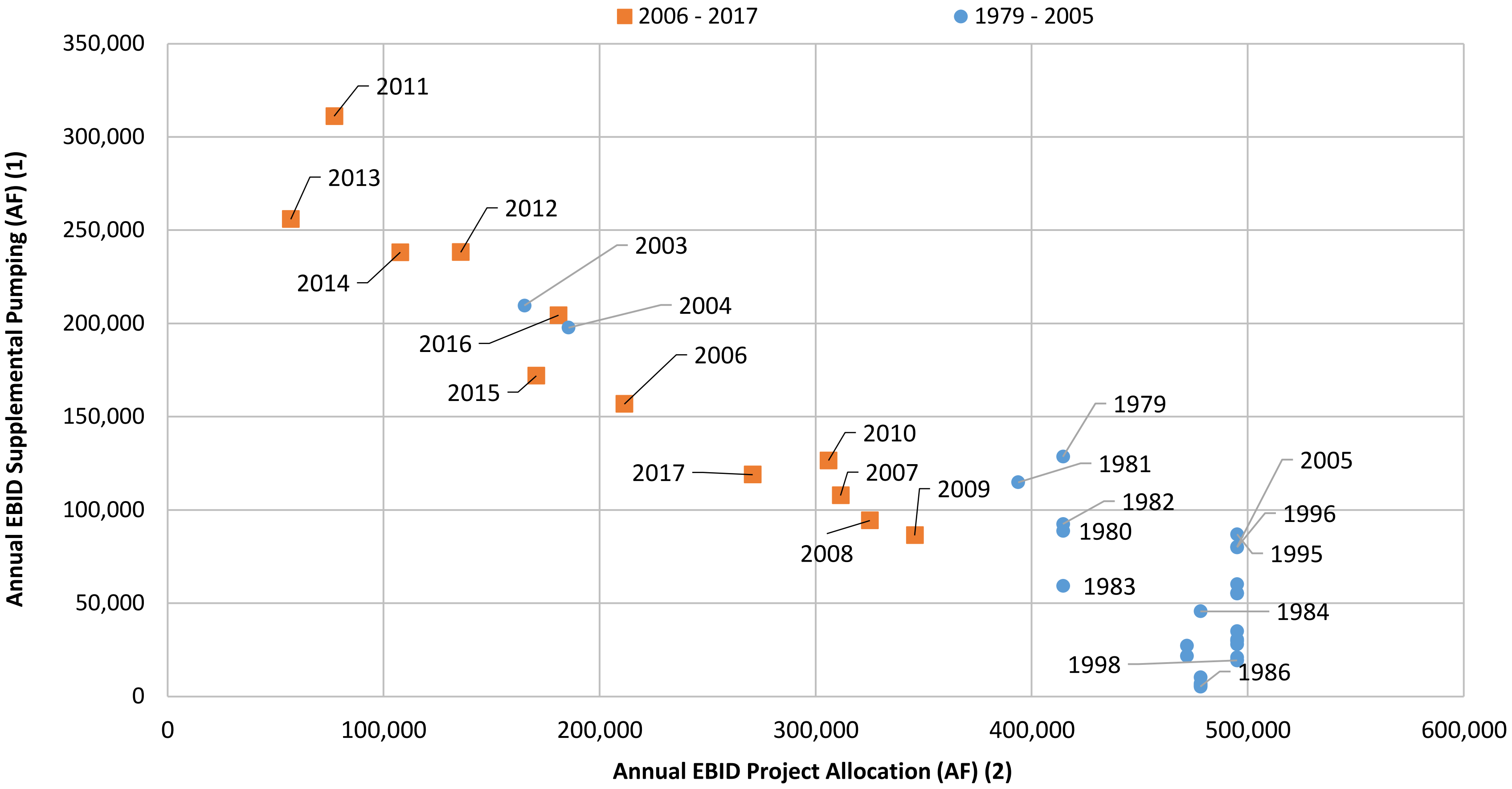
<u>Notes:</u>

(1) EPCWID (El Paso Valley) Waste from Water Distribution Reports in the SWE Accounting DataSet.

(2) Caballo Releases are the Rio Grande below Caballo flows from SWE SWDataSet.

Figure 19-21

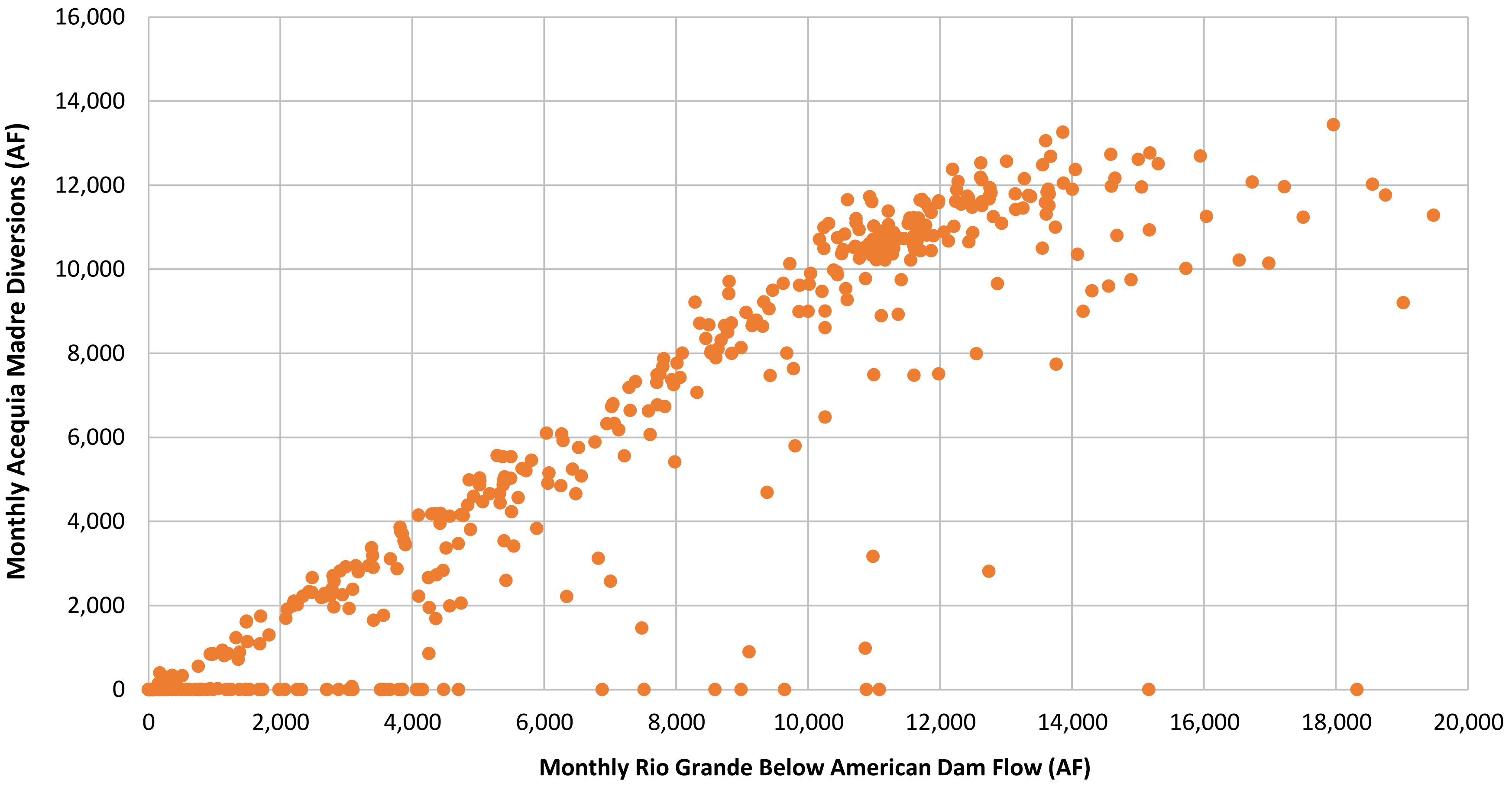
Annual EBID Supplemental Pumping vs. Annual Allocation
1979 - 2017 (acre-feet)



Notes:
(1) Supplemental irrigation pumping amounts from SWE CFB Model.
(2) Annual allocations and diversion charges from SWE Accounting DataSet.

Figure 19-22

Monthly Acequia Madre Diversions vs. Monthly Rio Grande Below American Dam Flows
1940 - 2017 (acre-feet)

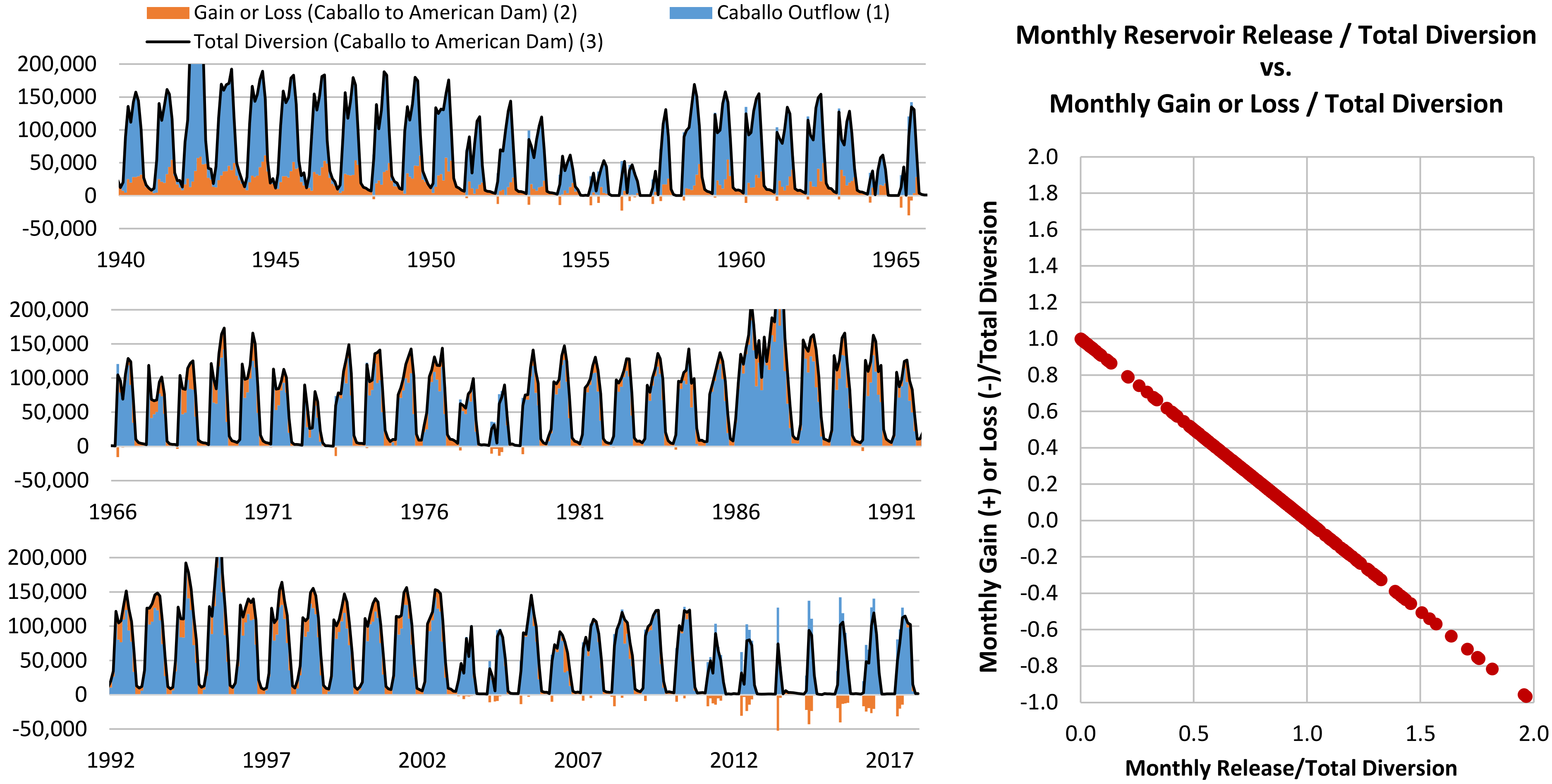


<u>Note:</u>
(1) No monthly data for 2007 (only annual data available).
(2) Monthly flow data from SWE SWDataSet.

7/15/2020

Figure 19-23

Monthly Reservoir Releases, Diversions, and Gains or Losses
Below Caballo Dam to Below American Dam
1940 - 2017 (acre-feet)



Notes:

Monthly flow data from SWE SWDataSet.

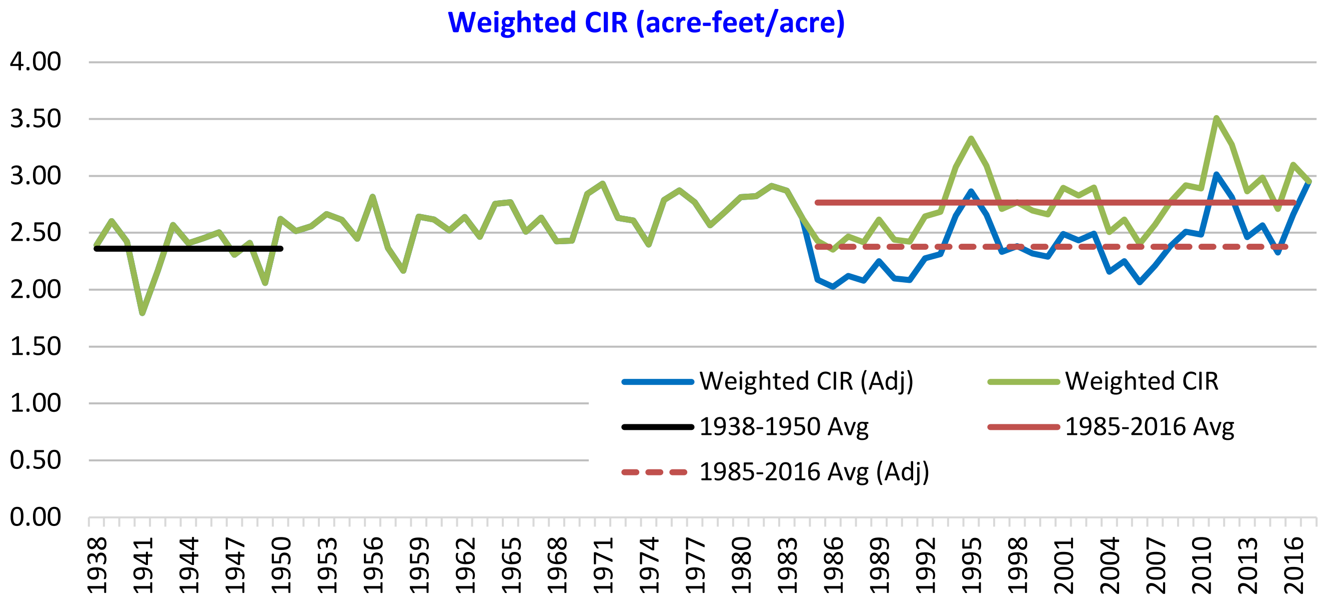
(1) Caballo releases from Rio Grande below Caballo Dam gage.

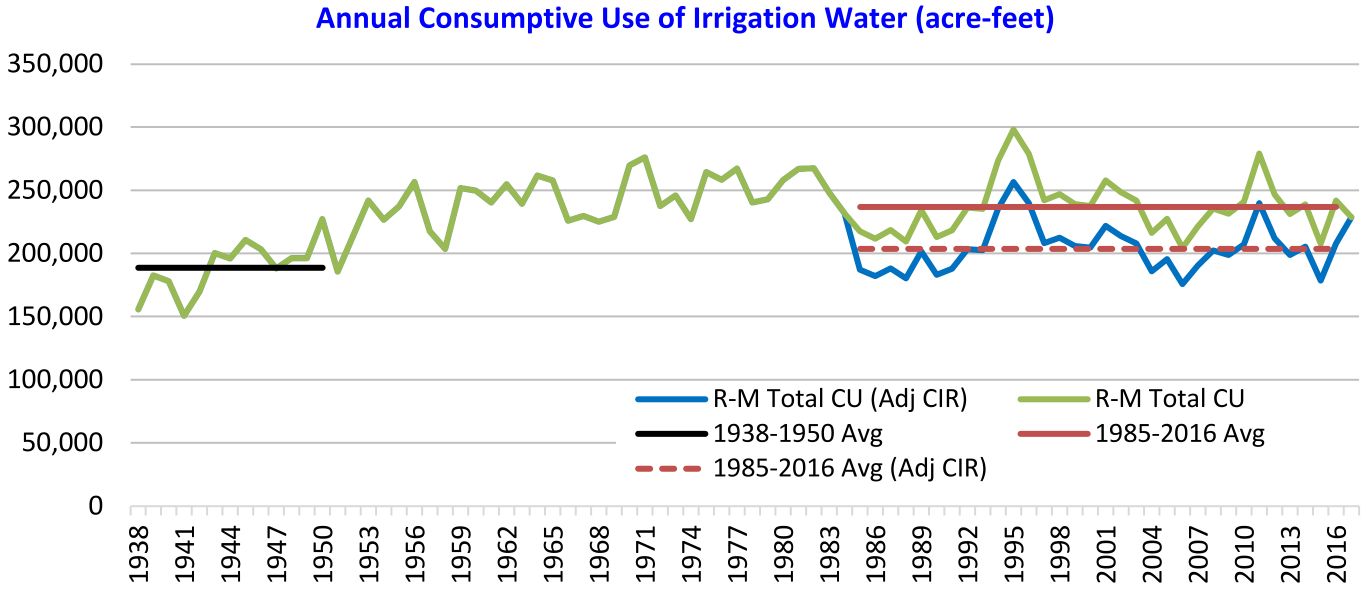
(2) Monthly gain or loss computed as total diversions plus Rio Grande below American Dam flow minus Caballo Reservoir releases.

(3) Total diversions at Arrey Dam (Arrey Canal and Percha Lateral), Leasburg Dam (Leasburg Canal, California Extension, and Pumped from River), Mesilla Dam (Eastside Canal, Westside Canal, and Del Rio Lateral), and American Canal PLUS Rio Grande below American Dam flow.

7/15/2020

Figure 20-1
Total Consumptive Use of Irrigation Water
Rincon and Mesilla Valleys (EBID and EPCWID)
SWE Canal and Farm Budget Model





	CIR (acre-feet/acre)					Consumptive Use (acre-feet)		
	EBID Rincon		EBID Mesilla		EPCWID Mesilla	EBID	EPCWID	R-M
Period	Suppl	Primary	Suppl	Primary	Total	Total	Total	Total
(1) 1938-1950	2.35	2.69	2.36	2.71	2.35	173,395	15,436	188,830
(2) 1985-2016	2.74	2.91	2.78	2.95	2.61	223,057	13,858	236,916
(3) 1985-2016 (adj)	2.35	2.69	2.36	2.71	2.35	191,301	12,461	203,763
Ratio (1)/(2)	0.86	0.92	0.85	0.92	0.90			

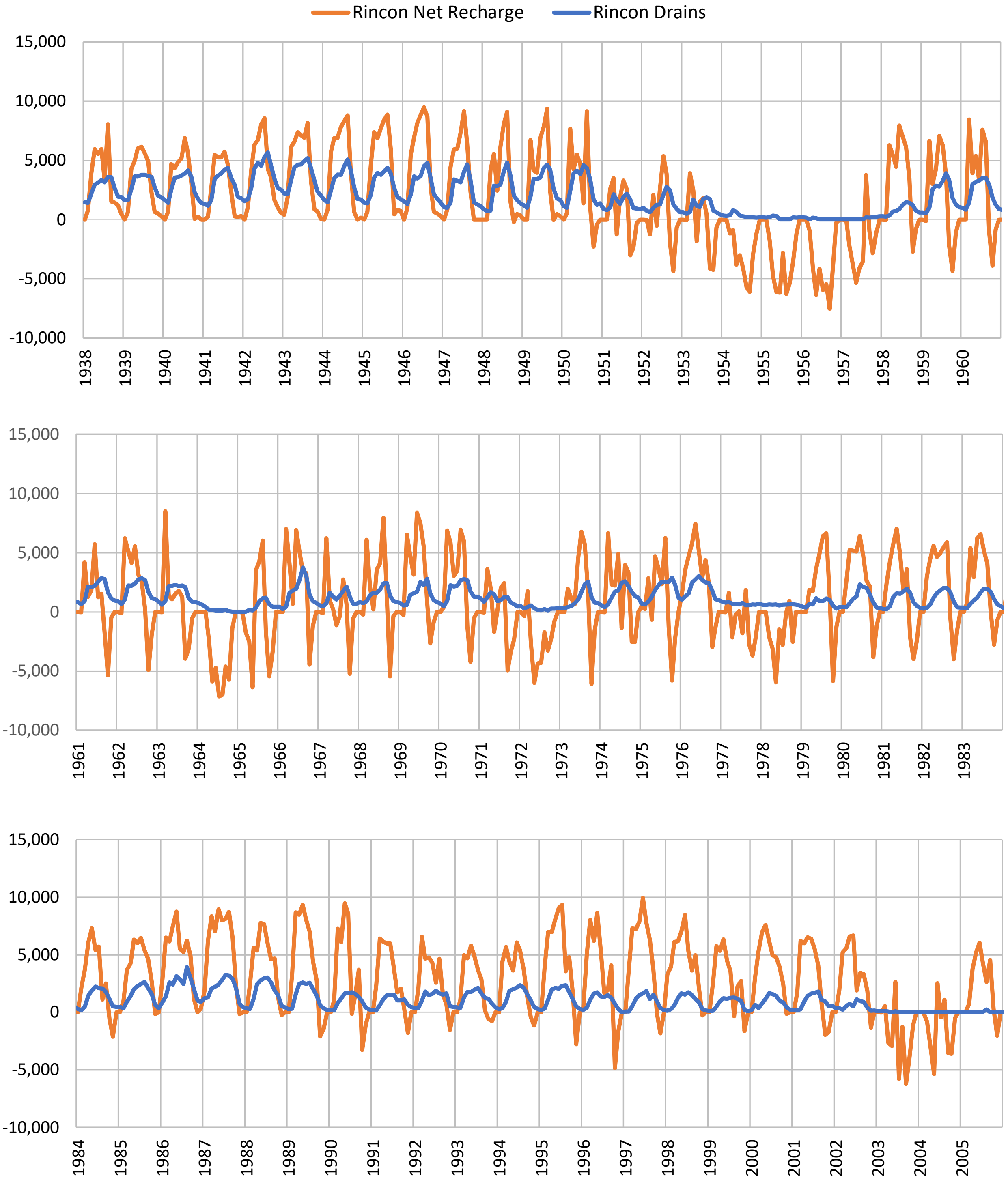
Notes:

(1,2) CIR and consumptive use of irrigation water from SWE CFB Model.

(3) CU is adjusted for 1985-2016 by multiplying monthly CIR by the ratio of CIR: (1) 1938-1950 average/(2) 1985 - 2016 average.

Figure 23-1

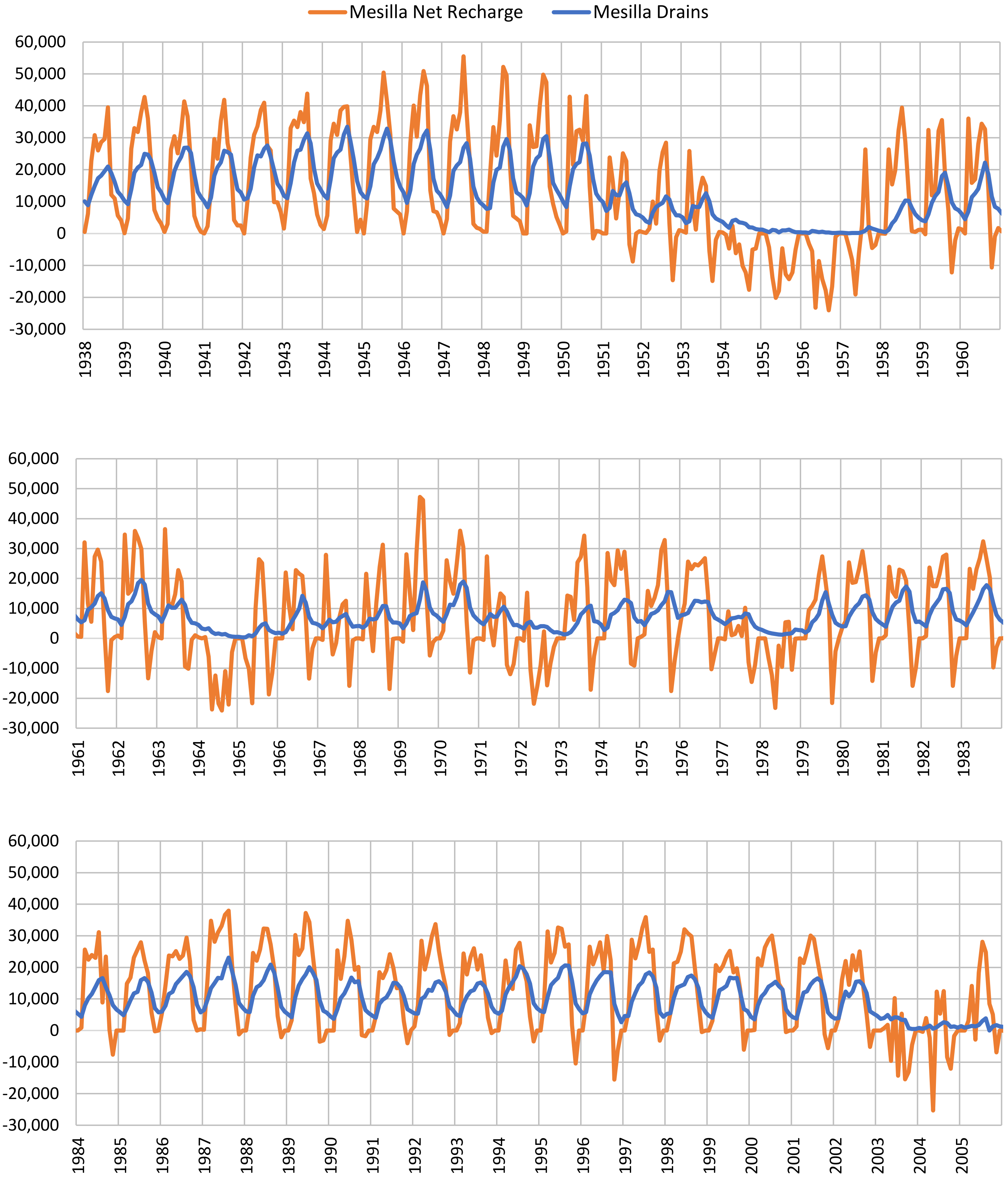
Monthly Net Recharge vs. Drain Flow
Rincon Valley
1938 - 2005 (acre-feet)



Notes: Net recharge computed as canal seepage + on farm deep percolation minus pumping from the SWE Canal and Farm Budget Model of the Rincon Valley.
Drain flows are the sum of the reported flows of the Rincon Valley drains.
Angostrata drain data is unavailable from 1983-2005.
Rincon drain data is unavailable from 2006-2017.

Figure 23-2

Monthly Net Recharge vs. Drain Flow
Mesilla Valley
1938 - 2005 (acre-feet)



Notes: Net recharge computed as canal seepage + on farm deep percolation minus pumping from the SWE Canal and Farm Budget Model of the Leasburg-Mesilla Valley (NM + TX). Drain flows are the sum of the reported flows of the Mesilla Valley drains. Drain data availability varies by drain.

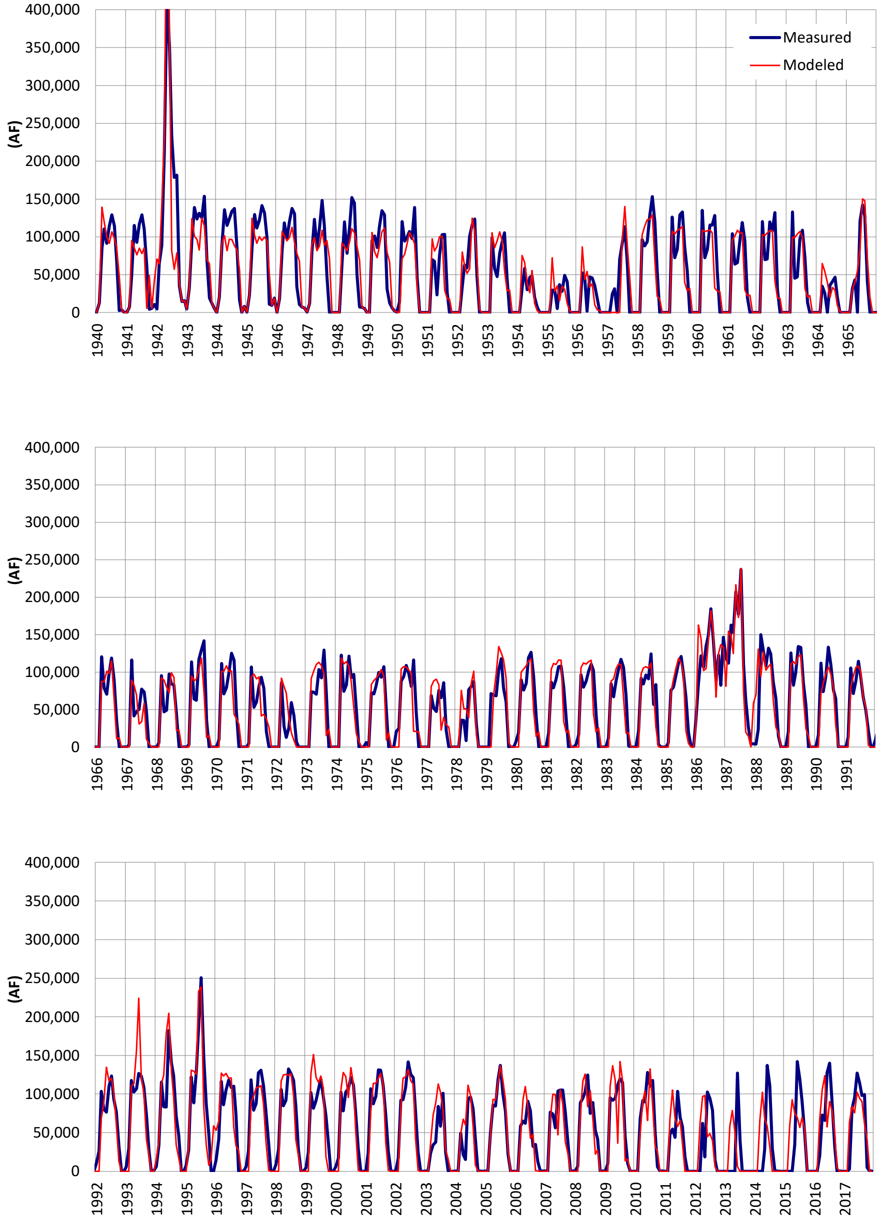
Figure 28-1

Integrated LRG Model Historical Calibration Results

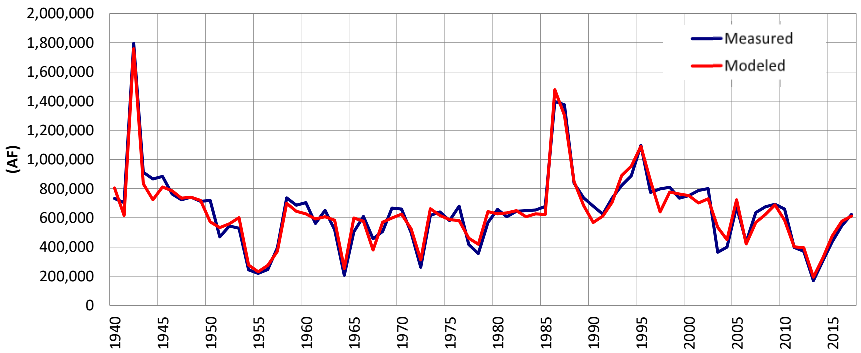
Caballo Release

1940 - 2017

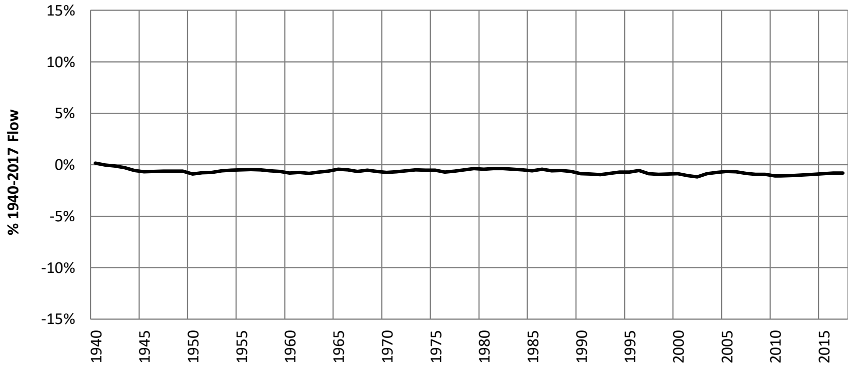
Monthly Flows (AF)



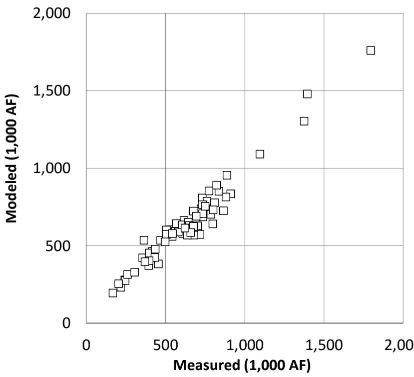
Annual Flows (AF)



Cumulative Annual Residual (% 1940 - 2017 Total)
Modeled minus Measured



Annual Scatter Plot



Flow Duration Curve (Annual)

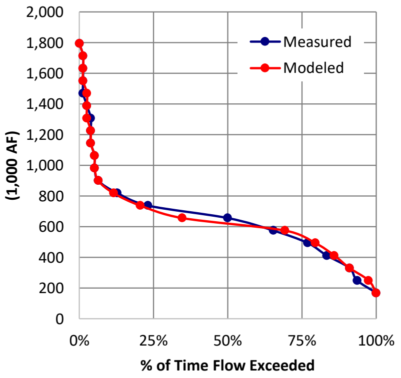


Figure 28-2

Integrated LRG Model Historical Calibration Results

Rio Grande at El Paso

1940 - 2017

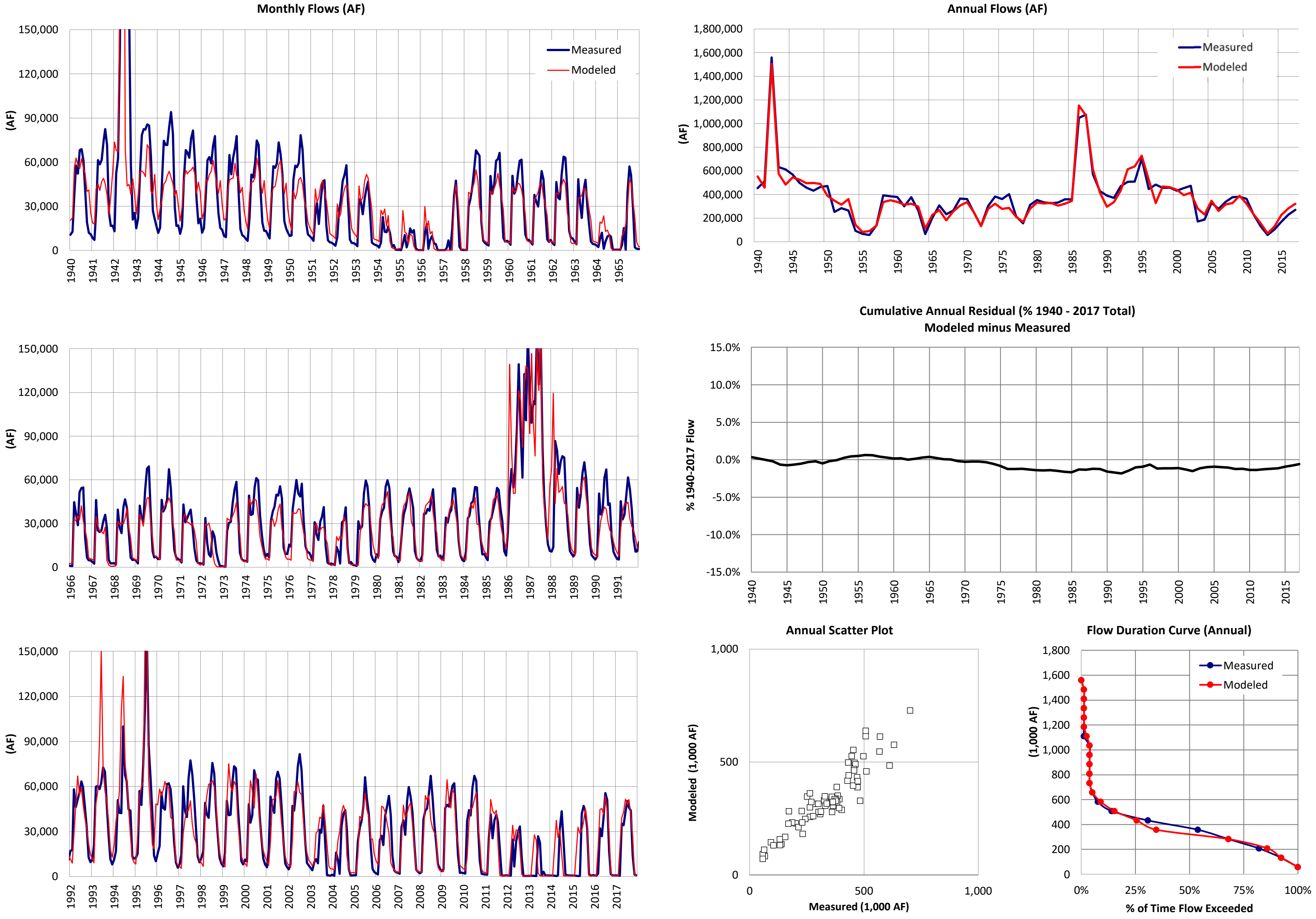


Figure 28-3

Integrated LRG Model Historical Calibration Results

Rio Grande at Fort Quitman

1940 - 2017

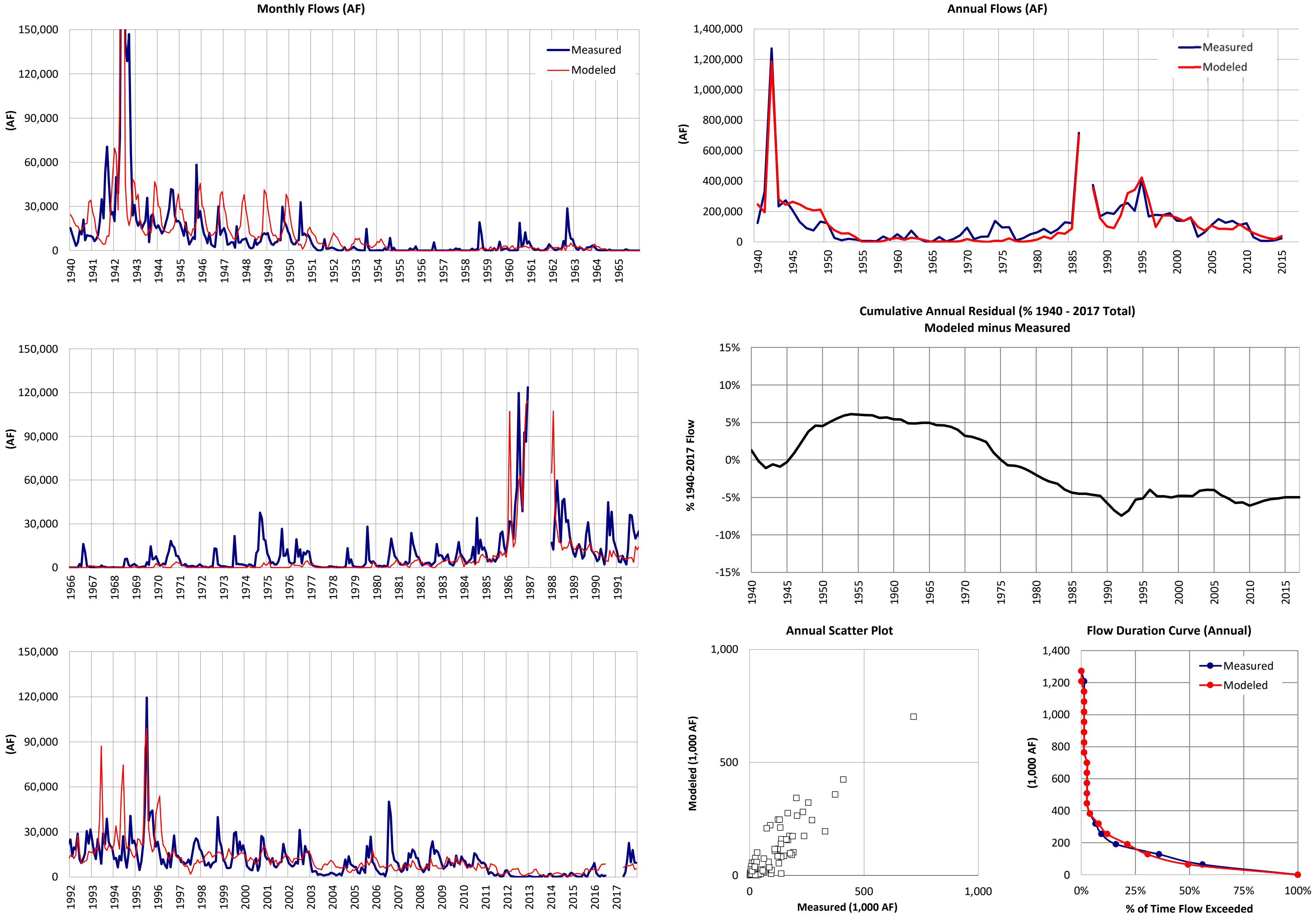
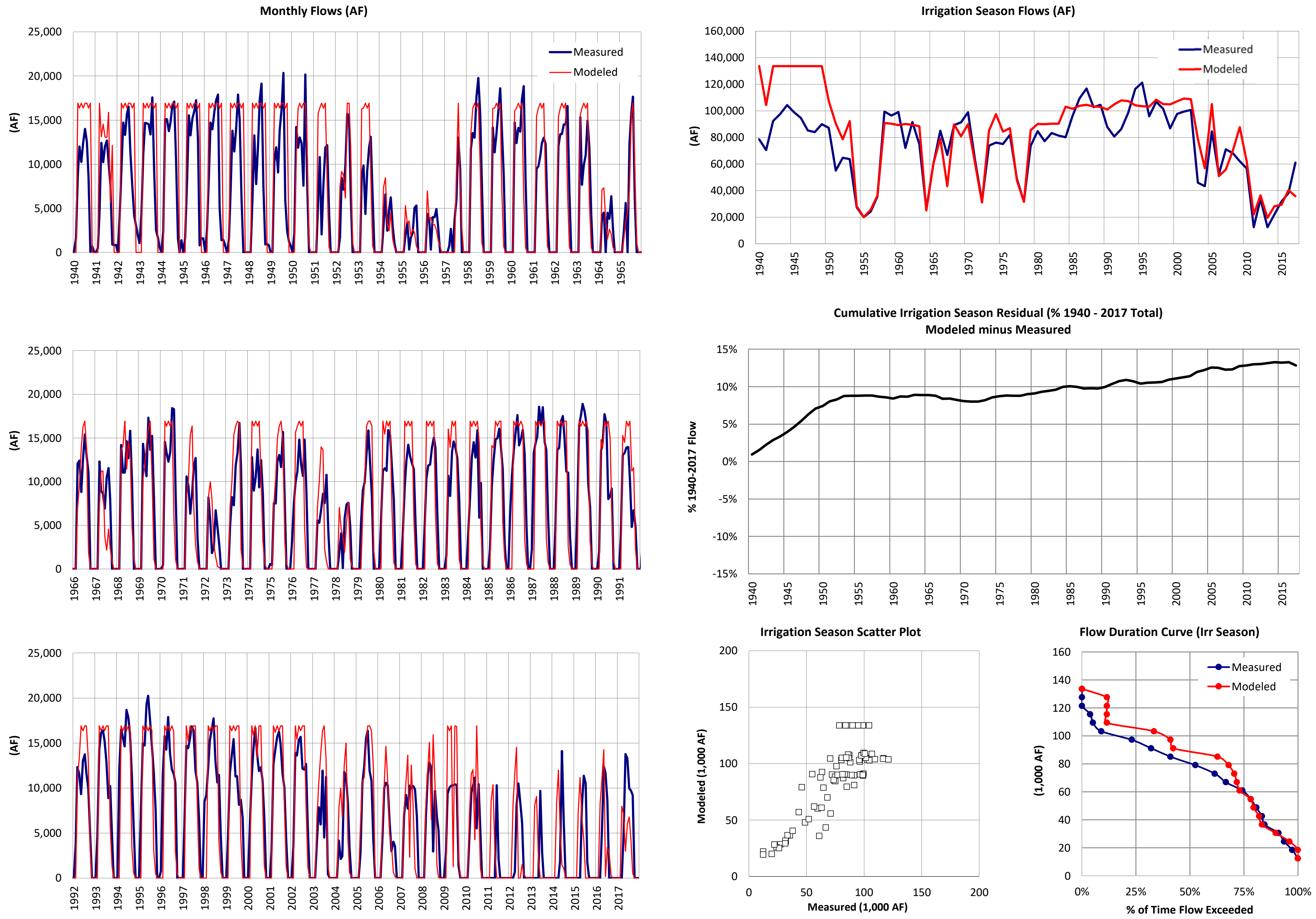


Figure 28-4

Integrated LRG Model Historical Calibration Results

Rincon Diversion

1940 - 2017



Monthly Flows (AF)

Irrigation Season Flows (AF)

Cumulative Irrigation Season Residual (% 1940 - 2017 Total)
Modeled minus Measured

Irrigation Season Scatter Plot

Flow Duration Curve (Irr Season)

Figure 28-5

Integrated LRG Model Historical Calibration Results

Leasburg Diversion

1940 - 2017

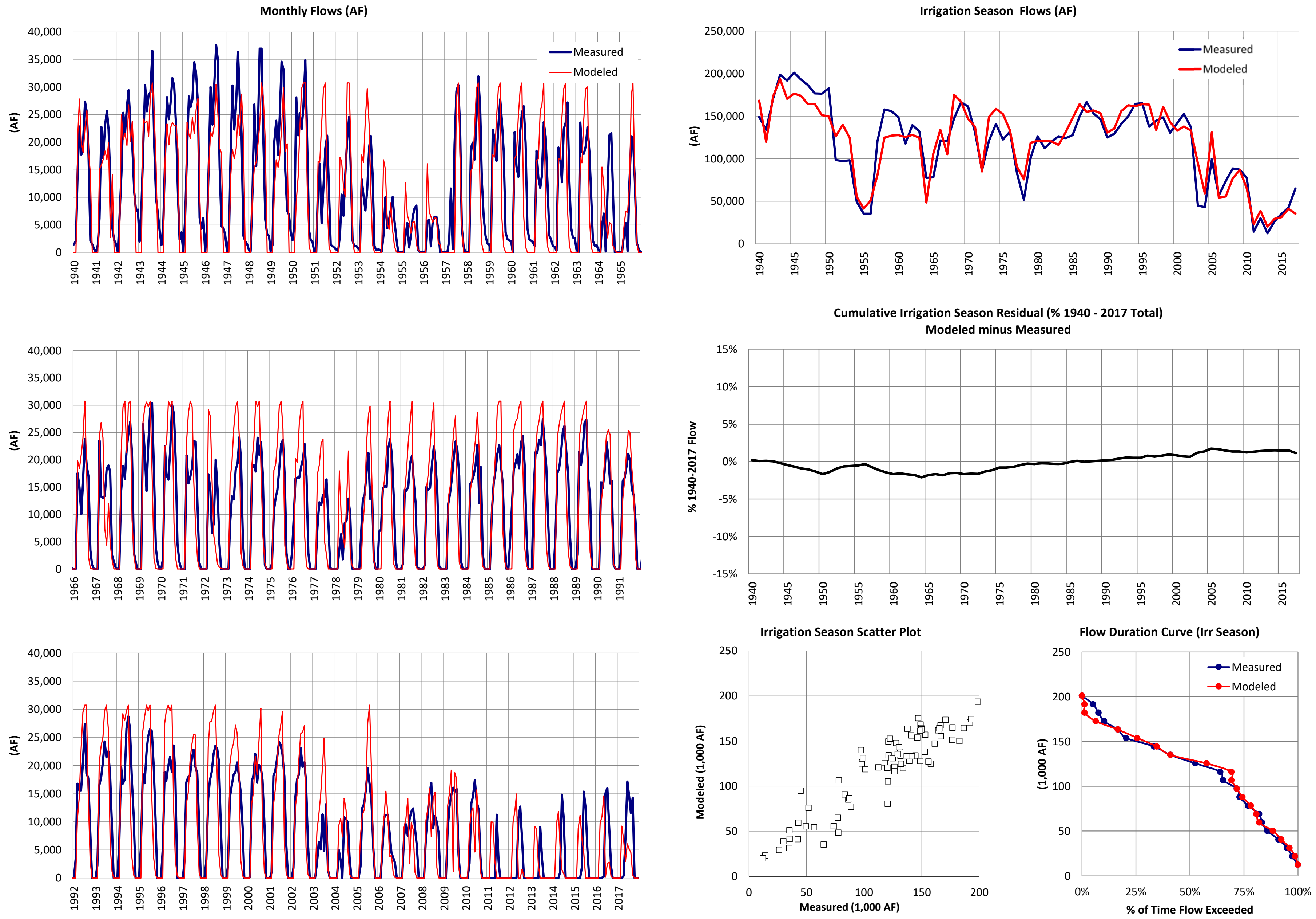
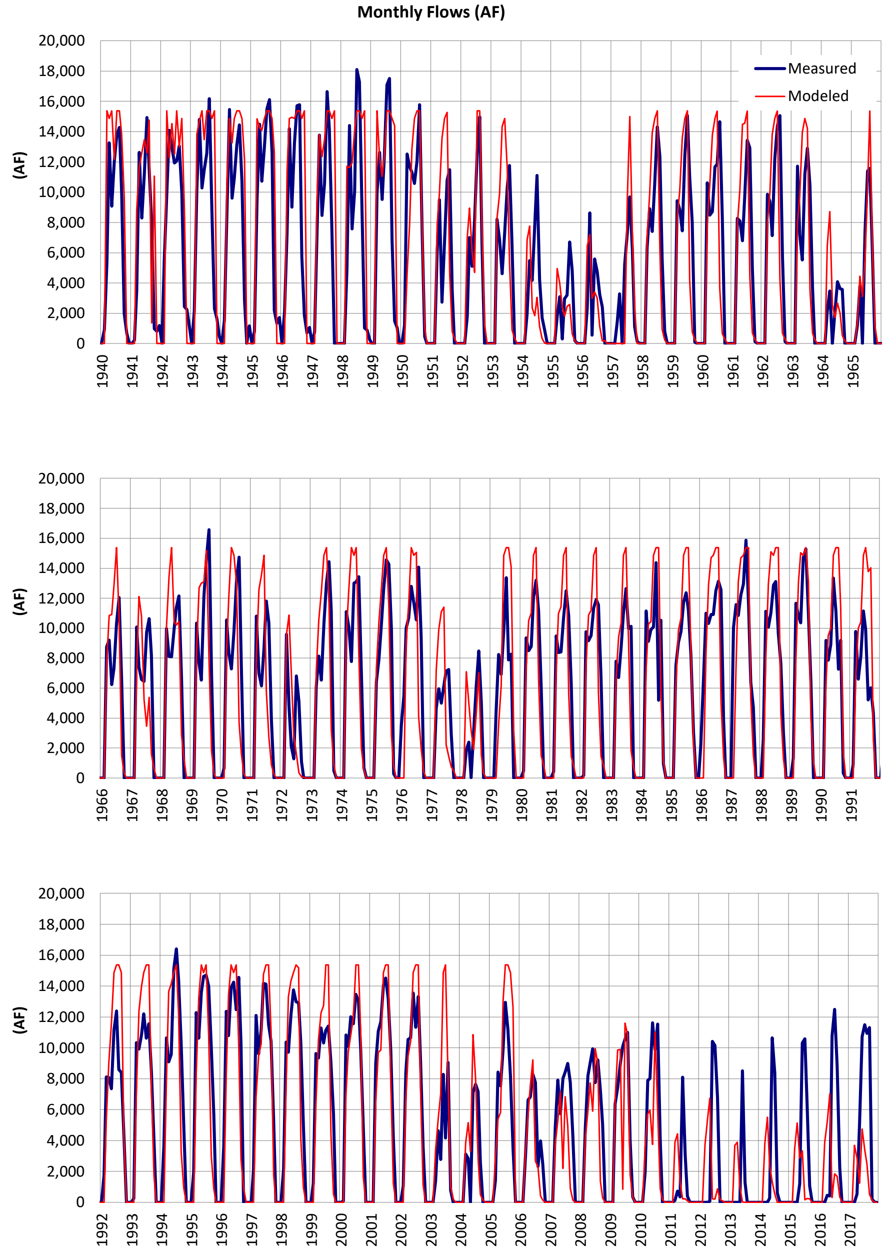
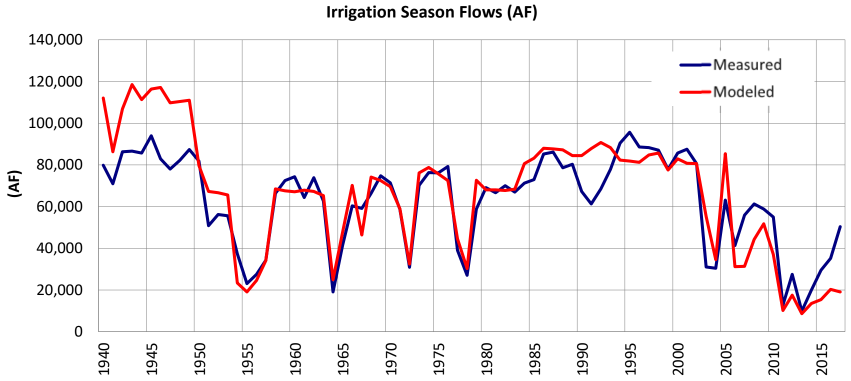
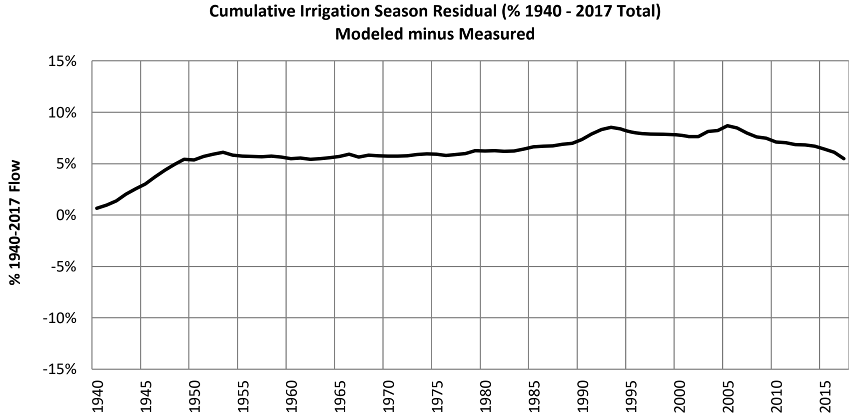


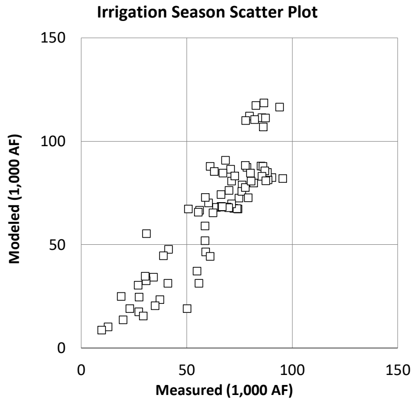
Figure 28-6

Integrated LRG Model Historical Calibration Results
Eastside Diversion
1940 - 2017


Monthly Flows (AF)


Irrigation Season Flows (AF)


Cumulative Irrigation Season Residual (% 1940 - 2017 Total)
Modeled minus Measured


Irrigation Season Scatter Plot

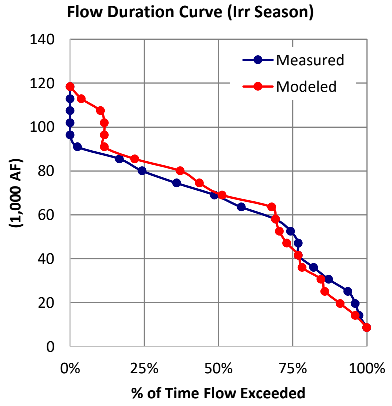
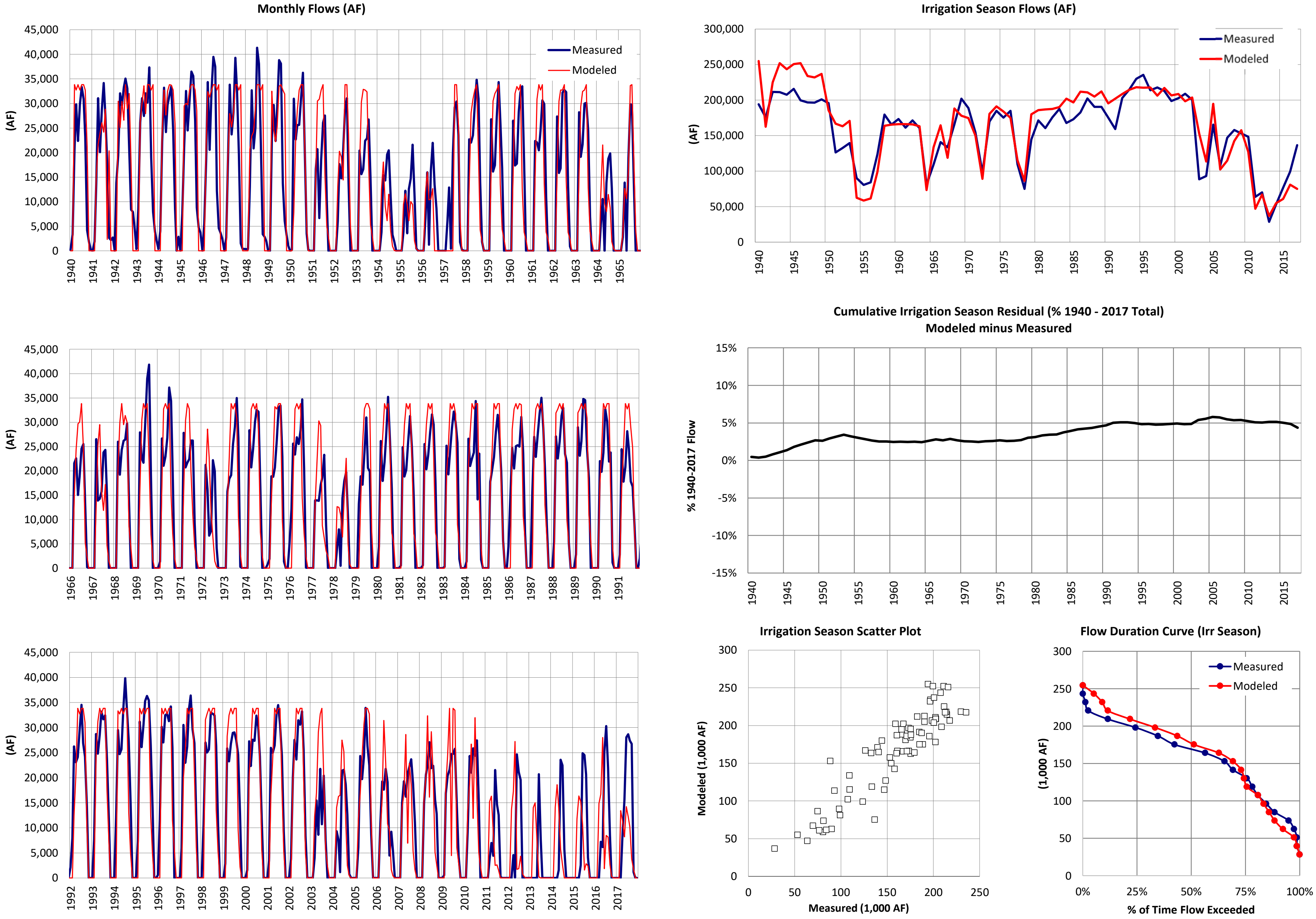

Flow Duration Curve (Irr Season)

Figure 28-7

Integrated LRG Model Historical Calibration Results

Westside Diversion

1940 - 2017



Monthly Flows (AF)

Irrigation Season Flows (AF)

Cumulative Irrigation Season Residual (% 1940 - 2017 Total)
Modeled minus Measured

Irrigation Season Scatter Plot

Flow Duration Curve (Irr Season)

Figure 28-8

Integrated LRG Model Historical Calibration Results

American Diversion

1940 - 2017

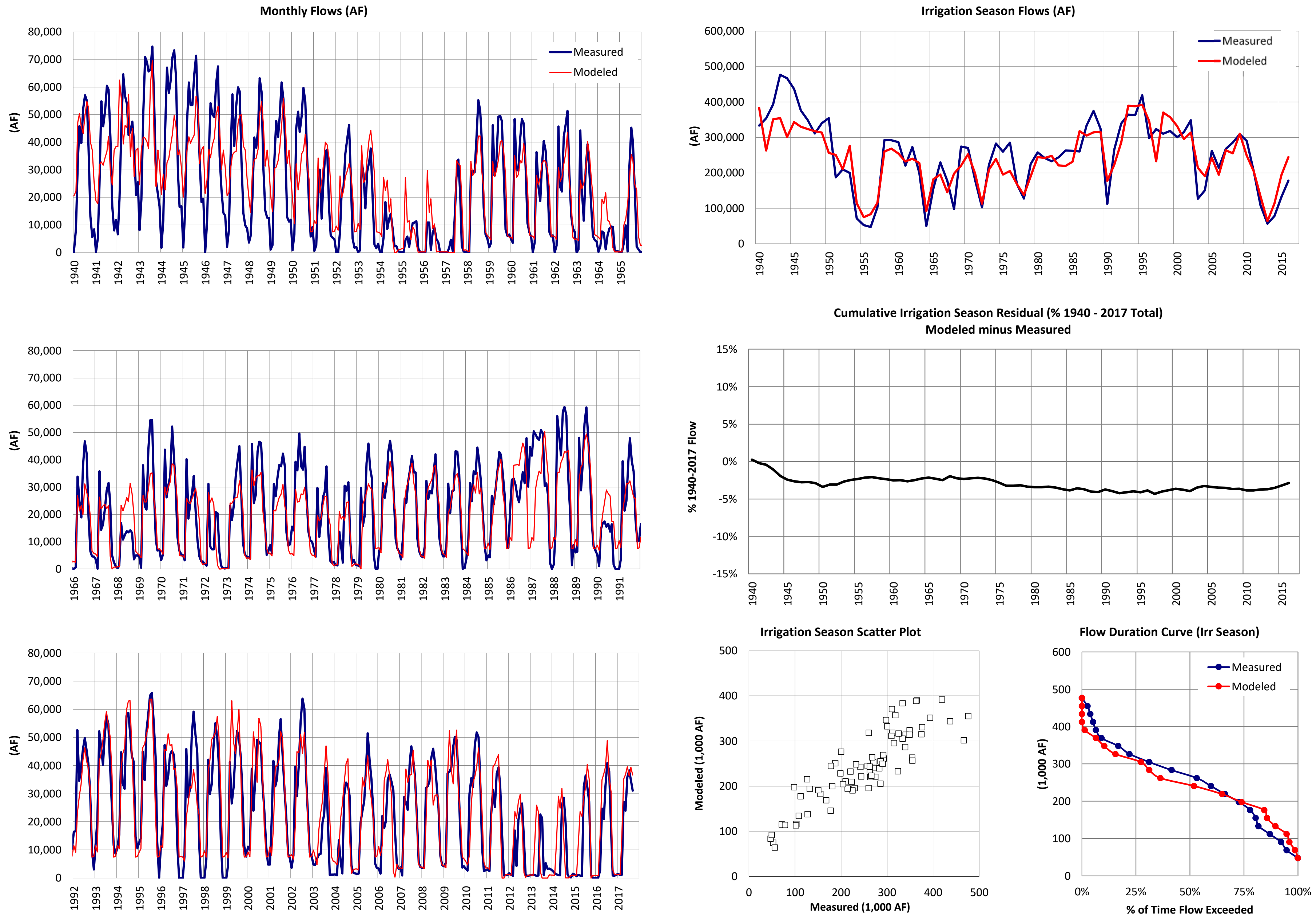


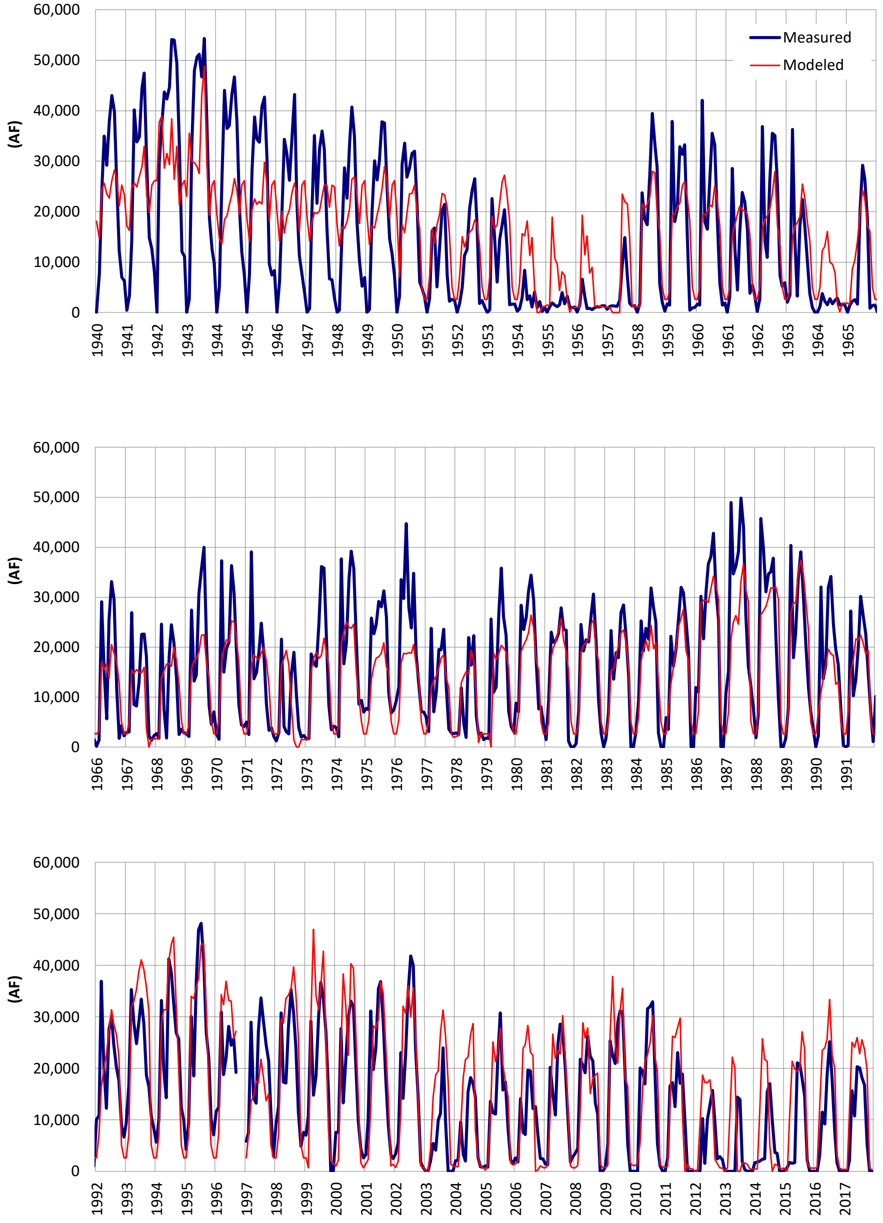
Figure 28-9

Integrated LRG Model Historical Calibration Results

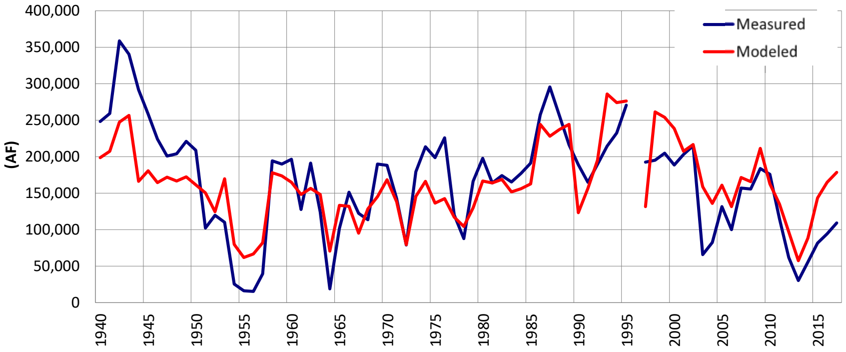
Riverside Canal Gage

1940 - 2017

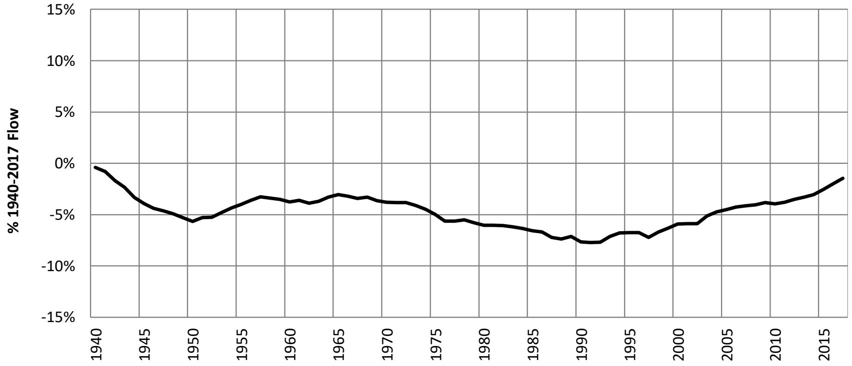
Monthly Flows (AF)



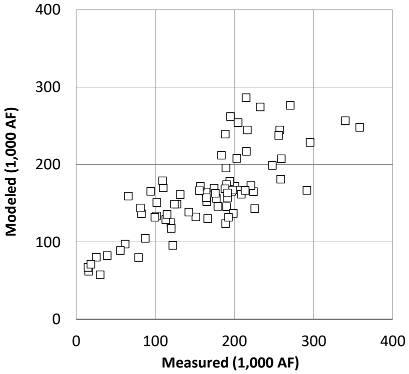
Irrigation Season Flows (AF)



Cumulative Irrigation Season Residual (% 1940 - 2017 Total)
Modeled minus Measured



Irrigation Season Scatter Plot



Flow Duration Curve (Irr Season)

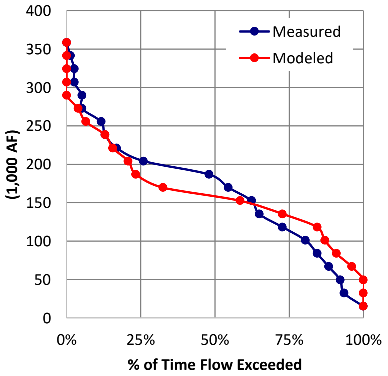


Figure 28-10

Integrated LRG Model Historical Calibration Results

Franklin Canal Gage

1940 - 2017

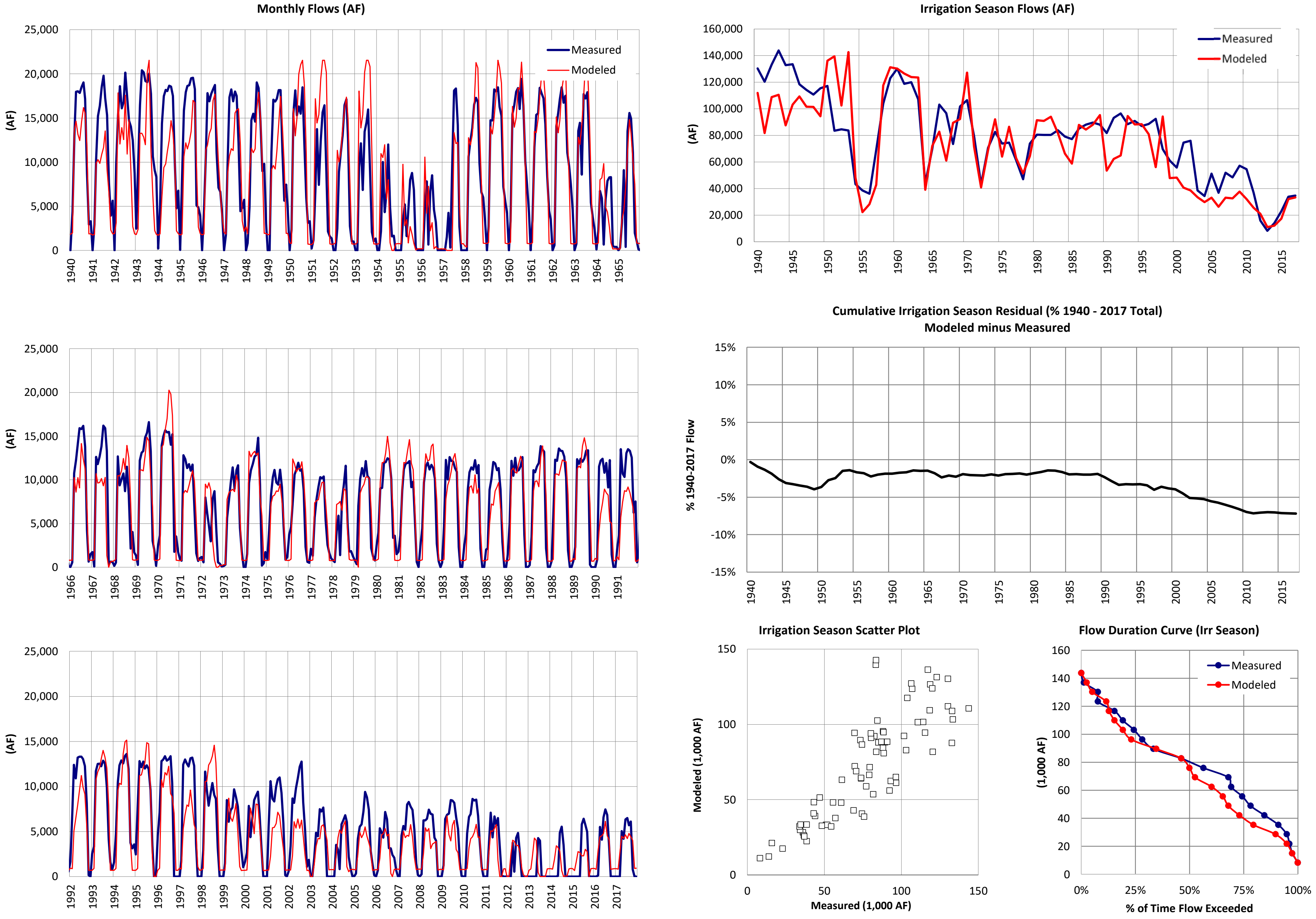


Figure 28-11

Integrated LRG Model Historical Calibration Results
Acequia Madre Diversion
1940 - 2017

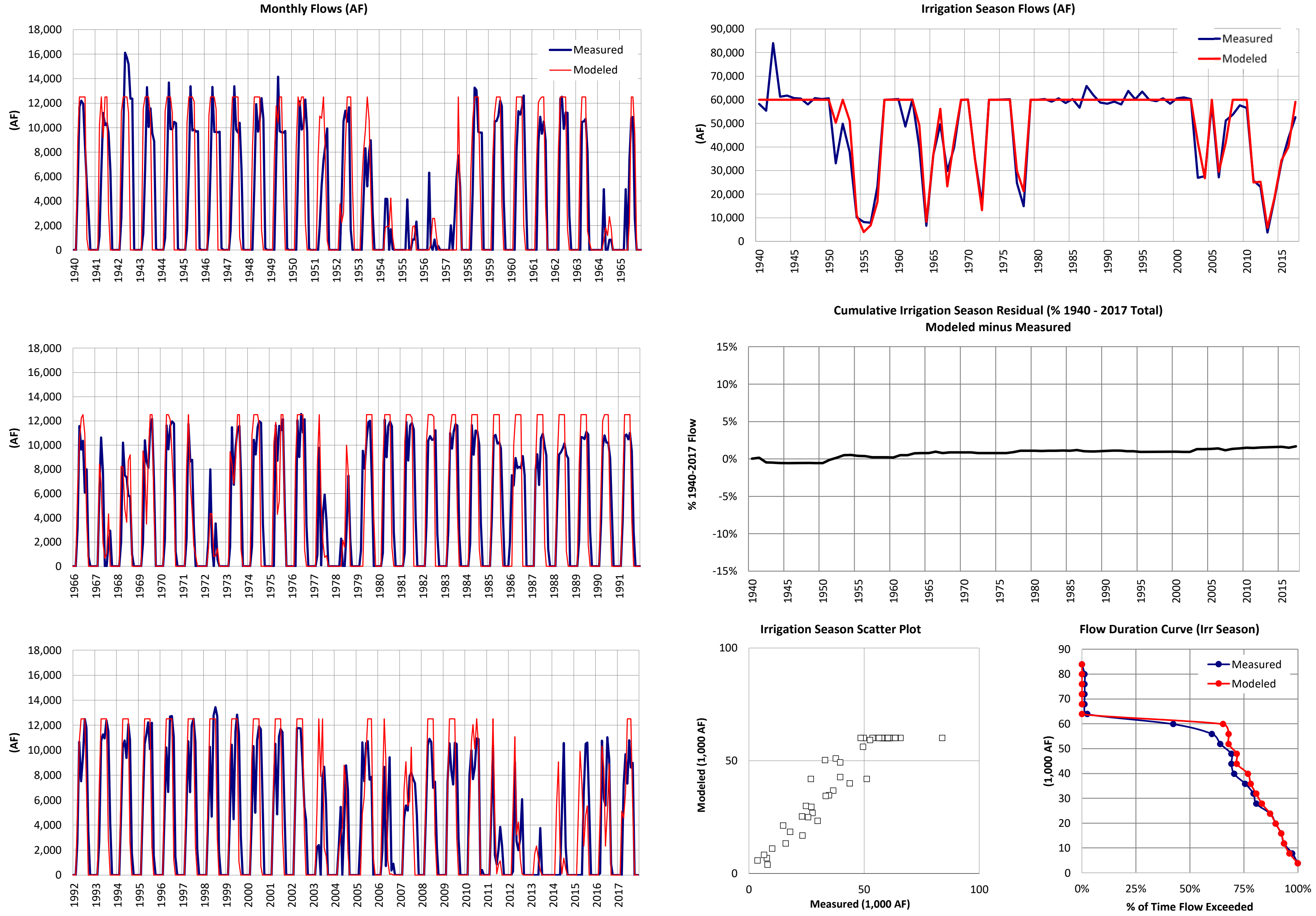
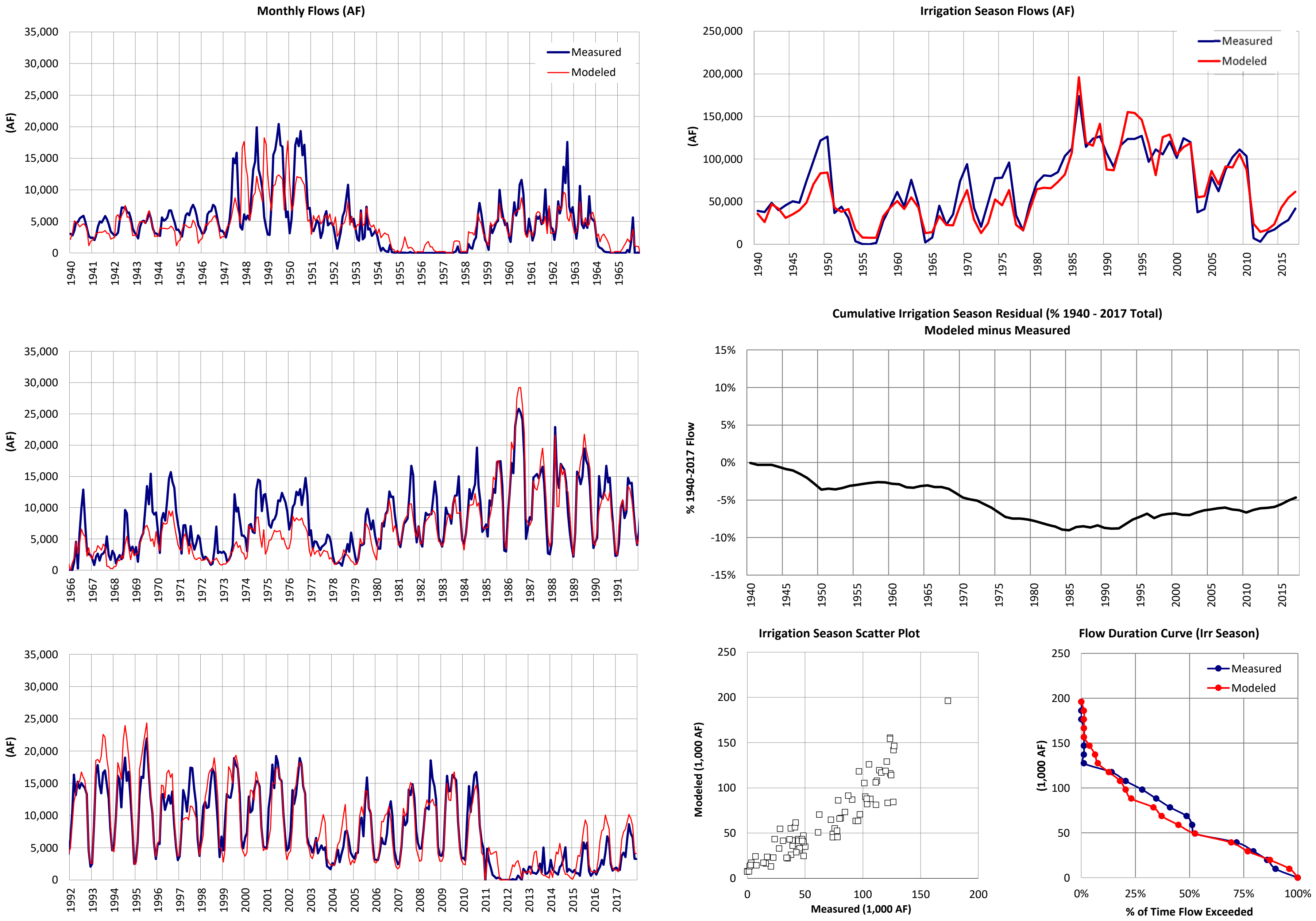


Figure 28-12

Integrated LRG Model Historical Calibration Results
Total HCCRD Supply
1940 - 2017


Monthly Flows (AF)

Irrigation Season Flows (AF)

Cumulative Irrigation Season Residual (% 1940 - 2017 Total)
Modeled minus Measured

Irrigation Season Scatter Plot

Flow Duration Curve (Irr Season)

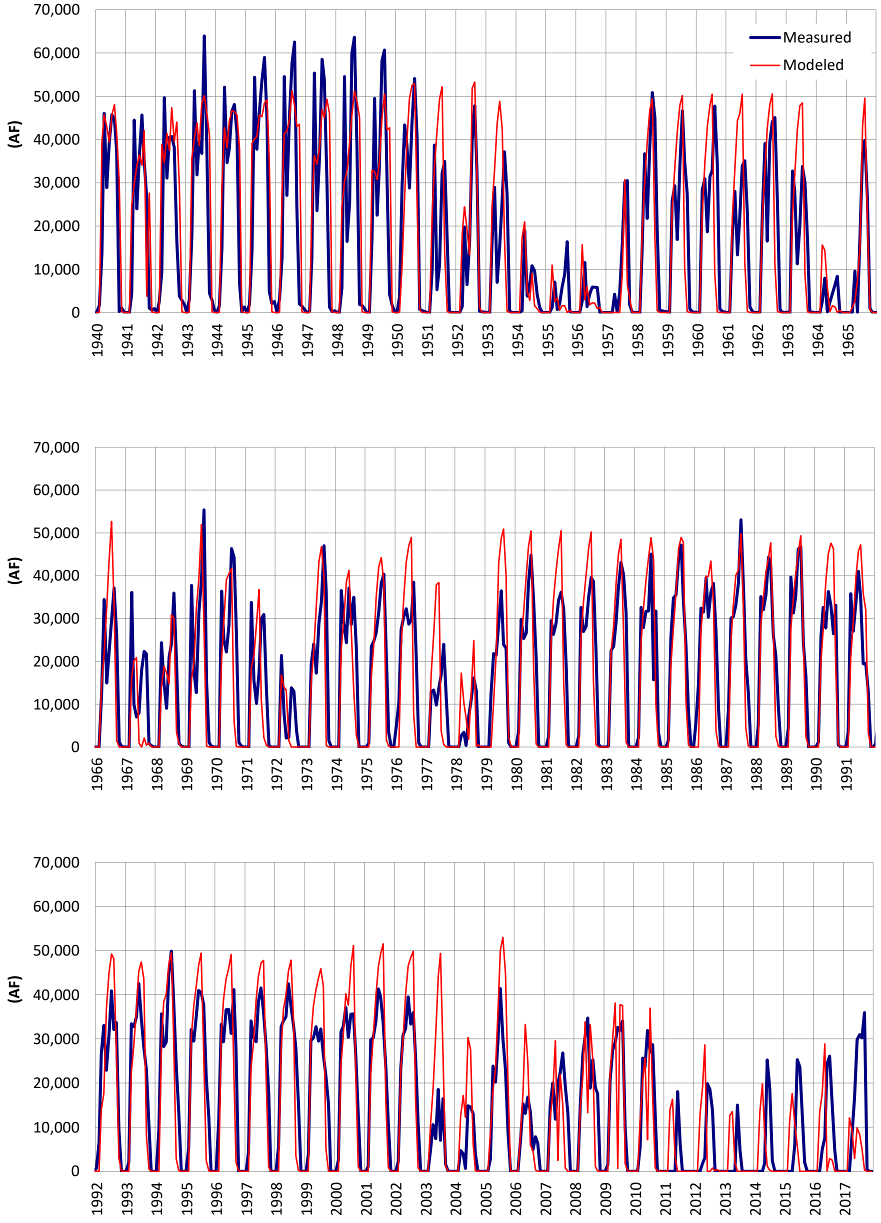
Figure 28-13

Integrated LRG Model Historical Calibration Results

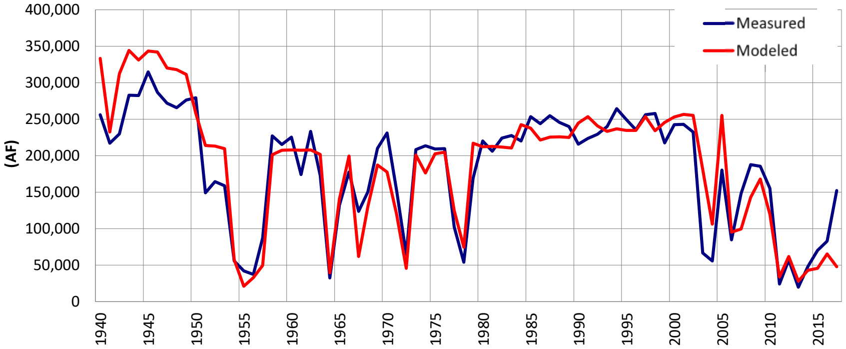
EBID FHG

1940 - 2017

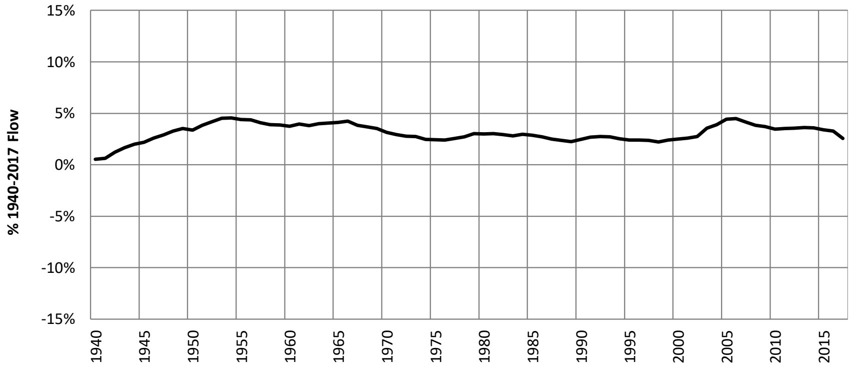
Monthly Flows (AF)



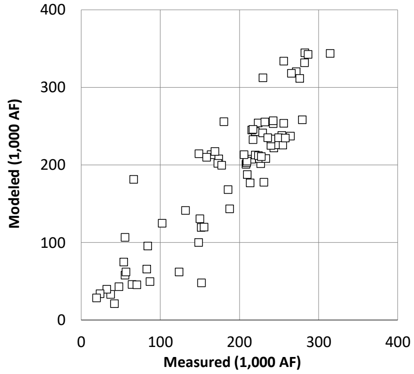
Irrigation Season Flows (AF)



Cumulative Irrigation Season Residual (% 1940 - 2017 Total)
Modeled minus Measured



Irrigation Season Scatter Plot



Flow Duration Curve (Irr Season)

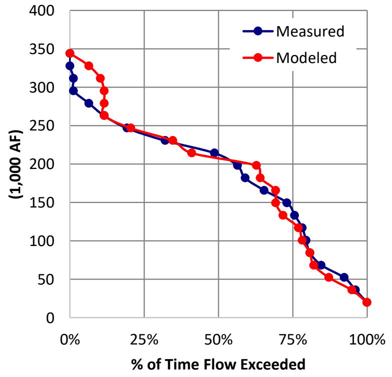
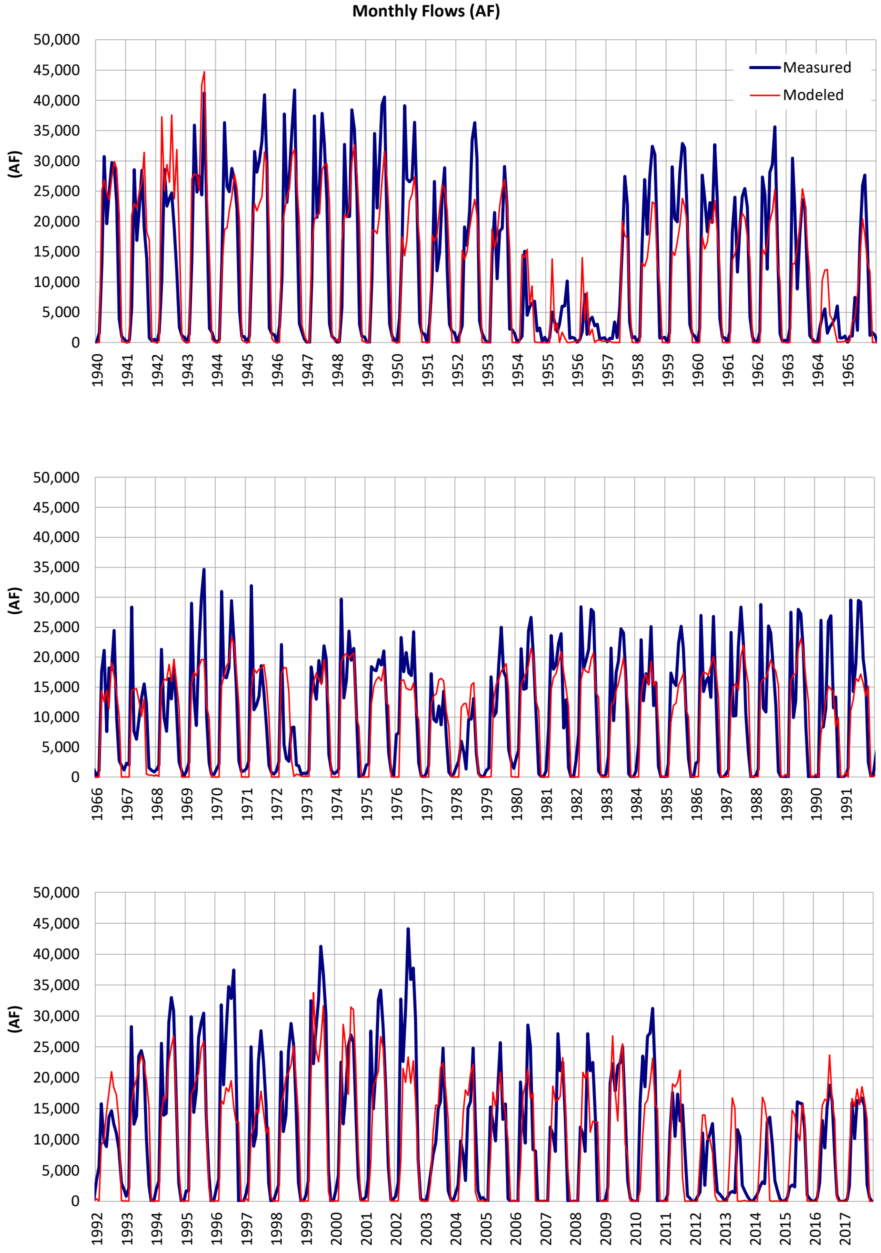


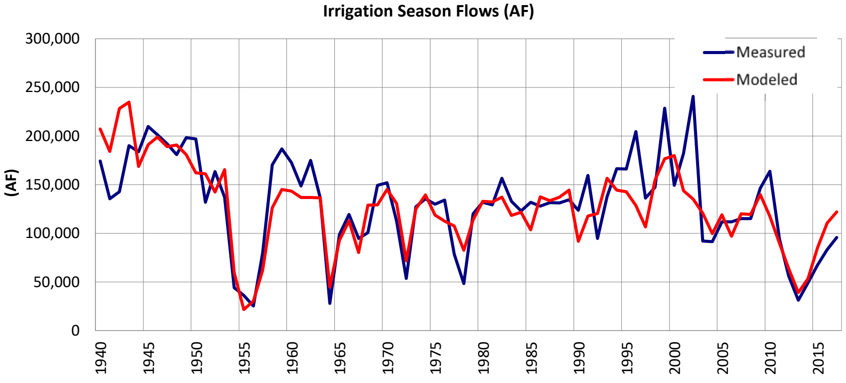
Figure 28-14

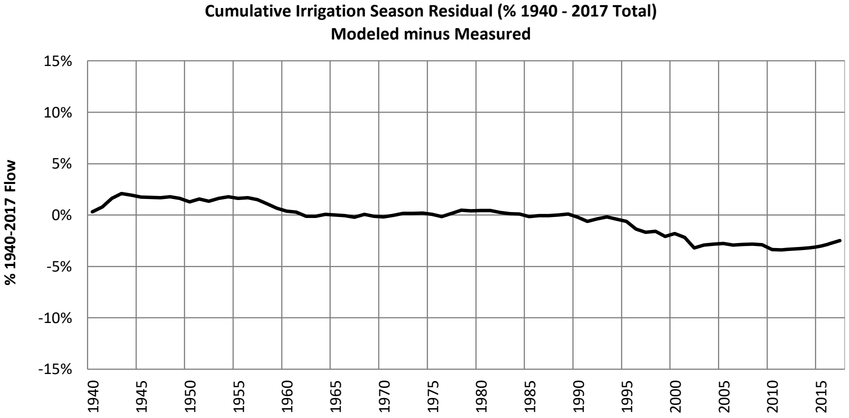
Integrated LRG Model Historical Calibration Results

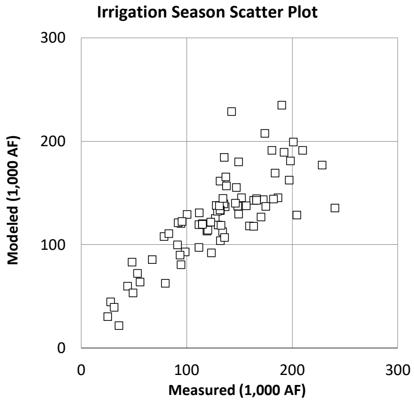
EPCWID FHG

1940 - 2017


Monthly Flows (AF)


Irrigation Season Flows (AF)


Cumulative Irrigation Season Residual (% 1940 - 2017 Total)
Modeled minus Measured


Irrigation Season Scatter Plot

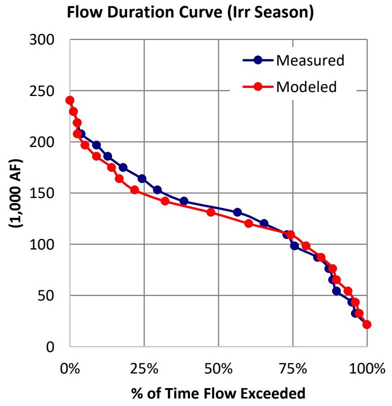

Flow Duration Curve (Irr Season)

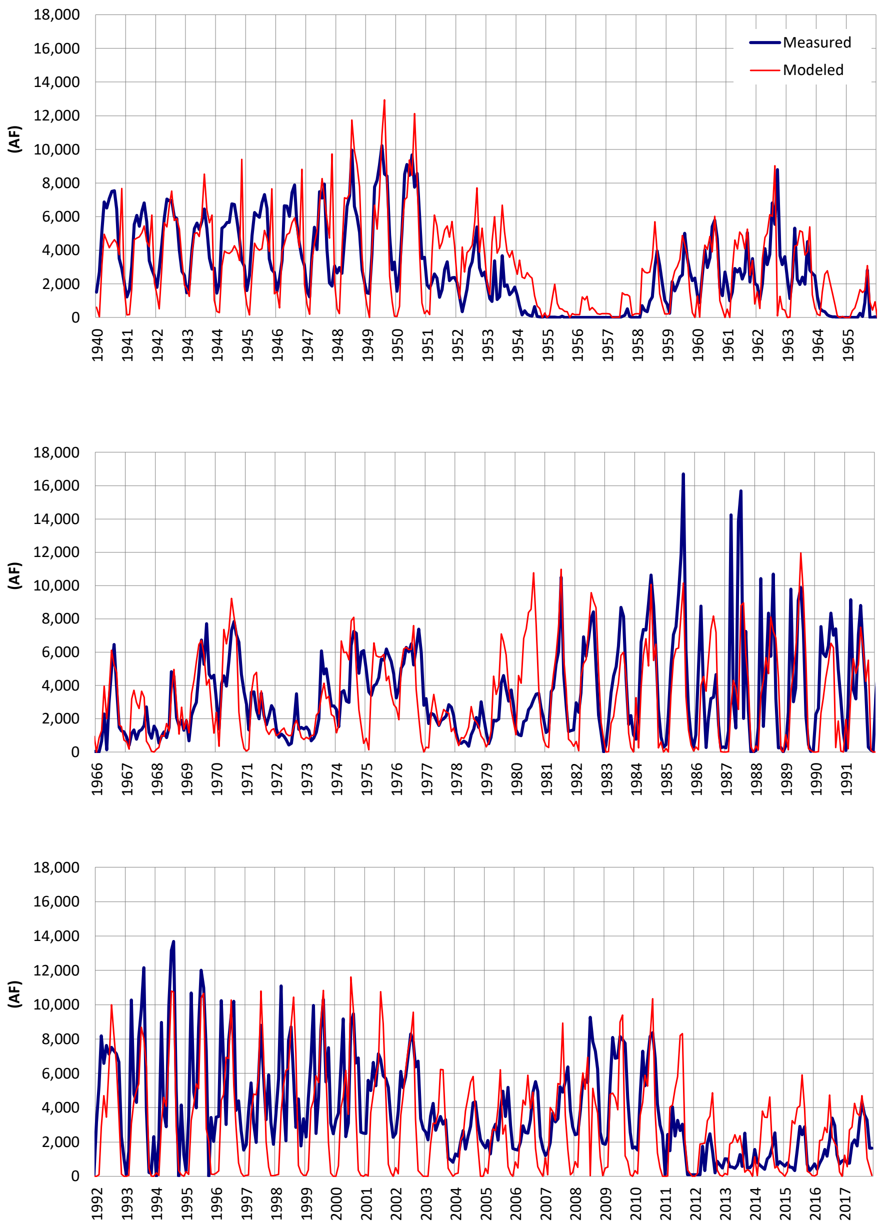
Figure 28-15

Integrated LRG Model Historical Calibration Results

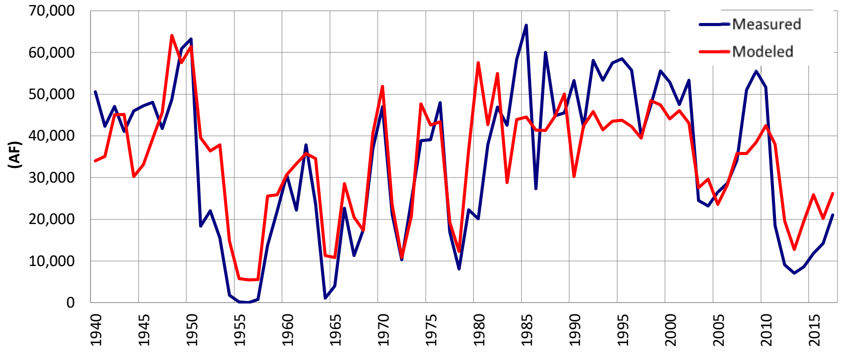
HCCRD FHG

1940 - 2017

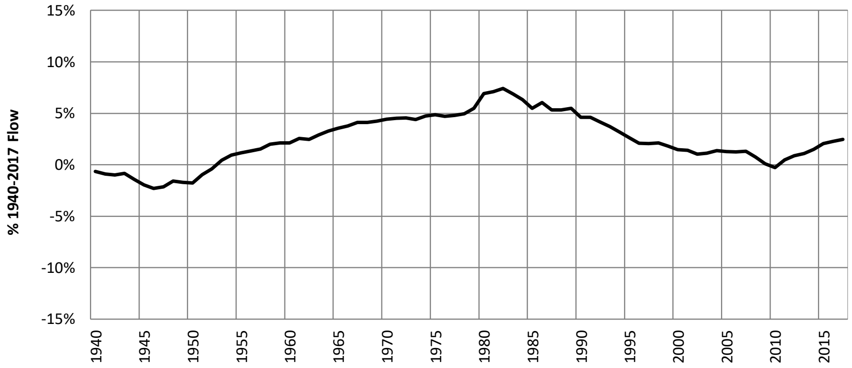
Monthly Flows (AF)



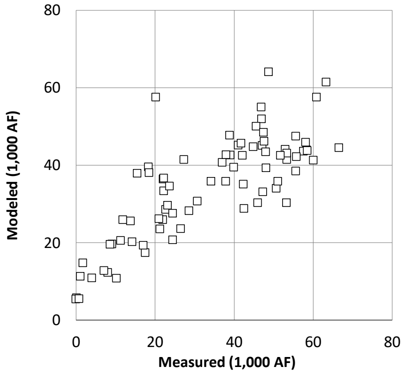
Irrigation Season Flows (AF)



Cumulative Irrigation Season Residual (% 1940 - 2017 Total)
Modeled minus Measured



Irrigation Season Scatter Plot



Flow Duration Curve (Irr Season)

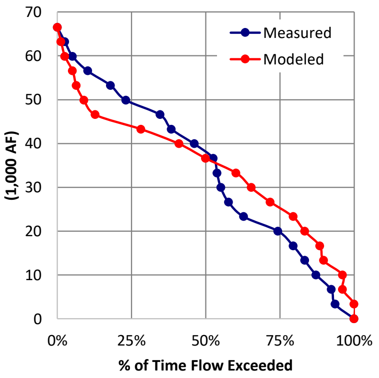


Figure 28-16

Integrated LRG Model Historical Calibration Results
EBID Supplemental Pumping
1940 - 2017

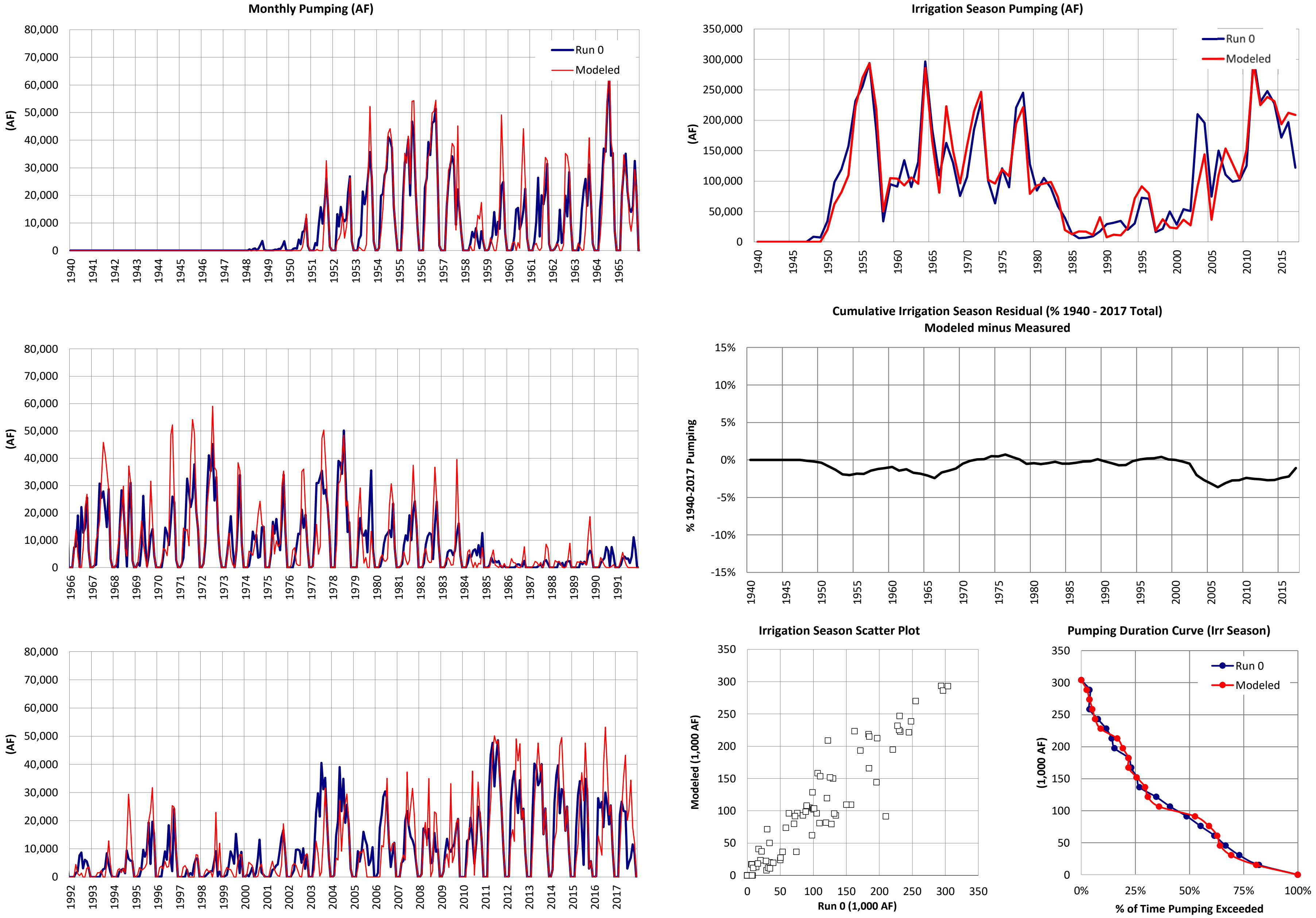
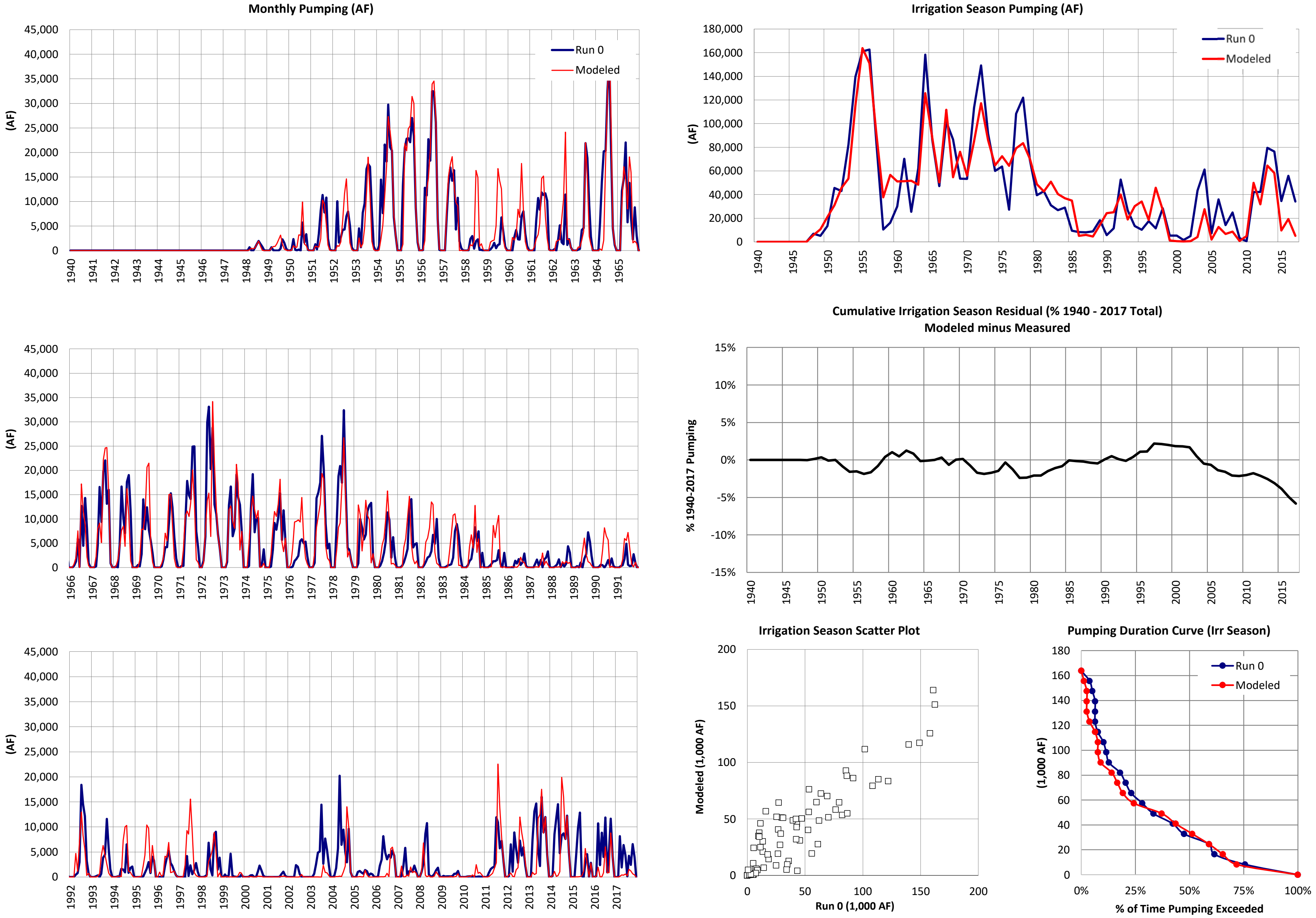


Figure 28-17

Integrated LRG Model Historical Calibration Results
EPCWID Supplemental Pumping
1940 - 2017



Monthly Pumping (AF)

Irrigation Season Pumping (AF)

Cumulative Irrigation Season Residual (% 1940 - 2017 Total)
Modeled minus Measured

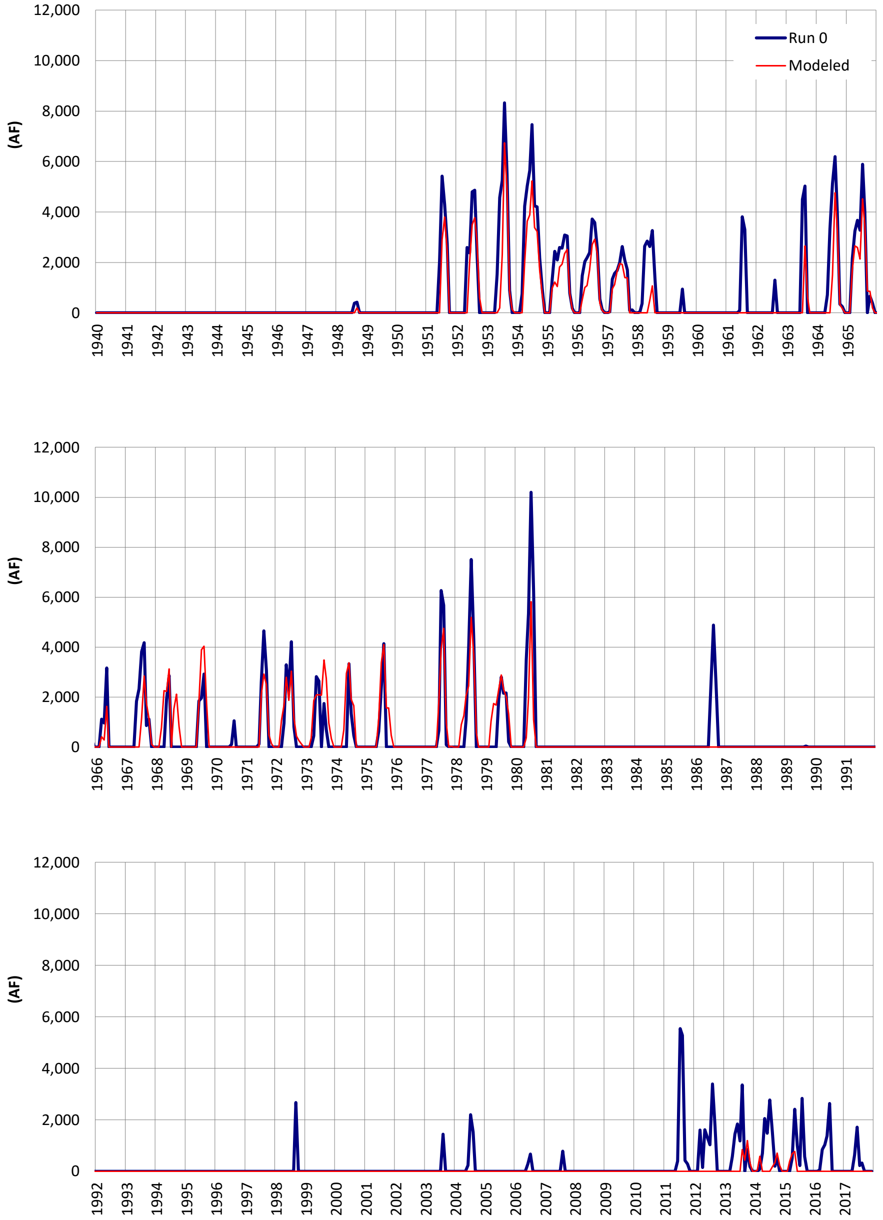
Irrigation Season Scatter Plot

Pumping Duration Curve (Irr Season)

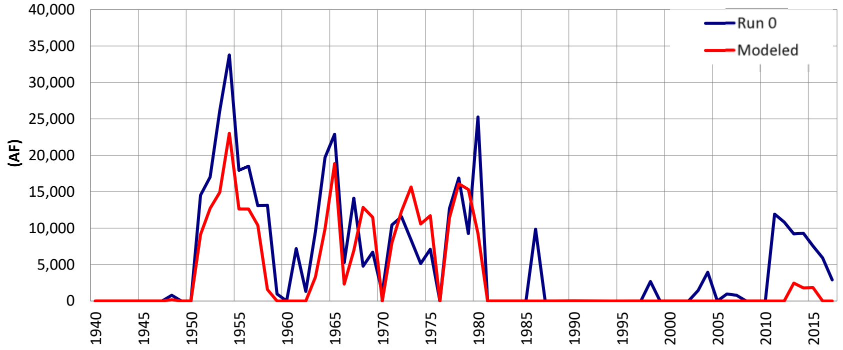
Figure 28-18

Integrated LRG Model Historical Calibration Results
HCCRD Supplemental Pumping
1940 - 2017

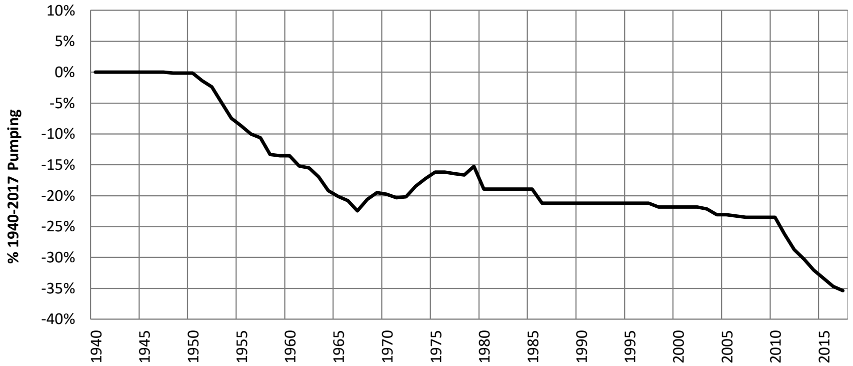
Monthly Pumping (AF)



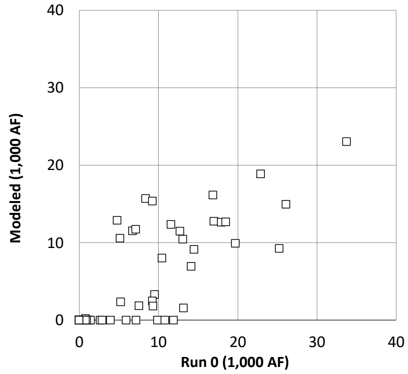
Irrigation Season Pumping (AF)



Cumulative Irrigation Season Residual (% 1940 - 2017 Total)
Modeled minus Measured



Irrigation Season Scatter Plot



Pumping Duration Curve (Irr Season)

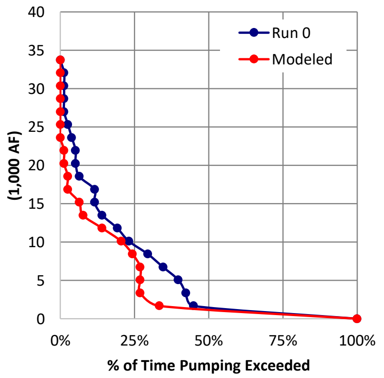
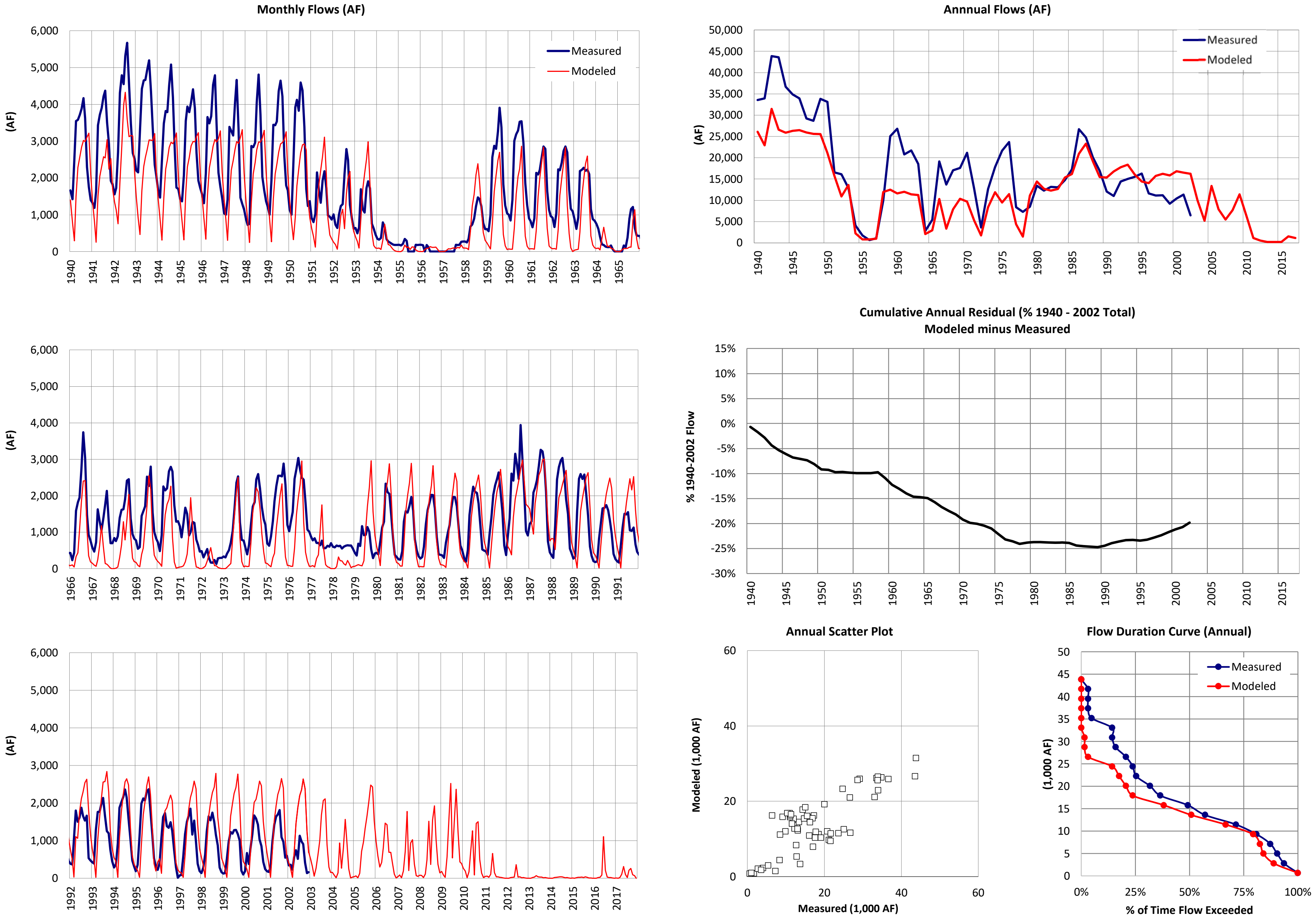


Figure 28-19

Integrated LRG Model Historical Calibration Results

Rincon Valley Drains

1940 - 2017



Note: Measured flows for Rincon Valley Drains shown for 1951-2002 due to limited data available after 2002. Modeled flows are shown in monthly and annual graphs after 2002 for reference.

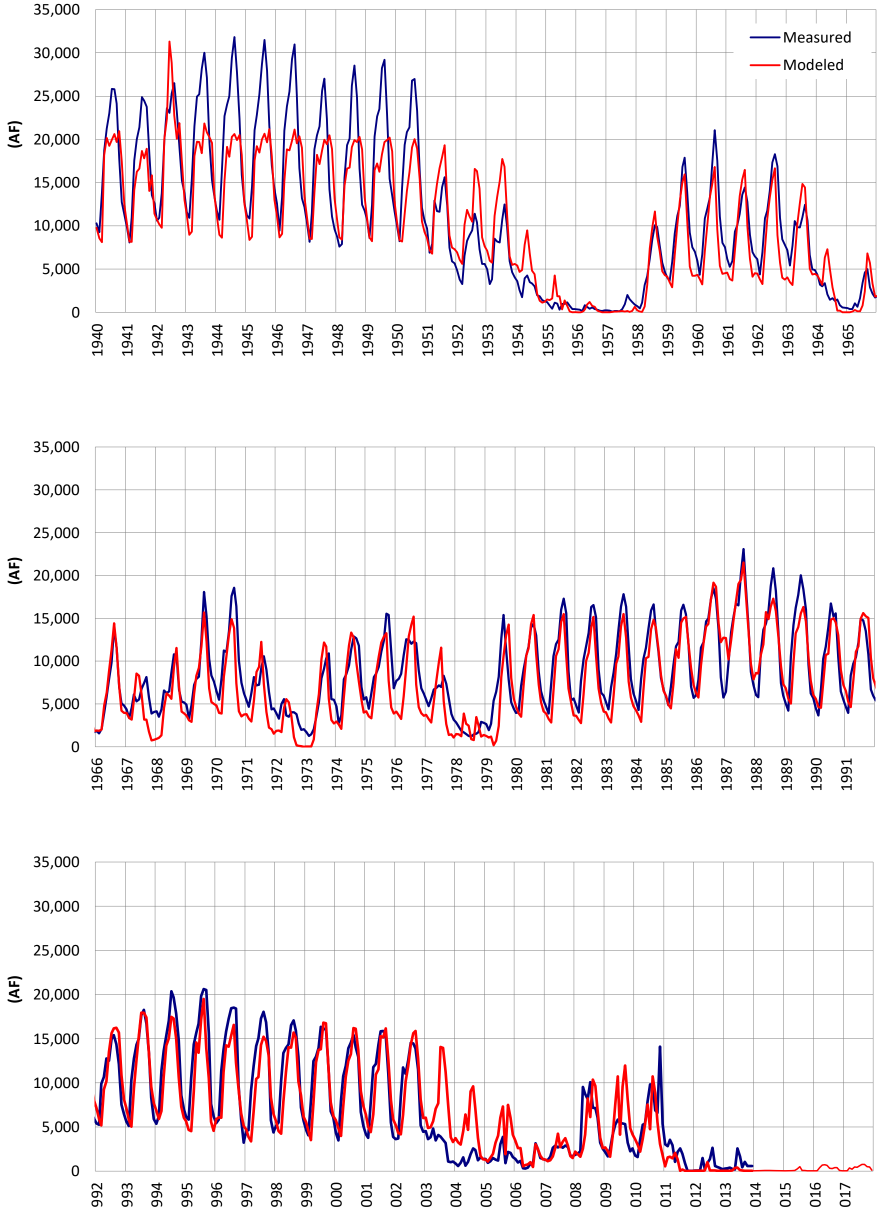
Figure 28-20

Integrated LRG Model Historical Calibration Results

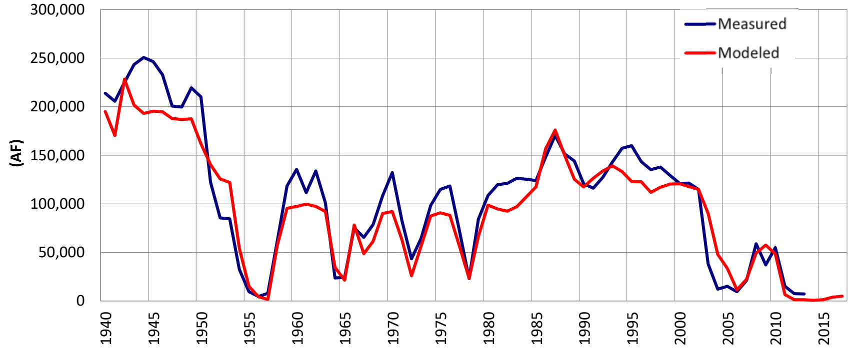
Mesilla Valley Drains

1940 - 2017

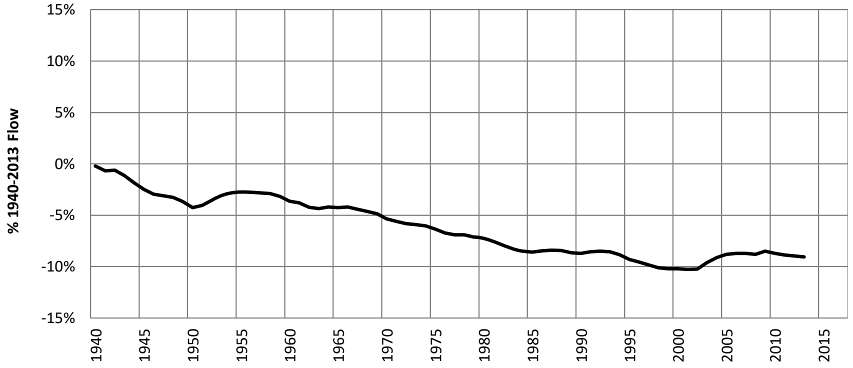
Monthly Flows (AF)



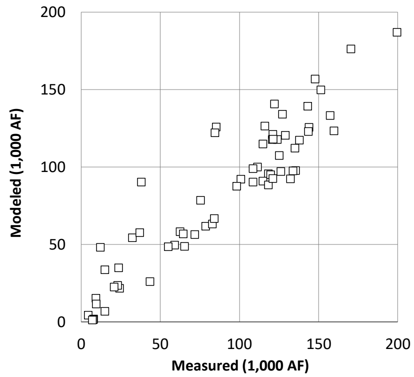
Annual Flows (AF)



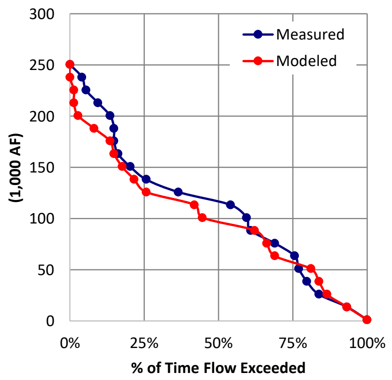
Cumulative Annual Residual (% 1940 - 2013 Total)
Modeled minus Measured



Annual Scatter Plot



Flow Duration Curve (Annual)



Note: Measured flows for Mesilla Valley Drains shown for 1951-2013 due to limited data available after 2013. Modeled flows are shown in monthly and annual graphs after 2013 for reference.

Figure 28-21

Integrated LRG Model Historical Calibration Results

El Paso Valley Drains

1940 - 2017

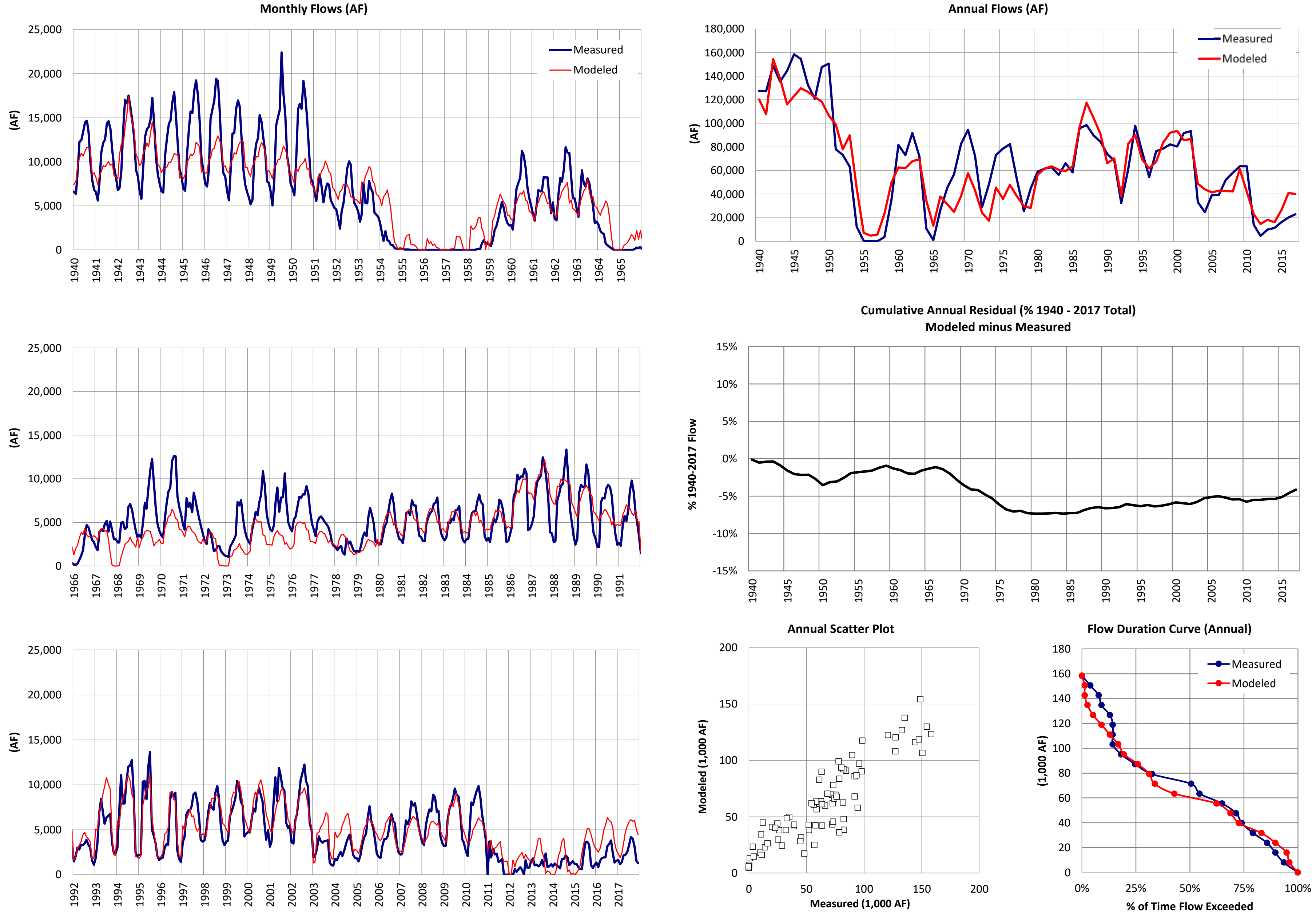
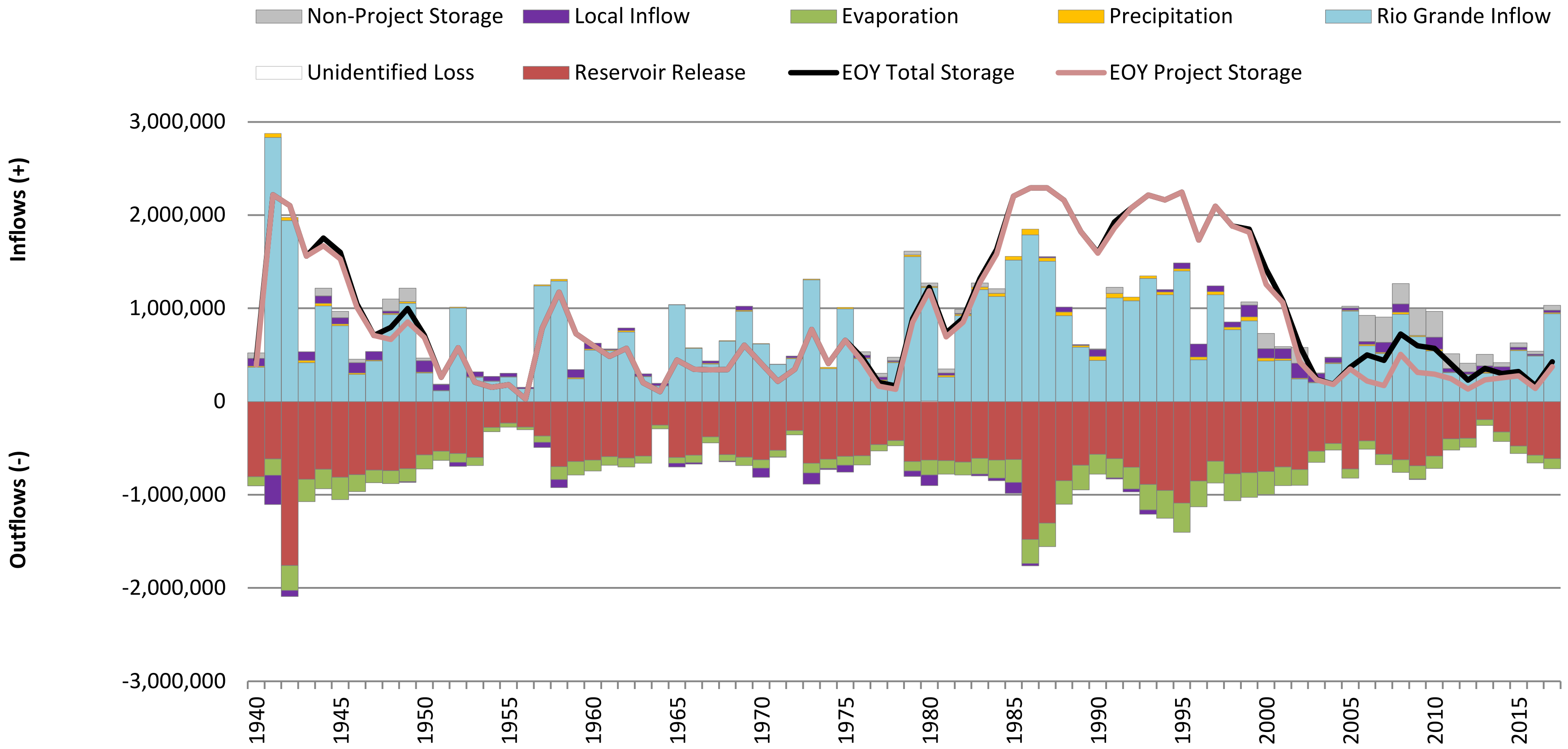


Figure 29-1

Annual Reservoir Water Budget Summary
Historical Base Run (Run 1)
Integrated LRG Model

1940 - 2017 (acre-feet)



Notes:

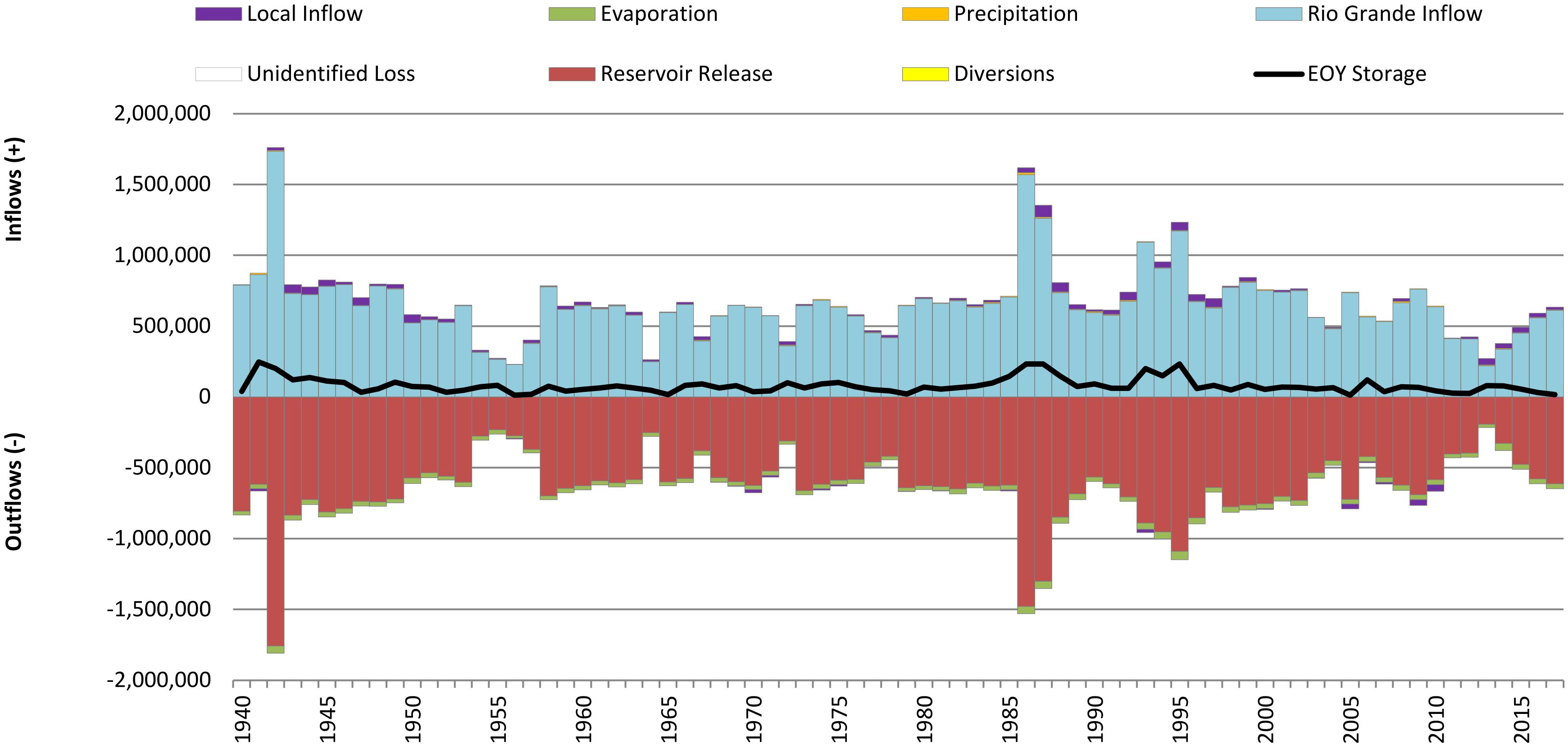
Model Version: LRG Model v116 Operational Run 1 - Historical Base Run.

Total Storage in Elephant Butte Reservoir includes New Mexico and Colorado compact storage and San Juan Chama storage.

Figure 29-1

Annual Reservoir Water Budget Summary
Historical Base Run (Run 1)
Integrated LRG Model
1940 - 2017 (acre-feet)

Caballo Reservoir



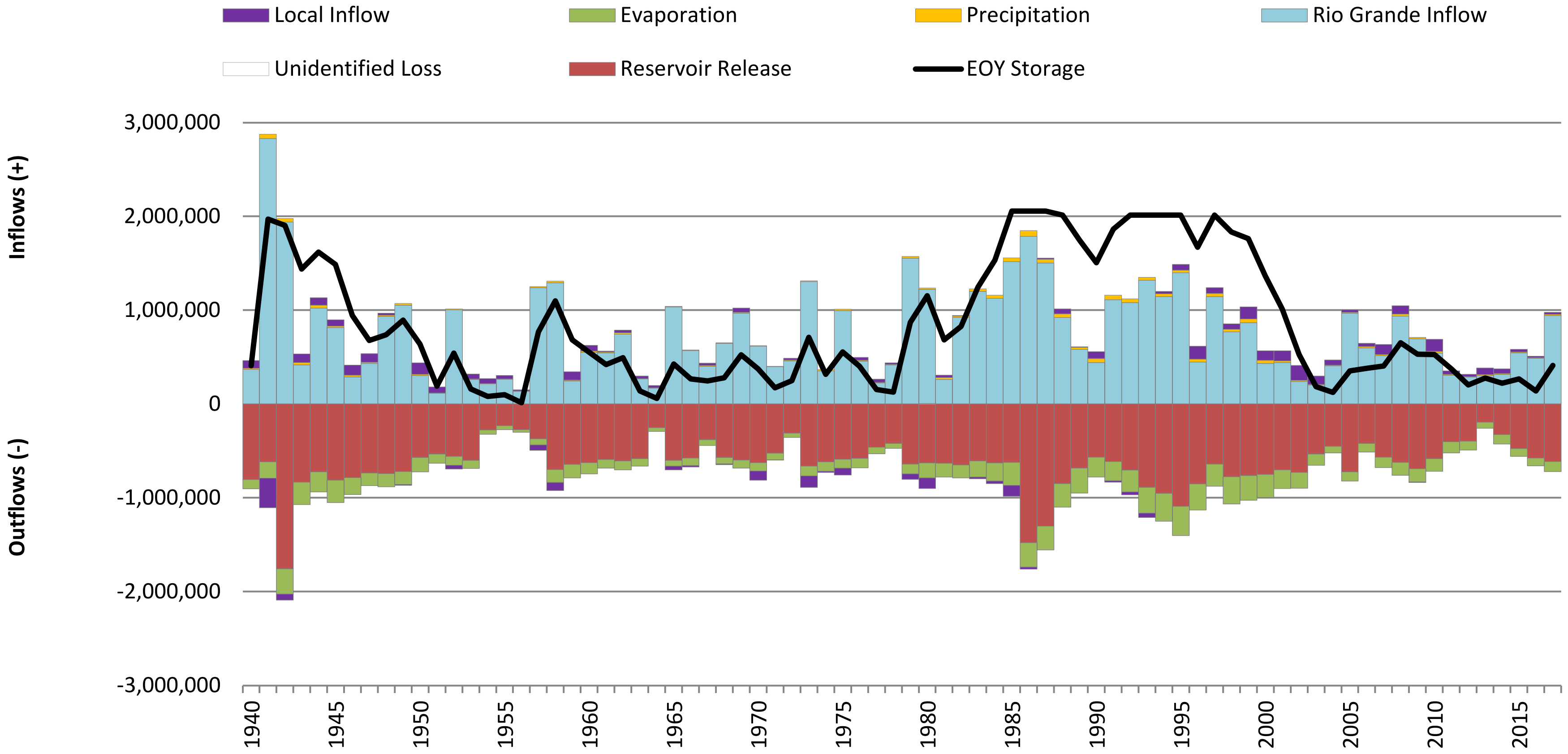
Notes:

Model Version: LRG Model v116 Operational Run 1 - Historical Base Run.

Figure 29-1

Annual Reservoir Water Budget Summary
Historical Base Run (Run 1)
Integrated LRG Model
1940 - 2017 (acre-feet)

Elephant Butte Reservoir

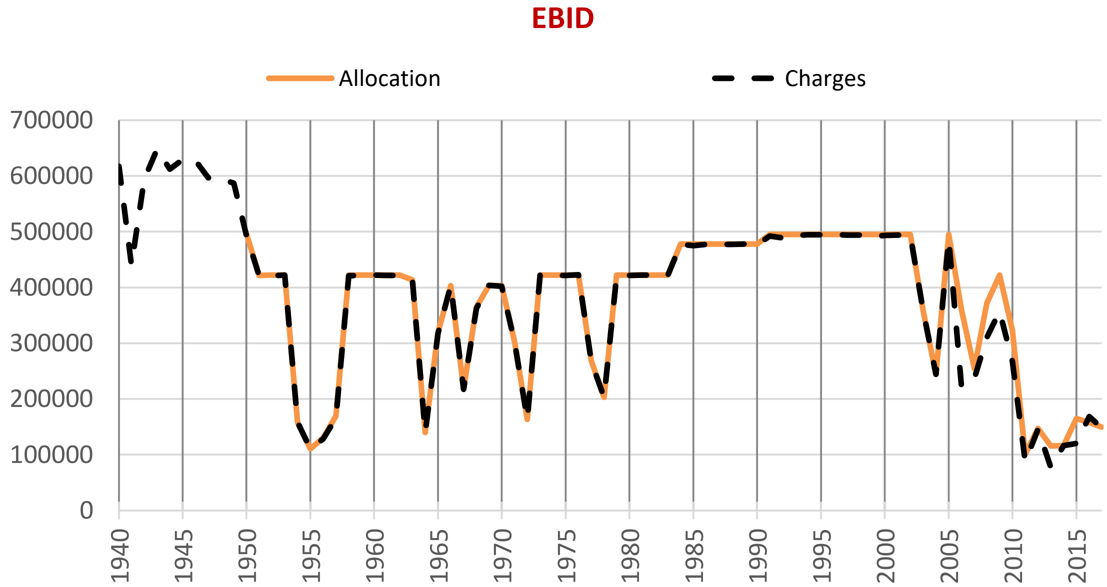


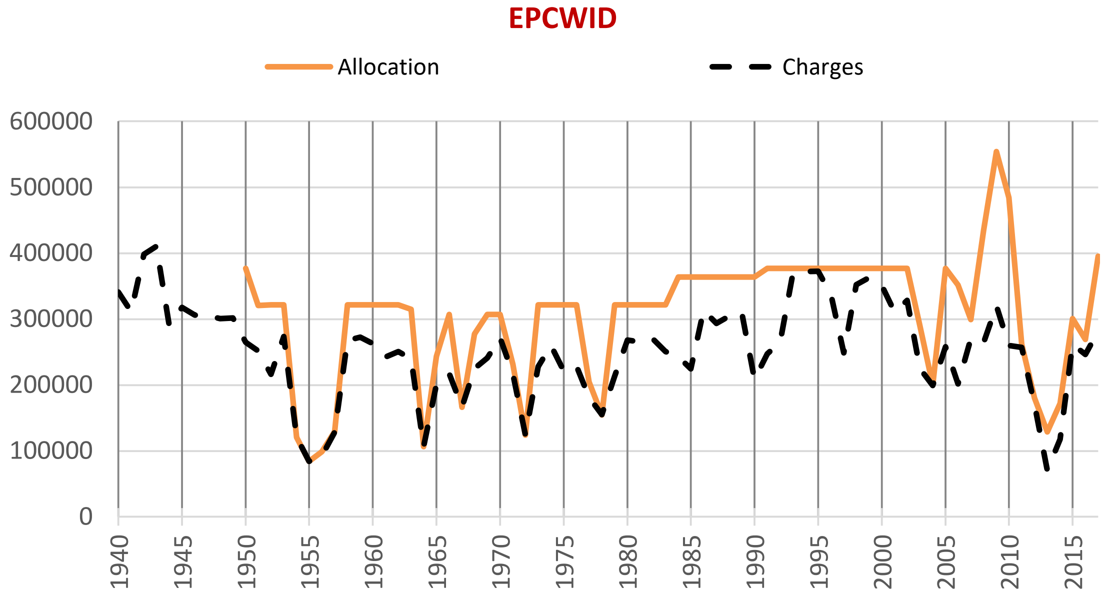
Notes:

Model Version: LRG Model v116 Operational Run 1 - Historical Base Run.
Total Storage in Elephant Butte Reservoir includes New Mexico and Colorado compact storage and San Juan Chama storage.

Figure 29-2

Annual Project Allocations and Charges
Historical Base Run (Run 1)
Integrated LRG Model
1940 - 2017 (acre-feet)





Notes:

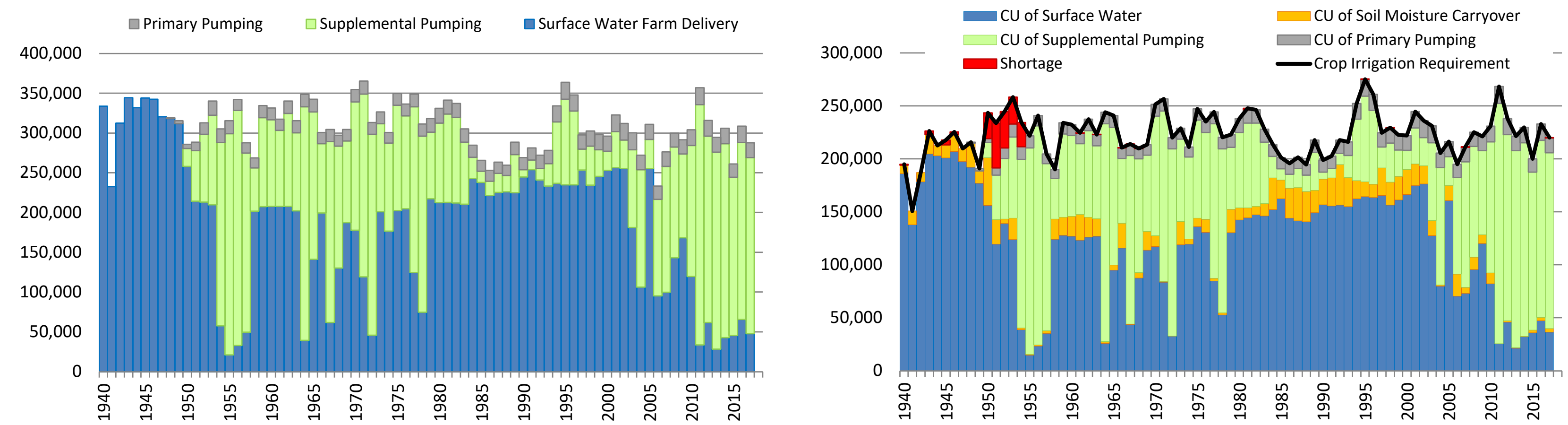
Model Version: LRG Model v116 Operational Run 1 - Historical Base Run.

Allocation calculated with carryover (2008 - 2017).

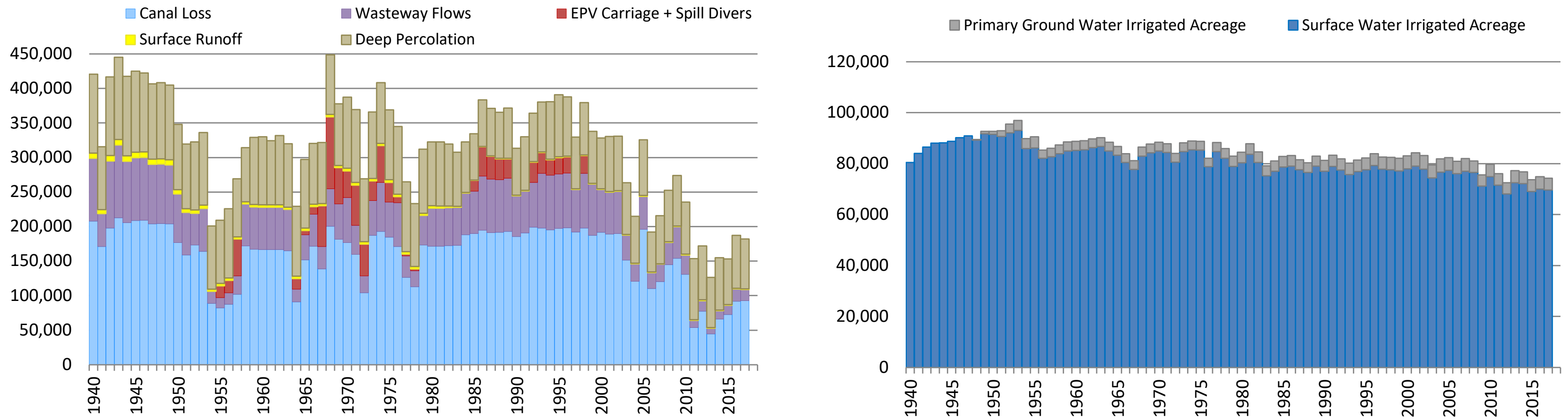
Allocation is calculated and used to limit diversions for EBID and EPCWID from 1950-2017.

Figure 29-3

Annual Canal and Farm Water Budget Summary
Historical Base Run (Run 1)
Integrated LRG Model
1940-2017
EBID Total


Annual Farm Deliveries (acre-feet)

Annual Consumptive Use (acre-feet)


Annual Losses (acre-feet)

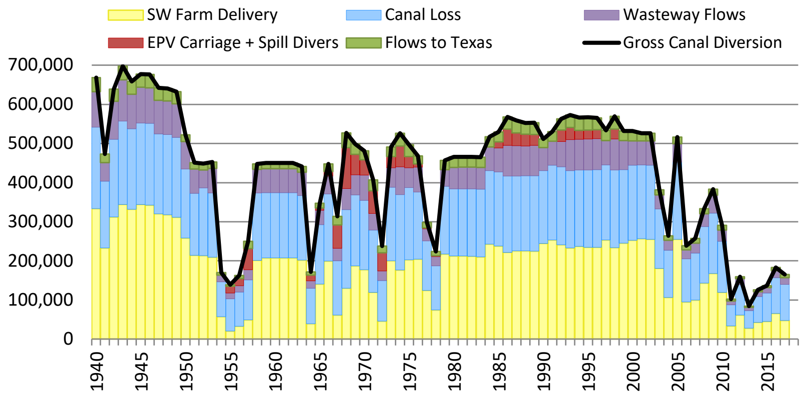
Annual Irrigated Acres

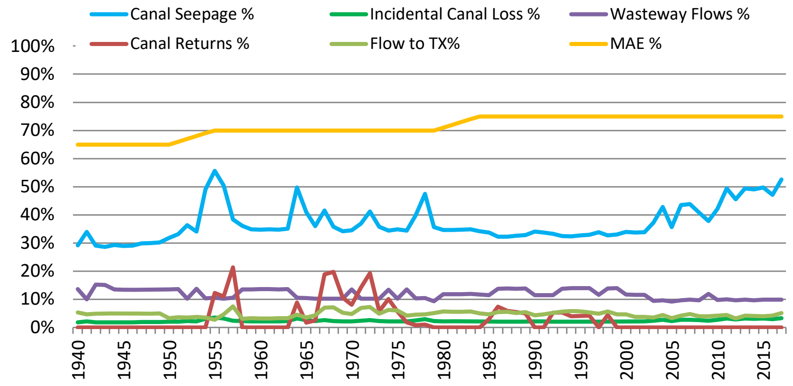
*Note: Different Scales

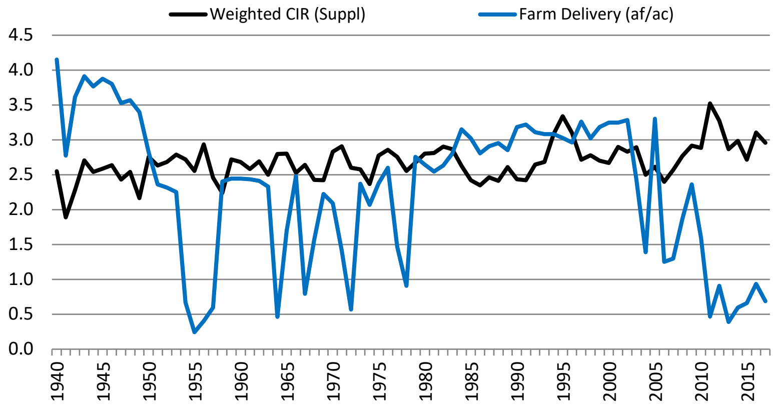
Model Version: LRG Model v116 Operational Run 1 - Historical Base Run.

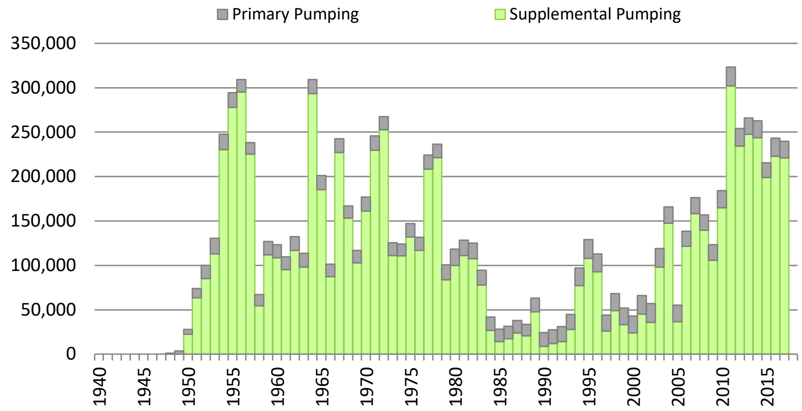
Figure 29-3

Annual Canal and Farm Water Budget Summary
Historical Base Run (Run 1)
Integrated LRG Model
1940-2017
EBID Total


Annual Canal Diversions and Farm Deliveries (acre-feet)


Maximum Application Efficiency and Loss Percentages


Annual Weighted Crop Irrigation Requirement (feet)


Annual Pumping (acre-feet)

Model Version: LRG Model v116 Operational Run 1 - Historical Base Run.

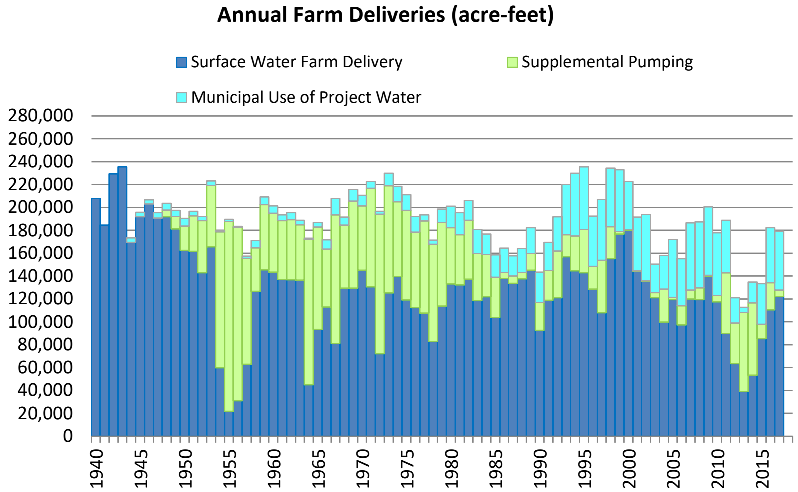
Notes:

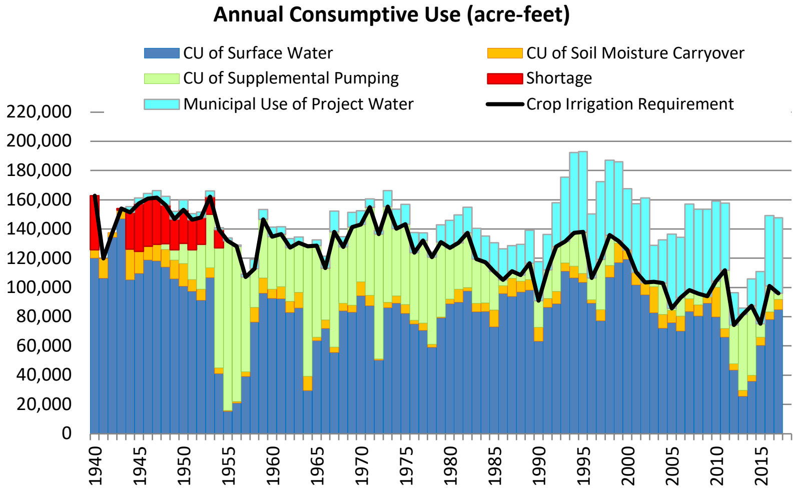
(1) Gross canal diversions are the sum of diversions at Percha Dam plus Leasburg Dam plus Mesilla Dam (East and West).
(2) Canal loss calculations occur at top of canal and are not in the surface water budget for Mesilla Texas. However a portion of the canal seepage accrues to the ground water objects for Mesilla TX.
(3) Canal returns to river are flows from the canal to the Rio Grande that are not through a wasteway. These can include EPV carriage water, spill water, and water diverted in excess of demands.
(4) Flows to Texas are flows to Texas from the Eastside and Westside Canal.
(5) Loss percentages are divided by canal diversion.
(6) Crop Irrigation Requirement ("CIR") is the total crop consumptive use (a.k.a. consumptive use of applied water) minus effective precipitation.

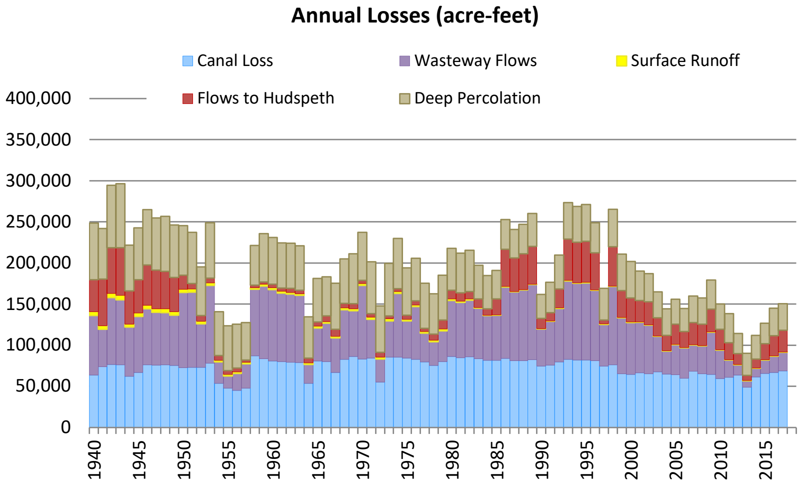
Figure 29-4

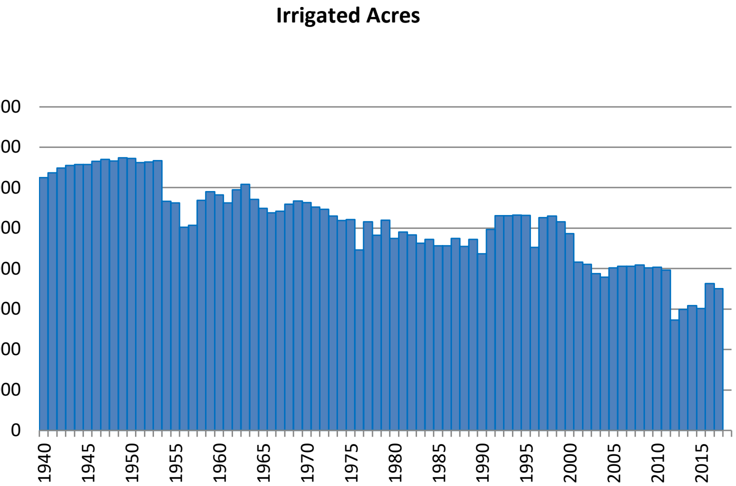
Annual Canal and Farm Water Budget Summary
Historical Base Run (Run 1)
Integrated LRG Model
1940-2017

EPCWID Total


Annual Farm Deliveries (acre-feet)


Annual Consumptive Use (acre-feet)


Annual Losses (acre-feet)


Irrigated Acres

*Note: Different Scales

Model Version: LRG Model v116 Operational Run 1 - Historical Base Run.

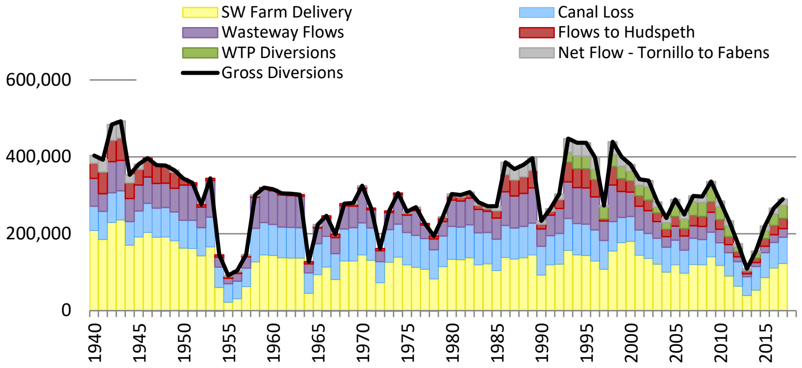
Figure 29-4

Annual Canal and Farm Water Budget Summary
Historical Base Run (Run 1)
Integrated LRG Model

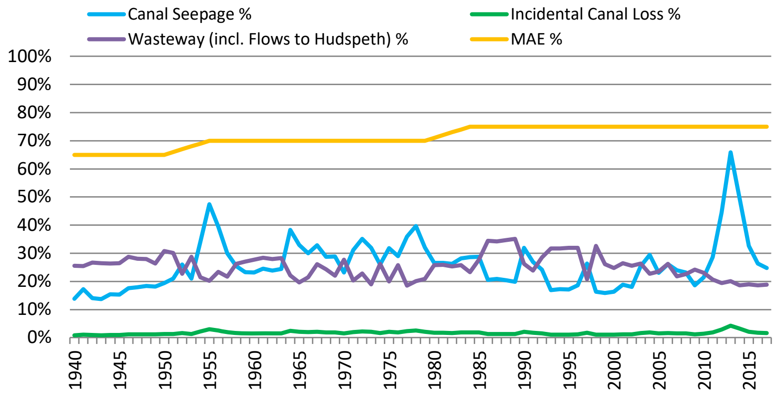
1940-2017

EPCWID Total

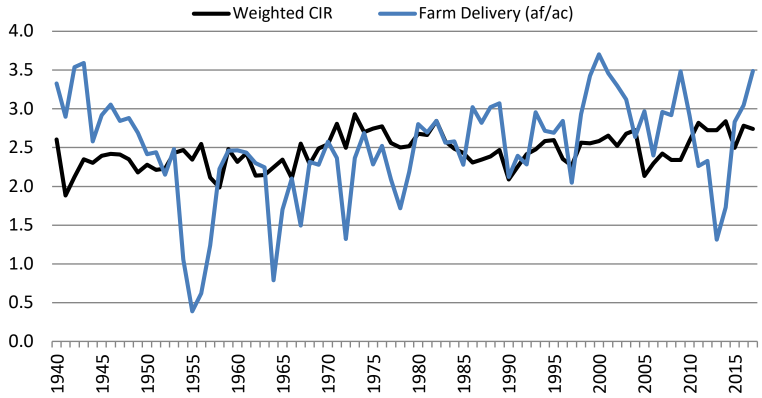
Annual Canal Diversions and Farm Deliveries (acre-feet)



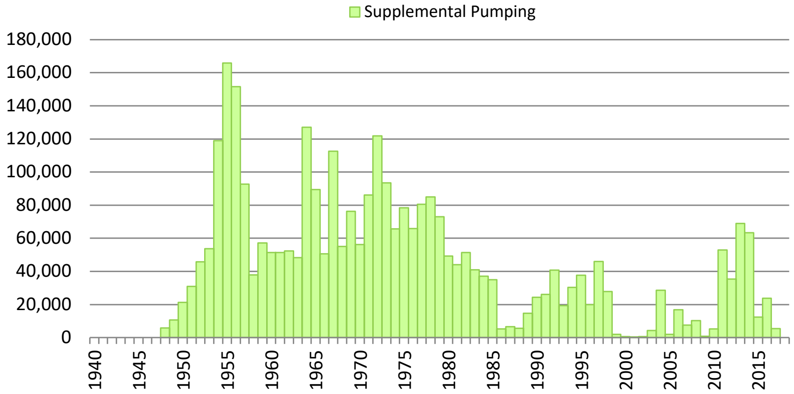
Maximum Application Efficiency and Loss Percentages



Annual Weighted Crop Irrigation Requirement (feet)



Annual Pumping (acre-feet)



Model Version: LRG Model v116 Operational Run 1 - Historical Base Run.

Notes:

(1) Gross Canal Diversions includes the sum of diversions from NM to TX Mesilla plus Franklin Canal diverisons plus Riverside Dam (or ACE post-1999) diversions plus net diversions to/from Tornillo Canal.

(2) Canal loss calculations occur at top of canal and are not in the surface water budget for Mesilla Texas. However a portion of the canal seepage accrues to the ground water objects for Mesilla TX.

(3) Net diversion includes canal diversions, drain returns to canals, and WWTP returns to canals.

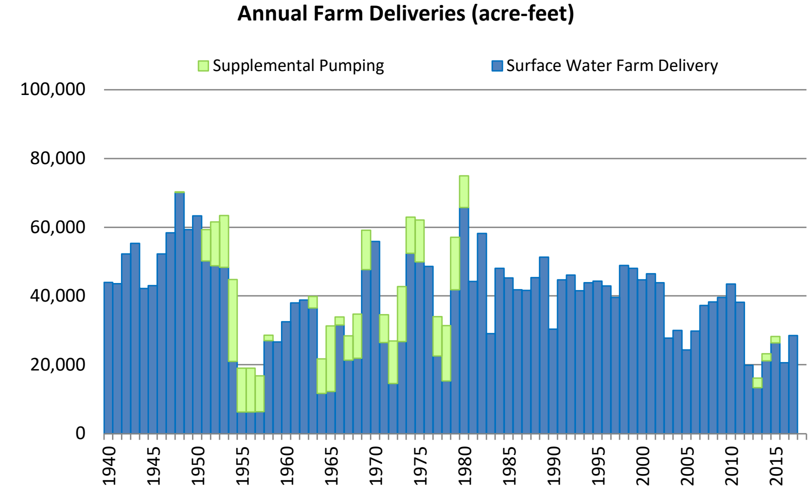
(4) Loss percentages are divided by canal diversion.

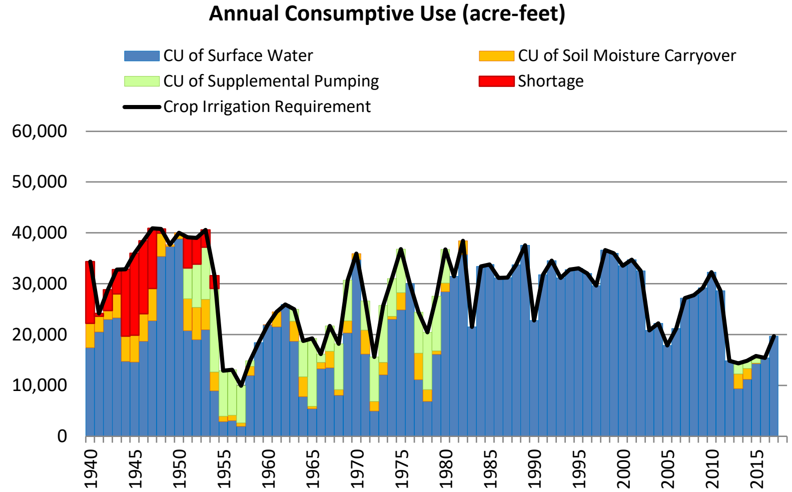
(5) Crop Irrigation Requirement ("CIR") is the total crop consumptive use (a.k.a. consumptive use of applied water) minus effective precipitation.

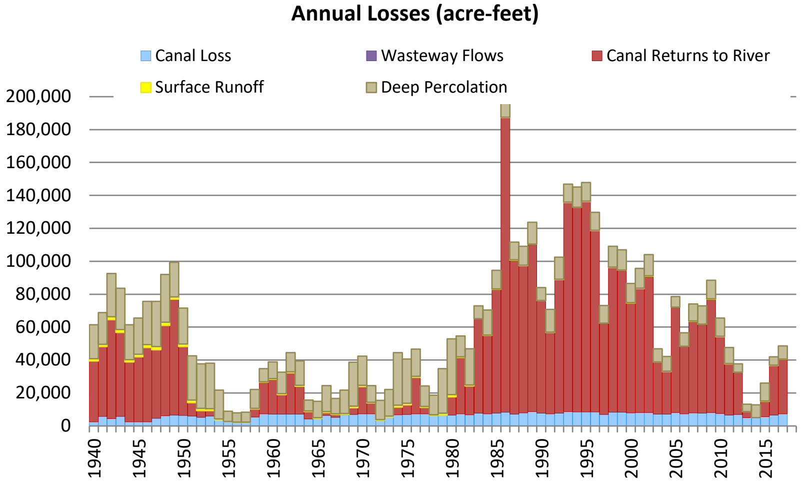
Figure 29-5

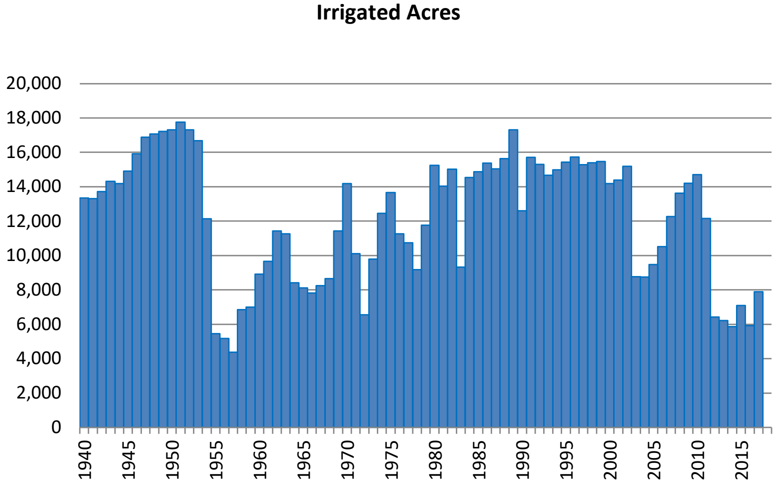
Annual Canal and Farm Water Budget Summary
Historical Base Run (Run 1)
Integrated LRG Model
1940-2017

HCCRD Total







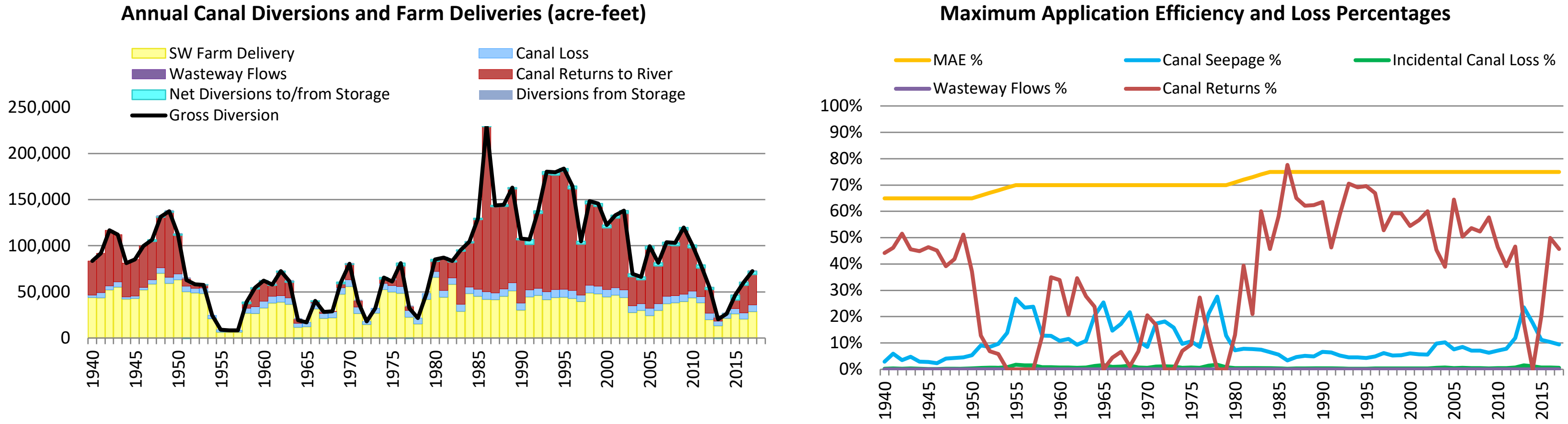


*Note: Different Scales

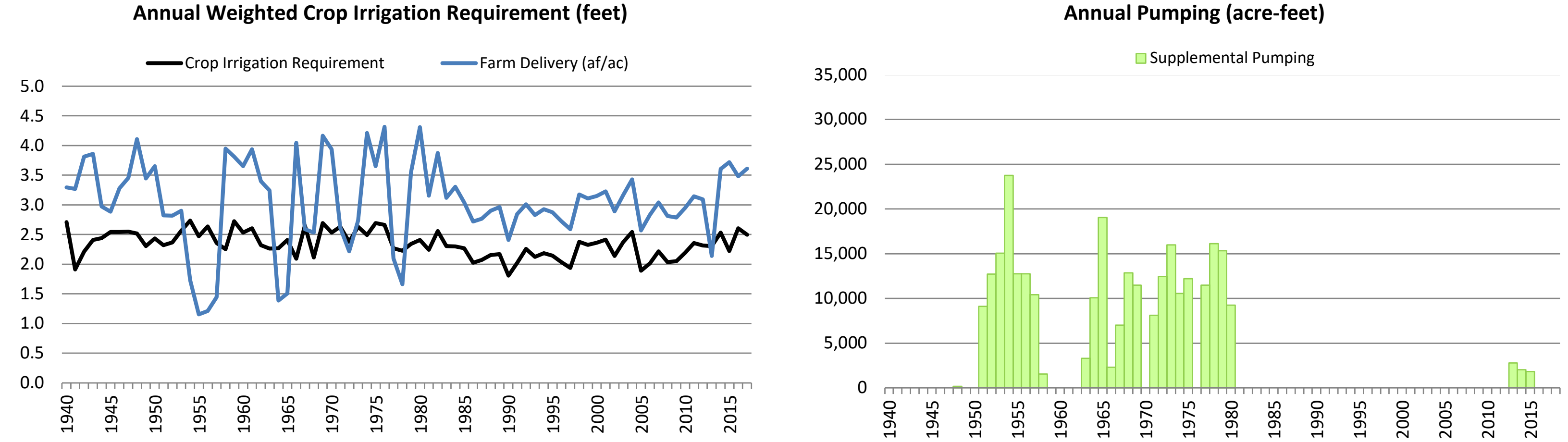
Model Version: LRG Model v116 Operational Run 1 - Historical Base Run.

Figure 29-5

Annual Canal and Farm Water Budget Summary
Historical Base Run (Run 1)
Integrated LRG Model
1940-2017
HCCRD Total


Annual Canal Diversions and Farm Deliveries (acre-feet)

Maximum Application Efficiency and Loss Percentages


Annual Weighted Crop Irrigation Requirement (feet)

Annual Pumping (acre-feet)

Model Version: LRG Model v116 Operational Run 1 - Historical Base Run.

Notes:

(1) Gross Canal Diversions includes the sum of Hudspeth Feeder Canal flows plus Tornillo Canal at Alamo Alto flows plus Tornillo Drain flows plus diversions from drains plus net diversions to/from storage.

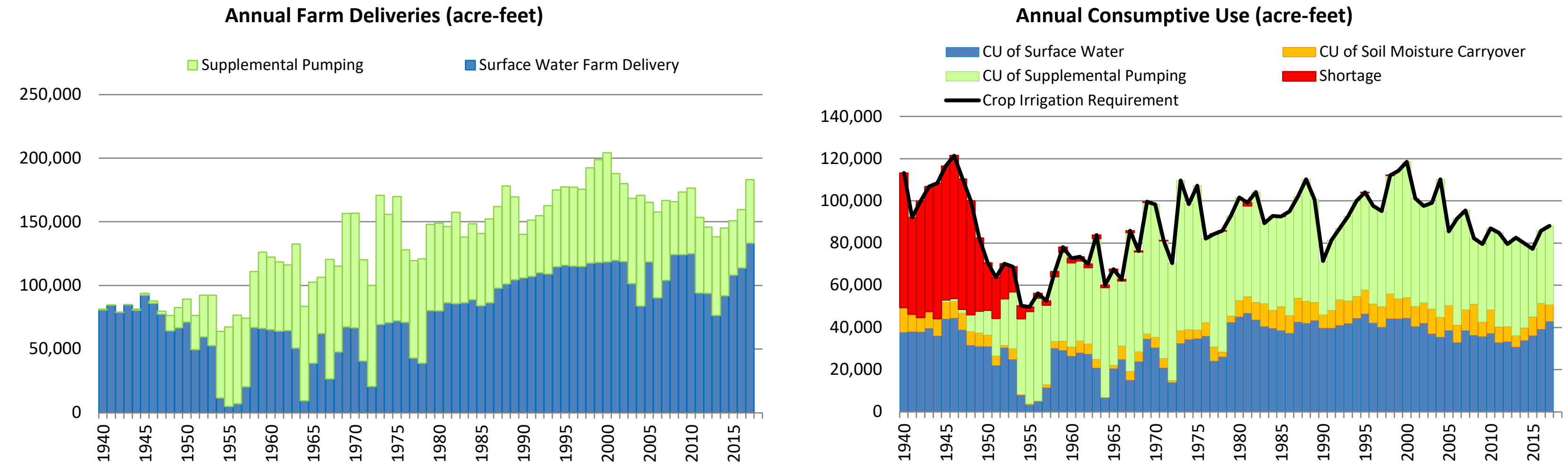
(2) Loss percentages divided by canal diversion. Canal seepage divided by canal diversion + water released from storage.

(3) Crop Irrigation Requirement ("CIR") is the total crop consumptive use (a.k.a. consumptive use of applied water) minus effective precipitation.

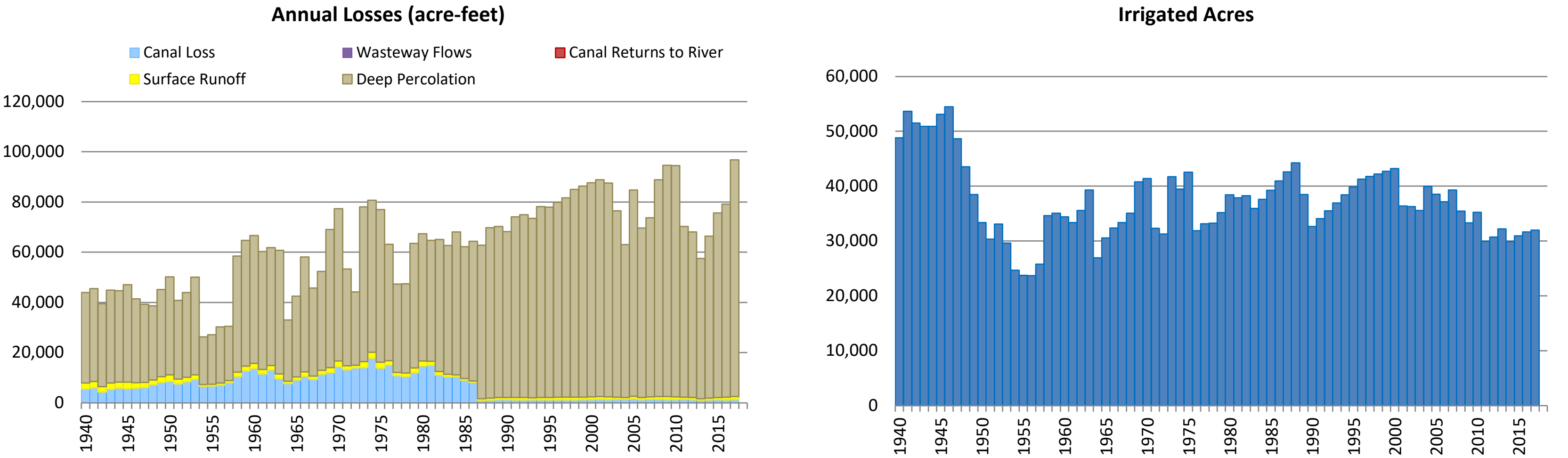
Figure 29-6

Annual Canal and Farm Water Budget Summary
Historical Base Run (Run 1)
Integrated LRG Model
1940-2017

JID Total


Annual Farm Deliveries (acre-feet)

Annual Consumptive Use (acre-feet)


Annual Losses (acre-feet)

Irrigated Acres

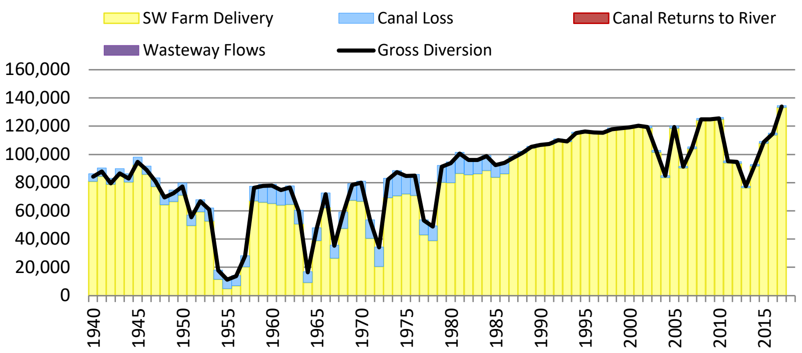
*Note: Different Scales

Model Version: LRG Model v116 Operational Run 1 - Historical Base Run.

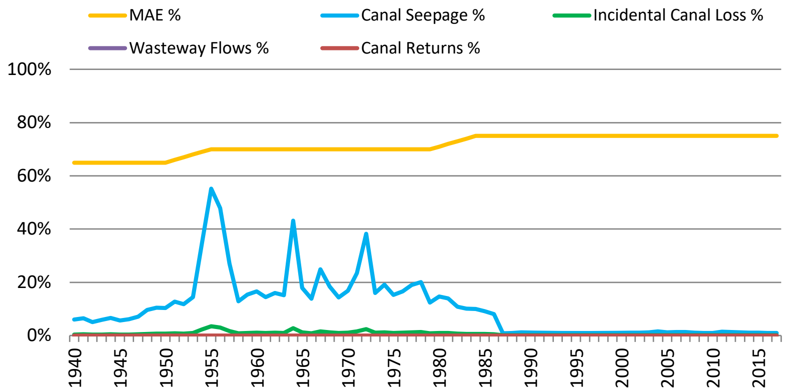
Figure 29-6

Annual Canal and Farm Water Budget Summary
Historical Base Run (Run 1)
Integrated LRG Model
1940-2017
JID Total

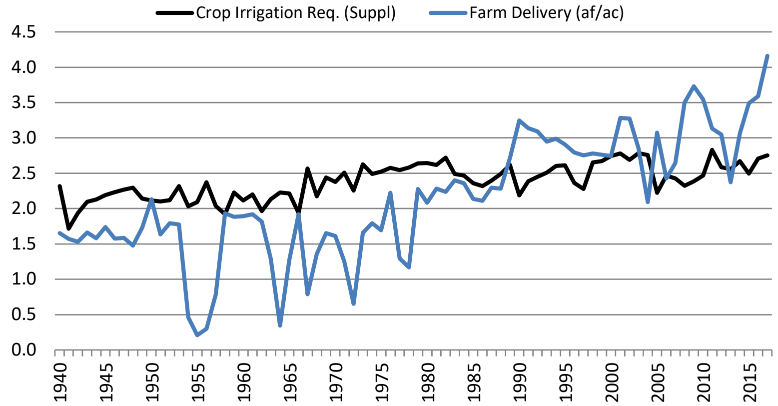
Annual Canal Diversions and Farm Deliveries (acre-feet)



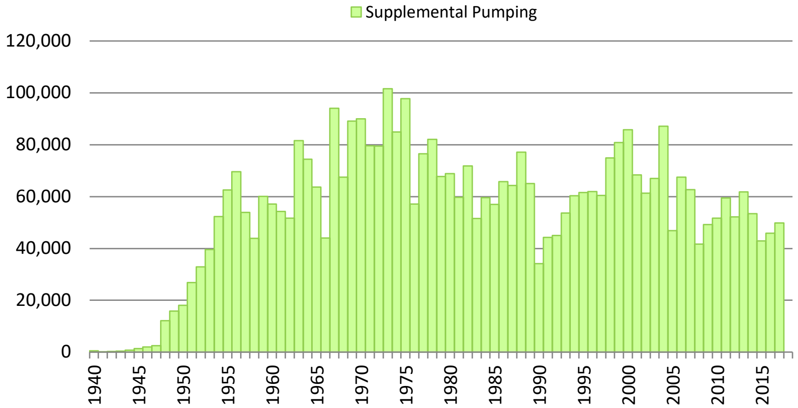
Maximum Application Efficiency and Loss Percentages



Annual Weighted Crop Irrigation Requirement (feet)



Annual Pumping (acre-feet)



Model Version: LRG Model v116 Operational Run 1 - Historical Base Run.

Notes:

(1) Gross Canal Diversions includes the sum of Acequia Madre diversions, lower river diversions, and WWTP flows into canals.

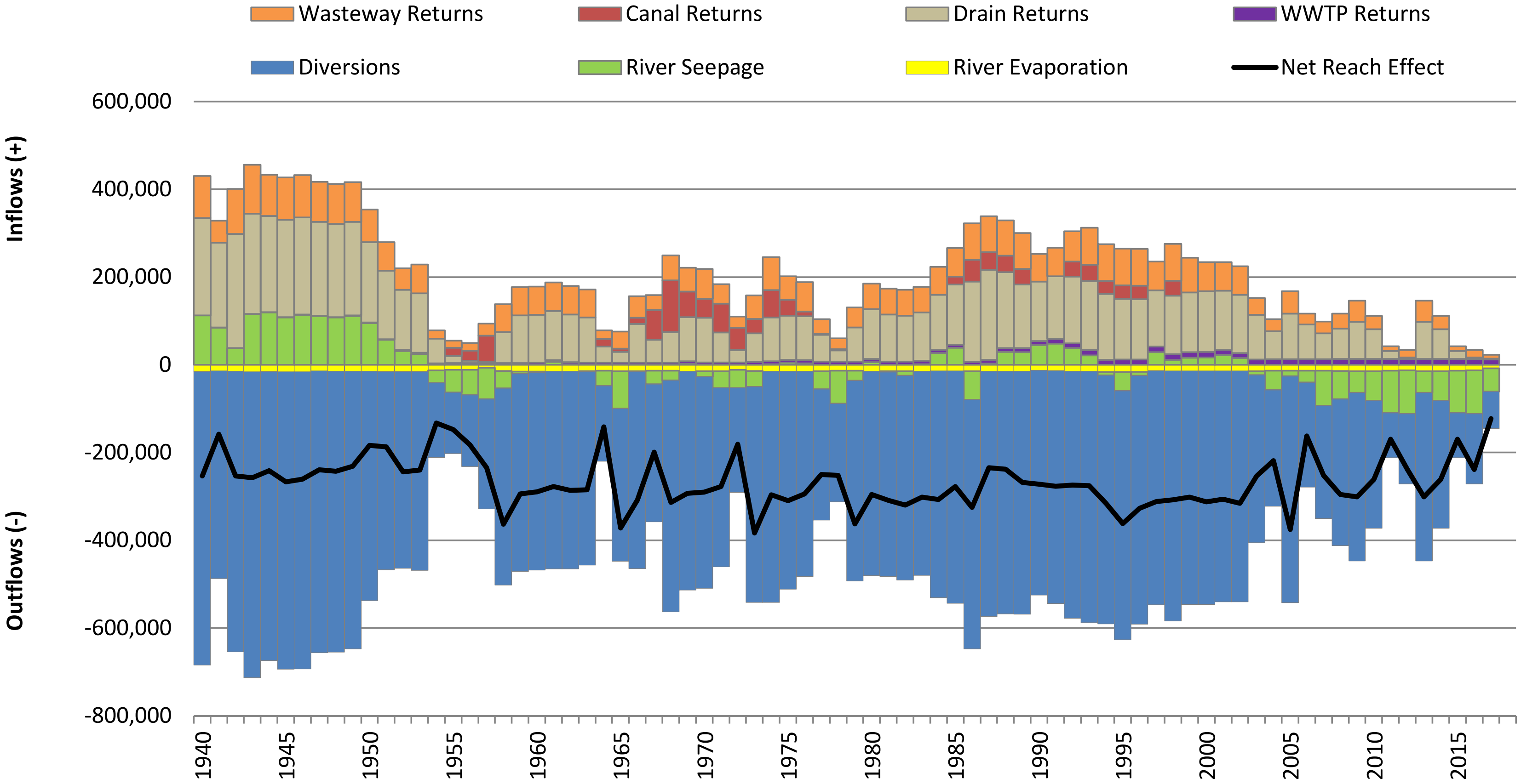
(2) Loss percentages divided by diversions.

(3) Crop Irrigation Requirement ("CIR") is the total crop consumptive use (a.k.a. consumptive use of applied water) minus effective precipitation.

Figure 29-7

Annual River Budget Summary
Historical Base Run (Run 1)
Integrated LRG Model
1940 - 2017 (Acre-Feet)

Total Rincon-Mesilla (Below Caballo to El Paso)

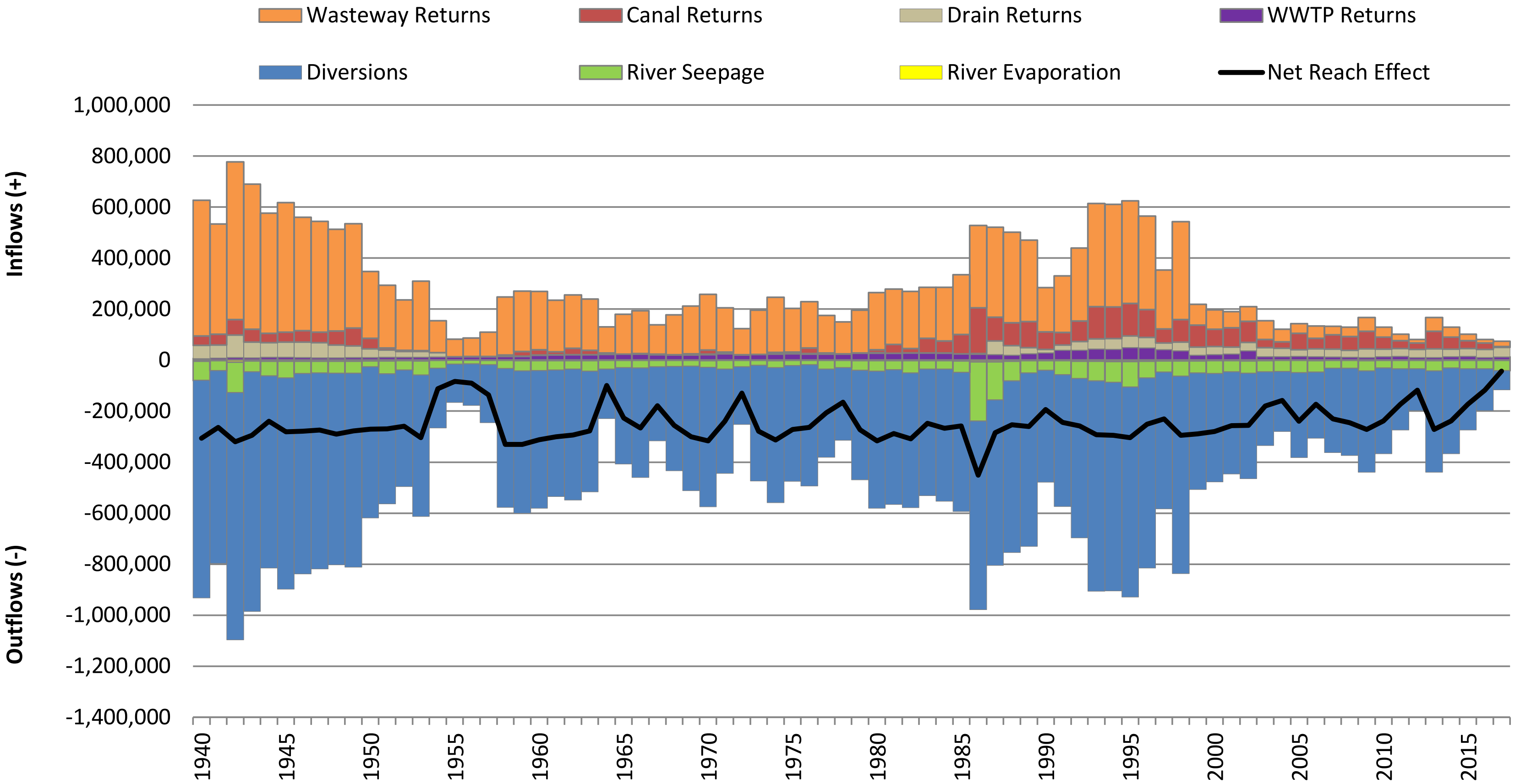


Note:
Net Reach Effect is the change in streamflow through the stream reach, equal to total inflows minus total outflows.
River inflows and outflows not shown on graph.
Model Version: LRG Model v116 Operational Run 1 - Historical Base Run.

Figure 29-8

Annual River Budget Summary
Historical Base Run (Run 1)
Integrated LRG Model
1940 - 2017 (Acre-Feet)

Total El Paso Valley (El Paso to Fort Quitman)



Notes:

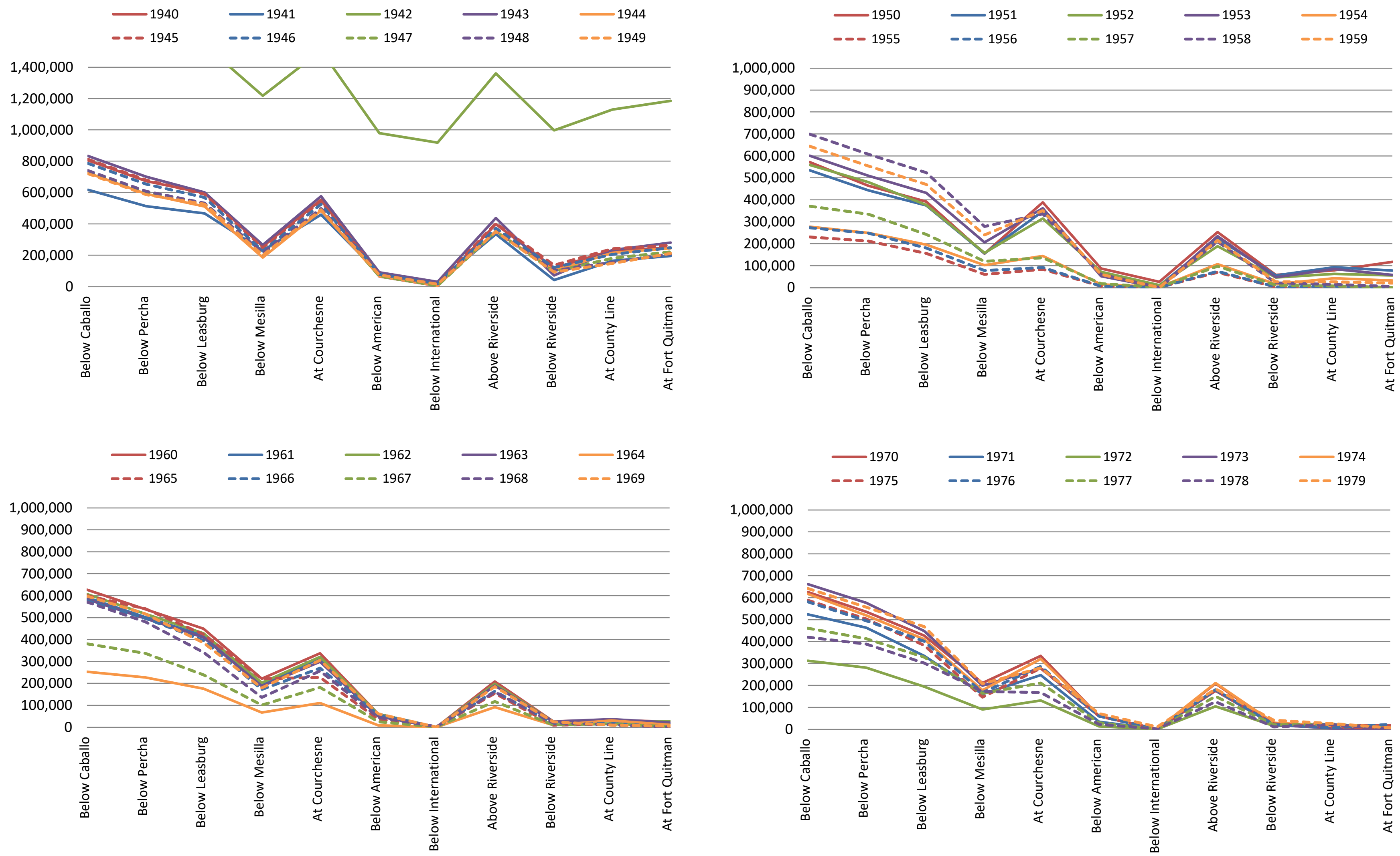
Net Reach Effect is the change in streamflow through the stream reach, equal to total inflows minus total outflows.

River inflows and outflows not shown on graph.

Model Version: LRG Model v116 Operational Run 1 - Historical Base Run.

Figure 29-9

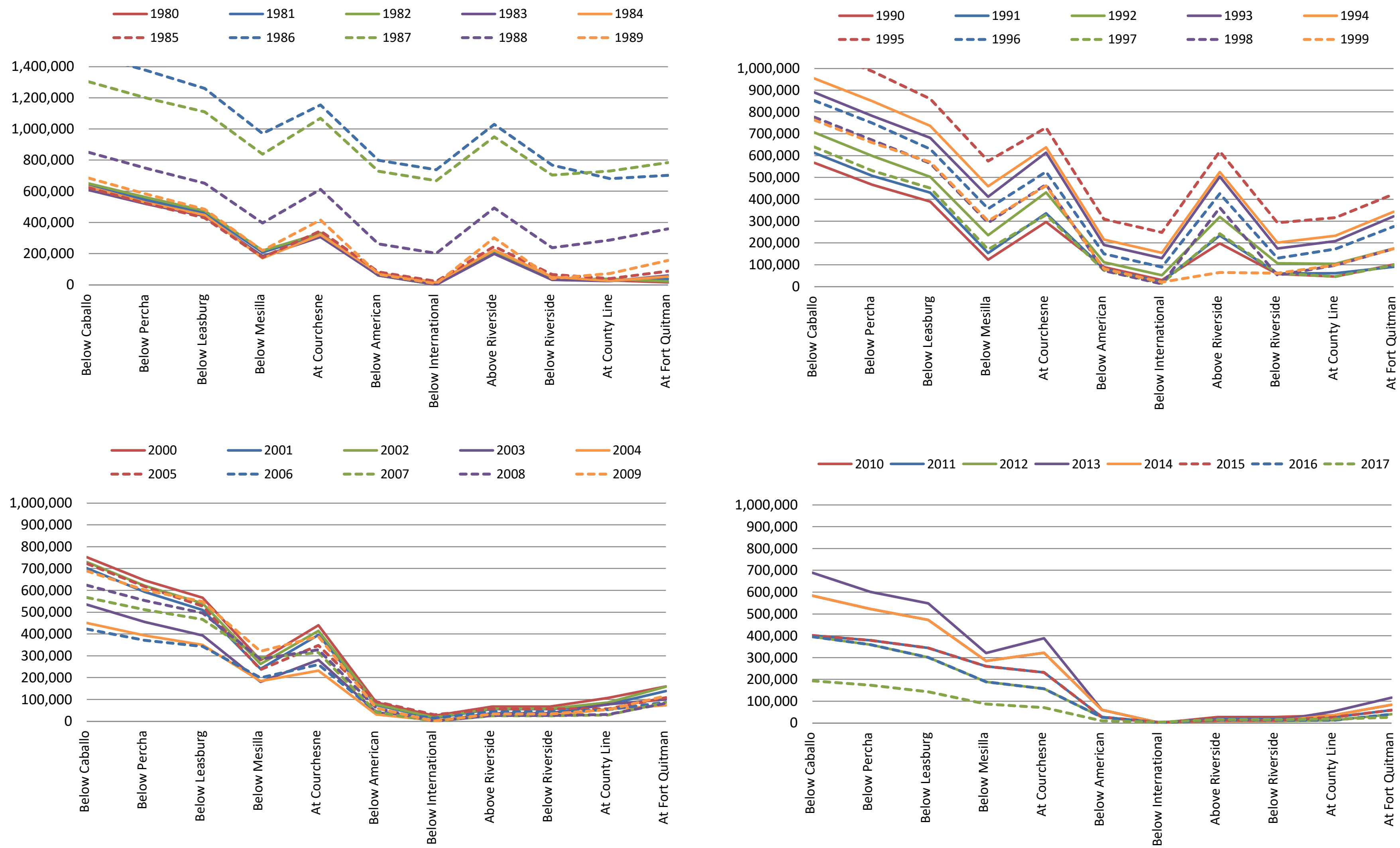
Annual Rio Grande Point Flows
Historical Base Run (Run 1)
Integrated LRG Model
1940-2017 (acre-feet)



*Note Different Scales
Model Version: LRG Model v116 Operational Run 1 - Historical Base Run.

Figure 29-9

Annual Rio Grande Point Flows
Historical Base Run (Run 1)
Integrated LRG Model
1940-2017 (acre-feet)



*Note Different Scales

Model Version: LRG Model v116 Operational Run 1 - Historical Base Run.

Figure 29-10
Monthly Average Rio Grande Flows
Integrated LRG Model - Historical Base Run (Run 1)
1940 - 2017 (cfs)

Flow Legend (CFS)

⬜	0	10
🟩	10	100
🟩	100	200
🟦	200	500
🟦	500	Max

	Month	Below Caballo	Below Percha Dam	Below Leasburg Dam	Below Mesilla Dam	At Courchesne	Below American Dam	Below Intern'l Dam	Below Riverside Dam	At County Line	At Fort Quitman
1940	Jan	2	115	115	174	333	0	0	0	209	397
	Feb	221	271	271	278	386	0	0	91	242	385
	Mar	2264	1989	1641	771	917	148	0	196	294	307
	Apr	2017	1826	1358	568	1056	210	0	222	318	283
	May	1633	1486	1162	395	945	203	0	193	300	270
	Jun	1534	1405	1101	383	935	210	0	185	295	231
	Jul	1736	1609	1241	475	1015	203	0	209	331	227
	Aug	1592	1479	1061	322	906	15	0	234	374	265
	Sep	1436	1333	1026	304	881	0	0	234	388	304
	Oct	793	717	485	71	652	0	0	169	333	301
	Nov	57	241	241	310	692	67	67	229	480	554
	Dec	1	130	130	178	412	0	0	0	260	558
1941	Jan	2	92	92	128	304	0	0	0	212	426
	Feb	131	181	181	192	321	0	0	0	198	394
	Mar	1550	1280	1035	592	683	166	0	0	146	224
	Apr	1435	1289	1022	444	762	210	0	0	142	147
	May	1240	1110	835	257	664	149	0	0	132	122
	Jun	1433	1324	1014	362	788	210	0	0	139	93
	Jul	1265	1178	903	336	799	203	0	0	139	69
	Aug	1394	1264	941	265	735	50	0	0	151	75
	Sep	95	198	152	181	631	140	140	136	260	165
	Oct	795	720	489	11	398	0	0	0	173	162
	Nov	95	241	241	289	624	0	0	159	403	513
	Dec	704	766	766	742	863	239	239	401	610	838
1942	Jan	1152	1184	1184	1133	1198	573	573	732	910	1132
	Feb	1157	1186	1186	1141	1225	100	100	491	847	1183
	Mar	2296	2063	1657	881	1090	184	0	78	272	450
	Apr	3892	3680	3336	2637	2976	2315	2105	2124	2163	1922
	May	9526	9255	8903	7954	8076	7328	7124	7146	7040	6697
	Jun	6349	6206	5879	5201	5727	4965	4755	4846	4856	4909
	Jul	1327	1311	876	241	1115	182	0	134	414	743
	Aug	932	884	558	0	714	148	148	182	414	381
	Sep	1326	1243	843	139	755	0	0	48	291	285
	Oct	625	573	307	0	616	167	167	193	407	363
	Nov	243	408	408	462	816	191	191	348	629	815
	Dec	260	369	369	400	615	0	0	164	444	750
1943	Jan	79	169	169	206	399	0	0	0	270	563
	Feb	580	611	611	588	678	0	0	0	416	689
	Mar	2018	1774	1380	695	870	188	0	52	227	316
	Apr	1696	1529	1134	411	906	210	0	50	224	243
	May	1572	1436	1049	301	856	203	0	47	208	202
	Jun	1385	1271	918	284	844	210	0	44	217	174
	Jul	2036	1906	1436	677	1169	178	0	75	264	179
	Aug	1866	1758	1258	537	1130	0	0	107	341	240
	Sep	1182	1103	680	0	675	12	12	66	273	205
	Oct	1049	969	709	0	630	240	240	262	439	378
	Nov	202	376	376	446	867	242	242	402	648	787
	Dec	95	215	215	266	520	0	0	68	344	702
1944	Jan	5	101	101	144	341	0	0	0	234	495
	Feb	355	393	393	386	494	0	0	211	368	503
	Mar	1492	1244	968	370	553	185	0	77	200	272
	Apr	1707	1517	1125	322	757	210	0	120	232	236
	May	1328	1185	868	243	761	203	0	125	224	208
	Jun	1632	1491	1111	345	857	210	0	150	265	209
	Jul	1568	1444	1061	309	876	181	0	167	284	195
	Aug	1441	1329	955	218	808	0	0	202	326	228
	Sep	1389	1283	896	166	764	0	0	192	320	249
	Oct	912	828	524	0	606	30	30	171	323	296
	Nov	5	198	198	281	685	60	60	224	470	524
	Dec	132	243	243	280	499	0	0	48	312	624

Figure 29-10
Monthly Average Rio Grande Flows
Integrated LRG Model - Historical Base Run (Run 1)
1940 - 2017 (cfs)

Flow Legend (CFS)

0	10
10	100
100	200
200	500
500	Max

	Month	Below Caballo	Below Percha Dam	Below Leasburg Dam	Below Mesilla Dam	At Courchesne	Below American Dam	Below Intern'l Dam	Below Riverside Dam	At County Line	At Fort Quitman
1945	Jan	11	103	103	142	326	0	0	0	219	456
	Feb	413	445	445	430	523	0	0	240	386	506
	Mar	2021	1755	1372	605	775	169	0	143	265	334
	Apr	1718	1536	1176	438	915	210	0	169	283	277
	May	1485	1340	1004	327	847	203	0	156	250	221
	Jun	1688	1549	1138	375	904	210	0	172	272	200
	Jul	1551	1430	1079	330	891	197	0	186	258	164
	Aug	1624	1507	1085	343	921	0	0	235	361	242
	Sep	1597	1486	1017	292	872	0	0	248	326	243
	Oct	837	761	577	0	631	104	104	226	383	342
	Nov	160	335	335	400	782	157	157	315	542	663
	Dec	310	415	415	439	646	21	21	192	444	741
1946	Jan	4	106	106	150	349	0	0	0	238	498
	Feb	328	369	369	363	474	0	0	194	335	498
	Mar	1746	1488	1228	645	786	179	0	147	251	305
	Apr	1710	1523	1157	360	787	210	0	161	198	227
	May	1540	1391	1049	326	840	203	0	166	199	181
	Jun	1664	1525	1138	372	905	210	0	177	229	176
	Jul	1833	1701	1204	460	997	187	0	215	257	173
	Aug	1500	1391	987	261	861	0	0	231	296	204
	Sep	1314	1214	895	168	759	0	0	189	299	223
	Oct	1110	1018	725	0	633	143	143	255	358	327
	Nov	126	309	309	385	799	174	174	265	473	637
	Dec	97	217	217	263	504	0	0	21	260	652
1947	Jan	10	105	105	145	336	0	0	0	199	480
	Feb	217	263	263	268	391	0	0	111	271	439
	Mar	1465	1215	999	503	639	146	0	97	199	253
	Apr	1667	1477	1162	443	804	210	0	120	217	224
	May	1329	1186	909	324	795	203	0	132	187	180
	Jun	1481	1346	1029	355	826	210	0	132	178	141
	Jul	1768	1634	1228	457	964	203	0	193	190	125
	Aug	1446	1336	991	249	824	17	0	200	248	169
	Sep	1595	1481	999	269	840	0	0	210	294	239
	Oct	1155	1064	712	0	639	11	11	152	294	272
	Nov	2	201	201	297	719	94	94	237	472	547
	Dec	2	131	131	188	436	0	0	0	241	617
1948	Jan	2	93	93	135	319	0	0	0	181	451
	Feb	2	70	70	101	252	0	0	0	119	366
	Mar	1493	1235	1060	480	622	136	0	95	162	193
	Apr	1470	1282	1023	417	778	210	0	133	146	170
	May	1329	1179	912	335	759	203	0	120	118	162
	Jun	1570	1427	1093	377	838	210	0	131	140	147
	Jul	1802	1667	1291	513	1020	203	0	189	170	118
	Aug	1716	1595	1095	359	915	27	0	226	221	159
	Sep	1476	1369	900	184	781	0	0	198	215	147
	Oct	1129	1038	709	0	632	122	122	225	269	212
	Nov	119	304	304	388	797	172	172	336	517	693
	Dec	85	207	207	258	499	0	0	44	289	624
1949	Jan	3	100	100	144	341	0	0	0	228	470
	Feb	2	74	74	107	266	0	0	0	172	381
	Mar	1724	1458	1276	431	619	124	0	96	138	209
	Apr	1354	1175	893	269	718	198	0	112	76	168
	May	1181	1037	785	266	711	169	0	108	101	173
	Jun	1475	1334	1040	416	842	210	0	127	103	147
	Jul	1736	1599	1234	459	948	203	0	171	138	101
	Aug	1816	1690	1203	456	993	84	0	223	216	149
	Sep	1336	1235	928	197	797	0	0	184	207	216
	Oct	1088	996	675	0	626	101	101	204	280	277
	Nov	101	283	283	360	768	143	143	309	537	643
	Dec	39	162	162	213	454	0	0	1	242	576

Figure 29-10
Monthly Average Rio Grande Flows
Integrated LRG Model - Historical Base Run (Run 1)
1940 - 2017 (cfs)

Flow Legend (CFS)

⬜	0	10
🟩	10	100
🟩	100	200
🟦	200	500
🟦	500	Max

	Month	Below Caballo	Below Percha Dam	Below Leasburg Dam	Below Mesilla Dam	At Courchesne	Below American Dam	Below Intern'l Dam	Below Riverside Dam	At County Line	At Fort Quitman
1950	Jan	9	100	100	137	318	0	0	0	215	417
	Feb	0	69	69	97	246	58	58	113	177	304
	Mar	1157	988	838	591	661	138	0	87	121	181
	Apr	1293	1088	859	323	591	210	0	0	13	130
	May	1460	1289	929	260	637	191	0	0	13	112
	Jun	1776	1619	1119	349	810	210	0	28	25	63
	Jul	1628	1495	995	261	804	203	0	43	28	69
	Aug	1479	1361	861	150	732	37	0	102	58	16
	Sep	603	583	377	0	562	20	20	70	36	52
	Oct	14	166	144	128	469	37	37	69	96	107
	Nov	0	97	97	144	325	200	200	236	293	236
	Dec	0	70	70	106	253	128	128	206	224	257
1951	Jan	0	55	55	83	216	29	29	170	226	208
	Feb	0	46	46	67	189	2	2	56	108	201
	Mar	1587	1326	1057	615	680	123	0	120	161	161
	Apr	1368	1167	893	201	549	184	0	21	55	100
	May	1422	1253	877	168	587	175	0	13	84	79
	Jun	1689	1533	1033	266	747	210	0	48	121	78
	Jul	1637	1499	999	262	776	125	0	88	149	83
	Aug	487	534	390	150	647	12	0	81	124	59
	Sep	312	402	384	327	575	0	0	53	100	42
	Oct	293	333	333	290	397	0	0	27	94	32
	Nov	0	51	51	84	196	71	71	109	155	91
	Dec	0	40	40	63	170	45	45	126	151	148
1952	Jan	0	36	36	53	156	0	0	110	134	194
	Feb	0	33	33	44	140	0	0	8	81	175
	Mar	1302	1146	866	475	514	62	0	72	135	142
	Apr	1052	916	639	140	372	38	0	20	84	106
	May	839	746	553	144	411	49	0	14	73	62
	Jun	968	906	736	401	606	144	0	43	70	41
	Jul	2027	1767	1267	447	684	203	0	54	51	24
	Aug	1748	1549	1049	292	728	203	0	60	31	10
	Sep	1192	1096	753	290	706	210	0	53	7	6
	Oct	61	172	135	123	431	80	0	32	47	4
	Nov	0	70	70	114	247	122	122	156	163	71
	Dec	0	52	52	85	193	68	68	145	149	79
1953	Jan	0	44	44	68	171	0	0	123	136	134
	Feb	0	38	38	56	152	0	0	17	78	133
	Mar	1716	1439	1151	675	713	84	0	125	176	137
	Apr	1435	1228	954	260	561	135	0	17	57	89
	May	1544	1368	972	208	590	159	0	14	88	68
	Jun	1793	1631	1131	363	793	210	0	51	131	74
	Jul	1535	1398	1020	355	842	173	0	77	132	61
	Aug	907	914	722	404	799	79	0	105	153	72
	Sep	486	553	529	457	635	0	0	73	120	45
	Oct	487	494	494	430	453	0	0	36	105	31
	Nov	0	33	33	65	134	9	9	49	115	50
	Dec	0	26	26	46	120	0	0	77	112	62
1954	Jan	0	27	27	40	115	0	0	70	109	102
	Feb	0	27	27	35	106	0	0	0	75	99
	Mar	1225	1069	797	417	443	0	0	66	127	130
	Apr	1114	972	720	261	409	31	0	20	89	94
	May	626	598	513	317	458	31	0	17	101	55
	Jun	440	408	337	194	279	32	0	0	85	40
	Jul	902	797	651	369	386	69	0	0	60	16
	Aug	204	175	110	33	94	18	0	2	16	2
	Sep	44	31	12	0	33	33	33	48	26	1
	Oct	1	7	5	3	18	18	18	33	14	0
	Nov	0	6	6	5	16	0	0	0	0	0
	Dec	0	5	5	4	18	0	0	0	0	0

Figure 29-10
Monthly Average Rio Grande Flows
Integrated LRG Model - Historical Base Run (Run 1)
1940 - 2017 (cfs)

Flow Legend (CFS)

⬜	0	10
🟩	10	100
▨	100	200
🟦	200	500
■	500	Max

	Month	Below Caballo	Below Percha Dam	Below Leasburg Dam	Below Mesilla Dam	At Courchesne	Below American Dam	Below Intern'l Dam	Below Riverside Dam	At County Line	At Fort Quitman
1955	Jan	0	5	5	7	23	0	0	0	0	0
	Feb	0	5	5	5	25	0	0	0	1	0
	Mar	1179	1034	828	508	442	0	0	22	31	0
	Apr	468	398	283	0	212	27	27	0	28	0
	May	577	487	396	159	188	0	0	0	23	0
	Jun	264	212	154	0	79	1	1	0	4	0
	Jul	567	480	392	132	181	31	0	0	6	0
	Aug	500	428	337	101	165	32	0	0	7	1
	Sep	200	163	139	65	49	0	0	0	2	1
	Oct	37	25	17	0	4	3	3	19	6	0
	Nov	0	2	2	3	3	0	0	0	1	0
	Dec	0	2	2	3	3	0	0	0	0	0
1956	Jan	0	2	2	3	3	0	0	0	1	0
	Feb	0	2	2	3	3	0	0	0	1	0
	Mar	1416	1233	972	581	485	0	0	48	45	2
	Apr	735	631	507	60	245	0	0	0	15	0
	May	884	770	663	378	325	8	0	0	18	0
	Jun	564	477	386	110	189	44	0	0	9	0
	Jul	622	529	426	122	210	42	0	0	10	1
	Aug	165	107	6	0	21	18	0	0	4	1
	Sep	60	29	0	0	7	0	0	0	2	1
	Oct	43	23	1	0	3	0	0	0	1	0
	Nov	0	1	1	2	3	0	0	0	1	0
	Dec	0	1	1	2	3	0	0	0	1	0
1957	Jan	0	2	2	3	3	0	0	0	1	0
	Feb	0	2	2	3	3	0	0	0	1	0
	Mar	0	3	3	3	4	4	4	20	7	0
	Apr	0	3	3	3	4	4	4	18	4	0
	May	0	2	2	3	4	4	4	19	7	0
	Jun	0	2	2	3	4	4	4	21	5	0
	Jul	1564	1340	882	341	541	0	0	20	25	1
	Aug	2278	1925	1425	688	728	203	0	33	30	0
	Sep	1461	1272	1000	475	601	73	0	38	33	0
	Oct	771	689	601	393	310	0	0	2	18	0
	Nov	0	24	24	29	15	0	0	0	0	0
	Dec	0	18	18	13	16	0	0	0	1	0
1958	Jan	0	19	19	13	8	0	0	0	1	0
	Feb	0	19	19	12	7	0	0	0	1	0
	Mar	1666	1415	1175	743	642	105	0	60	59	7
	Apr	1916	1659	1398	677	648	179	0	10	32	0
	May	1998	1784	1416	631	678	203	0	9	22	0
	Jun	2072	1885	1385	555	771	210	0	36	36	0
	Jul	2102	1936	1436	624	890	203	0	52	51	1
	Aug	1101	1071	912	524	774	88	0	50	20	1
	Sep	364	449	423	361	496	0	0	32	0	11
	Oct	291	353	353	321	381	0	0	19	0	31
	Nov	0	57	57	79	128	3	3	37	0	11
	Dec	0	41	41	52	99	0	0	52	9	29
1959	Jan	0	36	36	42	90	0	0	39	6	12
	Feb	0	32	32	35	81	0	0	0	1	12
	Mar	1750	1465	1177	685	660	123	0	83	63	41
	Apr	1742	1516	1225	495	650	187	0	12	31	14
	May	1761	1577	1182	425	687	203	0	15	42	15
	Jun	1857	1694	1194	415	773	210	0	41	51	16
	Jul	1852	1706	1206	451	852	203	0	57	60	4
	Aug	651	684	582	361	724	62	0	50	28	47
	Sep	487	550	532	470	617	0	0	46	44	21
	Oct	518	519	519	464	450	0	0	32	36	46
	Nov	0	30	30	63	105	0	0	15	28	54
	Dec	0	22	22	41	90	0	0	47	42	48

Figure 29-10
Monthly Average Rio Grande Flows
Integrated LRG Model - Historical Base Run (Run 1)
1940 - 2017 (cfs)

Flow Legend (CFS)

⬜	0	10
🟩	10	100
▧	100	200
🟦	200	500
■	500	Max

	Month	Below Caballo	Below Percha Dam	Below Leasburg Dam	Below Mesilla Dam	At Courchesne	Below American Dam	Below Intern'l Dam	Below Riverside Dam	At County Line	At Fort Quitman
1960	Jan	0	23	23	36	90	0	0	51	54	17
	Feb	0	24	24	31	84	0	0	0	25	37
	Mar	1768	1482	1206	732	703	130	0	101	93	56
	Apr	1800	1564	1265	501	669	210	0	12	23	23
	May	1755	1567	1162	379	663	203	0	12	25	30
	Jun	1838	1673	1173	398	769	210	0	42	29	25
	Jul	1713	1560	1060	316	733	203	0	43	25	39
	Aug	525	579	472	286	675	33	0	47	14	36
	Sep	482	527	511	461	569	0	0	40	29	42
	Oct	447	449	449	403	401	0	0	28	85	51
	Nov	0	29	29	62	109	0	0	26	86	42
	Dec	0	23	23	43	97	0	0	56	52	28
1961	Jan	0	24	24	38	96	0	0	56	57	42
	Feb	0	24	24	32	87	0	0	0	33	36
	Mar	1563	1291	1021	570	568	114	0	80	80	29
	Apr	1703	1465	1180	442	615	203	0	9	14	18
	May	1769	1577	1158	360	646	201	0	11	28	30
	Jun	1767	1602	1153	377	753	210	0	38	46	13
	Jul	1713	1567	1067	317	746	203	0	47	43	1
	Aug	489	529	405	194	595	57	0	46	39	1
	Sep	373	433	414	370	509	0	0	38	21	1
	Oct	376	395	395	353	379	0	0	30	44	2
	Nov	0	28	28	60	99	0	0	19	7	31
	Dec	0	25	25	45	98	0	0	60	69	38
1962	Jan	0	24	24	38	95	0	0	58	62	27
	Feb	0	25	25	33	87	0	0	0	32	39
	Mar	1670	1397	1120	654	637	135	0	93	94	32
	Apr	1718	1481	1198	471	644	210	0	8	14	37
	May	1710	1521	1123	356	645	203	0	9	28	22
	Jun	1821	1653	1153	375	747	210	0	40	38	7
	Jul	1763	1615	1115	365	787	203	0	44	25	50
	Aug	679	712	584	353	736	28	0	70	52	1
	Sep	327	372	352	319	431	0	0	32	36	57
	Oct	306	319	319	280	309	0	0	20	31	49
	Nov	0	23	23	54	93	0	0	13	25	86
	Dec	0	16	16	34	77	0	0	39	35	54
1963	Jan	0	19	19	31	82	0	0	41	52	45
	Feb	0	20	20	28	77	0	0	0	30	49
	Mar	1618	1340	1060	591	580	153	0	74	73	32
	Apr	1668	1428	1155	452	600	210	0	8	16	51
	May	1684	1492	1099	333	611	203	0	8	46	13
	Jun	1802	1633	1133	351	710	210	0	37	70	10
	Jul	1619	1473	985	259	681	26	0	72	98	25
	Aug	518	565	463	267	595	11	0	53	67	12
	Sep	343	397	380	336	453	0	0	35	46	3
	Oct	370	376	376	336	335	0	0	22	23	3
	Nov	0	31	31	63	109	0	0	31	42	48
	Dec	0	25	25	45	98	0	0	61	52	70
1964	Jan	0	25	25	38	90	0	0	55	74	43
	Feb	0	25	25	33	82	0	0	0	48	47
	Mar	1053	906	655	305	314	0	0	39	76	30
	Apr	912	793	588	58	311	13	0	8	71	18
	May	647	605	509	294	382	30	0	8	85	22
	Jun	337	317	273	102	218	20	0	0	78	19
	Jul	538	466	378	113	225	45	0	0	49	6
	Aug	478	408	325	111	165	28	0	0	19	1
	Sep	163	130	110	46	29	0	0	15	6	1
	Oct	24	17	10	0	4	1	1	31	13	0
	Nov	0	2	2	4	3	0	0	0	1	0
	Dec	0	2	2	3	3	0	0	0	1	0

Figure 29-10
Monthly Average Rio Grande Flows
Integrated LRG Model - Historical Base Run (Run 1)
1940 - 2017 (cfs)

Flow Legend (CFS)

	0	10
	10	100
	100	200
	200	500
	500	Max

	Month	Below Caballo	Below Percha Dam	Below Leasburg Dam	Below Mesilla Dam	At Courchesne	Below American Dam	Below Intern'l Dam	Below Riverside Dam	At County Line	At Fort Quitman
1965	Jan	0	2	2	4	3	0	0	0	1	0
	Feb	0	2	2	4	3	0	0	0	1	0
	Mar	495	429	356	223	161	0	0	0	5	0
	Apr	673	567	443	93	202	0	0	0	9	0
	May	897	765	647	350	282	0	0	0	16	0
	Jun	1418	1229	1027	572	487	37	0	13	20	1
	Jul	2447	2110	1648	835	781	203	0	40	43	1
	Aug	2401	2085	1585	727	746	203	0	33	34	1
	Sep	1197	1075	842	419	575	160	0	26	0	0
	Oct	335	380	349	290	369	0	0	25	46	2
	Nov	0	45	45	77	97	0	0	20	35	0
	Dec	0	22	22	39	41	0	0	10	20	0
1966	Jan	0	23	23	33	43	0	0	12	23	0
	Feb	0	23	23	28	44	0	0	0	22	0
	Mar	1427	1265	942	551	539	103	0	49	48	1
	Apr	1464	1291	982	374	533	174	0	3	6	0
	May	1646	1429	1086	411	577	199	0	5	38	0
	Jun	1652	1433	1031	313	546	210	0	20	4	0
	Jul	1866	1675	1175	397	685	178	0	36	3	1
	Aug	1041	951	662	151	520	62	0	32	0	1
	Sep	189	294	257	214	432	0	0	27	3	1
	Oct	205	255	254	243	307	0	0	20	27	0
	Nov	0	41	41	74	111	0	0	37	49	19
	Dec	0	30	30	53	93	0	0	60	57	20
1967	Jan	0	29	29	45	89	0	0	56	56	17
	Feb	0	27	27	38	79	0	0	0	31	21
	Mar	1451	1287	891	588	565	137	0	57	54	4
	Apr	1395	1220	768	256	486	116	0	4	22	1
	May	1136	986	596	72	407	32	0	0	33	0
	Jun	518	522	400	114	411	11	0	17	32	0
	Jul	549	526	454	206	376	17	0	0	19	1
	Aug	949	851	656	335	448	70	0	0	1	1
	Sep	183	147	69	0	82	0	0	0	0	1
	Oct	77	56	28	0	26	26	26	50	19	0
	Nov	0	5	5	9	11	0	0	0	0	0
	Dec	0	4	4	8	11	0	0	0	0	0
1968	Jan	0	6	6	8	12	0	0	0	0	0
	Feb	0	9	9	9	17	0	0	0	0	0
	Mar	1504	1293	951	423	514	134	0	51	30	0
	Apr	1498	1299	799	216	497	137	0	12	0	1
	May	1296	1105	605	0	498	117	40	50	34	1
	Jun	1219	1125	767	217	502	61	0	35	19	1
	Jul	1612	1422	930	369	543	142	0	26	0	0
	Aug	1512	1377	877	393	659	150	0	33	1	1
	Sep	372	426	276	224	464	0	0	32	11	1
	Oct	360	376	337	256	323	0	0	24	15	0
	Nov	0	38	38	70	107	0	0	25	24	0
	Dec	0	31	31	53	93	0	0	53	53	11
1969	Jan	0	29	29	44	83	0	0	44	15	0
	Feb	0	27	27	37	74	0	0	0	22	18
	Mar	1539	1357	919	561	592	155	0	65	44	1
	Apr	1489	1310	810	253	551	139	0	14	18	0
	May	1474	1265	767	118	458	57	0	11	7	0
	Jun	1752	1534	1034	378	644	154	0	32	0	1
	Jul	1934	1736	1236	497	772	203	0	36	0	1
	Aug	1181	1137	855	426	775	203	0	34	0	1
	Sep	218	318	286	217	499	77	0	22	0	1
	Oct	249	287	286	275	326	0	0	21	0	0
	Nov	0	45	45	82	140	15	15	56	51	12
	Dec	0	34	34	60	117	0	0	82	17	47

Figure 29-10
Monthly Average Rio Grande Flows
Integrated LRG Model - Historical Base Run (Run 1)
1940 - 2017 (cfs)

Flow Legend (CFS)

⬜	0	10
🟩	10	100
🟩	100	200
🟦	200	500
🟦	500	Max

	Month	Below Caballo	Below Percha Dam	Below Leasburg Dam	Below Mesilla Dam	At Courchesne	Below American Dam	Below Intern'l Dam	Below Riverside Dam	At County Line	At Fort Quitman
1970	Jan	0	32	32	51	110	0	0	73	26	27
	Feb	0	29	29	43	96	0	0	0	25	42
	Mar	1642	1371	1007	585	624	134	0	82	61	36
	Apr	1702	1498	1114	395	668	210	0	9	7	1
	May	1765	1593	1093	351	695	203	0	9	30	4
	Jun	1698	1545	1045	343	740	203	0	35	25	1
	Jul	1654	1501	1001	337	773	146	0	41	17	1
	Aug	709	739	602	404	711	93	0	41	23	1
	Sep	636	637	603	464	548	0	0	37	4	29
	Oct	495	477	477	423	395	0	0	24	20	42
	Nov	0	17	17	51	84	0	0	5	22	65
	Dec	0	16	16	35	78	0	0	46	42	51
1971	Jan	0	19	19	31	78	0	0	47	46	44
	Feb	0	20	20	28	72	0	0	0	30	43
	Mar	1519	1337	958	551	553	132	0	79	59	23
	Apr	1640	1449	968	350	618	210	0	23	21	11
	May	1477	1247	747	138	502	112	0	15	27	1
	Jun	1570	1347	847	188	511	76	0	40	39	0
	Jul	676	660	398	143	475	28	0	46	21	1
	Aug	710	701	582	396	493	15	0	55	41	2
	Sep	628	598	570	450	422	0	0	53	38	1
	Oct	430	399	399	333	283	0	0	31	23	0
	Nov	0	10	10	29	45	0	0	0	22	0
	Dec	0	7	7	14	26	0	0	1	16	0
1972	Jan	0	9	9	13	32	0	0	1	16	0
	Feb	0	12	12	13	36	0	0	0	20	0
	Mar	1491	1304	830	438	480	23	0	91	89	19
	Apr	1359	1192	722	218	485	73	0	23	37	0
	May	1171	1038	765	343	494	71	0	28	61	7
	Jun	668	633	530	302	412	14	0	45	68	12
	Jul	304	282	224	96	164	14	0	0	30	1
	Aug	145	119	105	59	46	24	0	13	0	0
	Sep	3	5	0	2	10	10	10	37	0	0
	Oct	1	3	1	1	4	4	4	30	2	0
	Nov	0	2	2	5	4	0	0	0	0	0
	Dec	0	2	2	4	3	0	0	0	0	0
1973	Jan	0	2	2	5	5	0	0	0	0	0
	Feb	0	3	3	5	5	0	0	0	0	0
	Mar	1487	1304	1041	625	546	154	0	63	46	1
	Apr	1705	1479	1149	538	547	142	0	20	6	1
	May	1793	1525	1104	360	524	111	0	18	7	1
	Jun	1905	1678	1178	388	591	150	0	37	0	1
	Jul	1763	1576	1077	325	631	203	0	32	0	1
	Aug	1594	1443	1058	413	728	203	0	40	0	1
	Sep	261	368	318	167	501	23	0	44	0	1
	Oct	382	406	397	344	363	0	0	35	0	0
	Nov	0	30	30	65	84	0	0	10	4	0
	Dec	0	21	21	42	63	0	0	33	1	0
1974	Jan	0	23	23	37	67	0	0	36	13	0
	Feb	0	23	23	32	63	0	0	0	7	0
	Mar	1932	1639	1323	769	767	176	0	133	89	22
	Apr	1867	1639	1245	510	723	210	0	26	20	1
	May	1855	1666	1167	420	744	203	0	19	33	1
	Jun	1802	1639	1139	409	785	210	0	45	33	5
	Jul	1425	1326	826	223	745	190	0	38	0	2
	Aug	862	831	542	105	577	0	0	37	0	1
	Sep	293	338	239	167	353	0	0	18	0	1
	Oct	132	176	158	140	236	0	0	27	0	16
	Nov	0	48	48	80	144	19	19	65	18	54
	Dec	0	29	29	51	92	0	0	58	45	30

Figure 29-10
Monthly Average Rio Grande Flows
Integrated LRG Model - Historical Base Run (Run 1)
1940 - 2017 (cfs)

Flow Legend (CFS)

0	10
10	100
100	200
200	500
500	Max

	Month	Below Caballo	Below Percha Dam	Below Leasburg Dam	Below Mesilla Dam	At Courchesne	Below American Dam	Below Intern'l Dam	Below Riverside Dam	At County Line	At Fort Quitman
1975	Jan	0	28	28	45	94	0	0	60	36	31
	Feb	0	27	27	38	86	0	0	0	8	71
	Mar	1363	1203	909	512	517	166	0	65	38	2
	Apr	1493	1313	989	405	558	200	0	21	3	1
	May	1496	1274	897	168	457	70	0	12	5	0
	Jun	1627	1408	908	154	532	91	0	32	0	0
	Jul	1682	1488	988	258	649	203	0	26	0	1
	Aug	1545	1409	992	339	706	203	0	28	0	1
	Sep	156	254	181	92	441	55	0	25	0	0
	Oct	305	337	314	272	343	0	0	32	0	0
	Nov	0	38	38	76	120	0	0	47	33	0
	Dec	0	24	24	50	89	0	0	60	23	0
1976	Jan	0	24	24	44	92	0	0	62	25	1
	Feb	0	24	24	37	84	0	0	0	0	20
	Mar	1693	1422	1094	599	615	141	0	99	40	50
	Apr	1799	1558	1230	447	623	210	0	17	0	21
	May	1735	1544	1112	313	605	203	0	5	0	25
	Jun	1723	1556	1056	294	672	210	0	19	0	23
	Jul	1605	1458	958	229	646	203	0	19	0	21
	Aug	340	426	325	114	510	22	0	19	0	5
	Sep	354	404	396	276	396	0	0	21	0	33
	Oct	330	341	341	301	305	0	0	21	0	64
	Nov	0	32	32	67	105	0	0	28	12	78
	Dec	0	23	23	44	82	0	0	49	35	40
1977	Jan	0	23	23	38	82	0	0	56	53	25
	Feb	0	24	24	32	76	0	0	0	26	49
	Mar	1310	1156	873	475	460	140	0	67	57	6
	Apr	1484	1307	987	419	505	210	0	19	25	0
	May	1470	1256	883	202	392	86	0	11	26	0
	Jun	1392	1220	820	152	428	33	0	36	41	1
	Jul	368	419	339	212	442	12	0	40	36	1
	Aug	649	629	587	447	448	15	0	44	33	1
	Sep	495	467	467	370	330	0	0	36	21	0
	Oct	434	401	401	322	261	0	0	25	28	0
	Nov	0	8	8	28	34	0	0	0	27	0
	Dec	0	6	6	13	20	0	0	0	27	0
1978	Jan	0	8	8	12	25	0	0	0	22	0
	Feb	0	9	9	11	27	0	0	0	26	0
	Mar	1227	1062	770	383	342	0	0	62	77	16
	Apr	854	761	594	266	308	0	0	19	53	3
	May	834	751	639	366	348	35	0	17	59	8
	Jun	655	598	532	360	327	26	0	0	55	6
	Jul	1382	1233	1039	643	559	163	0	1	21	1
	Aug	1647	1459	1107	571	523	123	0	35	4	1
	Sep	280	268	225	141	191	0	0	0	0	0
	Oct	6	22	8	22	49	34	34	50	35	0
	Nov	0	11	11	25	28	0	0	0	1	0
	Dec	0	15	15	23	30	0	0	5	3	0
1979	Jan	0	17	17	20	28	0	0	4	17	0
	Feb	0	19	19	19	25	0	0	0	21	0
	Mar	0	19	19	17	24	24	24	57	48	3
	Apr	1165	997	863	479	400	0	0	2	0	0
	May	1589	1369	1172	566	512	96	0	46	19	0
	Jun	2253	1951	1565	680	682	210	0	49	30	1
	Jul	2046	1810	1352	514	710	203	0	52	0	1
	Aug	1898	1698	1213	417	690	203	0	55	0	1
	Sep	1553	1394	1126	361	699	210	0	56	10	1
	Oct	103	240	215	113	434	67	0	46	23	0
	Nov	0	106	106	145	261	136	136	184	161	67
	Dec	0	69	69	96	158	33	33	127	108	34

Figure 29-10
Monthly Average Rio Grande Flows
Integrated LRG Model - Historical Base Run (Run 1)
1940 - 2017 (cfs)

Flow Legend (CFS)

⬜	0	10
🟩	10	100
🟦	100	200
🟦	200	500
🟦	500	Max

	Month	Below Caballo	Below Percha Dam	Below Leasburg Dam	Below Mesilla Dam	At Courchesne	Below American Dam	Below Intern'l Dam	Below Riverside Dam	At County Line	At Fort Quitman
1980	Jan	0	55	55	73	126	0	0	98	84	25
	Feb	0	44	44	57	104	0	0	0	24	0
	Mar	1627	1327	1098	572	580	137	0	38	59	8
	Apr	1755	1534	1253	576	721	210	0	50	45	0
	May	1765	1566	1207	457	725	203	0	45	55	4
	Jun	1929	1745	1279	495	791	210	0	52	49	2
	Jul	1909	1738	1238	479	844	203	0	63	58	11
	Aug	782	811	664	205	605	26	0	54	7	1
	Sep	239	332	318	210	413	0	0	37	2	22
	Oct	329	365	365	267	339	0	0	32	45	37
	Nov	0	42	42	70	132	7	7	57	35	58
	Dec	0	30	30	47	94	0	0	64	16	89
1981	Jan	0	28	28	39	86	0	0	57	41	52
	Feb	0	26	26	33	77	0	0	0	26	63
	Mar	1688	1376	1142	582	580	166	0	35	48	32
	Apr	1871	1616	1319	584	715	210	0	50	41	42
	May	1794	1590	1213	453	725	203	0	44	54	32
	Jun	1951	1764	1312	517	812	210	0	54	54	12
	Jul	1883	1713	1213	452	831	200	0	61	31	1
	Aug	555	609	492	98	514	0	0	45	1	48
	Sep	326	412	401	285	463	0	0	43	30	58
	Oct	360	388	388	283	342	0	0	35	54	79
	Nov	0	38	38	66	127	2	2	57	74	81
	Dec	0	22	22	36	76	0	0	51	10	98
1982	Jan	0	23	23	32	76	0	0	50	44	46
	Feb	0	23	23	28	71	0	0	0	34	67
	Mar	1725	1409	1172	603	595	165	0	42	45	27
	Apr	1890	1630	1336	597	713	210	0	60	57	35
	May	1799	1591	1225	464	714	203	0	47	65	40
	Jun	1920	1731	1270	472	763	210	0	47	63	16
	Jul	1881	1707	1213	447	808	201	0	55	63	6
	Aug	727	765	647	234	619	0	0	57	51	1
	Sep	337	421	410	291	477	0	0	41	21	0
	Oct	419	443	443	334	384	0	0	41	51	24
	Nov	0	39	39	68	128	3	3	60	85	40
	Dec	0	26	26	43	90	0	0	66	59	52
1983	Jan	0	26	26	37	87	0	0	63	60	64
	Feb	0	25	25	31	77	0	0	0	39	75
	Mar	1433	1142	931	433	444	110	0	25	25	75
	Apr	1532	1319	1065	438	559	188	0	33	18	95
	May	1705	1488	1150	401	645	203	0	29	42	77
	Jun	1862	1668	1244	436	718	210	0	35	62	59
	Jul	1791	1616	1159	387	759	203	0	43	32	66
	Aug	1073	1052	842	220	643	74	0	50	10	80
	Sep	306	412	392	251	523	0	0	41	32	65
	Oct	309	349	349	260	340	0	0	34	1	116
	Nov	0	49	49	77	149	24	24	76	14	140
	Dec	0	37	37	54	111	0	0	81	59	71
1984	Jan	0	32	32	44	98	0	0	70	70	12
	Feb	0	30	30	36	85	0	0	0	23	76
	Mar	1591	1282	1054	508	515	139	0	38	6	64
	Apr	1773	1520	1245	553	680	210	0	56	3	65
	May	1745	1536	1199	445	704	203	0	51	19	49
	Jun	1767	1582	1181	374	678	210	0	45	2	74
	Jul	1818	1643	1177	405	778	203	0	57	1	28
	Aug	1193	1087	739	0	481	33	10	52	0	61
	Sep	452	516	423	133	499	0	0	48	1	60
	Oct	9	133	125	96	340	58	58	87	36	124
	Nov	0	91	91	126	264	139	139	191	151	153
	Dec	0	61	61	86	175	50	50	148	93	121

Figure 29-10
Monthly Average Rio Grande Flows
Integrated LRG Model - Historical Base Run (Run 1)
1940 - 2017 (cfs)

Flow Legend (CFS)

⬜	0	10
🟩	10	100
🟦	100	200
🟦	200	500
🟦	500	Max

	Month	Below Caballo	Below Percha Dam	Below Leasburg Dam	Below Mesilla Dam	At Courchesne	Below American Dam	Below Intern'l Dam	Below Riverside Dam	At County Line	At Fort Quitman
1985	Jan	0	51	51	70	154	0	0	122	68	108
	Feb	0	42	42	56	130	0	0	17	43	111
	Mar	1172	928	741	314	369	112	0	23	2	69
	Apr	1514	1306	1054	447	594	210	0	33	8	59
	May	1719	1502	1153	451	752	283	80	131	62	136
	Jun	1990	1792	1292	526	804	210	0	75	32	123
	Jul	1829	1654	1154	425	819	203	0	77	3	135
	Aug	1599	1441	941	269	703	50	0	83	5	107
	Sep	356	438	317	0	503	34	34	87	1	185
	Oct	78	188	164	95	374	0	0	53	29	133
	Nov	0	99	99	138	301	176	176	222	224	169
	Dec	0	71	71	103	205	80	80	172	171	116
1986	Jan	443	459	459	436	459	271	271	418	336	283
	Feb	2928	2863	2863	2701	2510	2322	2322	2358	2119	1931
	Mar	2360	2098	1687	1109	1338	719	557	620	503	577
	Apr	1716	1532	1078	416	851	210	0	47	48	236
	May	1704	1532	1083	404	826	203	0	27	13	282
	Jun	2364	2202	1702	986	1385	748	538	556	362	566
	Jul	2962	2795	2295	1565	1973	1280	1076	1106	878	973
	Aug	2471	2364	2050	1324	1859	1109	1109	1152	953	1025
	Sep	1122	1213	1145	933	1384	643	643	693	565	679
	Oct	2037	2088	2077	1912	2073	1542	1542	1496	1407	1422
	Nov	2297	2330	2330	2265	2322	2197	2197	2213	2142	1881
	Dec	2168	2202	2202	2146	2214	2089	2089	2143	2055	1862
1987	Jan	1318	1373	1373	1360	1494	1310	1310	1438	1386	1356
	Feb	2785	2776	2776	2670	2643	2459	2459	2492	2421	2368
	Mar	2408	2177	1830	1292	1598	1122	988	1041	1015	1289
	Apr	2094	1925	1497	815	1284	732	521	564	620	779
	May	3521	3313	2871	2117	2458	1877	1674	1694	1699	1648
	Jun	2907	2763	2263	1560	2041	1457	1247	1290	1297	1439
	Jul	3876	3688	3188	2392	2777	2039	1836	1877	1864	1833
	Aug	1202	1140	882	294	990	175	146	225	328	599
	Sep	332	452	381	173	701	0	0	44	171	329
	Oct	233	339	327	243	555	0	0	0	199	265
	Nov	0	96	96	146	317	196	196	236	324	353
	Dec	952	955	955	906	906	785	785	857	865	805
1988	Jan	1137	1146	1146	1095	1108	924	924	1054	1028	1056
	Feb	2274	2250	2250	2139	2076	1892	1892	1926	1831	1866
	Mar	1525	1296	904	335	712	142	0	69	35	575
	Apr	2129	1918	1474	775	1138	547	337	364	474	437
	May	1665	1498	1036	362	835	203	0	44	222	284
	Jun	1812	1648	1148	442	891	210	0	38	119	289
	Jul	1802	1646	1146	448	901	203	0	39	160	195
	Aug	1018	932	709	166	713	21	0	37	147	227
	Sep	446	551	497	320	727	0	0	40	194	221
	Oct	296	390	382	310	570	0	0	0	161	236
	Nov	0	98	98	143	309	188	188	232	249	324
	Dec	0	61	61	91	197	76	76	163	195	271
1989	Jan	0	49	49	73	173	0	0	136	198	211
	Feb	0	41	41	59	148	0	0	31	109	223
	Mar	1809	1512	1124	475	663	134	0	18	52	246
	Apr	1914	1681	1237	518	838	210	0	28	88	218
	May	1791	1601	1144	433	824	203	0	27	73	214
	Jun	2029	1849	1349	602	993	210	0	37	103	215
	Jul	1999	1833	1333	590	1005	203	0	41	72	182
	Aug	1086	1013	830	204	775	29	0	38	88	193
	Sep	410	506	454	263	646	0	0	28	66	237
	Oct	231	312	305	230	433	0	0	0	38	270
	Nov	0	67	67	104	221	100	100	146	151	217
	Dec	0	45	45	71	153	32	32	123	160	165

Figure 29-10
Monthly Average Rio Grande Flows
Integrated LRG Model - Historical Base Run (Run 1)
1940 - 2017 (cfs)

Flow Legend (CFS)

	0	10
	10	100
	100	200
	200	500
	500	Max

	Month	Below Caballo	Below Percha Dam	Below Leasburg Dam	Below Mesilla Dam	At Courchesne	Below American Dam	Below Intern'l Dam	Below Riverside Dam	At County Line	At Fort Quitman
1990	Jan	0	40	40	61	139	0	0	106	136	180
	Feb	0	35	35	50	120	0	0	11	73	198
	Mar	1169	911	720	282	348	107	0	8	6	146
	Apr	1431	1223	976	383	537	202	0	16	5	136
	May	1585	1370	1046	311	596	203	0	23	7	120
	Jun	1793	1598	1189	387	694	210	0	39	4	115
	Jul	1576	1405	991	223	649	203	0	37	3	77
	Aug	1279	1158	758	19	496	63	0	33	2	69
	Sep	498	532	381	0	429	137	137	145	40	196
	Oct	15	141	126	88	380	101	101	134	88	117
	Nov	0	94	94	133	290	169	169	219	203	198
	Dec	0	68	68	99	202	81	81	174	191	139
1991	Jan	0	53	53	75	165	0	0	131	171	110
	Feb	0	43	43	59	138	0	0	26	78	129
	Mar	1302	1036	827	396	441	100	0	27	13	136
	Apr	1586	1372	1102	488	641	210	0	35	23	108
	May	1727	1515	1172	429	711	203	0	43	73	105
	Jun	1818	1628	1201	411	732	210	0	47	66	95
	Jul	1650	1480	1073	307	726	203	0	49	11	102
	Aug	1067	1012	711	77	536	63	0	44	5	109
	Sep	910	837	595	0	472	32	32	68	36	115
	Oct	41	166	132	44	415	0	0	56	59	57
	Nov	0	108	108	149	337	216	216	266	269	244
	Dec	0	76	76	108	227	106	106	203	210	197
1992	Jan	0	61	61	86	190	6	6	160	164	232
	Feb	0	49	49	67	156	0	0	47	63	254
	Mar	1112	915	746	408	449	78	0	16	6	200
	Apr	1494	1332	1093	584	800	318	140	186	156	249
	May	2191	1950	1579	843	1088	549	346	404	342	449
	Jun	1967	1774	1278	560	914	210	0	107	111	277
	Jul	1961	1781	1281	547	954	203	0	107	96	154
	Aug	1674	1513	1013	345	794	116	0	90	76	156
	Sep	1015	965	721	47	656	0	0	87	68	178
	Oct	207	311	261	102	517	0	0	67	72	181
	Nov	0	119	119	167	369	248	248	293	328	286
	Dec	0	83	83	116	235	113	113	204	245	265
1993	Jan	0	64	64	91	196	12	12	170	221	271
	Feb	0	51	51	72	164	0	0	51	71	271
	Mar	1804	1517	1185	665	784	115	0	25	47	319
	Apr	1909	1714	1320	621	951	210	0	45	83	301
	May	2548	2337	1929	1180	1495	699	495	537	560	628
	Jun	3767	3553	3053	2230	2520	1601	1391	1445	1431	1466
	Jul	1987	1847	1347	664	1164	204	0	92	174	494
	Aug	1640	1503	1072	416	930	48	0	57	130	314
	Sep	696	763	668	329	840	0	0	54	150	298
	Oct	320	421	402	296	588	0	0	0	113	341
	Nov	0	93	93	140	306	185	185	236	255	336
	Dec	0	63	63	96	209	88	88	182	228	293
1994	Jan	255	278	278	272	332	148	148	297	322	361
	Feb	707	706	706	659	656	472	472	532	489	611
	Mar	1843	1564	1168	517	749	120	0	39	69	408
	Apr	2090	1866	1375	652	952	210	0	44	121	313
	May	2901	2688	2234	1494	1792	1042	839	876	906	905
	Jun	3442	3243	2743	1934	2241	1240	1030	1102	1104	1253
	Jul	2114	1967	1467	749	1224	203	0	91	170	446
	Aug	1569	1454	1204	553	1067	43	0	70	178	304
	Sep	574	651	588	380	765	0	0	52	110	350
	Oct	284	341	333	266	445	0	0	0	70	295
	Nov	0	58	58	97	203	81	81	133	147	248
	Dec	0	41	41	69	150	29	29	123	200	209

Figure 29-10
Monthly Average Rio Grande Flows
Integrated LRG Model - Historical Base Run (Run 1)
1940 - 2017 (cfs)

Flow Legend (CFS)

⬜	0	10
🟩	10	100
🟦	100	200
🟦	200	500
🟦	500	Max

	Month	Below Caballo	Below Percha Dam	Below Leasburg Dam	Below Mesilla Dam	At Courchesne	Below American Dam	Below Intern'l Dam	Below Riverside Dam	At County Line	At Fort Quitman
1995	Jan	0	37	37	58	135	0	0	119	183	234
	Feb	576	562	562	513	496	320	320	382	377	458
	Mar	2127	1825	1401	715	871	125	0	45	116	403
	Apr	2178	1945	1462	739	1000	210	0	51	116	360
	May	2038	1846	1346	633	1029	203	0	55	117	346
	Jun	3916	3691	3191	2345	2560	1672	1462	1503	1422	1437
	Jul	3884	3687	3187	2387	2704	1679	1476	1557	1507	1611
	Aug	1364	1288	1060	463	1063	38	0	98	167	523
	Sep	578	642	584	392	734	0	0	48	148	374
	Oct	123	191	183	141	342	0	0	0	91	272
	Nov	265	280	280	281	312	199	199	246	270	309
	Dec	955	924	924	861	786	674	674	752	723	685
1996	Jan	861	856	856	809	778	603	603	744	702	785
	Feb	1131	1122	1122	1055	1012	836	836	887	849	936
	Mar	2066	1786	1339	680	876	143	0	53	106	489
	Apr	2072	1853	1353	647	963	210	0	47	109	358
	May	2059	1870	1370	646	1029	203	0	52	170	316
	Jun	2027	1845	1345	602	994	210	0	53	159	268
	Jul	1964	1791	1291	558	967	203	0	53	135	186
	Aug	920	832	641	34	641	20	0	43	100	229
	Sep	549	606	554	361	646	0	0	37	106	281
	Oct	440	481	475	377	506	0	0	0	119	289
	Nov	0	49	49	89	177	64	64	114	161	228
	Dec	0	33	33	58	120	7	7	101	159	207
1997	Jan	0	30	30	49	109	0	0	95	139	196
	Feb	0	29	29	42	97	0	0	0	33	231
	Mar	1461	1158	944	438	465	125	0	39	20	135
	Apr	1637	1405	1151	515	647	210	0	61	42	116
	May	1758	1547	1209	463	724	203	0	75	66	125
	Jun	1831	1643	1247	442	739	210	0	79	58	91
	Jul	1808	1634	1220	441	821	203	0	92	42	30
	Aug	1412	1261	848	109	569	38	0	77	10	70
	Sep	609	619	460	0	440	15	15	72	2	147
	Oct	16	150	135	72	367	11	11	60	9	149
	Nov	0	99	99	134	260	147	147	196	168	193
	Dec	0	63	63	89	173	61	61	160	174	150
1998	Jan	0	51	51	71	145	0	0	126	117	168
	Feb	0	42	42	57	123	0	0	17	52	188
	Mar	1896	1597	1218	572	727	115	0	22	105	233
	Apr	2094	1859	1393	660	903	210	0	45	115	252
	May	2039	1845	1391	674	997	203	0	54	133	275
	Jun	2088	1912	1412	658	1047	210	0	59	133	270
	Jul	2054	1891	1391	669	1038	203	0	60	144	213
	Aug	1590	1451	1173	468	973	48	0	66	147	231
	Sep	678	761	694	455	839	0	0	61	136	250
	Oct	336	406	396	319	494	0	0	0	98	270
	Nov	0	89	89	132	278	165	165	208	267	275
	Dec	0	51	51	79	160	48	48	135	162	250
1999	Jan	0	43	43	63	135	0	0	110	161	197
	Feb	0	37	37	51	118	0	0	129	132	205
	Mar	2055	1746	1418	776	798	145	0	33	83	228
	Apr	2541	2288	1905	1125	1261	210	0	32	123	318
	May	1980	1790	1400	657	979	203	0	24	92	259
	Jun	1928	1756	1300	574	947	210	0	22	108	219
	Jul	2007	1843	1423	663	1030	203	0	42	100	202
	Aug	1744	1597	1277	525	982	17	0	49	143	216
	Sep	322	412	360	206	622	0	0	32	56	242
	Oct	0	126	121	134	361	175	175	183	186	251
	Nov	0	69	69	108	231	119	119	216	253	272
	Dec	0	45	45	73	158	46	46	153	196	258

Figure 29-10
Monthly Average Rio Grande Flows
Integrated LRG Model - Historical Base Run (Run 1)
1940 - 2017 (cfs)

Flow Legend (CFS)

⬜	0	10
🟩	10	100
🟩	100	200
🟦	200	500
🟦	500	Max

	Month	Below Caballo	Below Percha Dam	Below Leasburg Dam	Below Mesilla Dam	At Courchesne	Below American Dam	Below Intern'l Dam	Below Riverside Dam	At County Line	At Fort Quitman
2000	Jan	0	40	40	61	140	0	0	148	183	239
	Feb	0	35	35	49	119	0	0	105	114	187
	Mar	1726	1416	1199	669	678	151	0	27	49	176
	Apr	2153	1900	1645	975	1072	210	0	26	90	218
	May	1992	1784	1432	673	935	203	0	22	94	188
	Jun	1606	1478	1169	421	767	210	0	17	76	183
	Jul	2181	1991	1595	788	1112	203	0	46	113	132
	Aug	1834	1672	1181	432	876	12	0	44	137	171
	Sep	874	864	716	210	651	0	0	46	116	224
	Oct	21	157	140	93	406	141	141	145	232	264
	Nov	0	103	103	140	292	181	181	276	325	337
	Dec	0	75	75	103	209	97	97	212	244	323
2001	Jan	0	57	57	79	166	0	0	162	179	258
	Feb	0	46	46	61	135	0	0	117	89	218
	Mar	1252	967	758	332	384	109	0	14	46	131
	Apr	1913	1667	1402	772	860	210	0	20	29	200
	May	1853	1649	1316	575	842	203	0	20	44	164
	Jun	2025	1836	1410	603	903	210	0	21	23	189
	Jul	2060	1883	1443	661	1038	203	0	42	82	125
	Aug	1823	1663	1182	438	850	54	0	40	105	150
	Sep	619	638	534	167	600	0	0	31	71	187
	Oct	19	151	139	97	370	89	89	98	122	207
	Nov	0	77	77	112	231	117	117	226	262	242
	Dec	0	51	51	75	150	34	34	142	206	237
2002	Jan	0	43	43	61	127	0	0	133	155	215
	Feb	0	37	37	50	110	0	0	108	108	196
	Mar	1330	1037	831	347	397	106	0	15	30	153
	Apr	2028	1782	1535	878	952	210	0	23	72	206
	May	1985	1772	1433	675	916	203	0	22	96	199
	Jun	2213	2016	1585	766	1056	210	0	26	91	217
	Jul	1906	1734	1312	538	912	203	0	36	72	189
	Aug	1833	1670	1229	475	890	56	0	42	115	189
	Sep	714	726	634	232	655	0	0	33	102	253
	Oct	20	152	139	108	386	81	81	90	107	253
	Nov	0	89	89	127	269	154	154	259	277	286
	Dec	0	57	57	86	174	60	60	177	201	278
2003	Jan	0	48	48	70	151	0	0	154	169	243
	Feb	0	40	40	56	127	0	0	120	128	200
	Mar	586	474	340	63	152	85	0	4	35	129
	Apr	1222	1043	854	429	487	210	0	9	37	101
	May	1433	1232	992	360	495	129	0	11	69	87
	Jun	1901	1665	1328	480	665	210	0	14	74	91
	Jul	1662	1467	1063	260	629	36	0	30	95	78
	Aug	1276	1162	929	485	781	25	0	38	137	125
	Sep	469	550	526	430	620	0	0	31	125	148
	Oct	255	298	298	259	334	0	0	17	106	129
	Nov	0	39	39	62	115	1	1	107	177	161
	Dec	0	29	29	41	86	0	0	87	143	178
2004	Jan	0	28	28	35	82	0	0	83	125	168
	Feb	0	26	26	30	75	0	0	82	100	147
	Mar	779	634	482	141	177	30	0	8	39	106
	Apr	1132	957	779	366	406	55	0	11	80	115
	May	977	898	778	410	482	62	0	13	83	98
	Jun	1871	1645	1407	679	712	148	0	17	93	100
	Jul	1598	1387	1190	596	771	117	0	33	96	106
	Aug	927	919	839	574	712	31	0	35	81	118
	Sep	138	188	178	135	240	0	0	12	57	75
	Oct	3	35	33	32	80	61	61	56	69	52
	Nov	0	16	16	20	41	0	0	43	46	52
	Dec	0	17	17	20	43	0	0	46	41	78

Figure 29-10
Monthly Average Rio Grande Flows
Integrated LRG Model - Historical Base Run (Run 1)
1940 - 2017 (cfs)

Flow Legend (CFS)

⬜	0	10
🟩	10	100
🟩	100	200
🟦	200	500
🟦	500	Max

	Month	Below Caballo	Below Percha Dam	Below Leasburg Dam	Below Mesilla Dam	At Courchesne	Below American Dam	Below Intern'l Dam	Below Riverside Dam	At County Line	At Fort Quitman
2005	Jan	0	19	19	21	43	0	0	58	54	69
	Feb	0	21	21	21	42	0	0	41	33	104
	Mar	762	640	518	227	222	0	0	11	15	90
	Apr	1568	1361	1172	709	673	83	0	18	17	141
	May	1501	1339	1141	582	625	102	0	16	11	152
	Jun	1943	1727	1446	637	771	166	0	18	50	117
	Jul	2220	1989	1540	685	905	203	0	35	37	126
	Aug	1915	1713	1213	415	723	203	0	26	8	179
	Sep	1555	1388	1064	288	669	210	0	23	21	133
	Oct	454	414	317	0	406	80	57	68	53	163
	Nov	0	154	154	197	420	304	304	395	382	300
	Dec	0	102	102	131	242	126	126	229	255	215
2006	Jan	0	73	73	94	174	0	0	165	174	203
	Feb	0	55	55	70	136	0	0	116	128	175
	Mar	729	633	510	260	296	107	0	10	31	105
	Apr	1564	1384	1196	764	787	210	0	18	46	114
	May	1787	1574	1323	632	749	147	0	18	73	115
	Jun	1402	1285	1091	517	721	20	0	21	82	98
	Jul	691	675	614	381	580	1	0	29	75	124
	Aug	773	728	662	434	474	1	0	24	46	114
	Sep	11	67	55	46	155	125	125	118	46	142
	Oct	3	43	42	42	104	109	109	100	65	107
	Nov	0	27	27	30	72	0	0	69	64	74
	Dec	0	17	17	20	47	0	0	51	63	67
2007	Jan	0	20	20	21	50	0	0	54	67	78
	Feb	0	22	22	22	51	0	0	49	49	115
	Mar	1081	922	776	407	373	111	0	13	14	75
	Apr	1680	1478	1301	835	797	153	0	20	9	144
	May	1619	1421	1191	542	636	90	0	17	37	127
	Jun	792	826	784	591	707	99	0	18	45	107
	Jul	1715	1492	1333	761	757	166	0	30	16	143
	Aug	1421	1313	1173	723	802	71	0	37	31	103
	Sep	643	664	647	505	575	0	0	29	9	184
	Oct	374	382	382	323	329	0	0	17	27	151
	Nov	0	25	25	38	72	0	0	70	89	104
	Dec	0	20	20	25	55	0	0	58	76	87
2008	Jan	0	22	22	24	53	0	0	56	79	79
	Feb	0	22	22	23	48	0	0	47	48	101
	Mar	1204	1027	861	448	410	110	0	15	14	78
	Apr	1968	1728	1520	977	906	210	0	21	20	112
	May	2047	1804	1546	809	831	203	0	19	19	134
	Jun	1405	1346	1223	790	908	210	0	21	51	97
	Jul	1694	1444	1213	512	618	203	0	21	9	201
	Aug	1116	1023	775	278	522	53	0	24	8	124
	Sep	376	453	422	317	492	0	0	25	18	122
	Oct	452	491	490	413	454	0	0	23	19	125
	Nov	0	47	47	64	106	0	0	97	132	97
	Dec	0	30	30	36	66	0	0	68	107	92
2009	Jan	0	29	29	31	63	0	0	65	78	94
	Feb	0	26	26	28	57	0	0	53	54	119
	Mar	1779	1462	1256	751	693	111	0	30	45	152
	Apr	2298	2027	1773	1097	1084	210	0	26	63	227
	May	1917	1712	1400	641	820	203	0	19	70	183
	Jun	612	710	692	591	767	210	0	17	53	172
	Jul	2311	2030	1726	902	936	203	0	37	53	134
	Aug	1905	1698	1412	659	901	52	0	43	79	148
	Sep	231	330	295	207	486	0	0	25	52	227
	Oct	256	314	312	255	365	0	0	19	67	161
	Nov	0	48	48	67	127	10	10	114	124	131
	Dec	0	42	42	53	103	0	0	100	148	181

Figure 29-10
Monthly Average Rio Grande Flows
Integrated LRG Model - Historical Base Run (Run 1)
1940 - 2017 (cfs)

Flow Legend (CFS)

⬜	0	10
🟩	10	100
🟦	100	200
🟦	200	500
🟦	500	Max

	Month	Below Caballo	Below Percha Dam	Below Leasburg Dam	Below Mesilla Dam	At Courchesne	Below American Dam	Below Intern'l Dam	Below Riverside Dam	At County Line	At Fort Quitman
2010	Jan	0	36	36	42	86	0	0	86	127	172
	Feb	0	32	32	35	75	0	0	67	70	141
	Mar	806	670	526	190	203	74	0	7	17	94
	Apr	1516	1309	1112	619	614	179	0	13	3	113
	May	1687	1503	1299	697	739	196	0	17	18	99
	Jun	1109	1075	997	684	770	170	0	18	19	124
	Jul	2154	1853	1599	808	837	203	0	32	20	95
	Aug	1382	1298	1126	726	911	166	0	38	36	72
	Sep	533	584	565	449	583	0	0	29	24	156
	Oct	414	428	428	362	375	0	0	19	48	125
	Nov	0	31	31	47	81	0	0	80	109	100
	Dec	0	18	18	23	45	0	0	52	96	101
2011	Jan	0	20	20	23	45	0	0	53	99	105
	Feb	0	21	21	23	42	0	0	45	52	119
	Mar	1103	926	763	377	349	96	0	13	49	75
	Apr	1768	1555	1387	937	860	210	0	20	28	149
	May	1112	1060	1010	770	715	72	0	20	34	132
	Jun	974	931	931	802	701	2	0	21	39	132
	Jul	1071	998	998	860	717	14	0	36	51	104
	Aug	589	536	536	456	362	18	0	18	36	35
	Sep	0	1	1	17	13	22	22	18	13	26
	Oct	0	1	1	10	10	20	20	16	4	28
	Nov	0	0	0	10	8	0	0	19	16	34
	Dec	0	0	0	9	7	0	0	18	17	40
2012	Jan	0	0	0	9	6	0	0	17	16	54
	Feb	0	0	0	9	6	0	0	15	4	60
	Mar	1002	813	653	303	251	86	0	9	3	62
	Apr	1629	1358	1156	674	575	186	0	12	7	88
	May	1597	1303	1060	416	387	52	0	10	11	84
	Jun	752	728	728	619	521	71	0	14	19	88
	Jul	797	741	741	627	498	22	0	24	29	94
	Aug	646	570	544	397	311	2	0	16	23	43
	Sep	95	70	64	39	23	0	0	2	6	22
	Oct	2	2	0	4	7	11	11	9	17	15
	Nov	0	1	1	10	7	0	0	13	27	22
	Dec	0	1	1	9	6	0	0	15	34	30
2013	Jan	0	1	1	9	6	0	0	28	31	39
	Feb	0	1	1	9	6	0	0	13	11	43
	Mar	941	758	609	256	214	27	0	10	27	50
	Apr	1321	1111	965	555	466	39	0	13	54	83
	May	827	742	707	488	394	21	0	12	66	83
	Jun	100	82	82	58	36	6	0	1	43	41
	Jul	0	2	2	10	9	20	20	16	18	22
	Aug	0	1	1	9	7	15	15	12	19	21
	Sep	0	0	0	9	7	16	16	13	0	16
	Oct	0	1	1	9	6	15	15	12	2	13
	Nov	0	0	0	8	6	0	0	16	24	16
	Dec	0	0	0	8	6	0	0	16	14	18
2014	Jan	0	0	0	8	6	0	0	15	0	22
	Feb	0	0	0	8	6	0	0	13	0	30
	Mar	1077	884	726	361	300	90	0	11	12	37
	Apr	1721	1444	1245	732	629	152	0	15	46	47
	May	1110	958	867	511	424	31	0	12	46	45
	Jun	982	892	867	651	525	2	0	16	64	42
	Jul	518	452	440	325	243	22	0	12	45	31
	Aug	0	2	2	10	8	18	10	8	8	18
	Sep	0	1	1	9	7	18	18	15	0	16
	Oct	0	1	1	9	7	18	18	14	1	11
	Nov	0	0	0	8	6	0	0	14	5	9
	Dec	0	0	0	8	6	0	0	15	3	10

Figure 29-10
Monthly Average Rio Grande Flows
Integrated LRG Model - Historical Base Run (Run 1)
1940 - 2017 (cfs)

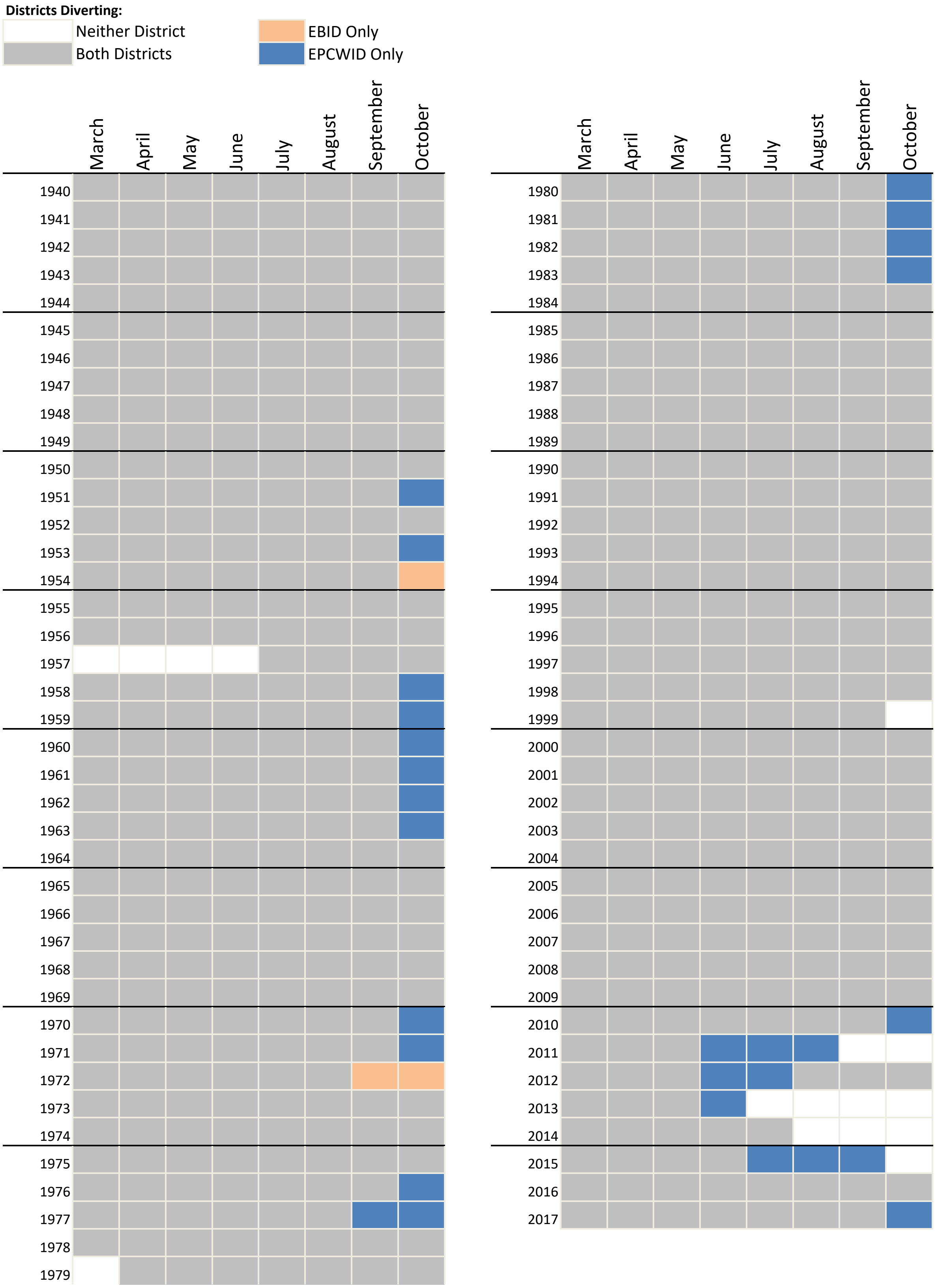
Flow Legend (CFS)

▢	0	10
🟩	10	100
▨	100	200
🟦	200	500
■	500	Max

	Month	Below Caballo	Below Percha Dam	Below Leasburg Dam	Below Mesilla Dam	At Courchesne	Below American Dam	Below Intern'l Dam	Below Riverside Dam	At County Line	At Fort Quitman
2015	Jan	0	0	0	8	6	0	0	15	13	18
	Feb	0	1	1	8	5	0	0	24	13	32
	Mar	940	766	622	309	252	75	0	10	9	38
	Apr	1556	1300	1112	651	554	166	0	12	21	38
	May	1227	1060	947	557	467	118	0	11	40	36
	Jun	1167	1035	960	626	520	39	0	15	52	29
	Jul	922	859	859	734	597	78	0	26	52	39
	Aug	1132	1059	1059	899	739	90	0	33	73	84
	Sep	921	857	857	719	582	0	0	30	72	92
	Oct	0	4	4	11	9	16	16	13	68	68
	Nov	0	2	2	9	8	0	0	13	56	79
	Dec	0	2	2	9	7	0	0	14	43	79
2016	Jan	0	3	3	10	7	0	0	14	35	83
	Feb	0	5	5	11	6	0	0	11	32	79
	Mar	1099	911	753	372	316	77	0	12	42	72
	Apr	1782	1529	1346	863	752	174	0	18	70	114
	May	2014	1743	1505	815	736	139	0	18	76	137
	Jun	968	989	986	843	697	39	0	20	96	142
	Jul	1467	1360	1319	1027	870	83	0	40	115	142
	Aug	1271	1163	1117	848	713	145	0	29	84	141
	Sep	826	768	763	624	508	0	0	26	85	141
	Oct	76	68	67	52	37	0	0	3	76	69
	Nov	0	3	3	10	9	0	0	16	73	82
	Dec	0	3	3	10	7	0	0	18	56	86
2017	Jan	0	4	4	11	7	0	0	18	49	78
	Feb	0	6	6	12	6	0	0	16	30	77
	Mar	1037	858	707	356	299	83	0	11	33	66
	Apr	1410	1244	1129	783	659	77	0	18	61	88
	May	1231	1145	1096	833	697	107	0	18	74	103
	Jun	1717	1553	1451	1004	867	210	0	20	93	123
	Jul	1535	1362	1279	911	783	203	0	30	81	127
	Aug	1467	1354	1280	970	834	203	0	32	79	120
	Sep	1039	1000	991	832	698	90	0	31	80	131
	Oct	668	633	633	539	433	0	0	22	68	143
	Nov	0	17	17	27	24	0	0	30	52	87
	Dec	0	7	7	12	10	0	0	20	30	90

Model Version: LRG Model v116 Operational Run 1 - Historical Base Run.

Figure 29-11
Simulated Monthly Charged Diversions of Project Water by EBID and EPCWID
Integrated LRG Model - Historical Base Run (Run 1)
1940 - 2017



Districts Diverting:

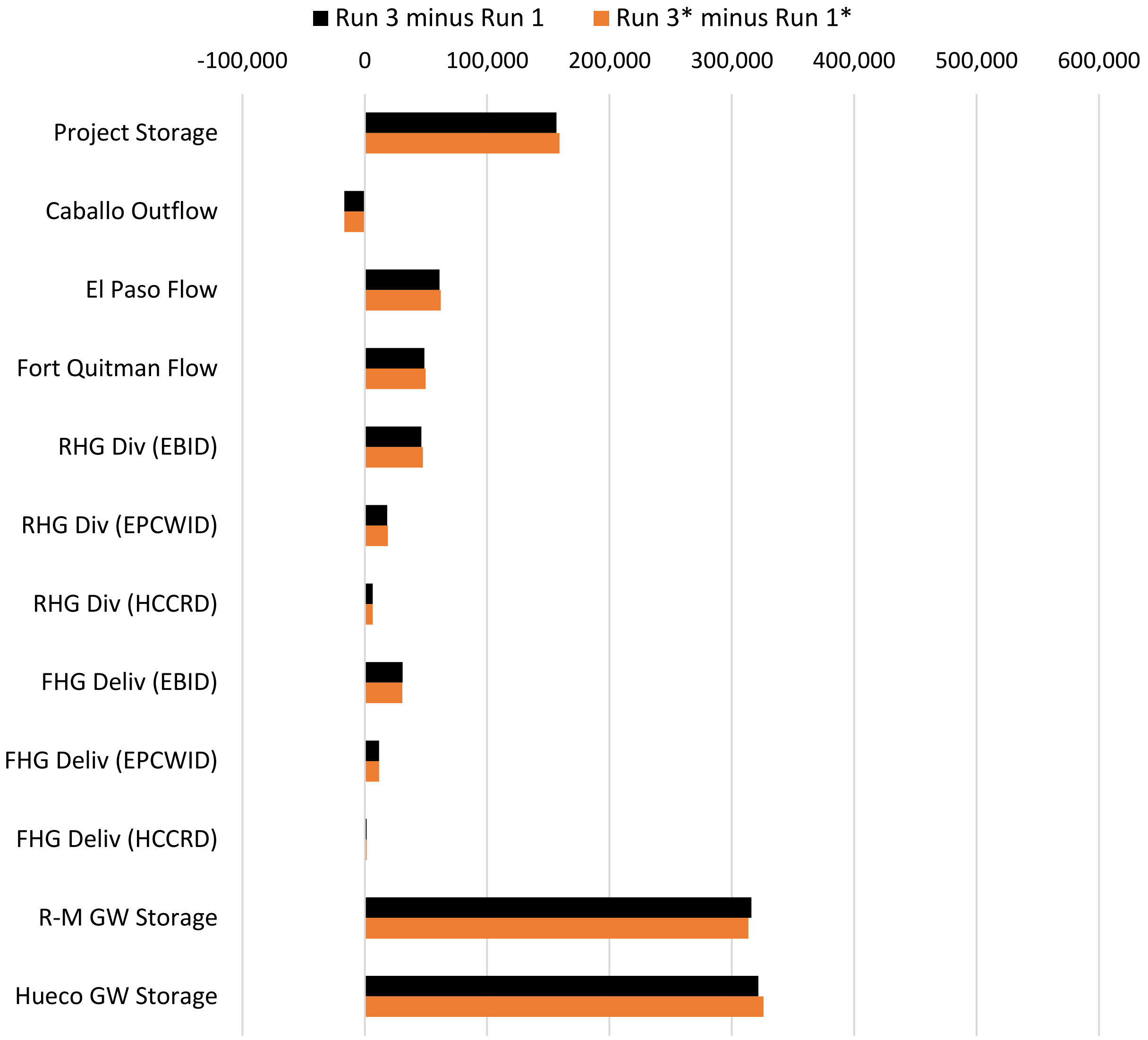
⬜ Neither District
▨ Both Districts
🟧 EBID Only
🟦 EPCWID Only

	March	April	May	June	July	August	September	October
1940	▨	▨	▨	▨	▨	▨	▨	▨
1941	▨	▨	▨	▨	▨	▨	▨	▨
1942	▨	▨	▨	▨	▨	▨	▨	▨
1943	▨	▨	▨	▨	▨	▨	▨	▨
1944	▨	▨	▨	▨	▨	▨	▨	▨
1945	▨	▨	▨	▨	▨	▨	▨	▨
1946	▨	▨	▨	▨	▨	▨	▨	▨
1947	▨	▨	▨	▨	▨	▨	▨	▨
1948	▨	▨	▨	▨	▨	▨	▨	▨
1949	▨	▨	▨	▨	▨	▨	▨	▨
1950	▨	▨	▨	▨	▨	▨	▨	▨
1951	▨	▨	▨	▨	▨	▨	▨	🟦
1952	▨	▨	▨	▨	▨	▨	▨	▨
1953	▨	▨	▨	▨	▨	▨	▨	🟦
1954	▨	▨	▨	▨	▨	▨	▨	🟧
1955	▨	▨	▨	▨	▨	▨	▨	▨
1956	▨	▨	▨	▨	▨	▨	▨	▨
1957	⬜	⬜	⬜	⬜	▨	▨	▨	▨
1958	▨	▨	▨	▨	▨	▨	▨	🟦
1959	▨	▨	▨	▨	▨	▨	▨	🟦
1960	▨	▨	▨	▨	▨	▨	▨	🟦
1961	▨	▨	▨	▨	▨	▨	▨	🟦
1962	▨	▨	▨	▨	▨	▨	▨	🟦
1963	▨	▨	▨	▨	▨	▨	▨	🟦
1964	▨	▨	▨	▨	▨	▨	▨	▨
1965	▨	▨	▨	▨	▨	▨	▨	▨
1966	▨	▨	▨	▨	▨	▨	▨	▨
1967	▨	▨	▨	▨	▨	▨	▨	▨
1968	▨	▨	▨	▨	▨	▨	▨	▨
1969	▨	▨	▨	▨	▨	▨	▨	▨
1970	▨	▨	▨	▨	▨	▨	▨	🟦
1971	▨	▨	▨	▨	▨	▨	▨	🟦
1972	▨	▨	▨	▨	▨	▨	🟧	🟧
1973	▨	▨	▨	▨	▨	▨	▨	▨
1974	▨	▨	▨	▨	▨	▨	▨	▨
1975	▨	▨	▨	▨	▨	▨	▨	▨
1976	▨	▨	▨	▨	▨	▨	▨	🟦
1977	▨	▨	▨	▨	▨	▨	🟦	🟦
1978	▨	▨	▨	▨	▨	▨	▨	▨
1979	⬜	▨	▨	▨	▨	▨	▨	▨

	March	April	May	June	July	August	September	October
1980	▨	▨	▨	▨	▨	▨	▨	🟦
1981	▨	▨	▨	▨	▨	▨	▨	🟦
1982	▨	▨	▨	▨	▨	▨	▨	🟦
1983	▨	▨	▨	▨	▨	▨	▨	🟦
1984	▨	▨	▨	▨	▨	▨	▨	▨
1985	▨	▨	▨	▨	▨	▨	▨	▨
1986	▨	▨	▨	▨	▨	▨	▨	▨
1987	▨	▨	▨	▨	▨	▨	▨	▨
1988	▨	▨	▨	▨	▨	▨	▨	▨
1989	▨	▨	▨	▨	▨	▨	▨	▨
1990	▨	▨	▨	▨	▨	▨	▨	▨
1991	▨	▨	▨	▨	▨	▨	▨	▨
1992	▨	▨	▨	▨	▨	▨	▨	▨
1993	▨	▨	▨	▨	▨	▨	▨	▨
1994	▨	▨	▨	▨	▨	▨	▨	▨
1995	▨	▨	▨	▨	▨	▨	▨	▨
1996	▨	▨	▨	▨	▨	▨	▨	▨
1997	▨	▨	▨	▨	▨	▨	▨	▨
1998	▨	▨	▨	▨	▨	▨	▨	▨
1999	▨	▨	▨	▨	▨	▨	▨	⬜
2000	▨	▨	▨	▨	▨	▨	▨	▨
2001	▨	▨	▨	▨	▨	▨	▨	▨
2002	▨	▨	▨	▨	▨	▨	▨	▨
2003	▨	▨	▨	▨	▨	▨	▨	▨
2004	▨	▨	▨	▨	▨	▨	▨	▨
2005	▨	▨	▨	▨	▨	▨	▨	▨
2006	▨	▨	▨	▨	▨	▨	▨	▨
2007	▨	▨	▨	▨	▨	▨	▨	▨
2008	▨	▨	▨	▨	▨	▨	▨	▨
2009	▨	▨	▨	▨	▨	▨	▨	▨
2010	▨	▨	▨	▨	▨	▨	▨	🟦
2011	▨	▨	▨	🟦	🟦	🟦	⬜	⬜
2012	▨	▨	▨	🟦	🟦	▨	▨	▨
2013	▨	▨	▨	🟦	⬜	⬜	⬜	⬜
2014	▨	▨	▨	▨	▨	⬜	⬜	⬜
2015	▨	▨	▨	▨	🟦	🟦	🟦	⬜
2016	▨	▨	▨	▨	▨	▨	▨	▨
2017	▨	▨	▨	▨	▨	▨	▨	🟦

Figure 31-1

Summary of ILRG Model Sensitivity Analyses
Alluvial Aquifer Hydraulic Conductivity
Average Annual New Mexico Pumping Impacts (Run 3 minus Run 1)
1951 - 2017 (acre-feet)



Notes:

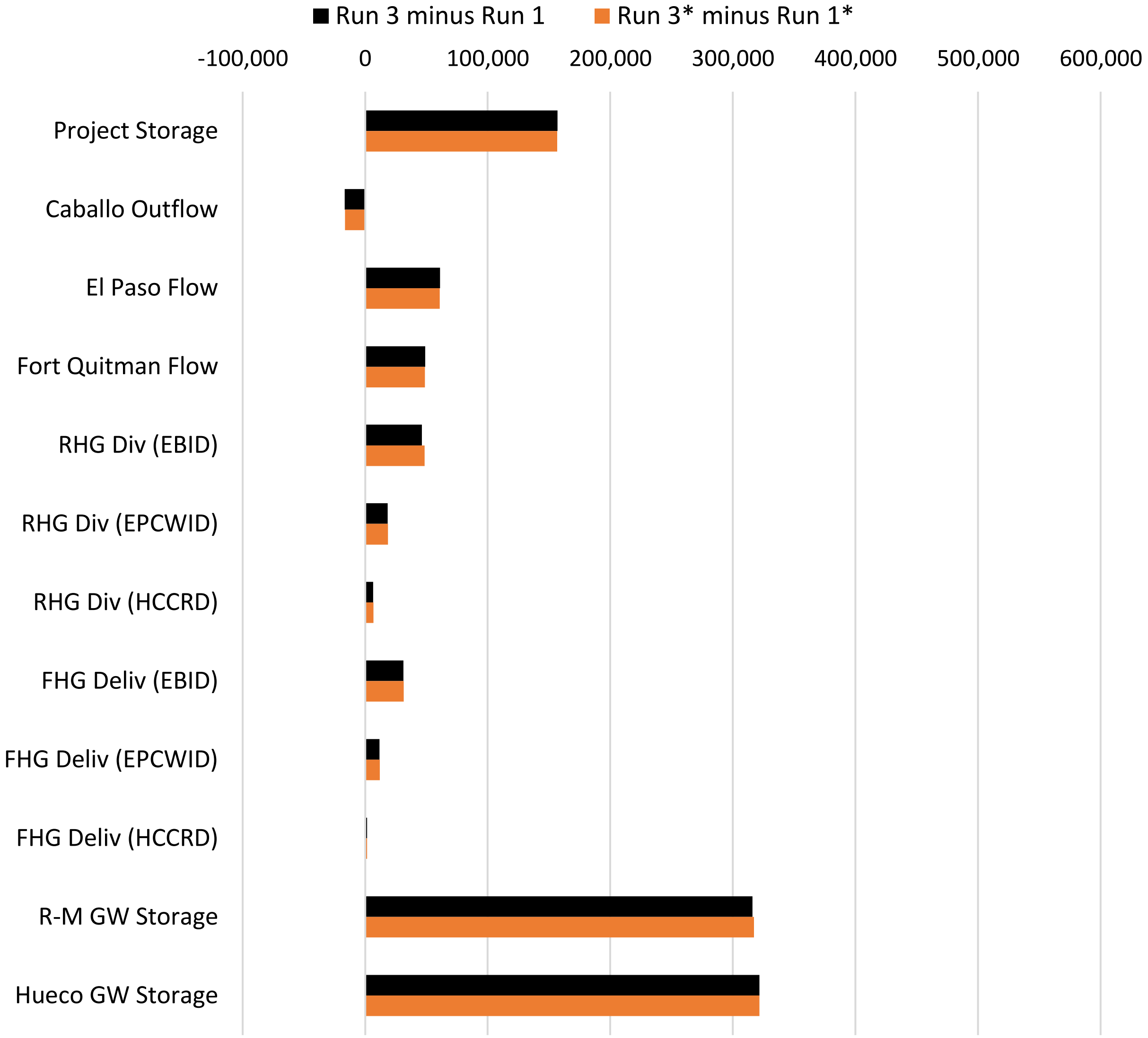
Sensitivity Runs (10% Increase in Alluvial Aquifer Hydraulic Conductivity)
Run 1* (Historical Base Run)
Run 3* (NM Pumping Off)

Original Runs
Run 1 (Historical Base Run)
Run 3 (NM Pumping Off)

Changes in storage and flows are annual. Changes in RHG and FHG are irrigation season.

Figure 31-2

Summary of ILRG Model Sensitivity Analyses
River Bed Conductance
Average Annual New Mexico Pumping Impacts (Run 3 minus Run 1)
1951 - 2017 (acre-feet)



Notes:

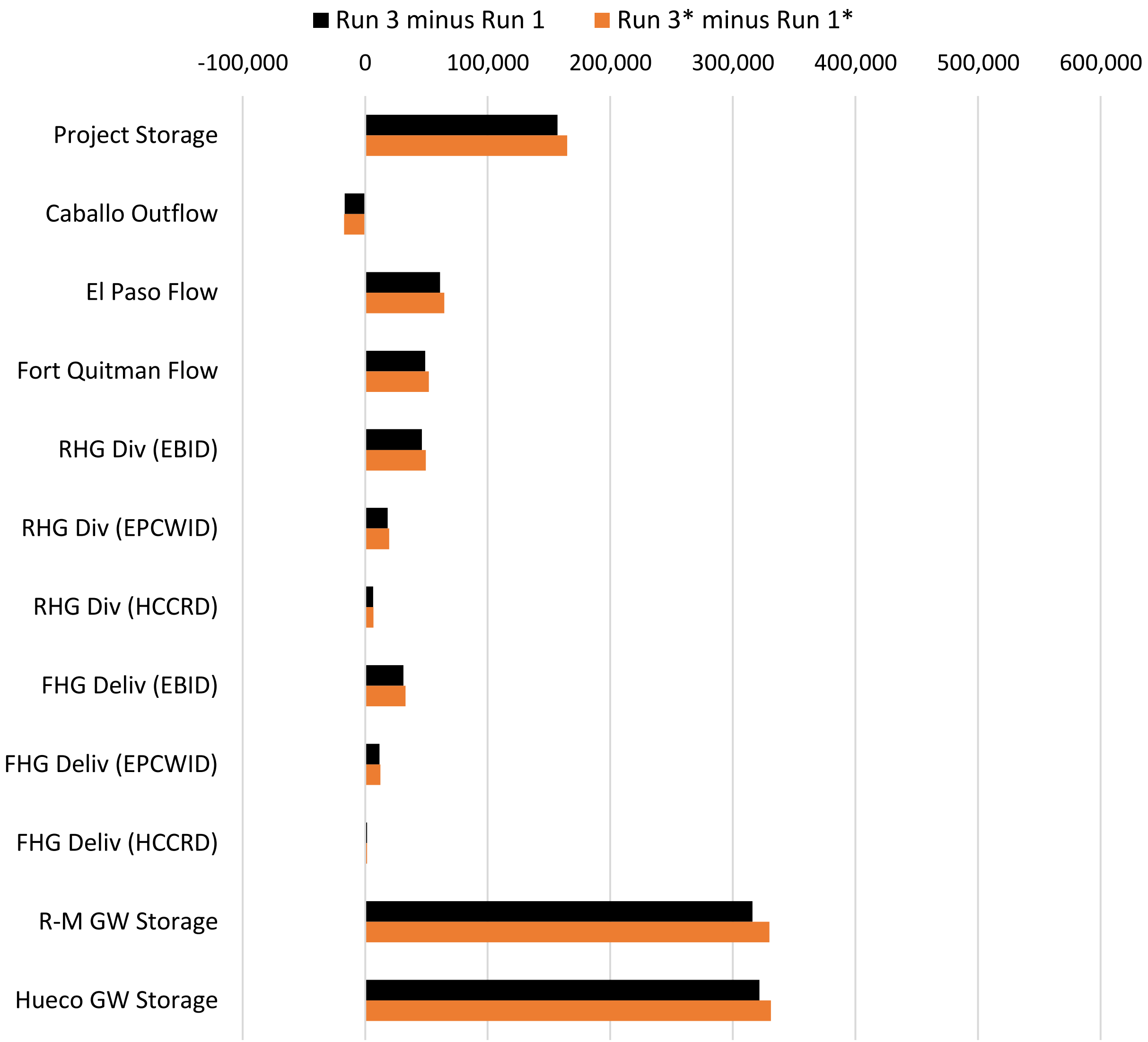
Sensitivity Runs (10% Increase in River Bed Conductance)
Run 1* (Historical Base Run)
Run 3* (NM Pumping Off)

Original Runs
Run 1 (Historical Base Run)
Run 3 (NM Pumping Off)

Changes in storage and flows are annual. Changes in RHG and FHG are irrigation season.

Figure 31-3

Summary of ILRG Model Sensitivity Analyses
Canal Bed Conductance
Average Annual New Mexico Pumping Impacts (Run 3 minus Run 1)
1951 - 2017 (acre-feet)



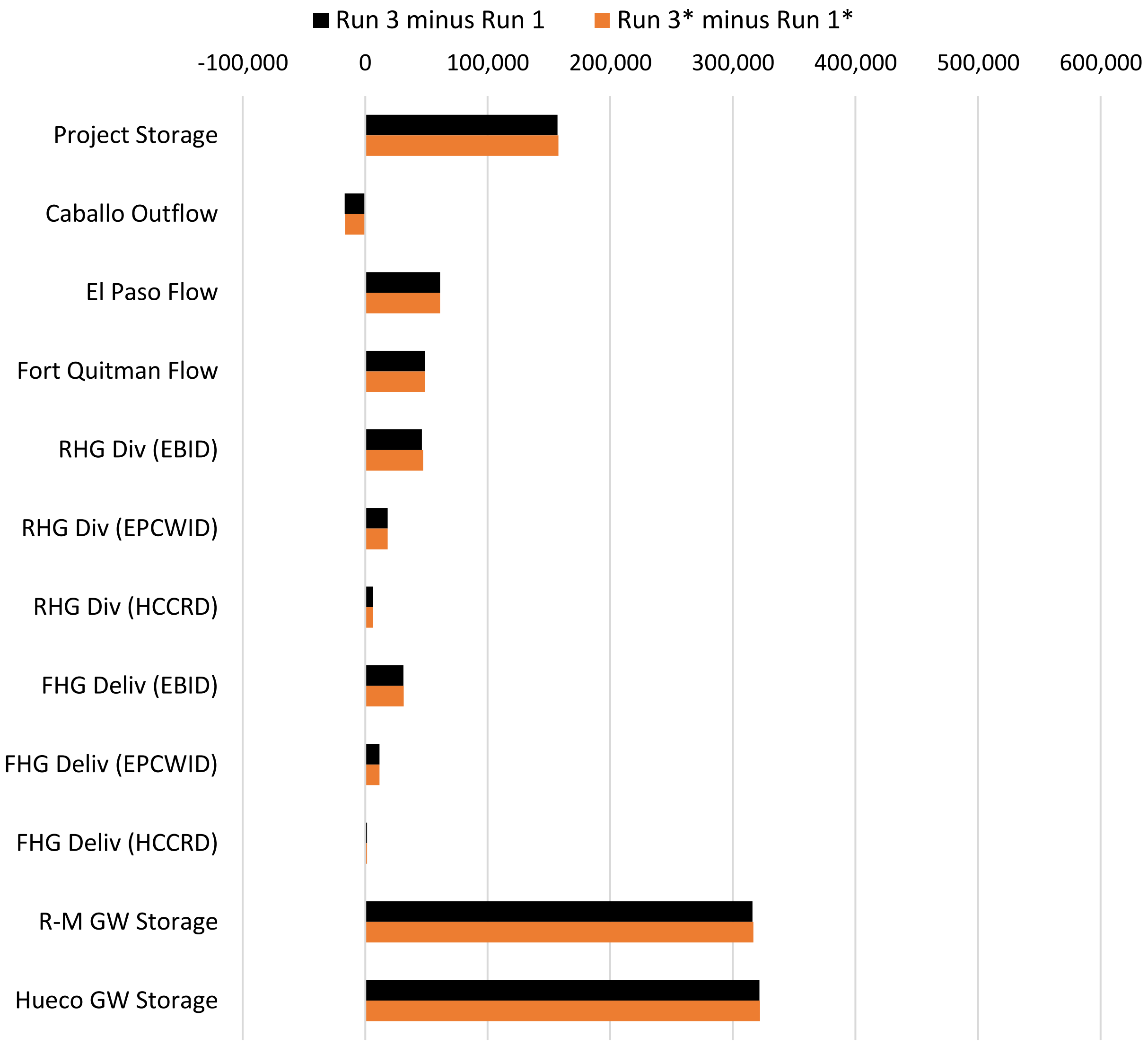
<u>Notes:</u>
<u>Sensitivity Runs (10% Increase in Canal Bed Conductance)</u>
Run 1* (Historical Base Run)
Run 3* (NM Pumping Off)

<u>Original Runs</u>
Run 1 (Historical Base Run)
Run 3 (NM Pumping Off)

Changes in storage and flows are annual. Changes in RHG and FHG are irrigation season.

Figure 31-4

Summary of ILRG Model Sensitivity Analyses
Drain Bed Conductance
Average Annual New Mexico Pumping Impacts (Run 3 minus Run 1)
1951 - 2017 (acre-feet)



Notes:

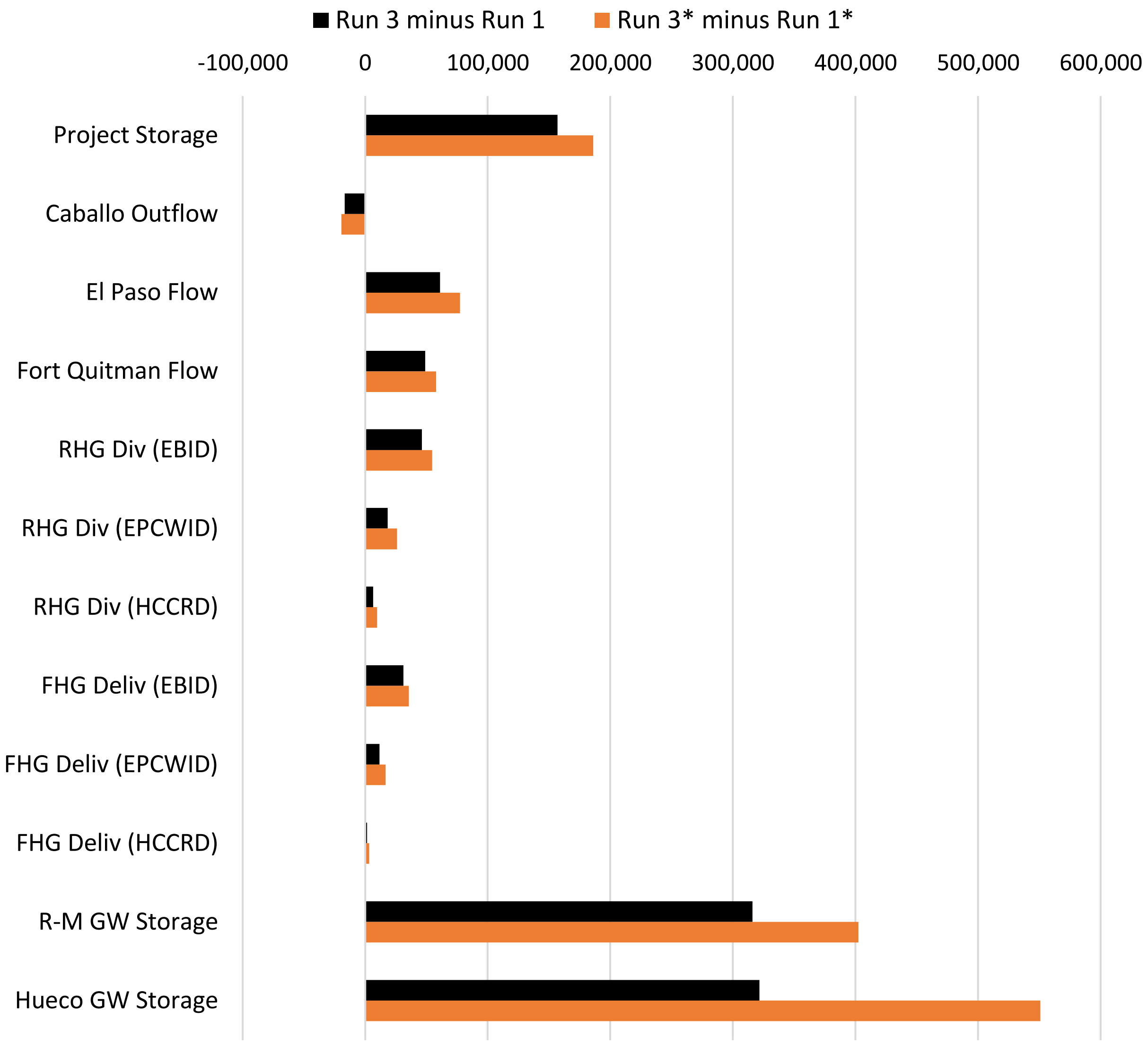
<u>Sensitivity Runs (10% Increase in Drain Bed Conductance)</u>
Run 1* (Historical Base Run)
Run 3* (NM Pumping Off)

<u>Original Runs</u>
Run 1 (Historical Base Run)
Run 3 (NM Pumping Off)

Changes in storage and flows are annual. Changes in RHG and FHG are irrigation season.

Figure 31-5

Summary of ILRG Model Sensitivity Analyses
Crop Irrigation Requirement
Average Annual New Mexico Pumping Impacts (Run 3 minus Run 1)
1951 - 2017 (acre-feet)



Notes:

Sensitivity Runs (10% Increase in Crop Irrigation Requirement)
Run 1* (Historical Base Run)
Run 3* (NM Pumping Off)

Original Runs
Run 1 (Historical Base Run)
Run 3 (NM Pumping Off)

Changes in storage and flows are annual. Changes in RHG and FHG are irrigation season.

TABLES

Table 19-1
Water Supply to HCCRD (Irrigation Season)
1940 - 2017 (acre-feet)

Year	(1) EPCWID (El Paso Valley) Supply	(2) 10% EPCWID (El Paso Valley) Supply	(3) Tornillo Canal at Alamo Alto	(4) Hudspeth Feeder Canal	(5) Tornillo Drain	(6) Total Hudspeth Supply	(7) Undiverted Fabens Drains	(8) Fabens Drains in Hudspeth Feeder Canal	(9) Fabens WWTP	(10) Waste in Hudspeth Feeder Canal	(11) Total Waste to Hudspeth	(12) Total Waste to Hudspeth Exceeding 10 % EPCWID Supply	(13) Total Waste to Hudspeth (% EPCWID Supply)
1940	346,498								0				
1941	346,859								0				
1942	461,031								0				
1943	451,903								0				
1944	389,191								0				
1945	378,158						68,671		0				
1946	357,474						42,693		0				
1947	320,556	32,056	22,843	10,871	40,380	74,094	43,907	10,871	0	0	22,843	0	7%
1948	329,891	32,989	23,757	33,274	40,459	97,490	25,100	25,100	0	8,174	31,931	0	10%
1949	334,924	33,492	19,906	49,244	52,538	121,688	50,166	49,244	0	0	19,906	0	6%
1950	328,905	32,891	24,889	52,010	49,612	126,511	54,714	52,010	0	0	24,889	0	8%
1951	197,781	19,778	8,348	12,283	16,070	36,701	15,340	12,283	0	0	8,348	0	4%
1952	211,238	21,124	7,955	18,095	17,986	44,036	17,475	17,475	0	620	8,575	0	4%
1953	200,541	20,054	3,568	10,573	16,852	30,993	15,356	10,573	0	0	3,568	0	2%
1954	69,829	6,983	641	496	2,338	3,475	755	496	0	0	641	0	1%
1955	54,554	5,455	62	119	139	320	0	0	0	119	181	0	0%
1956	50,307	5,031	0	0	0	0	0	0	0	0	0	0	0%
1957	104,549	10,455	877	710	0	1,587	0	0	0	710	1,587	0	2%
1958	262,838	26,284	15,293	10,830	1,393	27,516	751	751	0	10,079	25,372	0	10%
1959	285,895	28,590	12,948	17,407	13,540	43,895	9,077	9,077	0	8,330	21,278	0	7%
1960	290,868	29,087	12,242	24,502	24,584	61,328	33,220	24,502	0	0	12,242	0	4%
1961	225,631	22,563	6,860	16,395	21,144	44,399	17,004	16,395	0	0	6,860	0	3%
1962	281,486	28,149	17,805	28,667	29,223	75,695	33,720	28,667	0	0	17,805	0	6%
1963	205,708	20,571	9,900	17,946	19,518	47,364	21,900	17,946	0	0	9,900	0	5%
1964	60,017	6,002	0	110	2,109	2,219	1,811	110	0	0	0	0	0%
1965	161,887	16,189	4,128	3,828	82	8,038	324	324	0	3,504	7,632	0	5%
1966	236,678	23,668	19,994	19,569	5,747	45,310	10,031	10,031	0	9,538	29,532	5,864	12%
1967	200,399	20,040	3,396	7,365	11,873	22,634	10,672	7,365	0	0	3,396	0	2%
1968	191,422	19,142	9,907	13,125	12,051	35,083	20,492	13,125	0	0	9,907	0	5%
1969	267,410	26,741	15,315	36,957	21,731	74,003	45,024	36,957	0	0	15,315	0	6%
1970	260,696	26,070	25,567	40,386	27,987	93,940	47,210	40,386	0	0	25,567	0	10%
1971	211,116	21,112	4,155	17,446	20,928	42,529	25,470	17,446	0	0	4,155	0	2%
1972	120,152	12,015	3,343	7,709	9,460	20,512	4,006	4,006	0	3,703	7,046	0	6%
1973	256,173	25,617	3,709	27,236	17,905	48,850	15,512	15,512	0	11,724	15,433	0	6%
1974	303,760	30,376	8,691	41,797	27,162	77,650	25,045	25,045	0	16,752	25,443	0	8%
1975	274,579	27,458	6,860	43,190	28,057	78,107	32,947	32,947	0	10,243	17,103	0	6%
1976	308,010	30,801	10,412	51,947	33,615	95,974	28,378	28,378	0	23,569	33,981	3,180	11%
1977	184,060	18,406	2,280	14,520	17,177	33,977	13,691	13,691	0	829	3,109	0	2%
1978	138,218	13,822	2,037	6,621	7,483	16,141	4,964	4,964	0	1,657	3,694	0	3%
1979	228,105	22,811	7,194	25,068	15,329	47,591	18,094	18,094	0	6,974	14,168	0	6%
1980	284,164	28,416	14,659	36,297	21,569	72,525	24,799	24,799	0	11,498	26,157	0	9%
1981	248,427	24,843	23,027	36,492	21,421	80,940	27,642	27,642	0	8,850	31,877	7,034	13%
1982	257,786	25,779	21,711	36,054	22,192	79,957	27,870	27,870	0	8,184	29,895	4,116	12%
1983	245,314	24,531	16,741	46,826	21,094	84,661	23,240	23,240	0	23,586	40,327	15,796	16%
1984	257,429	25,743	14,422	65,705	23,652	103,779	29,942	29,942	0	35,763	50,185	24,442	19%
1985	275,730	27,573	18,074	72,252	22,001	112,327	24,859	24,859	0	47,393	65,467	37,894	24%
1986	349,112	34,911	19,275	126,275	28,137	173,687	51,094	51,094	0	75,181	94,456	59,545	27%
1987	388,735	38,874	38,132	45,471	30,663	114,266	49,687	45,471	0	0	38,132	0	10%

Table 19-1
Water Supply to HCCRD (Irrigation Season)
1940 - 2017 (acre-feet)

Year	(1) EPCWID (El Paso Valley) Supply	(2) 10% EPCWID (El Paso Valley) Supply	(3) Tornillo Canal at Alamo Alto	(4) Hudspeth Feeder Canal	(5) Tornillo Drain	(6) Total Hudspeth Supply	(7) Undiverted Fabens Drains	(8) Fabens Drains in Hudspeth Feeder Canal	(9) Fabens WWTP	(10) Waste in Hudspeth Feeder Canal	(11) Total Waste to Hudspeth	(12) Total Waste to Hudspeth Exceeding 10 % EPCWID Supply	(13) Total Waste to Hudspeth (% EPCWID Supply)
1988	365,141	36,514	55,121	42,576	26,128	123,825	49,630	42,576	0	0	55,121	18,607	15%
1989	327,647	32,765	32,551	69,114	25,052	126,717	46,791	46,791	0	22,323	54,874	22,109	17%
1990	294,259	29,426	17,992	66,085	22,485	106,562	41,248	41,248	0	24,837	42,829	13,403	15%
1991	258,422	25,842	12,299	56,042	22,476	90,817	32,552	32,552	0	23,490	35,789	9,947	14%
1992	312,821	31,282	21,015	69,125	26,103	116,243	36,153	36,153	0	32,972	53,987	22,705	17%
1993	339,355	33,936	20,741	70,159	32,645	123,545	22,138	22,138	0	48,021	68,762	34,827	20%
1994	364,321	36,432	20,548	69,661	33,372	123,581	49,940	49,940	0	19,721	40,269	3,837	11%
1995	406,084	40,608	25,631	76,410	35,470	137,511	47,866	47,866	0	28,544	54,175	13,567	13%
1996	284,568	28,457	14,805	61,728	28,405	104,938	34,649	34,649	0	27,079	41,884	13,427	15%
1997	330,354	33,035	27,512	55,659	28,269	111,440	32,849	32,849	0	22,810	50,322	17,287	15%
1998	327,544	32,754	29,215	46,598	29,633	105,446	33,051	33,051	0	13,547	42,762	10,008	13%
1999	340,614	34,061	27,905	59,769	33,086	120,760	32,813	32,813	0	26,956	54,861	20,800	16%
2000	304,540	30,454	32,291	39,339	29,760	101,390	32,290	32,290	0	7,049	39,340	8,886	13%
2001	337,460	33,746	34,891	55,401	34,290	124,582	40,204	40,204	406	14,791	49,682	15,936	15%
2002	318,751	31,875	31,756	56,121	31,898	119,775	43,833	43,833	422	11,866	43,622	11,747	14%
2003	147,557	14,756	4,617	16,059	16,983	37,659	11,800	11,800	425	3,834	8,451	0	6%
2004	163,859	16,386	7,572	19,164	14,671	41,408	10,063	10,063	316	8,786	16,358	0	10%
2005	252,179	25,218	13,146	43,619	21,893	78,658	17,281	17,281	308	26,030	39,176	13,958	16%
2006	199,124	19,912	7,378	32,437	22,544	62,359	16,829	16,829	314	15,294	22,672	2,760	11%
2007	286,682	28,668	13,757	45,503	28,203	87,463	23,963	23,963	313	21,227	34,984	6,316	12%
2008	281,528	28,153	24,454	45,830	31,880	102,164	26,075	26,075	314	19,441	43,895	15,742	16%
2009	316,071	31,607	35,870	43,948	31,377	111,194	32,262	32,262	321	11,365	47,235	15,628	15%
2010	303,197	30,320	28,291	43,214	31,873	103,377	31,693	31,693	302	11,219	39,510	9,190	13%
2011	220,158	22,016	4,299	28,209	4,520	37,028	13,084	13,084	413	14,712	19,011	0	9%
2012	121,622	12,162	1,557	13,033	3,601	18,191	3,469	3,469	398	9,166	10,723	0	9%
2013	67,564	6,756	1,298	4,968	7,830	14,096	2,084	2,084	383	2,501	3,799	0	6%
2014	114,523	11,452	1,748	6,806	8,722	17,276	2,466	2,466	388	3,952	5,700	0	5%
2015	157,991	15,799	4,578	9,930	9,169	23,677	7,076	7,076	382	2,472	7,050	0	4%
2016	194,874	19,487	5,171	10,134	13,155	28,460	6,944	6,944	384	2,806	7,977	0	4%
2017	215,165	21,517	12,425	15,469	14,111	42,005	8,822	8,822	425	6,222	18,647	0	9%
Avg 47-17	245,336	24,534	14,808	33,772	21,054	69,633	23,820	22,275	88	11,409	26,216	6,459	11%
Avg 51-79	201,514	20,151	7,706	17,755	14,534	39,995	16,147	14,019	0	3,736	11,443	312	6%
Avg 80-02	313,851	31,385	24,796	59,094	27,383	111,273	36,310	35,820	36	23,237	48,034	16,779	15%

Notes:

All flow data from SWE SWDataSet.

(1) Sum of Franklin Canal gage, Riverside Canal gage, EPW diversions, WWTP returns, and drains diverted minus Ascarate Wasteway.
(2) 10 % x (1).
(3) Flow data from SWE SWDataset.
(4) Flow data from SWE SWDataset.
(5) Flow data from SWE SWDataset.
(6) Sum of (3) plus (4) plus (5).
(7) Undiverted Fabens Drains is the sum of the River Drain, Middle Drain, Mesa Drain, Cuadrilla Drain, and Fabens Intercepting Drain minus drain water diverted to Tornillo Canal from 1947-1983, and the Fabens Waste Drain from 1984-2017.
(8) Minimum of Hudspeth Feeder Canal flows (4) and Undiverted Fabens Drains (7).
(9) Fabens WWTP discharge into Fabens Waste Channel that can be diverted into Hudspeth Feeder Canal.
(10) Hudspeth Feeder Canal (4) minus Fabens Drains in Hudspeth Feeder Canal (8) minus Fabens WWTP discharge (9).
(11) Sum of Tornillo Canal at Alamo Alto (3) plus Waste in Hudspeth Feeder Canal (10).
(12) Total Waste to Hudspeth (11) in excess of 10 % of EPCWID (El Paso Valley) Supply (2).
(13) Total Waste to Hudspeth (11) / EPCWID (El Paso Valley) Supply (1).

Table 23-1

Spatial Scale of Selected LRG Data Used in ILRG Model

	Portion of Study Period	
LRG Data	1940 - 1978	1979 - 2017
River Flows	Point (gage)	
River Headgate Diversions	Point (gage) (1)	
Farm Headgate Deliveries	Valley (2)	District (3)
Canal Loss	Valley (2)	District (3)
Total Waste	Valley (2)	District (3)
Irrigated Area	Valley (2, 4)	District (3, 4)
Cropping Pattern	Valley (2)	District (3)
ET/climate	Basin (5)	
Soils	Basin (5)	
Drain Flows	Point (gage/estimates) (1)	

Notes:

(1) Reported by Canal - Rincon, Leasburg, Eastside (NM and TX), Westside (NM and TX), American, Franklin, Riverside, and Acequia Madre.

(2) Reported by Valley - Rincon, Leasburg, Mesilla (Eastside plus Westside in NM and TX), and El Paso Valley.

(3) Reported by District - EBID, EPCWID, and HCCRD total There are several years after 1979 in which EBID data is separated into Rincon and Mesilla (including Leasburg) totals.

(4) Irrigated area determined by NDVI analysis of satellite imagery in selected years from 1975 - 2017 can be totaled by subarea.

(5) Computed for Rincon-Mesilla basin and Hueco basin.

Table 26-1
Summary of Estimated Data for Surface Water Dataset
Rio Grande Project, Hudspeth County, and Mexico
1903 - 2017

Structure	Start	Period of Record	Missing Data	Method for Estimating Missing Data
Canals - Hueco				
Acequia Madre	Pre-1903	1924 - 1925, 1930 - 1936, 6/1938 - 2006, 2008 - 2017	1903 - 1923, 1926 - 1929, 1937 - 5/1938, 2007	1903 -1923: Used 1924 - 1925 monthly regression with Courchesne gage capped at an estimated diversion capacity (300 cfs) and limited to season of use Mar 1 – Nov 30.
				1926 - 1929 and 1937: Used 1930 - 1936 monthly regression with Courchesne gage capped at an estimated diversion capacity (300 cfs) and limited to season of use Mar 1 – Nov 30.
				1/1938 – 5/1938: Used 1938 annual value less data for period of record in 1938 distributed from Mar - May using Franklin Canal flows.
				2007: Used reported 2007 annual diversion in Rio Grande Compact Commission Report distributed monthly using Franklin Canal diversions.
Franklin Canal	1889	1914 -1916, 1918 - 2017*	1903 – 1913, 1917	1903 -1913 and 1917: Used 1918 - 1938 monthly regression with Courchesne gage capped at an estimated diversion capacity (320 cfs) and limited to season of use Mar 1 – Nov 30. Do not have complete winter diversions in recent years - these winter diversions were not estimated.
Tornillo Canal at Alamo Alto	1947	1947 - 2017*	Various months 1995 – 1996 and 2004 – 2005	Various months 1995 - 1996 and 2004 - 2005: Used 1985 - 1994 monthly regression with Riverside Canal.
Hudspeth Feeder Canal	May-47	1947 - 2017*	2011 - 2012	2011 - 2012: Used 2005 - 2010 monthly regression with Franklin Canal.
Hudspeth Canal (Tornillo End)	1925	1935 - 1955 (ann)	1925 - 1934	1925 - 1934: Estimated flow using water balance (Tornillo Canal heading flow less seepage loss (15%*Tornillo Canal heading) less crop demand for Tornillo acres (CIR*acres/irrigation efficiency) less Tornillo Waste End flows).
				1935 - 1955: Annual data distributed monthly using Tornillo Canal heading flows.

Table 26-1
Summary of Estimated Data for Surface Water Dataset
Rio Grande Project, Hudspeth County, and Mexico
1903 - 2017

Structure	Start	Period of Record	Missing Data	Method for Estimating Missing Data
Canals - Hueco (cont.)				
Juarez River Diversions (below International Dam)	Pre-1903	Annual estimates 1930-1936, 1938-1947, and 1950-1984	1903 - 1929, 1937, 1948-1949, 1985 - 2017	1903 - 1929: Estimated flows based minimum of unmet demand (Farm Budget spreadsheet) limited by estimated flow below International Dam (Courchesne minus Franklin Canal minus Acequia Madre) minus Riverside Canal when applicable. 1930-1936, 1938-1947, and 1950-1984: Distributed annual estimates monthly using Acequia Madre flows. 1937: Set equal to 1936 annual estimate. 1948 - 1949: Estimated flows based on gage differences from Island Station to Fort Quitman. 1985 - 2017: Did not estimate because there are no gage records.
Wasteways - Hueco				
Franklin Settling Basin WW	1938?	No data		6/1938 – 2/1999: Data provided by Peggy Barroll, NMOSE. Computed using water balance approach (American Canal diversions less Franklin Canal diversions less City of El Paso municipal diversions). Split total computed waste 50/50 between Franklin Settling Basin and Leon St. wasteways. Estimates do not consider transit losses.
Leon St WW	1938?	No data		
Ascarate WW	1916?	1938 - 1954 (ann), 1955 - 2005*	1916 - 1937, 2011 - 2012	1916 - 1937: Used annual regression (1938 - 1949) with Franklin Canal and distributed annual data into monthly values proportional to Franklin Canal flows. 1938 - 1955: Distributed annual data into monthly values proportional to Franklin Canal flows. 2011 - 2012: Assumed no Ascarate Wasteway flows until more data become available due to little to zero flows reported since the completion of the American Canal Extension.

Table 26-1
Summary of Estimated Data for Surface Water Dataset
Rio Grande Project, Hudspeth County, and Mexico
1903 - 2017

Structure	Start	Period of Record	Missing Data	Method for Estimating Missing Data
Wasteways - Hueco (cont.)				
Riverside WW#1	1928?	1938 - 1955 (ann combined)**, 1981 - 1984, 1993 - 2017*	Pre-1938, 1956 - 1980,1985 - 1982	1928 – 1937: Used annual regression for combined Riverside WW#1 and WW#2 with Riverside Canal (1938 - 1949) and distributed annual data into monthly values using Riverside Canal diversions. Split between WW#1 and WW#2 using 1981 - 2013 average annual split. Assumed Riverside WW#2 flows do not start until 1930.
				1938 – 1955: Distributed annual data into monthly values proportional to Riverside Canal diversions. Split between WW#1 and WW#2 using 1981 – 2013 average annual split.
Riverside WW#2	1930?			1956 - 1980 and 1985 - 1992: Used annual regression for combined Riverside WW#1 and WW#2 with Riverside Canal (1993 - 2003) and distributed annual data into monthly values using Riverside Canal diversions. Split between WW#1 and WW#2 using 1981 - 2013 average annual split.
Municipal - Hueco				
Northwest WWTP Returns	1987	9/2002 - 2017*	1987 - 8/2002	1987 - 8/2002: Data provided by Nabil Shafike, NMISC - computed using regression with Mesilla EPWU ground water pumping.
Haskell WWTP Returns (1)	1923	1936 - 1939, 1940 - 1948**, 1949 - 1959, 1960 - 1975**, 1977 - 2017*	1923 - 1935, 1976, 1/1998 - 9/1998	1923 - 1935: Used annual 1936 - 1940 regression with EPWU pumping. Distributed annual data evenly in each month (divide by 12).
				1976: Used average 1975 and 1977 monthly flow data (i.e., Jan 1976 flow = average Jan 1975 and Jan 1977).
				1/1998 - 9/1998: Used average 1997 and 1999 monthly flow data.
Bustamante WWTP Returns	1991	9/1995 - 2017*	1991 – 8/1995	1991 - 1994: Annual volume derived from reported 1996 influent in gallons per day per capita scaled to Bustamante service area proportion of total City of El Paso population and subtracted Socorro WWTP flows (1991 - 1993). Annual volume divided by 12 to obtain monthly values.
				1/1995 - 8/1995: Annual reported value minus sum of remainder monthly flows (9/1995-12/1995) divided by 8.

Table 26-1
Summary of Estimated Data for Surface Water Dataset
Rio Grande Project, Hudspeth County, and Mexico
1903 - 2017

Structure	Start	Period of Record	Missing Data	Method for Estimating Missing Data
Municipal - Hueco (cont.)				
Socorro WWTP	1967	1967 - 2/1993	1985 - 1988	1967 - 1984: Distributed annual reported volumes evenly into each month (divided by 12).
				1985 - 1988: Computed annual volume using linear regression between 1984 and 1989 annual data. Distributed annual estimates evenly into each month (divided by 12).
				10/1991: Computed as average 9/1991 and 11/1991 flows.
Juarez Sewage to river	1926?	1940 - 1950 ann	1926 - 1939; 1951 - 2017	1926 - 1939: Data not estimated (not enough information available to estimate).
				1940 - 1950: Distributed annual reported estimates evenly into each month (divided by 12).
				1951 - 2017: Assume zero (discharge zero by late 1940s).
Juarez Sewage to canals	1926	1950 - 1984	1926 - 1949 and 1985 - 2017	1950 - 1984: Annual reported estimates divided by 12.
				1926 - 1949 and 1985 - 2017: Used JMAS pumping provided by MMA multiplied by 49% (same methodology as IBWC 1989 report) minus Juarez Sewage to river (1940 - 1950).
Robertson-Umbenhauer WTP (aka Canal St. WTP)	Nov-43	11/1943 - 2017**	Records for total El Paso WTP prior to 2007	1943 - 1992: Robertson-Umbenhauer WTP equal to total City of El Paso until Jonathan Rogers comes online in 1993.
Jonathan Rogers WTP	1993	1993 - 2017**		1993 - 2006: Split total City of El Paso into each WTP using distribution from available data from 2007 - 2013.
Fabens WWTP	2001	2001 - 2017**	1/2001 - 5/2001, 7/2004, 10/2004	1/2001 - 5/2001 , 7/2004, and 10/2004: Computed using monthly averages from prior and subsequent year.
Municipal - Rincon-Mesilla				
Hatch WWTP	1940	2000 - 2017*	1940 - 1999	1940 - 1999: Computed using regression with population (no pumping data available).
			1/2000 - 9/2000, 11/2005, 10/2013	1/2000 - 9/2000, 11/2005, and 10/2013: Computed using monthly averages from prior and subsequent year.
Las Cruces WWTP	1940	1976 - 2017*	1940 - 3/1976, 5/1979 - 6/1979, 4/1985, 9/1985 - 10/1985	1940 - 3/1976, 5/1979 - 6/1979, 4/1985, and 9/1985 - 10/1985: Computed using regression with pumping.
Anthony NM WWTP	1989	2002 - 2017*	1989 - 1995	1989 - 1995: Computed using regression with pumping.

Table 26-1
Summary of Estimated Data for Surface Water Dataset
Rio Grande Project, Hudspeth County, and Mexico
1903 - 2017

Structure	Start	Period of Record	Missing Data	Method for Estimating Missing Data
Municipal - Rincon-Mesilla (cont.)				
Anthony TX WWTP	1953	2005 - 2017*	1953-2004, 1/2005-4/2005, 2/2006, 11/2006, 8/2007, 8/2016-12/2017	1953 - 2004: Computed using regression with pumping. 1/2005 - 4/2005, 2/2006, 11/2006, 8/2007, and 8/2016 - 12/2017: Computed using monthly averages from prior and subsequent year.
El Paso Electric WWTP	1950	2004 - 2017*	1950 - 2003, 2/2005, 10/2005 - 12/2005, 8/2006, 5/2009	1950 - 2003: Computed using regression with pumping. 2/2005, 10/2005 - 12/2005, 8/2006, and 5/2009: Computed using monthly averages from prior and subsequent year.
Gadsden School District WWTP	1991	1991 - 2017*	1/2016 - 4/2016, 11/2016, 1/2017, 6/2017, 12/2017	1/2016 - 4/2016, 11/2016, 1/2017, 6/2017, 12/2017: Computed using monthly averages from prior and subsequent year.
Total Sunland Park + Santa Teresa	1972	2004 - 2017	1972 - 2003	1972 - 2003: Computed using monthly averages from prior and subsequent year.

Notes:
All estimated data calculations in source folder: LRG.Doc.SW118.
*Missing months of data within period of record.
**Records combined with other flows, split total diversions out by structure.
(1) Records from 1940 - 1948 and 1960 - 1975 include Ascarate and Yselta EPCWID plant discharges.
(2) Annual estimates from Rio Grande Joint Investigations (1938), Carreno (1957), and IBWC (1989).

Table 28-1
Summary of Annual and Irrigation Season Calibration Statistics
ILRG Model
1951-2017

Location	Ann/Irr (1)	Nash-Sutcliffe Efficiency (NSE)	Coeff. of Determin. (R^2)	Index of Agreement (d)	Mean Error (BIAS)	Percent Bias (PBIAS)	Mean Absolute Error (MAE)	Percent MAE (PMAE)	Root Mean Squared Error (RMSE)	RMSE - Obs Std Dev Ratio (RSR)	*(2) Log NSE*
Caballo Outflow	A	0.93	0.93	0.98	617	0.1%	47,646	7.8%	58,055	0.26	*0.93*
Rio Grande at El Paso	A	0.91	0.92	0.98	-376	-0.1%	41,484	12.3%	53,864	0.30	*0.90*
Rio Grande at Fort Quitman	A	0.83	0.86	0.96	-13,875	-13.9%	35,666	35.8%	48,108	0.41	*0.30*
Rincon Diversion	I	0.78	0.82	0.95	4,664	6.5%	9,889	13.8%	13,113	0.47	*0.86*
Leasburg Diversion	I	0.82	0.84	0.95	3,878	3.6%	14,379	13.3%	18,241	0.42	*0.86*
Eastside Diversion	I	0.75	0.81	0.94	77	0.1%	8,099	13.6%	10,836	0.50	*0.74*
Westside Diversion	I	0.80	0.84	0.95	3,253	2.1%	16,704	11.0%	21,247	0.45	*0.81*
American Diversion	I	0.79	0.79	0.93	1,585	0.7%	34,604	15.1%	41,637	0.46	*0.81*
Riverside Canal Gage	I	0.62	0.64	0.88	8,135	5.4%	33,251	22.1%	40,208	0.62	*0.59*
Franklin Canal Gage	I	0.55	0.73	0.91	-3,246	-4.6%	13,373	18.8%	18,231	0.67	*0.73*
Acequia Madre Diversion	I	0.93	0.93	0.98	1,275	2.7%	2,956	6.4%	4,829	0.27	*0.93*
(3) Total HCCRD Supply	I	0.86	0.87	0.97	-817	-1.2%	12,976	19.5%	15,752	0.37	*0.69*
EBID FHG	I	0.79	0.81	0.95	-1,738	-1.0%	25,768	15.2%	33,881	0.46	*0.79*
EPCWID FHG	I	0.65	0.67	0.87	-5,726	-4.7%	20,218	16.5%	27,008	0.59	*0.79*
HCCRD FHG	I	0.62	0.64	0.86	1,661	5.3%	8,922	28.6%	11,373	0.61	*0.57*
EBID Pumping	I	0.85	0.86	0.96	-850	-0.7%	23,365	19.9%	30,861	0.39	*0.80*
EPCWID Pumping	I	0.79	0.79	0.94	-3,065	-6.2%	15,478	31.4%	19,564	0.46	*0.51*
HCCRD Pumping	I	0.56	0.64	0.86	-2,276	-35.3%	3,381	52.5%	5,203	0.66	*0.61*
(4) Rincon Valley Drains	A	0.11	0.32	0.74	-2,252	-16.3%	4,707	34.1%	6,140	0.94	*0.50*
(5) Mesilla Valley Drains	A	0.82	0.83	0.95	-6,132	-6.9%	16,273	18.2%	20,406	0.43	*0.72*
(6) El Paso Valley Drains	A	0.61	0.63	0.89	-462	-0.8%	14,026	25.1%	17,745	0.62	*0.59*

Performance Evaluation Criteria for Selected Statistics from Moriasi (2015)

Rating	NSE	R^2	d	PBIAS
Very Good	0.80 < NSE	$0.85 < R^2$	0.90 < d	PBIAS < +/- 5
Good	0.70 < NSE ≤ 0.80	$0.75 < R^2 \leq 0.85$	0.85 < d ≤ 0.90	+/- 5 ≤ PBIAS < +/-10
Satisfactory	0.50 < NSE ≤ 0.70	$0.60 < R^2 \leq 0.75$	0.75 < d ≤ 0.85	+/- 10 ≤ PBIAS < +/-15
Not Satisfactory	0.00 < NSE ≤ 0.50	$0.18 < R^2 \leq 0.60$	0.60 < d ≤ 0.75	+/- 15 ≤ PBIAS < +/-30
Unacceptable	NSE ≤ 0.00	$R^2 \leq 0.18$	d ≤ 0.60	+/- 30 ≤ PBIAS

Notes:

(1) Annual statistics denoted with (A), irrigation season statistics denoted with (I)

(2) Log NSE computed using modeled and observed flows adjusted by adding 1,000 AF to streamflows and 100 AF to diversions, farm headgate deliveries, pumping, and drains flows

(3) Total Hudspeth Supply includes Tornillo Drain, Tornillo Canal at Alamo Alto, and Hudspeth Feeder Canal

(4) Rincon Valley Drains statistics are computed for 1951-2002 due to limited data available after 2002

(5) Mesilla Valley Drains are computed for 1951-2013 due to limited data available after 2013

(6) El Paso Valley Drains include the Fabens Waste Drain and the Tornillo Drain

Table 30-1

List of Original Model Runs
ILRG Model

Run No.	Name	Compare To Run	Notes
0	Historical Calibration Run		
1	Historical Base Run (All Pumping On)	0	
2	All Pumping Off	1	(1)
3	NM Pumping Off	1	(1)
4	TX Pumping Off	1	(1,2)
5	MX Pumping Off	1	(1)
6	R-M Pumping Off	1	(1,3)
7	TX Mesilla Pumping Off	1	(1)
8	TX Non-Irrigation Pumping Off	1	(1)
9	NM Non-Irrigation Pumping Off	1	(1)
10	MX Non-Irrigation Pumping Off	1	(1)
11	D1/D2 Allocation (All Pumping On)	1	(4)
12	D3+Carryover Allocation (All Pumping On)	11	(4)
13	Reduced Waste	1	

Notes:

(1) Corresponding WWTP returns and urban deep percolation returns are also turned off (no UDP simulated in Mexico).
(2) Including Texas Mesilla (EPCWID Mesilla and EPW Canutillo Wellfield).
(3) Including Texas Mesilla and Mexico Conejos-Medanos.
(4) Project allocation procedure simulated for 1950-2017.

Table 30-2

List of Additional Model Runs
ILRG Model

Run No.	Name	Compare To Run	Notes
14	All Hueco Pumping Off	1	
14a	TX Hueco Pumping Off	1	
14b	MX Hueco Pumping Off	1	
14c	Texas WWTP Discharges Off	1	
14d	TX Hueco Pumping Off (Returns Left On)	1	
15	Early EPCWID Ops (WWTP & Fabens Drains)	1	(1)
15a	Early EPCWID Ops (WWTP)	1	(2)
15b	Early EPCWID Ops (Fabens Drains)	1	(3)
15c	Early EPCWID Ops (TX Hueco Pumping Off)	15	(1)
16	Conj Use 1: Hist All Acres D1/D2 (Hist M&I)	1	(1,4,9)
16a	Conj Use 1a: Hist All Acres D1/D2 (1978 M&I)	1	(1,5,9)
17	Conj Use 2: Hist Proj Acres (Hist M&I)	1	(1,6,9)
17a	Conj Use 2a: Hist Proj Acres (Pre-Comp M&I)	1	(1,7,9)
18	Conj Use 3: Auth Proj Acres (Pre-Comp M&I)	1	(1,8,9)

Notes:

(1) EPCWID increased use of Fabens drain flows; charge EPCWID for use of EPW WWTP returns and drain flows; No ACE or Haskell credits.

(2) Charge EPCWID for use of EPW WWTP returns; no ACE or Haskell credits.

(3) EPCWID increased use of Fabens drain flows and charge for drain flow use.

(4) Conjunctive use pumping on historical Project acres; pumping on NM GW only acres; D1/D2 allocation and accounting for 1951-2017; limit 10-year average irrigation pumping to 1951-1978 average; historical M&I pumping.

(5) Same as (4) except limit M&I pumping to 1951-1978 max.

(6) Conjunctive use pumping on historical Project acres; no pumping on NM GW only acres; D1/D2 allocation and accounting for 1951-2017; no limit on irrigation pumping; historical M&I pumping.

(7) Same as (6) except limit M&I pumping to pre-compact amounts.

(8) Conjunctive use pumping on authorized acres; irrigation of authorized Project acres every year 1940-2017 (EBID-88,000 ac, EPCWID-67,000 ac); irrigation of 17,750 acres (max) for HCCRD1 every year; irrigation of historical Juarez acres; no pumping on NM GW only acres; limit M&I pumping to pre-compact amounts, no EPW use of Project water.

(9) Turn off Las Cruces WWTP discharge and urban deep percolation that originates from pumping of Jornada wells.

Table 30-3

Average Annual Change in Simulated Flows
Rincon-Mesilla Pumping Off
1951-2016 (AF)

	Change in Model Output	(1) ILRG Model (Annual)	(2) ILRG Model (Irrigation Season)	(3) Texas Model (Hutchison)	(4) Texas Model (Moran)
	Reservoir Evaporation	17,600	14,800	n/a	n/a
(5)	Caballo Reservoir Releases	-38,200	-38,100	n/a	n/a
	Caballo Reservoir Spills	19,500	15,500	n/a	n/a
	Rincon-Mesilla Diversions	48,000	47,900	n/a	95,200
	Rincon-Mesilla FHG Deliveries	33,800	33,700	n/a	69,700
	Rio Grande at El Paso Flows	79,800	33,200 (5)	124,700	51,700
	EPCWID (EPV) Diversions	20,600	17,900	n/a	n/a
	EPCWID (EPV) FHG Deliveries	8,700	8,700	n/a	n/a
	Rio Grande at Ft. Quitman Flows	56,700	18,000 (5)	n/a	n/a

Notes:

(1) New Mexico ILRG Model (Run 6 minus Run 1) annual.
(2) New Mexico ILRG Model (Run 6 minus Run 1) irrigation season.
(3) Texas Model (no reoperation); 100% R-M Pumping Off (Hutchison, 2019).
(4) Texas Model (crude redistribution); 100% R-M Pumping Off (Moran, 2019).
(5) Not including spills.

Table 31-1

Summary of ILRG Model Sensitivity Analyses
New Mexico Pumping Impacts (Run 3 minus Run 1)
Average Change in Run Differences

Model Output	Run 3 - Run 1 (Original)	Alluvial Aquifer Hydraulic Conductivity		River Bed Conductance		Canal Bed Conductance		Drain Bed Conductance		Crop Irrigation Requirement	
		(AF)	%	(AF)	%	(AF)	%	(AF)	%	(AF)	%
Project Storage	156,865	2,483	2%	-160	0%	7,997	5%	920	1%	29,195	19%
Caballo Outflow	-16,607	-19	0%	171	-1%	-543	3%	71	0%	-2,741	17%
El Paso Flow	61,104	1,023	2%	-187	0%	3,563	6%	52	0%	16,282	27%
Fort Quitman Flow	48,960	829	2%	-261	-1%	3,069	6%	56	0%	9,052	18%
RHG Div (EBID)	46,290	1,234	3%	2,183	5%	3,292	7%	905	2%	8,292	18%
RHG Div (EPCWID)	18,465	419	2%	272	1%	1,256	7%	-70	0%	7,476	40%
RHG Div (HCCRD)	6,547	112	2%	134	2%	261	4%	54	1%	3,290	50%
FHG Deliv (EBID)	31,204	-480	-2%	233	1%	1,801	6%	165	1%	4,589	15%
FHG Deliv (EPCWID)	11,745	66	1%	109	1%	755	6%	-115	-1%	5,033	43%
FHG Deliv (HCCRD)	1,642	-62	-4%	44	3%	-5	0%	41	2%	1,641	100%
R-M GW Storage	316,097	-2,557	-1%	1,236	0%	13,836	4%	531	0%	86,288	27%
Hueco GW Storage	321,784	4,080	1%	-100	0%	9,168	3%	364	0%	229,186	71%

Notes:

(1) Change in Run 3 minus Run 1 differences for a 10% increase in selected input parameters/data.
Run 3 (No NM Pumping) minus Run 1 (Historical Base Run)

(2) Percent change calculated using the following formula:

$$\frac{(Run\ 3^{*}\ minus\ Run\ 1^{*})\ minus\ (Run\ 3\ minus\ Run\ 1)}{(Run\ 3\ minus\ Run\ 1)}$$

(3) Changes in storage and flows are annual. Changes in RHG and FHG are irrigation season.

Appendix 17

Errata
Rebuttal Expert Report
Gregory K. Sullivan, P.E.
and
Heidi M. Welsh
Second Edition

Report Text

P. vi, Bullet 6, Line 1: “River Conductance” should read “River Bed Conductance”

P. vi, Bullet 7, Line 1: “Canal Conductance” should read “Canal Bed Conductance”

P. vi, Bullet 8, Line 1: “Drain Conductance” should read “Drain Bed Conductance”

P. 1, Bullet 6, added: Also on July 15, 2020, the New Mexico experts submitted revised or second editions of their opening expert reports.

P. 2, Paragraph 4, added: A second edition of the SWE Rebuttal Report was prepared to describe corrections and improvements that have been made to the ILRG Model, to report the results of the model re-tuning, and to present the results of the updated Base Run (Run 1) and alternative scenario runs (Runs 2 – 18). This second edition report also corrects typographical errors in the original SWE Rebuttal Report. A new Appendix 17 is attached that contains an errata list for Sections 17-29 and 31, a redline depiction of the changes to Section 30, and a list of the figures, tables, and appendices revised for this second edition.

P. 7, Paragraph 6, Line 4: “ILRG reflect” should read “ILRG Model reflect”

P. 8, Paragraph 5, Line 6: “evaluated” should read “evaluation”

P. 9, Paragraph 5, Line 6: “impacts being caused” should read “impacts caused”

P. 13, Paragraph 2, Line 1: “(v111)” should read “(v116)”

P. 14, Paragraph 6, Line 8: “Run 14c)” should read “(Run 14c)”

P. 25, Table for Run 14a, Line 2: “-900” should read “-600”, and “1,200” should read “-7,800”

P. 25, Table for Run 14a, Line 3: “-400” should read “-300”, and “1,600” should read “-4,000”

P. 25, Table for Run 14d, Line 2: “3,400” should read “8,200”, and “3,600” should read “3,400”

P. 25, Table for Run 14d, Line 3: “1,900” should read “5,000”, and “2,800” should read “2,000”

P. 26, Table for Run 14c, Line 2: “-6,300” should read “-15,200”, and “-21,300” should read “-25,000”

P. 26, Table for Run 14c, Line 3: “-3,500” should read “-8,200”, and “-10,600” should read “-11,700”

P. 32, Paragraph 8, Line 3: “and discharges” should read “discharges”

P. 32, Paragraph 8, Line 4: “discharges” should read “and discharges”

P. 33, Paragraph 2, Line 4: “Figure 19-16” should read “Figure 19-13”

P. 49, Paragraph 1, Line 3: “significance” should read “significant”

P. 54, Paragraph 3, Line 6: “variable. Rio Grande inflows to Project storage are supply is managed” should read “variable Rio Grande inflows to Project storage are managed”

P. 55, Paragraph 1, Line 6: “no” should read “not”

P. 60, Paragraph 1, Line 2: “irrigation from” should read “irrigation season from”

P. 70, Paragraph 5, Line 6: “15%” should read “16%”

P. 70, Paragraph 5, Line 6: “(satisfactory to very good)” should read “(not satisfactory to very good)”

P. 71, Paragraph 2, Line 3: “relative MAE” should read “PMAE”

P. 71, Paragraph 2, Line 4: “34%” should read “36%”

P. 71, Paragraph 4, Line 4: “three” should read “one”

P. 71, Paragraph 5: “Of the three NSE values that are less than 0.50, two are for HCCRD – FHG deliveries and the related supplemental pumping to meet unmet demands. The simulated Total HCCRD Supply is simulated well with an NSE of 0.89. The less impressive simulation of HCCRD FHG deliveries is hampered by the general lack of information disclosed by Texas regarding how HCCRD operates. The third NSE value less than 0.50 is for the aggregated Rincon Valley drain flows which on average after 1950 flowed less than 15,000 AF/y.” should read ”The only NSE value less than 0.50 is for the aggregated Rincon Valley drain flows which on average after 1950 flowed less than 15,000 AF/y.”

P. 72, Paragraph 7, Line 2: “0.94” should read “0.93”

P. 73, Paragraph 3, Line 7: “0.94” should read “0.93”

P. 75, Paragraph 2, Line 6: “-1.6%” should read “-1.8%”

P. 82, Paragraph 5, Line 4: “14,900” should read “17,800”

P. 82, Paragraph 5, Line 5: “64,100” should read “54,600”

P. 86, Paragraph 5, Line 3: “years, but not all, these impacts are particularly offset” should read “years some, but not all, of these impacts are offset”

P. 90, Paragraph 5, Line 1: “reoperation” should read “redistribution”

P. 93, Table, Heading: “Original (v 106) and Updated (v 111)” should read “Original (v106) and Updated (v116)”

P. 93, Table, Line 1: “(v111)” should read “(v116)”

P. 93, Table, Line 3: “ -0.3” should read “-0.9”

P. 93, Table, Line 4: “-1.4” should read “-0.7”

P. 93, Table, Line 7: “-2.3” should read “-3.0”

P. 93, Table, Line 8: “1.6” should read “2.3”

P. 93, Table, Line 9: “-0.5” should read “-0.6”

P. 93, Paragraph 4, Line 2: “44,700” should read “47,600”

P. 93, Paragraph 4, Line 2: “54,700” should read “58,100”

P. 95, Paragraph 2, Line 4: “average overprediction or underprediction” should read “average underprediction”

P. 95, Paragraph 2, Line 5:	“10%” should read “5%”
P. 95, Paragraph 2, Line 6:	“Good” should read “Very Good”
P. 102, Paragraph 2, Line 1:	“(v111)” should read “(v116)”
P. 104, Bullet 7, added:	River Headgate Demand - Rearrange the equation that computes the river headgate demands so that the tuning factor is only applied to the crop, soil moisture, and EPW demands, and not to the conveyance losses and EPCWID use of WWTP discharges and drain flows.
P. 104, Bullet 8, added:	EPCWID Allocation Limit - Adjust the rule that limits EPCWID diversions when the EPCWID has less remaining allocation than demand.
P. 104, Bullet 9, added:	EPCWID FHG Deliveries – Add river seepage as an independent term in the equation that computes the EPCWID farm headgate deliveries.
P. 104, Bullet 10, added:	ACE Credit – Revise the rule that computes the ACE Credit to use the equation that has historically been most frequently used in the Project accounting.
P. 105, Bullet 5, added:	Rincon and Mesilla Valley Canal Capacities – Reduce the simulated capacity of the Rincon, Leasburg, Eastside, and Westside canals to limit the simulated maximum monthly diversions consistent with historical diversion records.
P. 111, Bullet 4, Line 2:	“with a slight underprediction trend throughout the “should read “with some underprediction late in the”
P. 115 to 135, Section 30:	Section 30 changes are documented in the redline version of the text for this section that is included in this appendix as Attachment 17-A.
P. 137, Bullet 1, Line 3:	“(2% or less).” should read “(4% or less)
P. 137, Bullet 3, Line 4:	“(4% - 8%)” should read “(0% - 7%)”
P. 137, Bullet 3, Line 5:	“(3 - 4%)” should read “(3% - 5%)”
P. 137, Bullet 3, Line 6:	“(4% - 6%)” should read “(3% - 6%)”
P. 137, Bullet 5, Line 1	“had” should read “has”
P. 138, Paragraph 1, Line 2	“17% - 27%” should read “15% - 43%”

Figures, Tables, and Appendices Revised to Correct Typographical Errors

P. 148, Figure 19-3	Note “Missing Fabens Waste Drain flows in 1992, and in certain months in 1993-1996, 2003-2004, and 2012.” should read “Missing Fabens Waste Drain flows in 1992, and in certain months in 1993-1996, 2003, and 2012.”
P. 151, Figure 19-6	Note “(2) EPCWID Authorized Acres Demand computed as 3.024 AF/acre x EPCWID authorized acres (69,010).” should read “(4) EPCWID Authorized Acres Demand computed as 3.024 AF/acre x EPCWID authorized acres (69,010).”
P. 155, Figure 19-10	Note “(2) Sum of EPCWID and EBID irrigation pumping CU (incl. primary ground water lands) from SWE CFB Model plus Texas M&I pumping from NMR-M Model and Hueco Model minus return flows from NMR-M Model and Hueco Model inputs.” should read “(2) Sum of EPCWID and HCCRD irrigation pumping CU from SWE CFB Model plus Texas M&I pumping from NMR-M Model and Hueco Model minus return flows from NMR-M Model and Hueco Model inputs.”
P. 156, Figure 19-11	Note “(2) Sum of EPCWID and EBID irrigation pumping CU (incl. primary ground water lands) from SWE CFB Model plus Texas M&I pumping from NMR-M Model and Hueco Model minus return flows from NMR-M Model and Hueco Model inputs.” should read “(2) Sum of EPCWID and HCCRD irrigation pumping CU from SWE CFB Model plus Texas M&I pumping from NMR-M Model and Hueco Model minus return flows from NMR-M Model and Hueco Model inputs.”
P. 159, Figure 19-14	Note “(1) Socorro WWTP discharges estimated 1967 - 1988 from SWE SWDataSet.” should read “(1) Monthly Socorro WWTP discharges estimated 1967 - 1988 from SWE SWDataSet (annual data only 1967 - 1984).”
P. 161, Figure 19-16	Note “(5) Fabens Waste Drain flows were estimated in 1992 and some months in 1993 - 1996 and 2003.” should read “(5) Fabens Waste Drain flows were estimated in 1992 and some months in 1993 - 1996, 2003, and 2012.”
P. 162, Figure 19-17	Note “(4) Usable Drain Supply at Fabens computed as the sum of the River Drain plus Middle Drain (1940 - 1983) and 70% of Fabens Waste Drain (1984 - 2017). Fabens Waste Drain flows were estimated in 1992 and some months in 1993 - 1996 and 2003.” should read “ (4) Usable Drain Supply at Fabens computed as the sum of the River Drain plus Middle Drain (1940 - 1983) and 70% of Fabens Waste Drain (1984 - 2017). Fabens Waste Drain flows were estimated in 1992 and some months in 1993 - 1996, 2003, and 2012.”
P. 170, Figure 23-1	Note “Rincon drain data is unavailable from 2005-2017.” should read “Rincon drain data is unavailable from 2006-2017.”
P. 196, Figure 29-2	Footnote “Page 1 of 1” was removed.

P. 196, Figure 29-2	Note “Allocation is calculated and used to limit diversions for EBID and EPCWID from 1951-2017.” should read “Allocation is calculated and used to limit diversions for EBID and EPCWID from 1950-2017.”
P. 196, Figure 29-2	EBID Allocation: “1950 value” should be added
P. 196, Figure 29-2	EPCWID Allocation: “1950 value” should be added
P. 204, Figure 29-6	Footnote “(1) Gross Canal Diversions includes the sum of Acequia Madre diversions, lower river diversions, WWTP flows into canals, and drain returns to canals.” should read “(1) Gross Canal Diversions includes the sum of Acequia Madre diversions, lower river diversions, and WWTP flows into canals.”
P. 204, Figure 29-6	Footnote “(2) Diversions calculated as river headgate diversion + WWTP returns to canal.” should be deleted
P. 234, Table 23-1	Footnote “Reported by Distriect - EBID, EPCWID, and HCCRD total There are several years after 1979 in which EBID data is separated into Rincon and Mesilla (including Leasburg) totals.” should read “Reported by District - EBID, EPCWID, and HCCRD total There are several years after 1979 in which EBID data is separated into Rincon and Mesilla (including Leasburg) totals.”
P. 241, Table 30-1	D1/D2 Allocation (All Pumping On) value in column Compare to Run “- -” should be “1”
P. 243, Table 30-3	Footnote “New Mexico ILRG Model (Runs minus Run 1) annual.” should read “New Mexico ILRG Model (Run 6 minus Run 1) annual.”
P. 243, Table 30-3	Footnote “New Mexico ILRG Model (Runs minus Run 1) irrigation season.” should read “New Mexico ILRG Model (Run 6 minus Run 1) irrigation season.”
P. 243, Table 30-3	Footnote “(4) Texas Model (crude reoperation); 100% R-M Pumping Off (Moran, 2019).” should read “(4) Texas Model (crude redistribution); 100% R-M Pumping Off (Moran, 2019).”

Figures, Tables, and Appendices Revised Due to Updated Base Run (Run 1) and Alternative Scenario Runs (Runs 2 - 18)

P. 147, Figure 19-2	Depletion to Rio Grande at El Paso Flow from Pumping in the Rincon and Mesilla Valleys, ILRG Model, 1950-2017
P. 172, Figure 28-1	Integrated LRG Model Historical Calibration Results, Caballo Release, 1940-2017
P. 173, Figure 28-2	Integrated LRG Model Historical Calibration Results, Rio Grande at El Paso, 1940-2017
P. 174, Figure 28-3	Integrated LRG Model Historical Calibration Results, Rio Grande at Fort Quitman, 1940-2017
P. 175, Figure 28-4	Integrated LRG Model Historical Calibration Results, Rincon Diversion, 1940-2017
P. 176, Figure 28-5	Integrated LRG Model Historical Calibration Results, Leasburg Diversion, 1940-2017
P. 177, Figure 28-6	Integrated LRG Model Historical Calibration Results, Eastside Diversion, 1940-2017
P. 178, Figure 28-7	Integrated LRG Model Historical Calibration Results, Westside Diversion, 1940-2017
P. 179, Figure 28-8	Integrated LRG Model Historical Calibration Results, American Diversion, 1940-2017
P. 180, Figure 28-9	Integrated LRG Model Historical Calibration Results, Riverside Canal Gage, 1940-2017
P. 181, Figure 28-10	Integrated LRG Model Historical Calibration Results, Franklin Canal Gage, 1940-2017
P. 182, Figure 28-11	Integrated LRG Model Historical Calibration Results, Acequia Madre Diversion, 1940-2017
P. 183, Figure 28-12	Integrated LRG Model Historical Calibration Results, Total HCCRD Supply, 1940-2017
P. 184, Figure 28-13	Integrated LRG Model Historical Calibration Results, EBID FHG, 1940-2017
P. 185, Figure 28-14	Integrated LRG Model Historical Calibration Results, EPCWID FHG, 1940-2017
P. 186, Figure 28-15	Integrated LRG Model Historical Calibration Results, HCCRD FHG, 1940-2017

P. 187, Figure 28-16	Integrated LRG Model Historical Calibration Results, EBID Supplemental Pumping, 1940-2017
P. 188, Figure 28-17	Integrated LRG Model Historical Calibration Results, EPCWID Supplemental Pumping, 1940-2017
P. 189, Figure 28-18	Integrated LRG Model Historical Calibration Results, HCCRD Supplemental Pumping, 1940-2017
P. 190, Figure 28-19	Integrated LRG Model Historical Calibration Results, Rincon Drains, 1940-2017
P. 191, Figure 28-20	Integrated LRG Model Historical Calibration Results, Mesilla Valley Drains, 1940-2017
P. 192, Figure 28-21	Integrated LRG Model Historical Calibration Results, El Paso Valley Drains, 1940-2017
P. 193-195, Figure 29-1	Annual Reservoir Water Budget Summary, Historical Base Run (Run 1), Integrated LRG Model, 1940-2017
P. 196, Figure 29-2	Annual Project Allocation and Charges, Historical Base Run (Run 1), Integrated LRG Model, 1940-2017
P. 197-198, Figure 29-3	Annual Canal and Farm Water Budget Summary, Historical Base Run (Run 1), Integrated LRG Model, 1940-2017, EBID Total
P. 199-200, Figure 29-4	Annual Canal and Farm Water Budget Summary, Historical Base Run (Run 1), Integrated LRG Model, 1940-2017, EPCWID Total
P. 201-202, Figure 29-5	Annual Canal and Farm Water Budget Summary, Historical Base Run (Run 1), Integrated LRG Model, 1940-2017, HCCRD Total
P. 203-204, Figure 29-6	Annual Canal and Farm Water Budget Summary, Historical Base Run (Run 1), Integrated LRG Model, 1940-2017, JID Total
P. 205, Figure 29-7	Annual River Budget Summary, Historical Base Run (Run 1), Integrated LRG Model, 1940-2017, Total Rincon-Mesilla (Below Caballo to El Paso)
P. 206, Figure 29-8	Annual River Budget Summary, Historical Base Run (Run 1), Integrated LRG Model, 1940-2017, Total El Paso Valley (El Paso to Fort Quitman)
P. 207-208, Figure 29-9	Annual Rio Grande Point Flows, Historical Base Run (Run 1), Integrated LRG Model, 1940-2017
P. 209-224, Figure 29-10	Monthly Average Rio Grande Flows, Integrated LRG Model - Historical Base Run (Run 1), 1940-2017
P. 225, Figure 29-11	Simulated Monthly Charged Diversions of Project Water by EBID and EPCWID, Integrated LRG Model - Historical Base Run (Run 1), 1940-2017

P. 226, Figure 31-1	Summary of ILRG Model Sensitivity Analyses, Alluvial Aquifer Hydraulic Conductivity, Average Annual New Mexico Pumping Impacts (Run 3 minus Run 1), 1951-2017
P. 227, Figure 31-2	Summary of ILRG Model Sensitivity Analyses, River Bed Conductance, Average Annual New Mexico Pumping Impacts (Run 3 minus Run 1), 1951-2017
P. 228, Figure 31-3	Summary of ILRG Model Sensitivity Analyses, Canal Bed Conductance, Average Annual New Mexico Pumping Impacts (Run 3 minus Run 1), 1951-2017
P. 229, Figure 31-4	Summary of ILRG Model Sensitivity Analyses, Drain Bed Conductance, Average Annual New Mexico Pumping Impacts (Run 3 minus Run 1), 1951-2017
P. 230, Figure 31-5	Summary of ILRG Model Sensitivity Analyses, Crop Irrigation Requirement, Average Annual New Mexico Pumping Impacts (Run 3 minus Run 1), 1951-2017
P. 240, Table 28-1	Summary of Annual and Irrigation Season Calibration Statistics, ILRG Model, 1951-2017
P. 243, Table 30-3	Average Annual Change in Simulated Flows, Rincon-Mesilla Pumping Off, 1951-2016
P. 244, Table 31-1	Summary of ILRG Model Sensitivity Analyses, New Mexico Pumping Impacts (Run 3 minus Run 1), Average Change in Run Differences
P. 280-281, Appendix 18	Response to Revised Texas Analyses Submitted Without a Rebuttal Report (figures added)
P. 285-288, Appendix 18	Response to Revised Texas Analyses Submitted Without a Rebuttal Report (figures added)
P. 327-899, Appendix 30 B-AA	Comparison of ILRG Model Runs

Corrections to Run Summaries and Run Comparisons in Appendices 30B – 30AA

Column BB in the “ModelRun” tab in each run summary spreadsheet was corrected to reflect the total Rio Grande Project Storage (Elephant Butte Reservoir + Caballo Reservoir). This change affects the reservoir storage data presented in Figure 29-1. In addition, this change affects the reservoir storage data presented in the upper table on page 3, the upper graph on page 6, the upper left graph on page 11, and the graphs on page 19 for each run comparison included in Appendices 30B – 30AA.

Columns E, S, and AI on the “Diff Charts” tab in each run comparison spreadsheet were corrected to reflect annual Caballo Reservoir release data. This change affects the lower right inset graph for Caballo Reservoir Outflows on page 6 of each run comparison included in Appendices 30B – 30AA.

30.0 ALTERNATIVE RUNS OF ILRG MODEL

The updated ILRG Model (v11~~1~~6) was used to re-run the no-pumping scenarios and operations scenarios that were presented in the SWE Report (Runs 2 – 13). A list of the original model runs is provided in **Table 30-1**.

In addition to re-running the original 13 scenarios, the updated ILRG Model was used to simulate additional no-pumping scenarios and operations scenarios. These included Run 14 and several variants that simulate the effects of pumping in the Hueco and Run 15 and several variants that simulate early EPCWID operations prior to changes in water use practices. In addition, five other scenarios were simulated (Runs 16, 16a, 17, 17a, and 18) to analyze conjunctive use of surface water and ground water. These conjunctive use scenarios are based on either a D1/D2 level of supplemental pumping or a supplemental pumping level up to the crop demands on the authorized Project acres, and were developed in consultation with representatives and legal counsel for New Mexico. A list of the additional model runs is provided in **Table 30-2**. Additional specifications for the model runs are provided in **Appendix 30-A** including details for Runs 15-18 and details for the WWTP discharges and urban deep percolation returns that are turned off or reduced in certain of the alternative scenarios.

The results from the re-running of the original scenarios and simulation of the new scenarios are presented in a consistent format in the tables and graphs in **Appendix 30**. These include tabular and graphical results similar to those presented in the SWE Report as well as several additional tables and graphs. Unless otherwise noted, all of the results presented in **Appendix 30** are comparisons between an alternative scenario and the Historical Base Run (Run 1). There are 22 pages of tables and graphs included in the run comparisons for each scenario. An overview of the format and content of each of these tables and graphs follows:

- Cover Page (p. 1) – Selected input specifications for the two runs being compared.
- Comparison of ILRG Model Runs (p. 2-3) – This two-page table provides a high-level overview of how the ILRG Model distributes the change in inputs (e.g., change in pumping stress or change in operating rules) into changes in model outputs. The first five rows of values are the average annual pumping stresses in each run, which consist of the irrigation pumping that is on in Run 1 and off in the alternative run, and the total non-irrigation pumping and non-irrigation pumping return flows (WWTP discharges and urban deep percolation). The Total Stress is computed as the sum of the irrigation and non-irrigation pumping less the non-irrigation returns flows. The third column of numbers shows the difference in

stress between the two runs being compared. The remainder of the table reports the annual averages for selected ILRG Model outputs and the differences in outputs between the two runs. The fourth and fifth columns of numbers express the average annual output differences as percentages of the change in Total Stress and as percentages of the Base Run values. For the alternative runs that simulate differences in operating rules (i.e. Runs 11-13, 15-18), there are no rows in the table listing the stresses, nor is there a column listing the % Change Stress.

- Annual Differences in ILRG Model Outputs (p. 4-5) – This two-page table lists the differences in model outputs for selected model outputs. These include the differences in irrigation season and annual net RHG Diversions and FHG Deliveries, and differences in annual river flows at the Caballo outlet, El Paso, and Fort Quitman. Net RHG Diversions are defined as the simulated gross diversions less the historical El Paso carriage water that was delivered through the Rincon and Mesilla Valley canals and less the simulated flood control releases that were run through the canals in spill years. Reporting of differences in net RHG Diversions in the model results represents a change from the reporting of differences in gross RHG diversions that were presented in model results described in the SWE Report.

- Simulated Differences in ILRG Model Outputs (p. 6-9) – These four pages of graphs and tables show differences in model outputs expressed as either annual or irrigation season totals. There is a bar chart with the yearly differences in model output, an inset line chart showing the annual outputs that are differenced in the bar chart, and a table summarizing the yearly average differences (annual or irrigation season totals). The differences in net RHG diversions and FHG deliveries are shown in line graphs rather than bar charts.

- Annual Allocation and Charges (p. 10) – This chart summarizes for the two compared runs the simulated annual allocation and delivery charges for EBID and EPCWID, as well as the simulated annual Diversion Ratio computed as the sum of the annual diversion charges for EBID, EPCWID, and Mexico divided by the annual Caballo Reservoir releases.

- Annual Summary of Project Storage and Rio Grande Flows (p. 11) – This chart summarizes for the two compared runs the total year-end project storage in Elephant Butte and Caballo Reservoirs and the annual Rio Grande flow at the Caballo Reservoir outlet, at El Paso, and at Fort Quitman.

- Irrigation Season Summary of Irrigation Operations (p. 12-14) – These three pages of charts summarize for the two compared runs the net RHG diversions, FHG deliveries, irrigation pumping, and RHG diversions minus FHG deliveries (conveyance losses). There are separate pages for EBID, EPCWID, and HCCRD.

- <u>Cumulative Change in Ground Water Storage (p. 15)</u> – This chart summarizes for the two compared runs the cumulative year-end change in ground water storage in the alluvial and non-alluvial aquifers in the Rincon and Mesilla valleys and in the Hueco.

- <u>Monthly Net RHG Diversions (p. 16-18)</u> – These three pages of charts show for the two compared runs the simulated monthly net RHG diversions. There are charts showing the total EBID diversions, total EPCWID diversion, and the total flow to HCCRD.

- <u>End of Month Reservoir Storage (Elephant Butte + Caballo) (p. 19)</u> – This chart shows for the two compared runs the combined end-of-month Project storage in Elephant Butte and Caballo Reservoirs. This doesn't include storage of non-Project water.

- <u>Monthly Rio Grande Flows (p. 20-22)</u> – These three pages of charts show for the two compared runs the simulated monthly Rio Grande flows at the Caballo Reservoir outlet, at El Paso, and at Fort Quitman.

Narrative summaries of the ILRG Model simulations of alternative scenarios are provided below to highlight and explain some of the more significant results shown in the tabular and graphical summaries presented in **Appendix 30**. The tables in **Appendix 30** include annual and irrigation season differences in model outputs for all run comparisons. Averages are computed for the following noteworthy ranges of years:

1951-2017:	Period with irrigation pumping development commencing with the beginning of the D1/D2 data period (57/43 allocation until 2006).
1951-1978:	D1/D2 data period (57/43 allocation).
1979-2005:	Post D1/D2 data period prior to the 2008 OA allocation and accounting that commenced in 2006 (57/43 allocation).
2006-2017:	Period when the 2008 OA allocation and accounting was in effect (D3 allocation for 2006 and 2007, D3 allocation plus carryover for 2008-2017).
1985-2017:	Period for which alleged damages were computed by Texas (1985-2016) plus the last year of the study period (2017).

1985-2005: Portion of the Texas damages period prior to commencement of the 2008 OA allocation and accounting.

Averages for other portions of the study periods can be computed from the data in the run comparison spreadsheets that are being disclosed with this report.

30.1 All Pumping Off (Run 2)

In Run 2, all irrigation and non-irrigation pumping in the study area is turned off, and all non-irrigation returns, including WWTP discharges and urban deep percolation returns, are also turned off. The changes in irrigation returns that result from turning off the irrigation pumping are simulated by the farm budget processes included in the model.

The ILRG Model re-operates the Project and all of the simulated irrigation systems in the absence of pumping. Turning off pumping increases drain flows and reduces river seepage in most years. During full allocation years, this results in water accumulating in storage as less water needs to be released to meet demands. Accumulating water in storage increases allocations and Caballo Reservoir releases in subsequent dry years (e.g., several years in the 1960s, 1970s, and 2000s). Spills are also larger due to the accumulated water in storage.

The increased allocations result in increased diversions and FHG deliveries to EBID in dry years between 1950 and 1978. During the full allocation years from 1979 – 2002, there is little change in EBID diversions, however FHG deliveries increase modestly due to reductions in the simulated canal conveyance losses in the no-pumping run that allowed more of the water that is diverted to be delivered to the farms. When dry conditions return, EBID diversions and FHG deliveries increase again in 2003 and 2004. EBID diversions increase substantially beginning in 2006 due to the effects that pumping has when the 2008 OA is in effect. As is discussed in Barroll (2019), EBID's allocation under the 2008 OA is sensitive to the diversion ratio. When pumping is turned off, the diversion ratio increases resulting in increased allocations and increased deliveries to EBID. On average from 2006 – 2017, EBID's diversions increase by 148,700~~145,400~~ AF and FHG deliveries increase by 92,700~~93,200~~ AF.

The increase in Project water allocations also results in increased diversions and FHG deliveries to EPCWID in many dry years in the 1950s – 1970s. There are also modest increases in EPCWID diversions during many full allocation years in the 1980s and 1990s because the reduction in EPW WWTP discharges to EPCWID canals results in EPCWID requiring more reservoir releases to meet its demands. Increases in deliveries also occur in several dry years in the 2000s – 2010s although the increases are not near as large under the 2008 OA after 2005 as they are for EBID.

Turning off pumping and the resulting effects on Project operations and deliveries results in increased Rio Grande at El Paso flow in most years averaging 79,000~~80,500~~ AF annually during 1951 – 2017. Of this amount, an average of only 33,100~~38,900~~ AF occurs during the irrigation season (Mar-Oct) and the remaining 45,900~~41,600~~ AF occurs during the non-irrigation season (Nov-Feb) or during reservoirs spill. During the 1985-2005 period, the increase in irrigation season flows, excluding spills, averages 15,700~~28,600~~ AF. A portion of the increase is attributable to turning off New Mexico pumping and a portion is due to turning off Texas pumping. Cessation of pumping also produces substantial increases in flow at Fort Quitman averaging 100,300~~102,900~~ AF annually during 1951-2017.

30.2 NM Pumping Off (Run 3)

In Run 3, all irrigation pumping and all non-irrigation pumping and returns in New Mexico is turned off. This includes all EBID supplemental irrigation pumping, all primary irrigation pumping in the Rincon Valley and Mesilla Valley, and all non-irrigation pumping and associated WWTP discharges and deep percolation returns in New Mexico.

Many of the simulated effects of turning off New Mexico pumping are similar to but smaller than the effects of turning off all pumping in Run 2. There is a similar pattern of accumulations in Project storage that are released in dry years when the simulated Project allocations increase~~d~~. The accumulated storage again leads to larger spills.

EBID diversions increase by an average of 46,300~~46,600~~ AF during 1951-2017, while FHG deliveries increase by an average of 31,200~~33,700~~ AF. When the 2008 OA is in effect during 2006-2017, turning off New Mexico pumping increases EBID diversions by an average of 137,500~~134,200~~ AF, and FHG deliveries increase by an average of 83,900~~84,100~~ AF.

The impacts of New Mexico pumping on EPCWID supply are less than the impacts on EBID. From 1951 – 2017, EPCWID irrigation season diversions increase by an average of 18,500~~19,200~~ AF and FHG deliveries increase by an average of 11,700~~11,600~~ AF. After 1984 when Texas is claiming damages, New Mexico pumping impacts EPCWID irrigation season diversions by an average of 17,200~~13,200~~ AF and irrigation season FHG deliveries by an average of 9,700~~7,400~~ AF (1985-2017). During 1985-2005, prior to implementation of the 2008 OA, EP~~W~~CWID irrigation season diversions increase by an average of 10,900~~7,200~~ AF and irrigation season FHG deliveries increase by an average of 5,100~~3,200~~ AF.

Simulated flows in the Rio Grande at El Paso increase when New Mexico pumping is turned off by an average of 61,100~~62,500~~ AF annually during 1951-2017, of which an average of 22,900~~24,800~~ AF occurs during the irrigation season and 38,200~~37,700~~ AF occurs during the non-irrigation season or during spills. Average annual flows at Fort Quitman during 1951-2017 increase by an average of 49,000~~49,900~~ AF due largely to return flows from increased surface water deliveries and reduced surface water depletions from pumping. This run shows that the Texas Model without reoperation greatly exaggerates the impacts of New Mexico pumping on El Paso flows.

30.3 TX Pumping Off (Run 4)

In Run 4, all supplemental irrigation pumping in EPCWID and HCCRD is turned off, as is all non-irrigation pumping and associated returns in the Texas portion of the Mesilla Valley and in the El Paso Valley. Deliveries of Project water to EPW and the associated return flows continue to be simulated in Run 4.

When Texas pumping is turned off, annual EBID diversions increase by an average of 5,400~~6,600~~ AF/y during 1951-1978, and by an average of 15,500~~20,400~~ AF during 2006-2017 when the 2008 OA is in effect. The impacts of Texas pumping are magnified by the sensitivity of changes in the diversion ratio on EBID allocations. The pattern of impacts on EBID FHG deliveries is similar with impacts to diversions that average 4,300~~4,900~~ AF during 1951-1978 and 9,600~~13,300~~ AF during 2006-2017.

Texas pumping also impacts Project water deliveries to EPCWID. The net effect on EPCWID supply depends on the relative positive effect of reducing depletions from pumping compared to the negative effect of turning off Texas WWTP discharges. During 1951-1978, EPCWID diversions increase by an average of 200~~3,100~~ AF, but FHG deliveries increase by an average of ~~only~~ 2,600~~800~~ AF. During the mostly full supply years of 1979-2005, EPCWID diversions increase by an average of 10,200~~11,900~~ AF to replace the significant reduction in WWTP discharges to the EPCWID canal system.

The reduction in the Texas WWTP discharges due to turning off the non-irrigation pumping and the concurrent increased deliveries of Project water to EPCWID, along with the reduction in stream depletions caused by Texas Mesilla irrigation pumping results in increased Rio Grande at El Paso flow in many years, particularly in the 1980s and 1990s. During 1985-2005, El Paso flows increase by an average of 27,800~~28,200~~ AF during the irrigation season, excluding spills.

30.4 MX Pumping Off (Run 5)

In Run 5, all supplemental pumping in JID and all municipal pumping and associated WWTP discharges in Ciudad Juarez is turned off. Turning off pumping in Mexico has much less effect on Project operations than turning off pumping in New Mexico or Texas.

Turning off Mexico pumping reduces the river and conveyance system losses in delivering Project water to EPCWID farmers. As a result, in full supply years, less water needs to be released from storage to meet EPCWID demands. This results in an accumulation of water in storage that increases allocations and deliveries in later non-full supply years. This is seen in the increased reservoir releases and deliveries in ~~1954,~~ 1955, 1964, 1967, ~~1971,~~ 1977, 1978 and several other years after 2000.

EBID FHG deliveries increase~~d~~ by an average of 2,400~~900~~ AF during 1951-1978, and 2,400~~1,900~~ AF during 2006-2017. EPCWID FHG deliveries increase~~d~~ by similar amounts averaging 1,500~~900~~ AF during 1951-1978 and 2,100~~1,800~~ AF during 2006-2017. The impact of Mexico pumping on the HCCRD supply is larger than on EBID or EPCWID, with the total irrigation season supply to HCCRD increasing by an average of 3,900~~4,800~~ AF during 1951-2007.

Mexico pumping also has a large impact on ground water storage in the Hueco. From 1951-2017, Hueco ground water storage is~~was~~ depleted by an average of 59,500~~59,700~~ AF/y. The effect of Juarez pumping from the new Conejos-Medanos wellfield is evident in the recent changes in Rincon-Mesilla ground water storage.

30.5 R-M Pumping Off (Run 6)

In Run 6, all irrigation pumping and non-irrigation pumping and associated returns in the Rincon and Mesilla basins is turned off. This includes turning off irrigation and non-irrigation pumping in the Texas portion of the Mesilla basin. The purpose of this run is to simulate a scenario that is~~was~~ directly comparable to the 100% reduced pumping run of the Texas Model described in the Hutchison Report.

As expected, the effect of turning off all Rincon-Mesilla pumping in Run 6 has a larger effect than turning off New Mexico pumping in Run 3, but with a similar pattern. Turning off R-M pumping increases the Project delivery efficiency by increasing drain flows, reducing river losses, and reducing canal seepage. In full allocation years, releases from storage can be reduced while still delivering full allocations to EBID and EPCWID. This accumulates water in storage leading to increased allocations and deliveries in dry years, and greater spills in very wet years.

As discussed in Section 18.0, the comparisons of simulated changes in El Paso flow between the ILRG Model and the Texas Model that were presented in the SWE Report were revised with results from the updated ILRG Model. The revised results are shown in revised **Figures 13-1** and **13-2** in **Appendix 18**.

Additional comparisons of the R-M Pumping Off results to comparable runs of the Texas Model presented in the Hutchison Report and the Second Supplemental Moran Report are presented in **Table 30-3**. These include comparisons of 1951-2016 averages for selected model outputs for the updated ILRG Model (Run 6), the Texas Model without reoperation (Hutchison; 100% R-M Pumping Off), and the Texas Model with crude redistribution~~reoperation~~ (Moran; 100% R-M Pumping Off). The updated ILRG Model results are summarized as annual averages and irrigation season averages. The Texas Model results are annual averages consistent with the annual stress periods in the Texas Model. The table entries for the Texas Model shown as "n/a" and shaded grey indicate outputs that are not simulated in the Texas Model.

Table 30-3 highlights many of the processes simulated in the ILRG Model that are not simulated in the Texas Model. It also contrasts long-term average differences between the models as to simulated changes in Rincon-Mesilla diversions and FHG deliveries, and El Paso flows. During 1951-2016, the average annual change in El Paso flow in the Texas Model is 124,700 AF without reoperation (Hutchison) and 51,700 AF with crude redistribution~~reoperation~~ (Moran). These results compare to the change in flow in the ILRG Model that averages 79,800~~79,500~~ AF year-around, and 33,200~~33,600~~ AF during the irrigation season, excluding spills. The change in flow goes down to ~~15,600~~12,900 AF during the irrigation season from 1985-2005.

30.6 TX Mesilla Pumping Off (Run 7)

In Run 7, all supplemental irrigation pumping and non-irrigation pumping in the Texas portion of the Mesilla basin is turned off. This includes turning off the EPW Canutillo wells and associated M&I return flows. The results of this run show that turning off Texas-Mesilla pumping has, on average over the whole study period, more impact on Project operations than does turning off all Texas pumping in Run 4. This is due to significant WWTP offsets that occur in Run 4.

Similar to many of the runs described above, turning off Texas-Mesilla pumping and returns increases the Project delivery efficiency due to increased drain flows, reduced river seepage, and reduced canal seepage. In turn, this reduces reservoir releases needed to deliver full supply allocations in wet years and the resulting storage accumulations increase allocations and deliveries in dry years.

Turning off Texas-Mesilla pumping causes EBID diversions to increase by an average of 7,200~~8,500~~ AF during 1951-1978 and 21,300~~21,300~~ AF during 2006-2017. EBID FHG deliveries increase in a similar pattern with average increases of 5,800~~6,800~~ AF in 1951-1978 and 12,500~~13,200~~ AF in 2006-2017. Impacts during recent years are magnified by the effect of the 2008 OA on EBID allocations.

EPCWID operations are also impacted by Texas-Mesilla pumping. Average irrigation season diversions by EPCWID increase by an average of 4,100~~5,800~~ AF during 1951-1978 and 2,600~~2,200~~ AF during 2006-2017. EPCWID FHG deliveries during 1951-1978 increase by an average of ~~2,000~~2,600 AF and during 2006-2017 by an average of 400~~300~~ AF.

30.7 TX Non-Irrigation Pumping Off (Run 8)

In Run 8, all Texas non-irrigation pumping and associated urban return flows are turned off. This includes pumping by EPW and other minor pumpers from the Hueco and pumping from EPW's Canutillo wellfield in the Mesilla Valley. Discharges from EPW's WWTPs are turned off except for amounts attributed to EPW's use of Project water which continue to be simulated. All urban deep percolation is also similarly eliminated or reduced.

Turning off the non-irrigation pumping and returns in Texas results in EPCWID ordering more Project water to replace the loss in WWTP discharge supply. This reduces the supply available for allocation in some dry years resulting in reduced diversions and/or deliveries to EBID and EPCWID. ~~has a similar but smaller effect on Project operation compared to Run 4 in which all Texas pumping is turned off. Additional flow in the river from turning off the pumping allows the releases from storage to be reduced during full allocation years from 1958-1980. The accumulated additional stored water is allocated and released in dry years during this period. During the relatively wet period from 1980-2002, the loss of EPW WWTP discharges as an irrigation source causes increased releases from storage to meet EPCWID demands.~~

EBID diversions decrease~~increase~~ by an average of 2,900~~1,600~~ AF during 1951-1978.~~ with the increases occurring in years of less than full allocation when accumulated storage adds to the allocations.~~ After the 2008 OA becomes effective, the increases in Project water diversions by EPCWID to replace the reduced WWTP discharge supply increases the computed diversion ratio resulting in ~~and magnifies the effects of Texas pumping,~~ EBID diversions increasing~~e~~ by an average of 12,100~~16,300~~ AF during 2006-2017. EBID FHG deliveries change~~increase~~ by corresponding amounts with an average decrease~~sincreases~~ of 1,000~~1,900~~ AF from 1951-1978 and an average increase~~s~~ of 7,600~~11,100~~ AF from 2006-2017. ~~The increase in EBID FHG deliveries is greater than the increase in EBID diversions during 1951-1978 because the reduction in Texas Mesilla pumping reduces EBID canal losses allowing more of the water that EBID diverts to be delivered to the farms.~~

Turning off Texas non-irrigation pumping causes EPCWID to order more Project water to replace the lost WWTP returns~~has a significant effect on EPCWID supply~~. There is a modest increase in diversions during 1951-1978 averaging 2,500~~1,200~~ AF/y, which ~~. This~~

is followed by a much larger increase in diversions during 1979-2005 averaging 14,300~~13,500~~ AF/y.

30.8 NM Non-Irrigation Pumping Off (Run 9)

In this scenario, all non-irrigation pumping in New Mexico along with the associated WWTP discharges and urban deep percolation are turned off. The effects are similar in pattern, but much smaller than the effects of turning off all New Mexico pumping in Run 3.

The familiar pattern of accumulated water in Project storage in wet years followed by increases in allocation and releases in dry years is repeated in Run 9. EBID diversions increase by averages of 2,500~~2,500~~ AF during 1951-1978 and 23,400~~21,100~~ AF during 2006-2017 when the effects of pumping are elevated by interaction with the revised allocation procedure under the 2008 OA. EBID FHG deliveries increase proportionally by an average of 2,000~~2,000~~ AF/y during 1951-1978 and 14,100~~13,700~~ AF/y during 2006-2017.

EPCWID diversions and FHG deliveries increase by small amounts when the non-irrigation pumping in New Mexico is turned off. On average, irrigation season diversions for EPCWID increase by 900~~1,300~~ AF during 1951-1978 and 4,500~~2,500~~ AF during 1985-2017. Irrigation season FHG deliveries to EPCWID increase by 800~~1,000~~ AF from 1951-1978 and 2,000~~1,400~~ AF during 1985-2017.

The increases in Rio Grande at El Paso flow during the irrigation season are generally limited to times of increased deliveries to EPCWID, and these average 4,000~~2,800~~ AF during 1951-2017. ~~There are larger~~ The increases in El Paso flow during the non-irrigation season and during spills ~~that~~ average 2,100~~3,400~~ AF during 1951-2017.

~~This run shows that New Mexico M&I pumping has a relatively small effect on EPCWID diversions and deliveries to Texas water users. In sum, when New Mexico's non-irrigation pumping is turned off, EPCWID diversions only increase on the range of 9001,300 AF/yr (1951-1978) to 5,3002000 AF/yr (1985-2005) in the years prior to the implementation of the 2008 OA.~~

30.9 MX Non-Irrigation Pumping Off (Run 10)

In this scenario, all non-irrigation pumping for Ciudad Juarez in Mexico along with the associated sewage/WWTP returns are turned off. Mexico non-irrigation pumping has a relatively minor effect on Project operations and deliveries to EBID and EPCWID. For the analysis of all Mexico groundwater pumping off, refer to Run 5 in section 30.4 above.

Mexico irrigation pumping increases due to loss of Juarez WWTP discharges. This in turn increases EPCWID conveyance losses resulting in EPCWID having to increase diversions to deliver similar amounts to the farms. EPCWID irrigation season diversions increase by an average of 700~~700~~ AF/y during 1951-2017, and~~but~~ FHG deliveries ~~decrease~~increase by an average of 200~~500~~ AF over the same period. The increase in EBID diversions and FHG over 1951-2017 is minimal averaging 300~~100~~ AF.

30.10 2008 Operating Agreement Scenarios (Runs 11 and 12)

Two runs of the ILRG Model were made to evaluate the effect of the D3+Carryover accounting in the 2008 OA on Project operations and LRG water supplies. In Run 11, the D1/D2 allocation procedure is simulated to allocate Project water during the entire period from 1950 - 2017 period, and in Run 12 the D3+Carryover accounting is simulated during this 68-year period[5]. Otherwise, both runs employ the same RiverWare simulation rules that are used in the Historical Base Run. Irrigation pumping is computed based on the unmet irrigation demand and the non-irrigation pumping and associated return flows are set at historical levels.

Comparison of the results of Run 11 to Run 1 show the effects of the 2008 OA on Project operations in Run 1 compared to what would have happened had the 2008 OA not been implemented and the D1/D2 allocation procedure been left in place.

When the D1/D2 allocation procedure is left in place during 2006-2017, the annual allocations to EBID increase substantially in most years during this period resulting in large increases in EBID diversions averaging 94,200~~103,200~~ AF and in EBID FHG deliveries averaging 54,600~~64,100~~ AF. These impacts on EBID from the 2008 OA are far greater than the impacts of New Mexico pumping on EPCWID irrigation season FHG deliveries that average 17,800~~14,900~~ AF during 2006-2017 as shown in the Run 3 results.

Conversely EPCWID diversions decline by an average of 23,000~~28,900~~ AF and FHG deliveries decline by an average of 17,200~~22,200~~ AF during 2006-2007. The reason for the decline in EPCWID supply is primarily due to the limited amount of Project water in storage. The increases in EBID's allocations and deliveries result in smaller amounts of Project water to allocate between the districts in subsequent years. Another factor is the absence of carryover for the individual districts and this results in more water allocated to EBID and less water available for EPCWID to use.

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[5] The RiverWare rules do not simulate annual allocations during the wet period from 1940 – 1949.

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Comparison of the results of Run 12 to Run 11 allows differences between the D1/D2 and D3+Carryover allocation procedures to be evaluated over the entire 1950-2017 period. The differences between these runs are computed based on Run 12 (D3+CO) minus Run 11 (D1/D2) and therefore reflect the impacts of going from the D1/D2 allocation procedure to the D3+CO allocation procedure.

Comparison of Run 12 and Run 11 shows clearly the effect of the 2008 OA on EBID varies depending on the type of year. In wet years with a relatively high diversion ratio, the annual EBID allocation is greater under the D3+CO method than under D1/D2 method and this results in increased diversions and FHG deliveries during 26 of the 67 years between 1951-2017 period (1951-1952, 1959-1962, 1982-2001). EBID diversions and FHG deliveries were lower in the other 41 years which were generally years of average and below average water supply. On average during 1951-2017, EBID diversions declined by 34,400~~37,600~~ AF and FHG deliveries declined by 19,800~~22,100~~ AF.

Conversely, the 2008 OA has a positive effect on EPCWID allocations, diversions, and FHG deliveries in most years. During the irrigation season, diversions increased by an average of 13,100~~15,300~~ AF and FHG deliveries increased by an average of 8,200~~10,700~~ AF. The average increase in EPCWID supply is much less that the average decrease in EBID supply.

The following is a summary of the average annual effect on EBID and EPCWID FHG deliveries in dry, wet, and all years during~~three intervals of~~ the 1951-2017 period.

Cumulative Volume Impact of 2008 Operating Agreement
on March - October FHG Deliveries
In Wet and Dry Periods
1951-2017

Condition	Years	EBID	EPCWID
Dry	1953-1958, 1963-1981, 2002-2017	-2.47~~-2.74~~ MAF	+0.37~~+0.47~~ MAF
Wet	1951-1952, 1959-1962, 1982-2001	+1.14~~1.26~~ MAF	+0.17~~+0.25~~ MAF
All	1951-2017	-1.33~~-1.48~~ MAF	+0.55~~+0.71~~ MAF

The results in the above table show that the 2008 OA takes away critical surface water in the dry years when EBID has a greater need for water (2.47~~2.74~~ MAF) than it gives back to EBID in wet years when the need is less (1.14~~1.26~~ MAF) As a result, the 2008 OA forces EBID to pump more ground water in dry years to make up for the reduction in surface water supplies. The increased EBID pumping negatively affects the diversion ratio which contributes to the reduction in water allocated and delivered to EBID in dry years. This was termed a "vicious cycle" by Dr. Barroll (2019, 2020a).

30.11 Reduced Waste (Run 13)

As was described in Section 5.0 of the SWE Report, beginning with the 1950s drought and continuing through the 1970s, Reclamation was able to operate the Project with reported operational waste below 10% during most years. In a few years during the wet periods of the mid-1980s and mid-1990s, the EBID waste increased to approximately 20%. The situation in EPCWID was markedly different than in EBID from the 1980s through the 2000s (after EPCWID took over operations) with the operational waste consistently in the range of 20% to 30%.

A run of the ILRG Model was made to evaluate the benefit to the Project from reducing the operational waste. The RiverWare operational rules were modified so that the operational waste was limited to the lesser of the historical amounts or 10% of the simulated diversions.

Limiting operational waste in both Districts to no more than 10 percent reduces releases from Project storage in full allocation years resulting in increased allocations and deliveries in dry years with less than full allocations. As a result of the more efficient

Project operation, FHG deliveries to EBID and EPCWID increase~~occur~~ in many years during the 1950s – 1970s, and again after 2002. Increases in FHG deliveries to EBID average~~d~~ 35,300~~36,100~~ AF during 1951-1978 and 57,300~~48,900~~ AF during 2006-2017. Increases in FHG deliveries to EPCWID average~~s~~ 17,800~~30,700~~ AF during 1951-1978 and 18,500~~20,600~~ AF during 2006-2017.

30.12 Hueco Pumping Off (Runs 14, 14a, 14b, 14c, and 14d)

In response to questions from Texas legal counsel during depositions of the New Mexico experts, and in response to opinions from Texas and U.S. experts, several runs of the ILRG Model were made in which all or a portion of the pumping in the Hueco was turned off, as well as runs in which pumping was turned off without turning off WWTP discharges and vice-versa. The results from these runs are useful in assessing the effects of the Hueco pumping in isolation from pumping in other areas of the LRG basin and the effect of WWTP discharges in offsetting impacts from Hueco pumping.

The No Hueco Pumping Scenarios is~~were~~ simulated in the same manner as the other no pumping scenarios. The supplemental irrigation pumping from the Hueco in Texas and/or Mexico is~~was~~ turned off. In addition, the non-irrigation pumping in these areas and the corresponding WWTP and urban deep percolation return flows are~~were~~ also turned off. Specifications and summaries of the results of the No Hueco Pumping Scenarios are presented below. Runs 14a, 14b, 14c, and 14d were made to test various components of Run 14.

- All Hueco Pumping Off (Run 14) – In Run 14, all supplemental irrigation pumping and non-irrigation pumping in the Hueco in Texas and Mexico is~~was~~ turned off. In addition, the WWTP discharges by EPW and Ciudad Juarez from their Hueco pumping are~~were~~ turned off, as is~~was~~ the urban deep percolation from EPW[6].

  There are opposing effects within EPCWID from turning off Hueco pumping. Turning off Hueco pumping reduces canal and lateral losses in EPCWID and reduces river seepage between American Dam and Riverside Dam before the ACE was constructed in 1999. These changes can result in reduced Project water orders to deliver the same amount of water to EPCWID farm headgates. On the other hand, the reduction in WWTP discharges to the EPCWID canal system when M&I pumping is turned off reduces the irrigation supply available to deliver to EPCWID farm headgates and increases RHG demands for Project water. These

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[6] No urban deep percolation is simulated for Mexico in the historical Base Run.

opposing effects can result in net increases or decreases in annual EPCWID FHG deliveries.

The effects within EPCWID from turning off Hueco pumping can propagate upstream and impact reservoir operations and deliveries to EBID depending on whether it is a full allocation year or non-full allocation year. In full allocation years, there is little effect on EBID FHG deliveries because EBID's allocation does not change. In non-full allocation years, accumulated changes in reservoir storage resulting from changes in EPCWID orders of Project water can result in changes in EBID allocations and deliveries.

When Hueco pumping is turned off in Run 14, there are some increases and decreases in EBID FHG deliveries that average to a 1,500~~300~~ AF increase during 1951-2017 with the increases occurring in dry years. ~~After the 2008 OA goes into effect, turning off Hueco pumping has a larger benefit to EBID, with FHG deliveries increasing by an average of 9002,300 AF during 2006-2017, with a few years of increases exceeding 10,000 AF~~. ~~The increases in recent years are elevated due to the effect of Hueco pumping on the diversion ratio and the sensitivity of the EBID allocation to changes in the diversion ratio.~~

Turning off Hueco pumping increases~~reduces~~ EPCWID FHG deliveries by an average of 800~~1,200~~ AF during 1951-2017. Turning off Hueco pumping results in a substantial increase in the total HCCRD supply (RHG diversions) averaging 7,500~~10,900~~ AF during 1951-2017.

- Texas Hueco Pumping Off (Run 14a) – In Run 14a, all supplemental irrigation pumping and non-irrigation pumping by Texas in the El Paso Valley is~~was~~ turned off, along with the WWTP discharges and urban deep percolation from the EPW Hueco pumping.

  Turning off Texas Hueco pumping reduces EBID FHG deliveries by an average of 1,000~~100~~ AF during 1951-2017. ~~However,~~ EBID FHG deliveries decrease~~increase~~ by an average of 4,000~~1,600~~ AF during 2006-2017 when the 2008 OA is in effect.

  During 1985-2017, Texas Hueco pumping reduces EPCWID FHG deliveries during the irrigation season by an average of 1,400~~1,700~~ AF and increases the total flow to HCCRD an average of 2,100~~2,300~~ AF.

  Contrary to the claims of the Texas and U.S. experts, the impacts of Texas Hueco pumping on Project operations and surface water supplies to EBID, EPCWID, and HCCRD are not negligible.

- Mexico Hueco Pumping Off (Run 14b) – In Run 14b, all supplemental irrigation pumping and non-irrigation pumping in the Mexico portion of the Hueco is~~was~~ turned off, along with the WWTP discharges from Ciudad Juarez pumping.

  Turning off Mexico pumping reduces canal seepage and river seepage in EPCWID causing reduced Project orders at EPCWID canal headings. This results in accumulation of water in Project storage that increases Project water deliveries to EBID in years with less than a full Project water allocation. Simulated increases in EBID FHG deliveries average 1,700~~800~~ AF during 1951-2017, and 3,200~~1,900~~ AF during 2006-2017, with increases exceeding 5,000 AF in several years and 10,000 AF in 2010~~2013~~.

  Turning off Mexico Hueco pumping has similar effects on EPCWID with FHG deliveries increasing by an average of 1,500~~800~~ AF during 1951-2017. The increase in total HCCRD supply is greater averaging ~~4,800~~3,900 AF during 1951-2017.

- Texas WWTP Discharges Off (Run 14c) – In Run 14c, all discharges from Texas WWTPs are~~were~~ turned off. This includes~~d~~ turning off discharges from the EPW's Northwest, Haskell, Socorro, and Bustamante WWTPs, as well as discharges from the Anthony TX WWTP and the Fabens WWTP. The purpose of this run is~~was~~ to quantify the benefit to the Project operations and LRG water users from the Texas WWTP discharges. Without these discharges, the impacts of Texas Hueco pumping would be much larger.

  When the Texas WWTP returns are turned off, EBID FHG deliveries decrease markedly in numerous years with less than full allocations. This shows the interconnected nature of the Project and how changes in supply at the bottom of the Project area can ripple through the Project and affect operations hundreds of miles upstream. On average during 1951-2017 the reduction in diversions averages 14,600~~9,500~~ AF and the reduction in FHG deliveries averages 6,600~~4,700~~ AF.

  Turning off Texas WWTP discharges results in increased Project releases and diversions to EPCWID to replace the reduction in irrigation supply to EPCWID farmers from the WWTP discharges. This results in large increases in El Paso flows to deliver additional Project water to EPCWID, particularly during the wet period in the 1980s and 1990s. The increase in El Paso flows during the irrigation season, excluding spills, average 38,300~~36,300~~ AF during 1985-2005.

Without the Texas WWTP discharges, the simulated impacts from Texas pumping would be much larger than the impacts shown in Runs 4, 7, 8, 14, and 14a. The results for Run 14c show the effect of Texas WWTP discharges have in offsetting the impacts of Texas pumping. Without these discharges (for example if EPW reused its WWTP discharges for non-potable uses), the effects of Texas pumping on Project operations, including deliveries to EBID would be much greater.

- Texas Hueco Pumping Off without WWTP Discharges Off (Run 14d) – In Run 14d, Texas Hueco pumping is~~was~~ turned off without turning off the associated Texas WWTP discharges and urban deep percolation. This test run simulates the effect of Texas Hueco pumping without the offsets from Texas M&I return flows.

  When the Texas Hueco pumping is turned off without turning off the M&I returns, the simulated impacts on Project operations increase. EBID FHG deliveries increase by an average of 5,000~~1,900~~ AF during 1951-1978 and 2,000~~2,800~~ AF during 2006-2017. FHG deliveries to EPCWID increase by 4,600~~6,200~~ AF during 1951-1978 and 2,000~~2,500~~ AF during 2006-2017. Total flows to HCCRD increase by 7,100~~9,700~~ AF during 1951-1978 and 3,700~~3,200~~ AF during 2006-2017.

30.13 Early EPCWID Ops (Runs 15, 15a, 15b, 15c)

Four scenarios were simulated using the ILRG Model to evaluate the effects on Project operations that would result from a return to EPCWID operations consistent with how the Project was operated in the past. These include simulating increased irrigation use of drain flows in the Fabens area and charging EPCWID for all water that it uses. Runs 15a, 15b, and 15c were made to test various components of Run 15. Descriptions of the four Early EPCWID Ops scenarios are provided below along with the scenario results.

- Early EPCWID Ops (WWTP & Fabens Drains) (Run 15) – In Run 15, simulation of EPCWID operations in the El Paso Valley are~~were~~ modified to simulate irrigation use of all available supplies consistent with how the Project was originally operated in the El Paso Valley. This includes simulation of irrigation use of the usable Fabens drain flows, which are~~were~~ estimated as 70% of the total Fabens drain flows limited to a monthly volume of 6,000 AF, based on available historical data (see response to Ferguson Opinion 9 for more information). In addition, EPCWID is charged for all use of drain flows and WWTP flows, and the ACE Credit and Haskell WWTP discharge credits are disabled. These changes reflect operations consistent with the original concept and implementation of the Project which was to use all available supplies ~~in the river~~ to minimize the amount of storage releases needed to meet Project water demands. Further, since EPCWID is charged for all of its water use including the water that arises within the EPCWID system, it has less unused allocation in many years and uses its entire allocation in more years than in the Historical Base Run (Run 1). The increased use of water arising within the EPCWID system reduces the releases from Project storage to meet EPCWID demands and the accumulated Project storage increases the supply available for allocation and use in subsequent years. When accounting under 2008 OA commences, EPCWID has less unused allocation to carryover to subsequent years. The following is a summary of the effects of the foregoing changes in EPCWID operations:

  - EBID – FHG deliveries increase modestly by an average of 4,300~~4,500~~ AF during 1951-1978 and by a much larger amount, averaging 41,900~~37,800~~ AF~~,~~ during 2006-2017. The large increases during the recent period result from significant increases in the diversion ratio that result from EPCWID being charged for all water that it uses, and the positive feedback of increases in the diversion ratio on EBID allocations under D3 accounting.

  - EPCWID – FHG deliveries increase by an average of 1,400~~3,100~~ AF during 1951-2017. Simulated EPCWID RHG diversions decrease by an average of 15,100~~12,100~~ AF during 1951-2017 as diversions of Project water from the river are eschewed in favor of the supplies arising within EPCWID.

  - HCCRD – The changes in EPCWID operations result in minor reductions in the water flowing to HCCRD. Annual total flow to HCCRD decreases by an average of 3,100~~2,100~~ AF during 1951-2017.

- Early EPCWID Ops (WWTP) (Run 15a) – In Run 15a, EPCWID is charged for irrigation use of WWTP flows, and the ACE Credit and Haskell WWTP discharge credits are~~were~~ disabled. However, the simulated use of drain flows is left at the historical levels simulated in Run 1, and EPCWID is not charged for the historical use of the drain flows. The results are similar in pattern to the Run 15 results but smaller in magnitude as follows:

  - EBID – FHG deliveries increase modestly by an average of only 200~~400~~ AF during 1951-1978, but by much larger amounts averaging 27,200~~23,600~~ AF during 2006-2017. Similar to Run 15, the large increases during the recent period result from the effect of an increase in the diversion ratio on EBID allocations under the 2008 OA.

  - EPCWID – FHG deliveries decrease by an average of 1,900~~1,800~~ AF during 1951-2017. Simulated EPCWID RHG diversions decrease by an average of

2,900~~2,800~~ AF during 1951-2017 with the increased use and charge for supplies arising within EPCWID.

  - HCCRD – Charging EPCWID for use of WWTP flows and elimination of credits against charges reduces the total flow to HCCRD by an average of 500~~700~~ AF during 1979-2005 and 2,200~~2,500~~ AF during 2006-2017

- Early EPCWID Ops (Fabens Drains) (Run 15b) – In Run 15b, the model simulates and charges EPCWID for use of the usable Fabens drain flows as described above in Run 15. However, EPCWID is not charged for use of WWTP flows and is credited for Haskell WWTP discharges and the ACE Credit. The results are similar in pattern to the Run 15 results as follows:

  - EBID – FHG deliveries increase modestly by an average of 4,300~~4,200~~ AF during 1951-1978, and by an average of 21,800~~17,000~~ AF during 2006-2017. Similar to Run 15, the large increases during the recent period result from the effect of an increase in the diversion ratio on EBID allocations under the 2008 OA.

  - EPCWID – FHG deliveries increase by an average of 3,100~~5,300~~ AF during 1951-2017. Simulated EPCWID RHG diversions decrease by an average of 12,900~~9,100~~ AF during 1951-2017 with the simulated increased use and charge for drain flows arising within EPCWID.

  - HCCRD – The increased use of drain flows in EPCWID results in a reduction in the total flow to HCCRD averaging 2,600~~1,300~~ AF.

- Early EPCWID Ops (TX Hueco Pumping Off) (Run 15c) – In this scenario, the changes to EPCWID operations and accounting from Run 15 were simulated with the Texas Hueco pumping turned off. The effects of Texas Hueco pumping with the modified EPCWID operation were assessed by comparing the results of Run 15c and Run 15. The effects of the Texas Hueco pumping on EBID are mixed due to the opposing effects on EPCWID from pumping and WWTP discharges from pumping.

30.14 Conj Use 1: Hist All Acres D1/D2 (Runs 16 and 16a)

Two scenarios are~~were~~ simulated to evaluate conjunctive use of surface water and ground water within the Rio Grande Project under the D1/D2 allocation procedure with the historical irrigated area that evolved over time (including irrigation of the primary ground water only acres in New Mexico), and with the early EPCWID operations that are~~were~~ simulated in Run 15. In both scenarios, irrigation pumping in EBID and EPCWID is limited based on the irrigation pumping that existed during the 1951-1978 D1/D2 data period. This is implemented by not allowing the 10-year running average pumping after 1978 to exceed the 1951-1978 historical average annual pumping.

- Conj Use 1: Hist All Acres D1/D2 (Hist M&I) (Run 16) – Run 16 essentially combines the early EPCWID operations from Run 15 with the Run 11 continuation of D1/D2 allocation of Project water after 2005 along with a limit on irrigation pumping after 1978. In Run 16, the M&I pumping and returns are set at the historical amounts simulated in Run 1. The results for Run 16 are very similar to Run 15 until 2005. After that time, the differences from Run 1 represent the combination of the early EPCWID operations and continuation of D1/D2 accounting. The following are summaries of the differences between Run 16 and Run 1 after 2005:
  - EBID – FHG deliveries increase by an average 69,000~~78,300~~ AF during 2006 -2017 which is much greater than the increase of 41,900~~37,800~~ AF in Run 15.
  - EPCWID – FHG deliveries decrease by an average of 14,500~~20,100~~ AF during 2006 -2017 with the D1/D2 accounting compared to an average increase~~decrease~~ of ~~only~~ 700~~400~~ AF ~~decrease~~ in Run 15.
  - HCCRD – Total flows to HCCRD decline by an average of 9,500~~11,700~~ AF during 2006-2017, compared to an average decline of 3,800~~3,800~~ AF during this same period in Run 15.
- Conj Use 1: Hist All Acres D1/D2 (1978 M&I) (Run 16a) – The conditions simulated in Run 16a are the same as Run 16 except that M&I pumping in New Mexico and Texas after 1978 is limited to the levels that existed in 1978 at the end of the D1/D2 period. This limit has minimal effect on Texas M&I pumping because it exceeded the 1978 amount by only small amounts in a few years after 1978. When the M&I pumping is limited by the 1978 amount, the simulated M&I returns are scaled down proportionally. The results of Run 16a are very similar to Run 16 which reinforces that New Mexico M&I pumping has relatively little impact on Project operations.

- EBID – FHG deliveries increase by an average of 72,400~~80,700~~ AF during 2006-2017 compared to an average increase of 69,000~~78,300~~ AF in Run 16.
- EPCWID – FHG deliveries decrease by an average of 12,600~~18,500~~ AF during 2006-2017 compared to a decrease of 14,500~~20,100~~ AF in Run 16.
- HCCRD – Total supply to HCCRD from 2006-2017 decreases by 9,200~~11,100~~ AF compared to an average decrease of 9,500~~11,700~~ AF in Run 16.

30.15 Conj Use 2: Hist Proj Acres (Runs 17 and 17a)

A second set of conjunctive use scenarios are simulated in Run 17 and Runs 17a under the D1/D2 allocation procedure with irrigation limited to the historical Project acres and no irrigation of the non-Project primary (ground water only) acres in New Mexico. The early EPCWID operations from Run 15 are also a part of these conjunctive use scenarios.

- Conj Use 2: Hist Proj Acres (Hist M&I) (Run 17) – In Run 17, the M&I pumping and returns are set at the historical amounts simulated in Run 1. The results from Run 17 are similar to the results from Run 16 and the differences largely reflect the effect of ground water pumping on primary acres in New Mexico.
    - EBID – Annual FHG deliveries increase by an average of 7,500~~9,300~~ AF during 1951-1978, and by a much larger average of 75,600~~82,600~~ AF following the change to D1/D2 after 2005.
    - EPCWID – Annual FHG deliveries increase by an average 5,100~~6,300~~ AF during 1951-1978, and decline by 10,700~~16,200~~ AF during 2006-2017 due to the change in allocation method from D3 to D1/D2 starting in 2006.
    - HCCRD – Total flows to HCCRD decrease by an average of 8,600~~9,600~~ AF during 2006-2017.
- Conj Use 2: Hist Proj Acres (Pre-Comp M&I) (Run 17a) – The conditions simulated in Run 17a are the same as Run 17 except that M&I pumping in New Mexico and Texas is set at the pre-Compact amounts that existed in 1938 (736 AF/y in New Mexico and 13,744 AF/y in Texas). M&I returns are scaled down proportionally consistent with the pre-Compact pumping volumes. The differences between Run 17 and Run 17a reflect the effects of the post-compact increases in total M&I pumping throughout the study area on simulated surface water supplies.
    - EBID – Annual FHG deliveries increase by an average of 9,500~~13,500~~ AF from 1951 – 1978 and 87,900~~93,400~~ AF from 2006-2017. These compare

to an increase of 7,500~~9,300~~ AF and an increase of 75,600~~82,600~~ AF in Run 17, respectively.

- EPCWID – Annual FHG deliveries increase by an average 6,100~~1,700~~ AF during 1951-1978, and decrease by 4,300~~9,900~~ AF during 2006-2017 due to the change in allocation method to D1/D2. These compare to a 1951-1978 increase of 5,100~~6,300~~ AF and 2006-2017 decrease of 10,700~~16,200~~ AF in Run 17.

- HCCRD – Total supply to HCCRD increases by an average of 1,100~~2,800~~ AF during 1951-2017 compared to an average decrease of 2,800~~2,300~~ AF in Run 17.

30.16 Conj Use 3: Auth Proj Acres (Pre-Comp M&I) (Run 18)

A third conjunctive use scenario is simulated in Run 18 under the D1/D2 allocation procedure with irrigation of the original authorized Project acres simulated in every year from 1940-2017 (88,000 acres in EBID and 67,000 acres in EPCWID). The irrigated area in HCCRD is set at the reported maximum historical amount of 17,750 acres that occurred in 1951, and the irrigated area in JID is set at historical levels. M&I pumping and returns are~~were~~ limited to the pre-Compact amounts as in Run 17a. The early EPCWID operations are also simulated as in the other conjunctive use scenarios. Finally, because the authorized EPCWID acres are simulated as irrigated in every year, there is no simulation of EPW use of Project water.

- EBID – Annual FHG deliveries decrease~~increase~~ by an average of 1,800~~2,700~~ AF during 1951-1978, and increase by 51,500~~64,300~~ AF during 2006-2017 under D1/D2.

- EPCWID – Annual FHG deliveries increase~~decrease~~ by an average of 5,600~~4,000~~ AF during 1951-1978 and decrease by an average of 35,700~~38,650~~ AF during 2006-2017 when allocations revert back to the D1/D2 method.

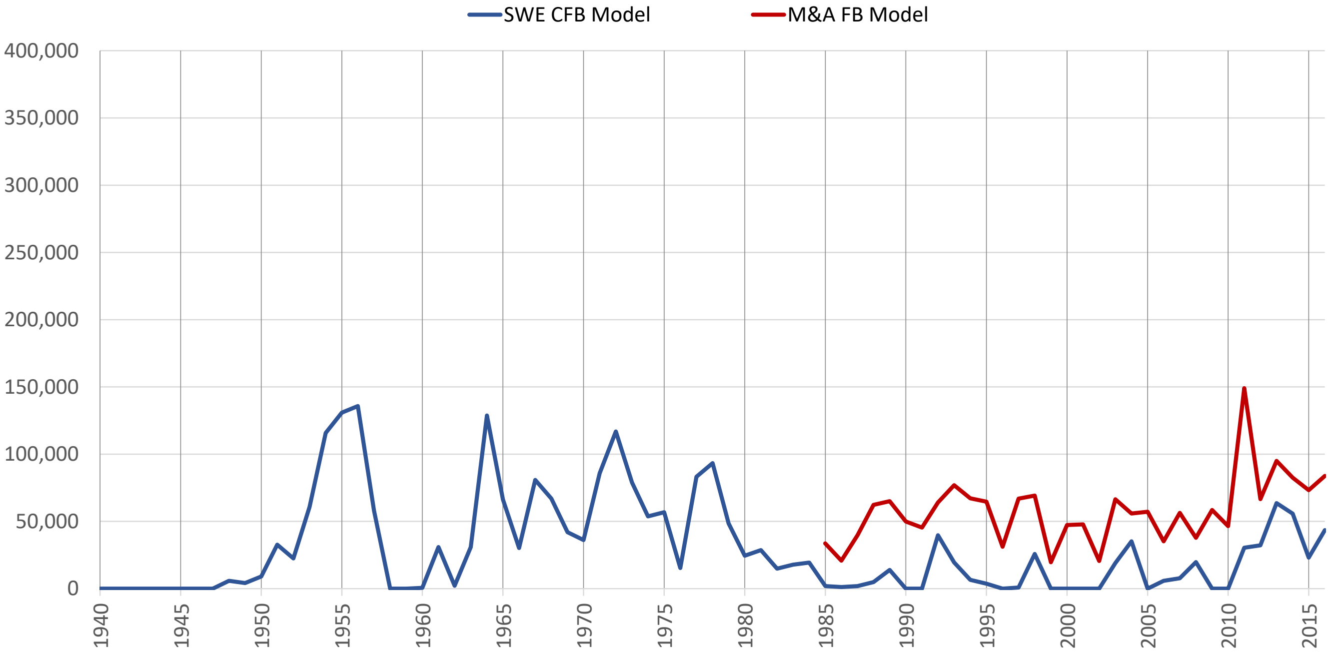
- HCCRD – Total supply to HCCRD increases by 500~~1,200~~ AF during 1951-1978 and decreases by an average of 13,500~~13,700~~ AF during 2006-2017.

Appendix 18

Response to Revised Texas Analyses Submitted Without a Rebuttal Report

Figure 12-12

Comparison of Annual Quantities
SWE Farm Budget vs. M&A Farm Budget
1940-2016
El Paso Valley
Total Irrigation Pumping (AF/y) [1]



Averages	SWE	M&A	Difference	% Diff
1951-2016	34,340			
1985-2016	14,258	58,018	43,760	306.9%

Note:

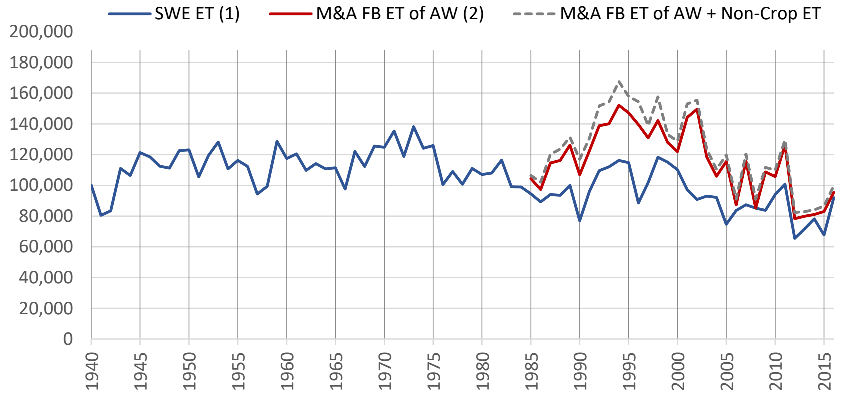
(1) Supplemental pumping for El Paso Valley.

(2) Updated M&A values for irrigation pumping were obtained from the February 4, 2020 State of Texas's Seventh Supplemental Disclosure of Expert Witness Information.

Figure 12-13

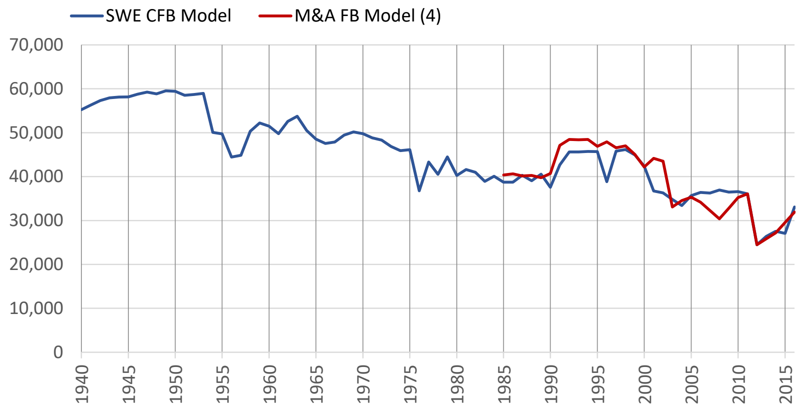
Comparison of Annual Quantities
SWE Farm Budget vs. M&A Farm Budget
1940-2016
El Paso Valley

Actual ET Volume (AF/y)



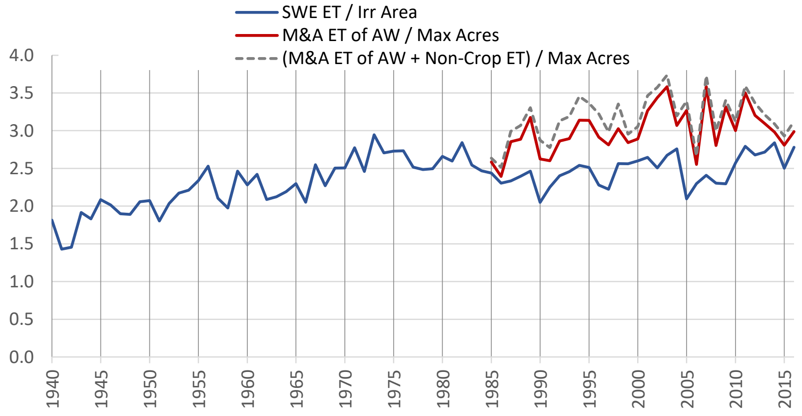
	(1)	(3)		
Averages	SWE	M&A	Difference	% Diff
1951-2016	103,997			
1985-2016	93,408	122,722	29,314	31.4%

Irrigated Area (acres)



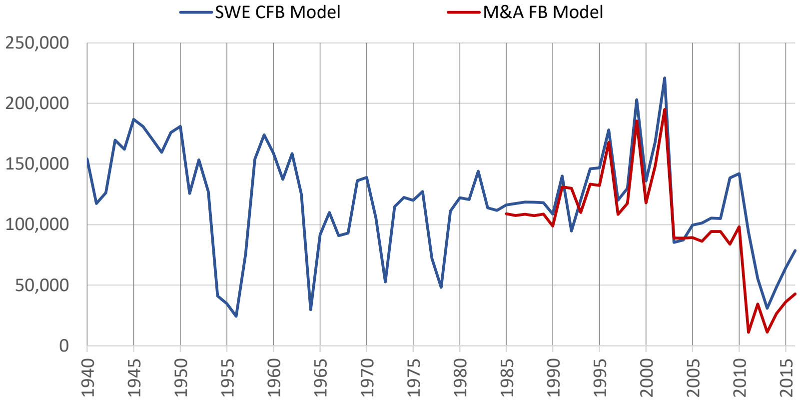
Averages	SWE	M&A	Difference	% Diff
1951-2016	42,952			
1985-2016	37,895	38,764	869	2.3%

Unit ET (ft/y)



	(1)	(3)		
Averages	SWE	M&A	Difference	% Diff
1951-2016	2.44			
1985-2016	2.48	3.17	0.69	28.0%

FHG Deliveries (AF/y)



Averages	SWE	M&A	Difference	% Diff
1951-2016	112,196			
1985-2016	116,818	100,099	-16,719	-14.3%

Notes:

(1) SWE ET calculated as sum of Consumptive Use (CU) of Surface Water and Groundwater.

(2) M&A ET is CU of applied water.

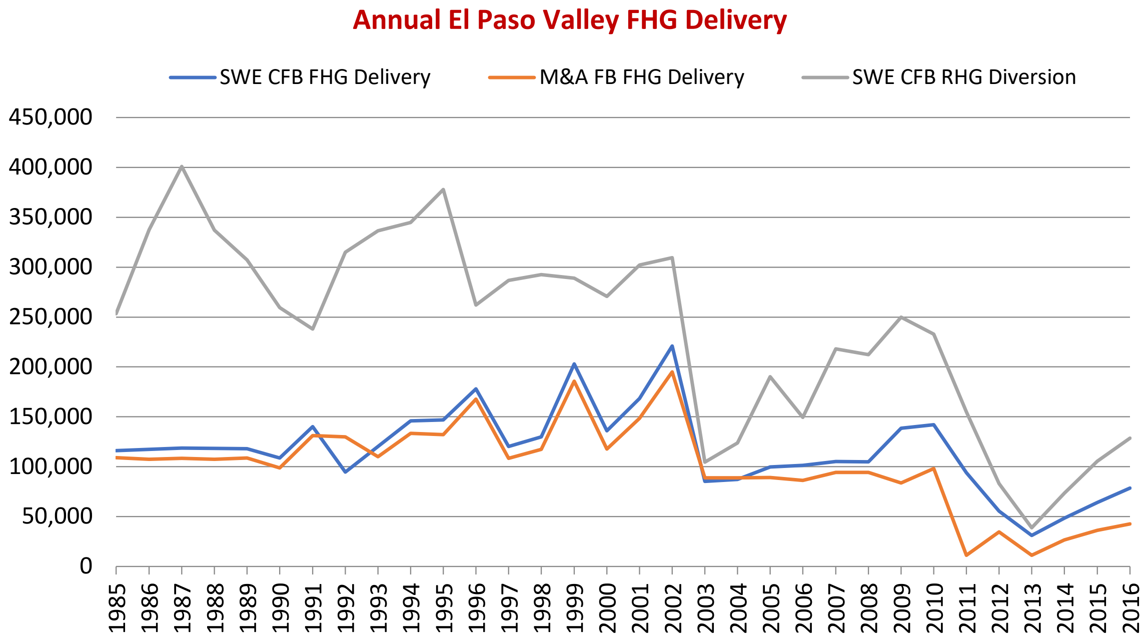
(3) Volume of bare ground ET within footprint of maximum monthly crop acres.

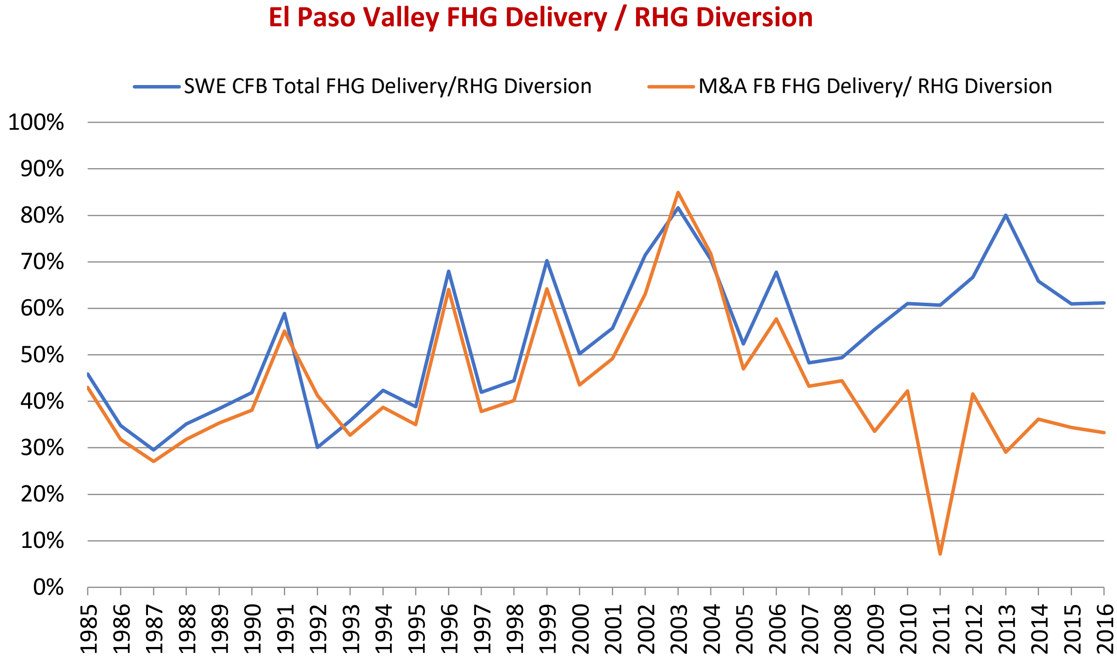
(4) M&A FB irrigated area is the maximum monthly crop acreage during each year.

(5) Updated M&A values for Actual ET Volume, Irrigated Area, and FHG Deliveries were obtained from the February 4, 2020 State of Texas's Seventh Supplemental Disclosure of Expert Witness Information.

Figure 12-14

Comparison of Annual FHG Deliveries
SWE Farm Budget vs. M&A Farm Budget
1985 - 2016





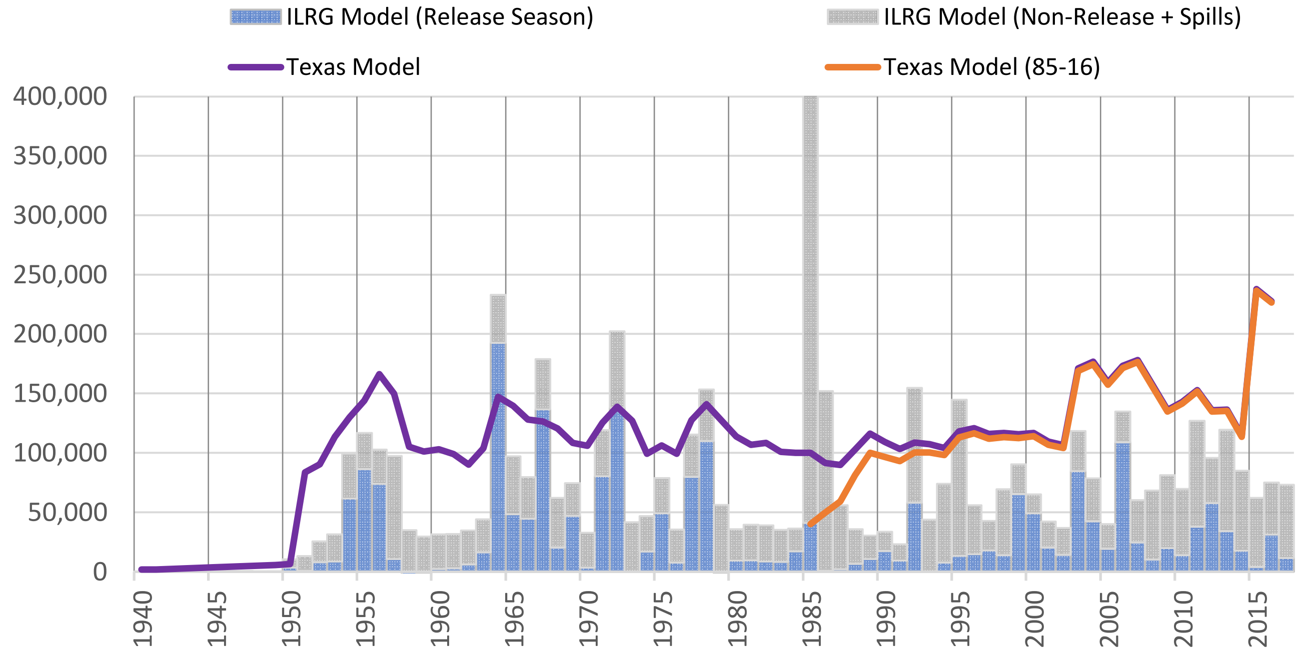
Notes:

El Paso RHG Diversion is equal to Franklin Canal diversions minus Ascarate Wasteway (Pre-1999) plus Riverside Canal diversions.

Updated M&A values for 2010 FHG Deliveries were obtained from the February 4, 2020 State of Texas's Seventh Supplemental Disclosure of Expert Witness Information.

Figure 13-1

Annual Impact of Pumping on Rio Grande at El Paso Flows
Integrated LRG Model (No R-M Pumping)
vs.
Texas Model (100% Reduction in R-M Pumping)
(acre-feet)



Averages	(1) ILRG Model (No R-M Pump)	(2) Texas Model (100% Reduction)	(3) Texas Model 85-16 (100% Reduction)
1985 - 2016 Annual (af):	87,479	132,866	124,658
1951 - 2016 Annual (af):	79,842	124,667	
1985 - 2016 Release Season (af):	27,152		
1951 - 2016 Release Season (af):	32,742		

Notes:

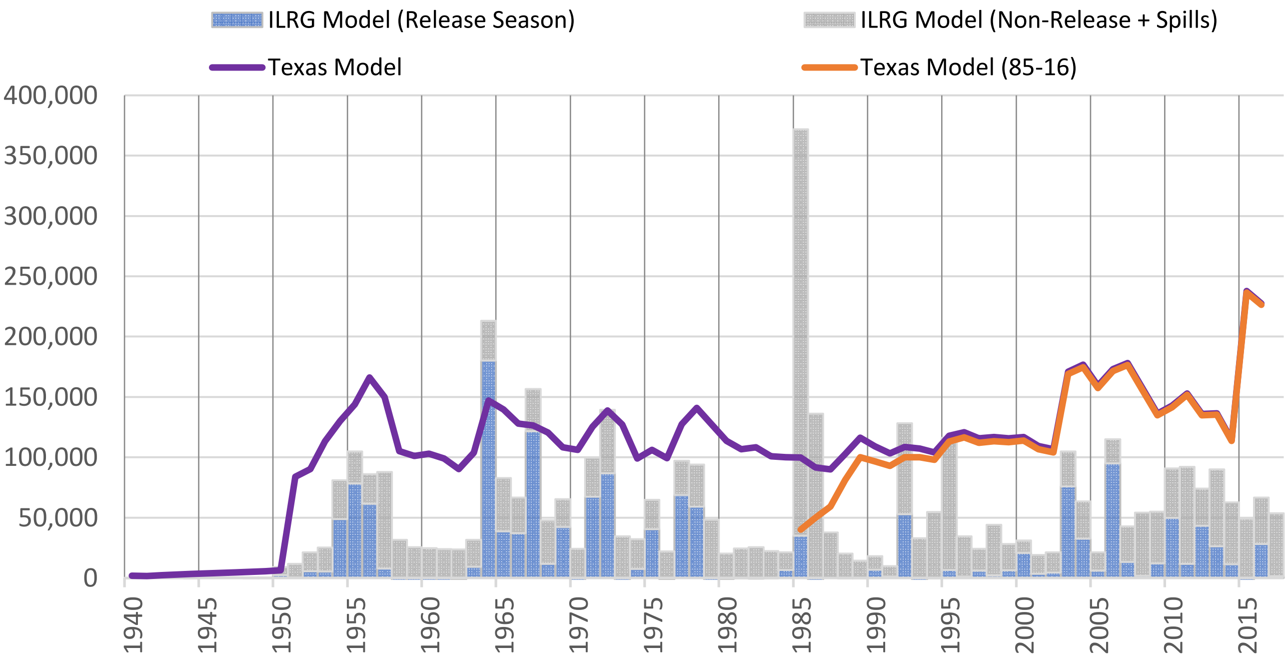
(1) ILRG Model change is computed as flows in Run 6 (no Rincon-Mesilla pumping) minus Run 1 (Historical Base Run).

(2) Texas Model (1938 - 2016 run) change is computed as the simulated flows with reduced pumping (100%) minus flows with no pumping reduction (historical simulation).

(3) Texas Model (1985 - 2016 run) change is computed as the simulated flows with reduced pumping (100%) minus flows with no pumping reduction (historical simulation).

Figure 13-2

Annual Impact of Pumping on Rio Grande at El Paso Flows
Integrated LRG Model (No NM Pumping)
vs.
Texas Model (100% Reduction in R-M Pumping)
(acre-feet)



Averages	(1) ILRG Model (No NM Pump)	(2) Texas Model (100% Reduction)	(3) Texas Model 85-16 (100% Reduction)
1985 - 2016 Annual (af):	65,965	132,866	124,658
1951 - 2016 Annual (af):	61,218	124,667	
1985 - 2016 Release Season (af):	16,890		
1951 - 2016 Release Season (af):	22,348		

Notes:

(1) ILRG Model change is computed as flows in Run 3 (no New Mexico pumping) minus Run 1 (Historical Base Run).

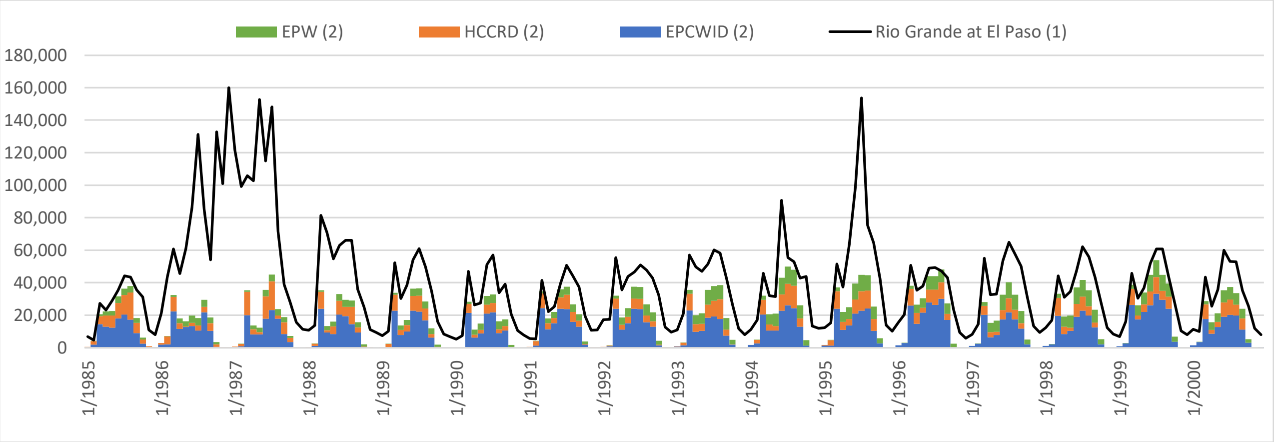
(2) Texas Model (1938 - 2016 run) change is computed as the simulated flows with reduced pumping (100%) minus flows with no pumping reduction (historical simulation).

(3) Texas Model (1985 - 2016 run) change is computed as the simulated flows with reduced pumping (100%) minus flows with no pumping reduction (historical simulation).

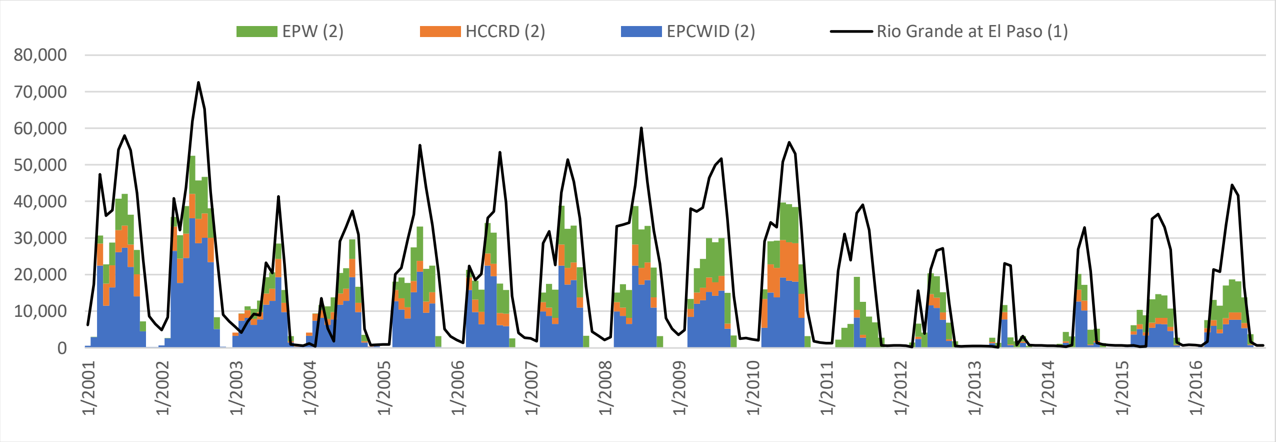
Figure 14-1

Historical Adjusted Rio Grande at El Paso Flows and Texas Deliveries
Dorrance Analysis
(acre-feet)

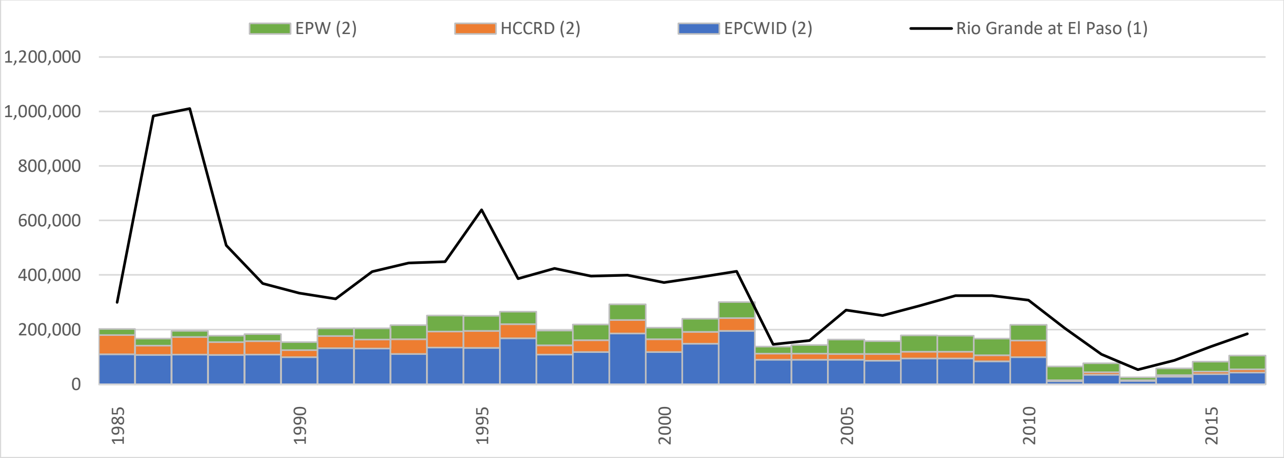
Monthly (1985-2000)



Monthly (2001-2016)



Annual (1985-2016)



Notes:

(1) Rio Grande at El Paso is equal to historical Rio Grande at El Paso flow minus Acequia Madre diversions.

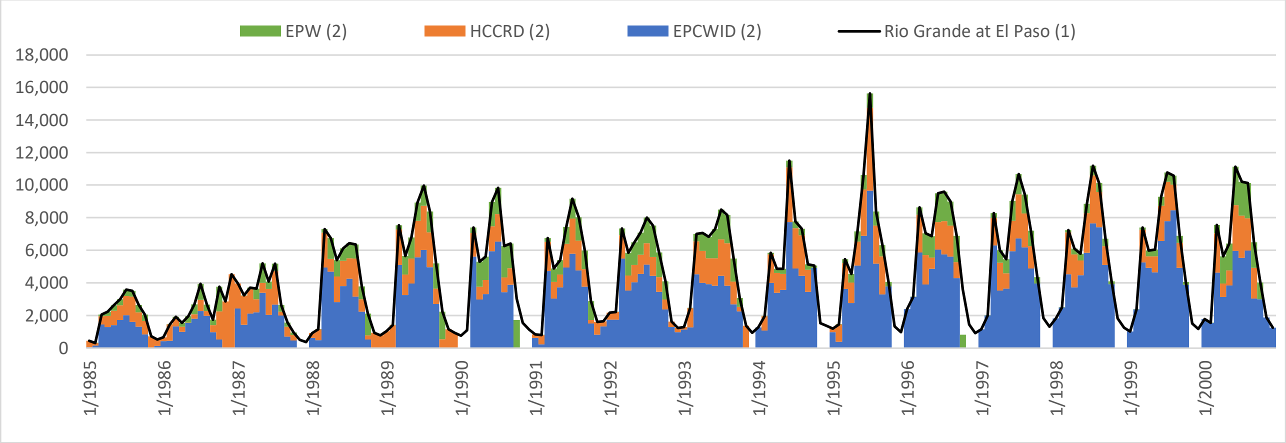
(2) Actual and estimated deliveries to Texas water users.

(3) Delivery data revised based on new data provided in the 12-30-2019 Sunding Reply and Rebuttal Expert Report.

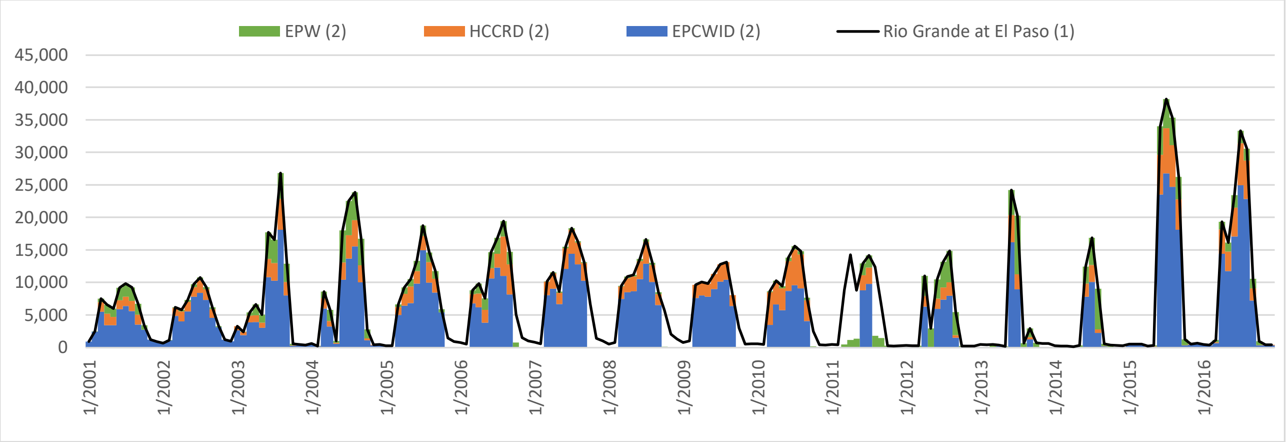
Figure 14-2

Increased Rio Grande at El Paso Flow and Amounts Made Available to Texas Water Users
Dorrance Analysis
(acre-feet)

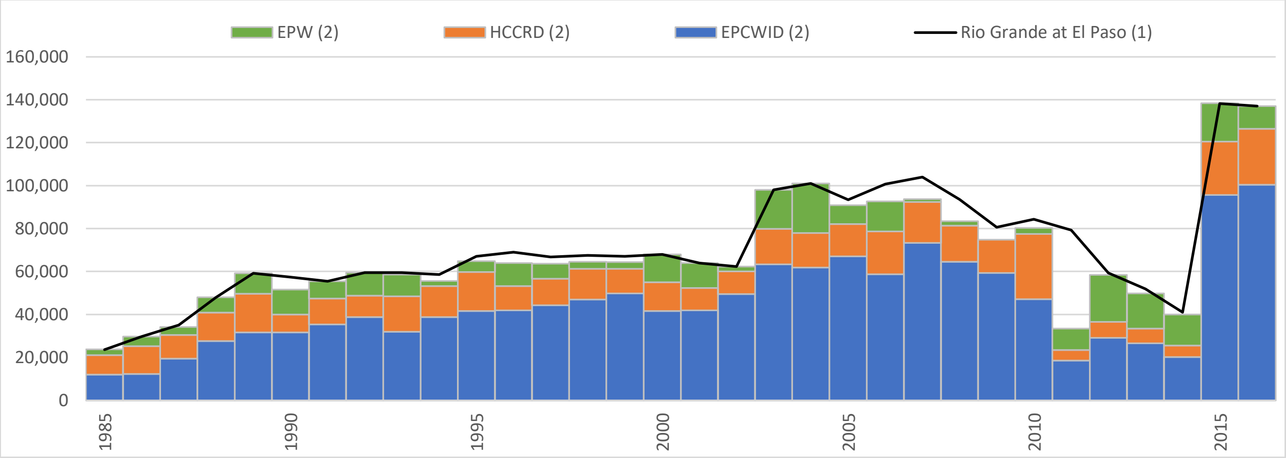
Monthly (1985-2000)



Monthly (2001-2016)



Annual (1985-2016)



Notes:

(1) Increased Rio Grande at El Paso flow in 60% Rincon-Mesilla pumping reduction scenario simulated in Texas Model.

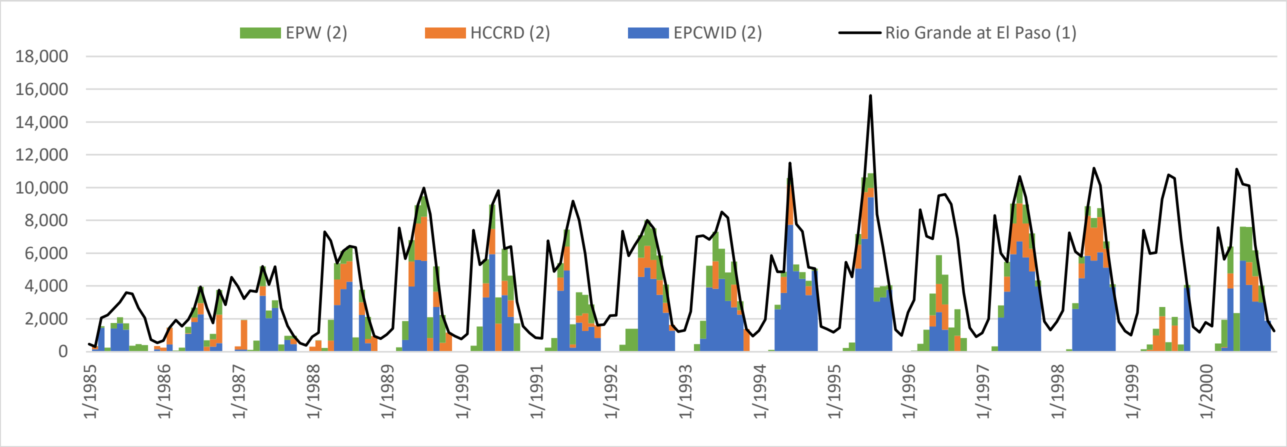
(2) Amounts of increased Rio Grande at El Paso flow made available for delivery to Texas water users.

(3) Delivery data revised based on new data provided in the 12-30-2019 Sunding Reply and Rebuttal Expert Report.

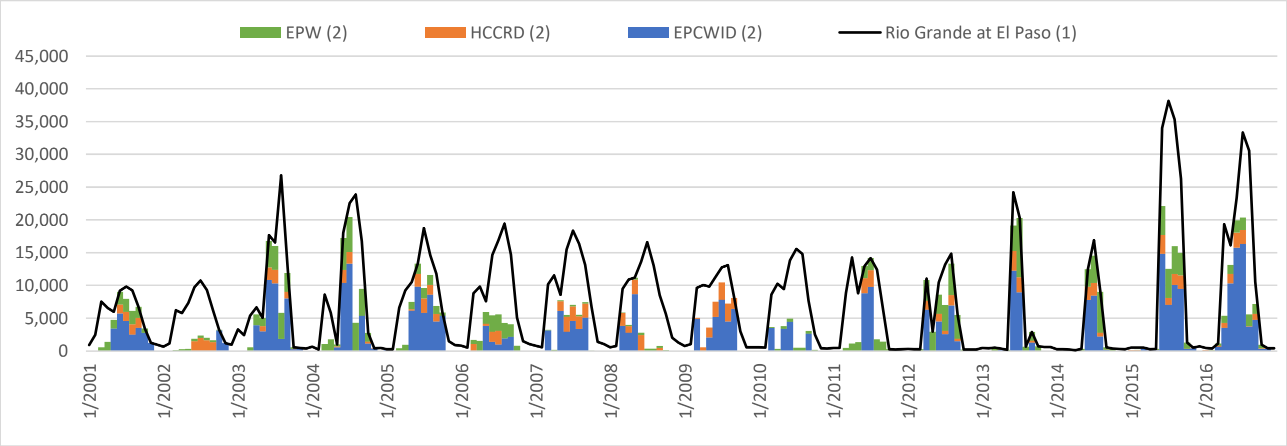
Figure 14-3

Increased Rio Grande at El Paso Flow and Increased Deliveries to Texas Water Users
Dorrance Analysis
(acre-feet)

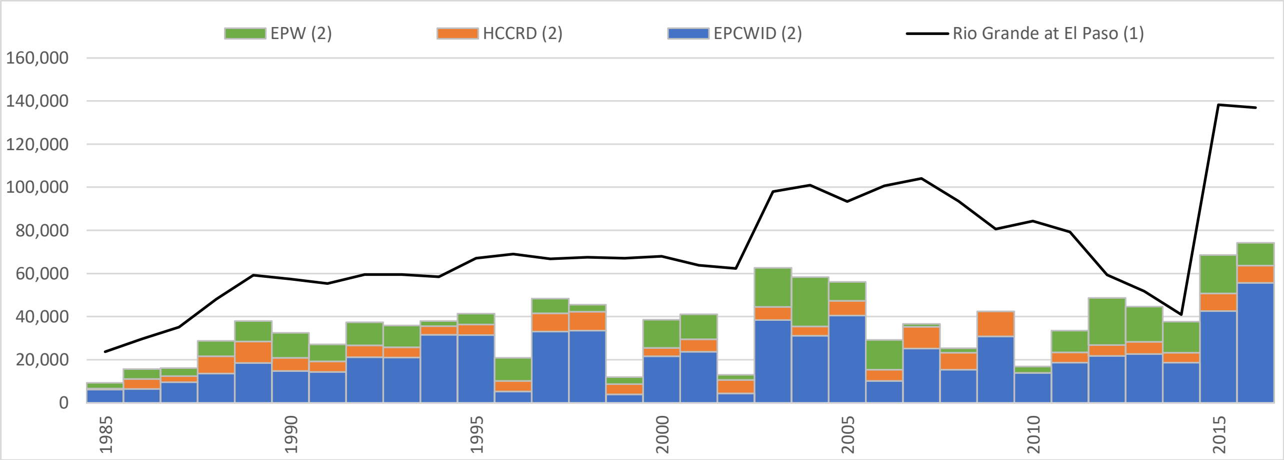
Monthly (1985-2000)



Monthly (2001-2016)



Annual (1985-2016)

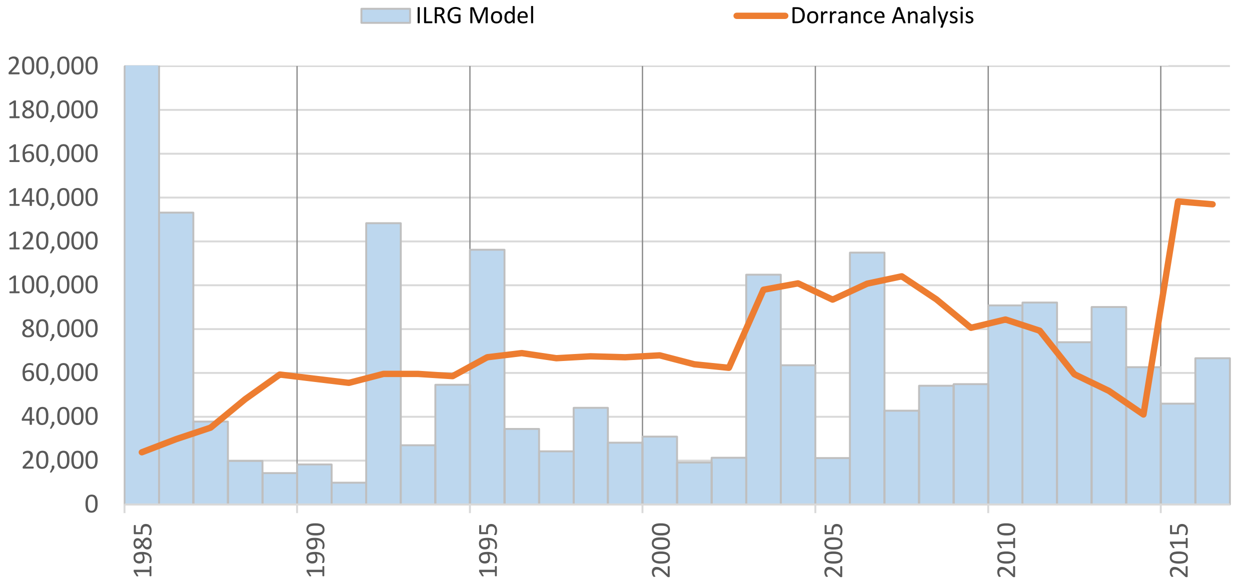


Notes:

(1) Increased Rio Grande at El Paso flow in 60% Rincon-Mesilla pumping reduction scenario simulated in Texas Model.
(2) Amounts of increased Rio Grande at El Paso flow assumed delivered to Texas water users to replace historical pumping.
(3) Delivery data revised based on new data provided in the 12-30-2019 Sunding Reply and Rebuttal Expert Report.

Figure 14-4

Annual Impact of Pumping on Rio Grande at El Paso Flows
Integrated LRG Model (No NM Pumping)
vs.
Dorrance (60% Reduction in R-M Pumping)
(acre-feet)



	(1) ILRG Model (No NM Pump)	(2) Dorrance (60% Reduction)
1985 - 2016 Average Annual (af):	65,965	71,232

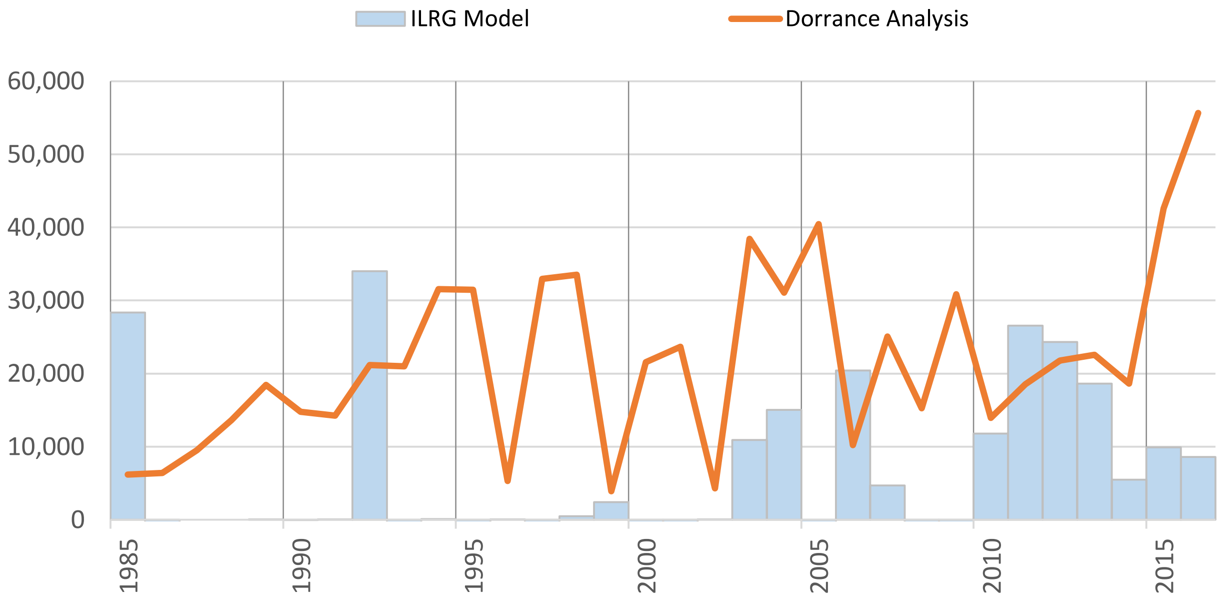
Notes:

(1) ILRG Model change computed as flows in Run 3 (no New Mexico pumping) minus Run 1 (all pumping on).

(2) Dorrance change computed as the increase in El Paso gage flows (Texas Model simulation of 60% reduction in R-M pumping minus historical El Paso gage flows) from 1985 - 2016 only.

Figure 14-5

Annual Impact of Pumping on EPCWID Irrigation Deliveries
Integrated LRG Model (No NM Pumping)
vs.
Dorrance (60% Reduction in R-M Pumping)
(acre-feet)



	(1) ILRG Model (No NM Pump)	(2) Dorrance (60% Reduction)
1985 - 2016 Average Annual (af):	6,416	21,837

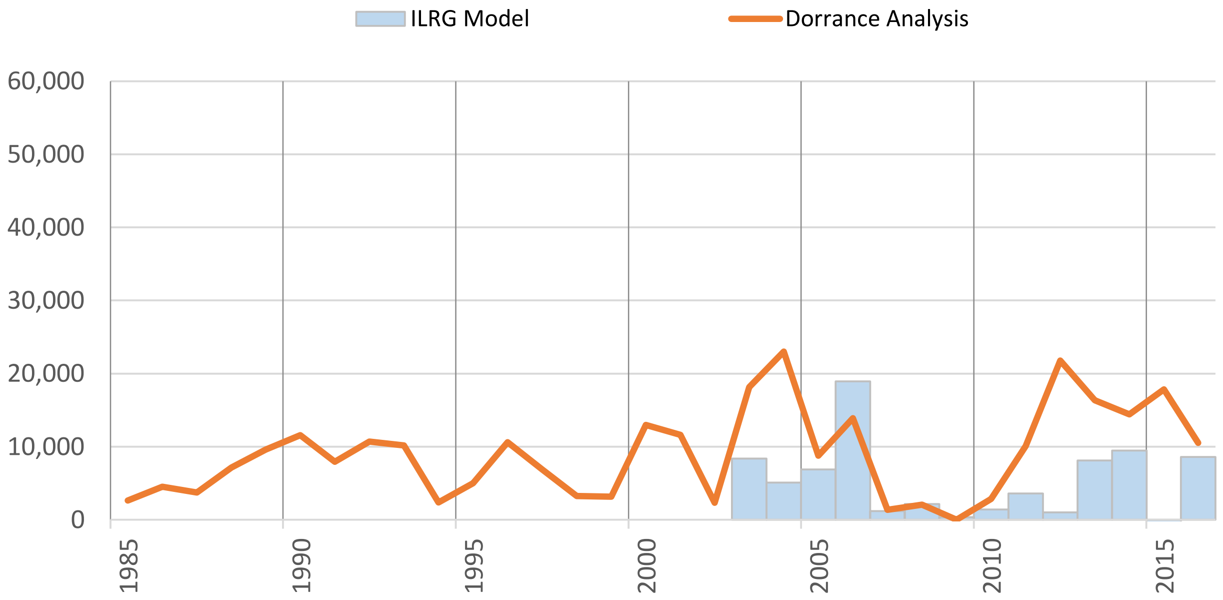
Notes:

(1) ILRG Model change computed as the El Paso Valley EPCWID farm deliveries in Run 3 (no New Mexico pumping) minus Run 1 (all pumping on).

(2) Dorrance change computed as the increase in El Paso gage flows (Texas Model simulation of 60% reduction in R-M pumping minus historical El Paso gage flows) distributed monthly using historical ratios of monthly to annual El Paso flows and ratios to historical EPCWID El Paso Valley deliveries.

Figure 14-6

Annual Impact of Pumping on EPW Deliveries
Integrated LRG Model (No NM Pumping)
vs.
Dorrance (60% Reduction in R-M Pumping)
(acre-feet)



	(1) ILRG Model (No NM Pump)	(2) Dorrance (60% Reduction)
1985 - 2016 Average Annual (af):	2,280	8,984

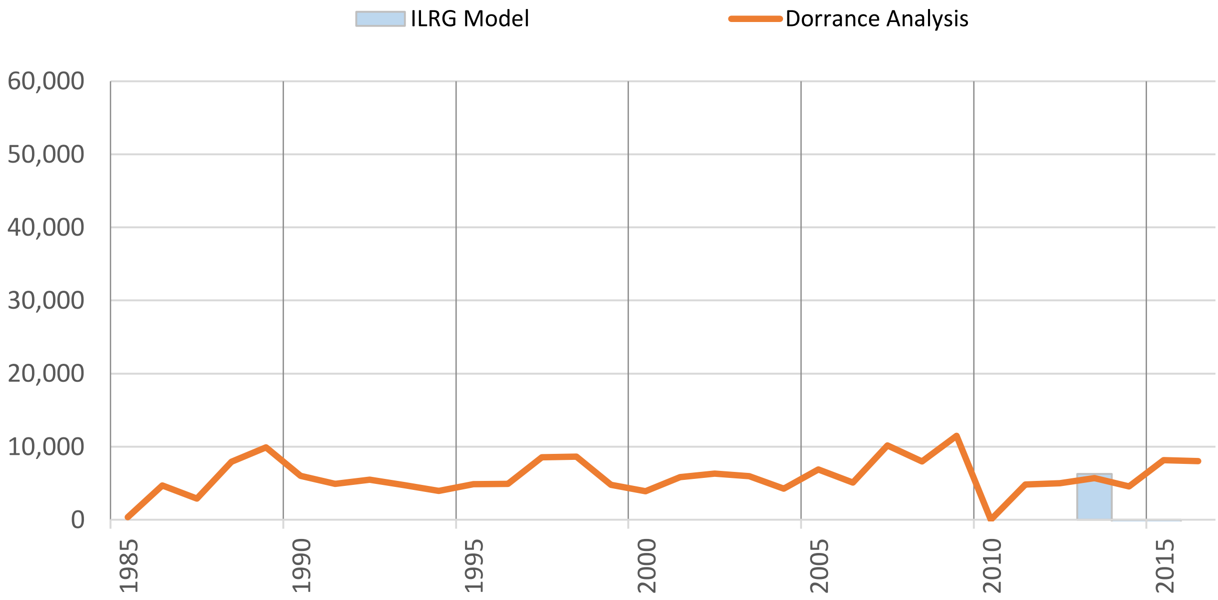
Notes:

(1) ILRG Model change computed as flows in Run 3 (no New Mexico pumping) minus Run 1 (all pumping on).

(2) Dorrance change computed as the increase in El Paso gage flows (Texas Model simulation of 60% reduction in R-M pumping minus historical El Paso gage flows) distributed monthly using historical ratios of monthly to annual El Paso flows and ratios to historical EPW deliveries. EPW deliveries limited maximum historical monthly deliveries.

Figure 14-7

Annual Impact of Pumping on HCCRD Deliveries
Integrated LRG Model (No NM Pumping)
vs.
Dorrance (60% Reduction in R-M Pumping)
(acre-feet)



	(1) ILRG Model (No NM Pump)	(2) Dorrance (60% Reduction)
1985 - 2016 Average Annual (af):	68	5,844

Notes:

(1) ILRG Model change computed as the HCCRD farm deliveries in Run 3 (no New Mexico pumping) minus Run 1 (all pumping on).

(2) Dorrance change computed as the increase in El Paso gage flows (Texas Model simulation of 60% reduction in R-M pumping minus historical El Paso gage flows) distributed monthly using historical ratios of monthly to annual El Paso flows and ratios to historical HCCRD deliveries.

Appendix 27

Inputs for Hueco Annual CFB Models

1903 – 1937

1. Introduction

The CFB Models contain canal and farm budget calculations on an annual time-step for units overlying the Hueco ground water basin, including EPCWID (El Paso Valley), HCCRD, and JID Units 1 – 3. The annual Hueco CFB Models are from 1903 – 1937. This appendix describes the inputs used in the annual Hueco CFB Models.

2. Annual Hueco CFB Model Inputs

2.1 Surface Water Supplies

Surface water supplies were input into the CFB Models using flow data from the surface water dataset ("SWDataSet") and accounting dataset prepared by SWE. The following table summarizes the annual surface water supplies used in the annual Hueco CFB Models for the 1903 – 1937 period.

Irrigation Unit	**Surface Water Supplies (1903 – 1937)**
EPCWID (El Paso Valley)	1903-1919, 1922, 1924-1926, 1928-1930, 1932, and 1935: Franklin Canal (1903 – 1937) - Ascarate Wasteway (1916 – 1937) + Riverside Canal (1928 – 1937) 1920-1921, 1923, 1927, 1931, 1933-1934, 1936-1937: Reported annual total diversion from WDR reports.
HCCRD	1915 – 1923: Calculated (irrigated acres x 4 feet) 1924 – 1937: Tornillo Canal Waste End + Tornillo Drain
JID Unit 1	Acequia Madre (1903 – 1937) + Cuidad Juarez Sewage (1926 – 1937) + River Diversions (1907 – 1937); split proportionally between units using irrigated acreage
JID Unit 2	
JID Unit 3	

Available surface water flows from 1903 – 1937 have been compiled, but there are significant data gaps during this period. SWE coordinated with MMA to estimate the missing 1903 – 1937 annual data. The start dates for different canals, wasteways, and drains were provided by MMA. These estimates are described in detail below.

EPCWID (El Paso Valley) 1903 – 1937

Annual data for the Franklin Canal date back to 1914 (missing data in 1917). Prior to the construction of the American Dam in 1938, the Franklin Canal diverted at the International Dam. Franklin Canal diversion data from 1903 – 1913 and 1917 were estimated using an annual 1918 – 1938 regression with streamflows for the Rio Grande at El Paso gage. The Franklin Canal diversions were estimated as the minimum of the computed canal flow using the regression and the estimated capacity of the canal (320 cubic feet per second ["cfs"]). The Franklin Canal diversions were also limited to an irrigation season of March to November.

The Ascarate Wasteway was constructed around 1916, but annual flow records are only available after 1938. Annual Ascarate Wasteway flows from 1916 – 1937 were estimated using a 1938 – 1949 annual regression with the Franklin Canal.

The Riverside Canal was constructed around 1928 and the annual records for the Riverside Canal from 1928 – 1937 are complete.

HCCRD 1903 – 1937

Irrigation in HCCRD commenced around 1915 with the construction of ditches that diverted water from the Rio Grande and HCCRD was organized in 1924 (Reclamation, 2013). HCCRD flows were measured starting in the 1920s. Measurement of the Tornillo Drain flows began in 1923 and measurement of the Hudspeth Canal (Tornillo End) began in 1925. The total flow to HCCRD was assumed to be the sum of the Tornillo Drain and the Hudspeth Canal (Tornillo End). According to the HCCRD water supply schematic (see SWE Report Figure 6-4; Sullivan and Welsh 2019), the Hudspeth Canal (Tornillo End) began in 1925. There are no Hudspeth Canal (Tornillo End) flow records from 1925 – 1934 and only annual data are available 1935 – 1937. The Hudspeth Canal (Tornillo End) flows are estimated from 1925 – 1934 using a water balance approach, calculated as the Tornillo Canal heading flow minus an assumed seepage loss minus farm headgate demands for the Tornillo acres minus Tornillo Waste. Annual Hudspeth Canal (Tornillo End) flows are distributed monthly using the same distribution as the Tornillo Canal heading monthly flows.

Various regression equations to estimate diversions for the Tornillo Drain and Hudspeth Canal (Tornillo End) from 1915 – 1923 were tested and did not yield good fits. Therefore, the diversions from 1915 – 1923 were estimated as the total irrigated acres multiplied by four feet.

JID Units 1 – 3 1903 – 1937

Diversion records for Acequia Madre are available from 1924 – 1925 and 1930 – 1936. Missing data for 1903 – 1923, 1926 – 1929, and 1937 were estimated using an annual 1930 – 1936 regression with the Rio Grande at El Paso gaged flows. The Acequia Madre diversions were estimated as the minimum of the computed canal flow using the regression and the estimated capacity of the canal (300 cfs). The Acequia Madre diversions were also limited to an irrigation season of March to November. A water balance calculation was conducted to check that the estimated combined diversions at Franklin Canal and Acequia Madre did not exceed the total Rio Grande flow at El Paso gage.

The Sewage Flow from 1926 – 1937 was estimated to be 49 percent of the Cuidad Juarez (“JMAS”) pumping using methodology described in the report. There are no data for JMAS pumping prior to 1926, although the annual JMAS pumping was less than 500 acre-feet in the late 1920s. Because of the lack of data and the small magnitude of the JMAS pumping, no Sewage Flows were computed to include in the surface water supply to Juarez prior to 1926. Sewage Flow available to the farms from 1926 – 1937 was limited to the irrigation season of March to October.

Annual estimates of River Diversions from 1930 – 1936 from the 1938 Rio Grande Joint Investigation (“RGJI”) were used in the CFB Models (USNRC, 1938). Due to similar hydrological conditions, annual data for 1937 was assumed to be equal to 1936. The River Diversions prior to 1930 were computed as the estimated available river flow limited to the JID irrigation demand.

The total JID water supplies from 1903 – 1937 were distributed to the JID units based on the irrigated area in each unit. This distribution of water is consistent with the water distribution used during this period in Carreno (1957), except in the drought years 1903 – 1906 in which water was assumed to only be available to JID Unit 1.

2.2 Irrigated Area

Available irrigated area data from 1903 – 1937 were compiled for use in the annual Hueco CFB Models. There are no data on primary acres in Texas and Mexico and all irrigated lands for these areas are assumed to be supplemental acres.

Available irrigated area in Texas, EPCWID (El Paso Valley) and HCCRD, from 1903 – 1937 are from the 1938 RGJI. The 1938 RGJI records are not complete from 1903 – 1937, and missing irrigated area data were estimated using interpolation/extrapolation of the years with data. The reported and estimated irrigated acreage data used in the CFB Models are shown in the table below.

The irrigated area data for JID was obtained from various reports (USNRC, 1938 and IBWC, 1989). Similar to EPCWID (El Paso Valley) and HCCRD, the irrigated acreage for years of no data were interpolated between the available reported acreage. The total acreage was distributed into the three JID units primarily using the reported distribution from Carreno (1957), except from 1903 – 1906, it was assumed that during low flows all diversions would go to JID Unit 1. In 1904, it was assumed that there were zero irrigated acres since there were no flows at the Rio Grande at El Paso gage that year from March – July.

The irrigated area used in the annual Hueco CFB Models is summarized in the table below.

District	**Supplemental Acres 1903 – 1937**
EPCWID (El Paso Valley)	1903 – 1906: Set equal to 1907 acreage from RGJI (USNRC, 1938) 1907, 1914, and 1920 – 1935: Acreage from RGJI (USNRC, 1938) 1908 – 1913: Linear interpolation between 1907 and 1914 acreage from RGJI (USNRC, 1938) 1915 – 1917: Set equal to 1914 acreage from RGJI (USNRC, 1938) 1918 – 1919 and 1936 – 1937: Reclamation Water Distribution Reports (Accounting DataSet)
HCCRD	1903 – 1914: Assumed zero irrigated acres (MMA) 1915 – 1919: Linear interpolation between zero acres in 1914 to 1920 acreage from RGJI (USNRC, 1938) 1920 – 1936: Acreage from RGJI (USNRC, 1938) 1937: Davids Engineering (2018)
JID Units 1 – 3	1903, 1905, 1908 – 1914, 1916 – 1922, 1927 – 1929, and 1931 – 1937: Acreage interpolated from IBWC (1989) and RGJI (USNRC, 1938), data provided by MMA 1904, 1906, 1915, and 1930: Acreage from IBWC (1989), data provided by MMA 1907 and 1923 – 1926: Acreage from RGJII (USNRC, 1938), data provided by MMA

2.3 Crop Irrigation Requirement and Excess Effective Precipitation

For the 1903 – 1935 annual Hueco CFB Models, the CIR is the average annual 1936 – 1937 CIR from DE reduced by 5 percent. For 1936 – 1937, the annual CIR from DE was reduced by 5 percent. There is no assumed excess effective precipitation simulated in the 1903 – 1937 annual CFB Models.

2.4 Conveyance and Other Losses

For the HCCRD and JID CFB Models, the total canal loss and wasteway flows loss is a user-specified percent of the total diversions for each annual CFB Model. These percentages do not vary from year-to-year. The total canal loss is set to 40% for the HCCRD and JID CFB Models from 1903 – 1937. The wasteway flow percentage is set to 0%.

For the EPCWID (El Paso Valley), the canal loss and waste are user-specified percentage (40% and 10%) for years with no WDR records (1903-1919, 1922, 1924-1926, 1928-1930, 1932, and 1935).

For years with WDR records (1920-1921, 1923, 1927, 1931, 1933-1934, 1936-1937), the total canal loss is the minimum of 40% and the river headgate (“RHG”) diversion minus the farm headgate (“FHG”) delivery divided by the RHG diversion. However, in all years, the canal loss is equal to the minimum 40%. For years with WDR records, the waste is computed as a residual (RHG diversion minus the canal loss). The waste residual volume is used to compute a waste percent (waste residual divided by RHG diversion) that is used in the EPCWID (El Paso Valley) annual CFB Model.

2.4.1 Incidental Canal Loss and Canal Seepage

The incidental canal loss is computed based on a user specified a percentage of the total canal loss and is set at 6%.

2.5 Maximum On-Farm Irrigation Efficiency ("MFE")

The MFE is a user-specified percent for each annual CFB Model. The MFE does not vary from year-to year. The MFE is currently set at 68% for all irrigation units.

2.6 On-Farm Loss Split

The surface runoff percentage is a user-specified percent for each annual CFB Model that does not vary from year-to year. The surface runoff percentage is currently set at the 6% for all irrigation units. The deep percolation percent is computed as one minus the surface runoff percent (94%).

2.7 Soil Moisture Reservoir

The soil moisture reservoir (inches) for the annual Hueco CFB Models are set equal to the values used in the monthly CFB Models.

2.8 Ground Water Pumping

There is no ground water pumping for irrigation supply on the Hueco lands from 1903 – 1937. However, the structure to simulate the supplemental and primary pumping has been added to the annual Hueco CFB Models.

Appendix 28

Hydrologic and Water Quality Models: Performance Measures and Evaluation Criteria

Moriasi et al. (2015)

HYDROLOGIC AND WATER QUALITY MODELS: PERFORMANCE MEASURES AND EVALUATION CRITERIA

D. N. Moriasi, M. W. Gitau, N. Pai, P. Daggupati

ABSTRACT. *Performance measures (PMs) and corresponding performance evaluation criteria (PEC) are important aspects of calibrating and validating hydrologic and water quality models and should be updated with advances in modeling science. We synthesized PMs and PEC from a previous special collection, performed a meta-analysis of performance data reported in recent peer-reviewed literature for three widely published watershed-scale models (SWAT, HSPF, WARMF), and one field-scale model (ADAPT), and provided guidelines for model performance evaluation. Based on the synthesis, meta-analysis, and personal modeling experiences, we recommend coefficient of determination (R^2; in conjunction with gradient and intercept of the corresponding regression line), Nash Sutcliffe efficiency (NSE), index of agreement (d), root mean square error (RMSE; alongside the ratio of RMSE and standard deviation of measured data, RSR), percent bias (PBIAS), and several graphical PMs to evaluate model performance. We recommend that model performance can be judged "satisfactory" for flow simulations if monthly $R^2 > 0.70$ and $d > 0.75$ for field-scale models, and daily, monthly, or annual $R^2 > 0.60$, $NSE > 0.50$, and $PBIAS \leq \pm 15\%$ for watershed-scale models. Model performance at the watershed scale can be evaluated as "satisfactory" if monthly $R^2 > 0.40$ and $NSE > 0.45$ and daily, monthly, or annual $PBIAS \leq \pm 20\%$ for sediment; monthly $R^2 > 0.40$ and $NSE > 0.35$ and daily, monthly, or annual $PBIAS \leq \pm 30\%$ for phosphorus (P); and monthly $R^2 > 0.30$ and $NSE > 0.35$ and daily, monthly, or annual $PBIAS \leq \pm 30\%$ for nitrogen (N). For RSR, we recommend that previously published PEC be used as detailed in this article. We also recommend that these PEC be used primarily for the four models for which there were adequate data, and used only with caution for other models. These PEC can be adjusted within acceptable bounds based on additional considerations, such as quality and quantity of available measured data, spatial and temporal scales, and project scope and magnitude, and updated based on the framework presented herein. This initial meta-analysis sets the stage for more comprehensive meta-analysis to revise PEC as new PMs and more data become available.*

Keywords. *Guidelines, Model calibration and validation, Performance measures and evaluation criteria.*

Hydrologic and water quality (H/WQ) models are increasingly being used to determine the impacts of land management, land use, climate, and conservation practices on water resources, ecology, and water-related ecosystem services. Hydrologic cycle components and fate and transport of sediments and chemicals are examples of complex systems comprised of many processes that can be simulated using H/WQ models. A majority of H/WQ models require some degree of calibration to reduce the uncertainty of predictions (Engel et al., 2007; USEPA, 2009). Calibration is the process of adjusting input parameter values and initial or boundary conditions within reasonable ranges until the simulated results closely match the observed variables (Zeckoski et al., 2015). Calibration requires the examination of accuracy of outputs and process simulation (Sorooshian, 1983) to ensure adequate watershed and scenario representation. This requires use of model performance measures (PMs) and the corresponding performance evaluation criteria (PEC). Throughout this article, the term "PMs" refers to the statistical and graphical methods used during model calibration and validation, "performance data" refers to the reported values of each of the statistical PMs (e.g., 0.5 for NSE), and "PEC" refers to model performance qualitative ratings (e.g., very good, good, satisfactory, or unsatisfactory) with the corresponding quantitative thresholds for the statistical PMs of interest (e.g., NSE, PBIAS, or R^2). Validation is the process by which a calibrated model is shown to be capable of reproducing a set of field observations or predicting future conditions without further adjustment to the calibrated parameters (Zheng et al., 2012).

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Modelers have used different PMs, including statistical, graphical, or a combination of both. For example, Herr and Chen (2012) preferred the use of absolute and relative error, while Huth et al. (2012) recommended and used a variety of measures, including Nash-Sutcliffe efficiency (NSE; Nash and Sutcliffe, 1970) and the ratio of root mean square error (RMSE) and standard deviation of measured data (RSR; Moriasi et al., 2007). Commonly used graphical PMs include time series plots (e.g., van der Keur et al., 2001; Mutiti and Levy, 2010; Palosuo et al., 2011; Arnold et al., 2012; Herr and Chen, 2012; Huth et al., 2012), scatter plots (e.g., Palosuo et al., 2011; Herr and Chen, 2012), cumulative charts (e.g., Herr and Chen, 2012), and contour maps (e.g., Zheng et al., 2012).

Nevertheless, the use of both graphical and statistical PMs is essential for robust model performance evaluation (Biondi et al., 2012; Bennett et al., 2013; Harmel et al., 2014; Daggupati et al., 2015a). For instance, measures such as the NSE are insensitive to systematic errors and yield good model performance even if low values are poorly fitted (Krause et al., 2005; Ritter and Muñoz-Carpena, 2013; Pfannerstill et al., 2014). In such cases, graphical PMs provide supplementary evidence as to where (e.g., in the time series, magnitude of event, depth, etc.) the model is not performing adequately. In addition, pre-inspection of graphical output likely minimizes equifinality (or parameter non-uniqueness), a situation in which a variety of parameter sets can yield acceptable model performance (Beven and Freer, 2001; Doherty and Johnston, 2003). This is achieved by allowing identification of parameter sets that provide better process simulation, thereby reducing the number of possible parameter sets that yield acceptable model performance. Recent works indicate that the intended use of the model could serve as an important factor in the selection of PMs and PEC (Finsterle et al., 2012; Harmel et al., 2014).

Past literature on model PMs includes Willmott (1984), Loague and Green (1991), ASCE (1993), Refsgaard (1997), Gupta et al. (1998), Legates and McCabe (1999), Santhi et al. (2001), Krause (2005), McCuen et al. (2006), Engel et al. (2007), and Moriasi et al. (2007). With respect to PEC, several studies have provided a summary of ranges of values for use in assessing model performance (Popov, 1979; Ramanarayanan et al., 1997; Gassman et al., 2007; Moriasi et al., 2007; Douglas-Mankin et al., 2010; Tuppad et al., 2011; Ritter and Muñoz-Carpena, 2013). The use of PEC provides objective indications of the adequacy of model performance, hence affording greater credibility to the modeling work (Duda et al., 2012). General PEC help model users and decision makers estimate model calibration and validation accuracy, usability for their specific application, and uncertainty or reliability of model predictions (Duda et al., 2012). It is also important to set PEC before beginning model evaluation (ASCE, 1993; USEPA, 2002; Engel, 2007; Moriasi et al., 2007).

Selection and use of PEC also varies by study and by model (Santhi et al., 2001; Van Liew et al., 2007; Parajuli et al., 2009; Benett et al., 2013, Daggupati et al., 2014; Harmel et al., 2014). This could result in inconsistent model evaluation, making it difficult to provide a benchmark for further model improvements. Moriasi et al. (2007) provided guidance to facilitate a more consistent and structured approach for model performance evaluation. However, the scope of the guidelines provided by Moriasi et al. (2007) was limited to NSE, percent bias (PBIAS; Gupta et al., 1999), and RSR for stream flow, sediment, and nutrient (N and P) simulations at a monthly temporal scale and watershed spatial scale. Different PMs can have differing ranges of conditions for which they are best suited (Krause et al., 2005; Gupta et al., 2009; Westerberg et al., 2011; Pushpalatha et al., 2012). Just as there are differences in PMs, there are also differences in the PEC for each measure. In addition, models perform differently for different simulated response outputs and, perhaps, at different temporal and spatial scales (Westerberg et al., 2011; Biondi et al., 2012), which may require different PEC. For example, regions with a shallow water table (e.g., south Florida) experience rapid water table rise within 12 hours of rainfall or irrigation input (Jaber et al., 2006; Hendricks et al., 2013). Hendricks et al. (2013) evaluated a daily temporal scale model for simulating water table responses in a shallow water table region of Florida and concluded that a daily temporal scale was a fundamental limitation because the hydrologic response time was less than 12 hours. Therefore, there is need to explore how different models perform under different conditions using different PMs to help determine appropriate PEC. Further, Moriasi et al. (2007) stated that “as new and improved methods and information are developed, the recommended guidelines should be updated to reflect these developments.”

Recently, Biondi et al. (2012), Ritter and Muñoz-Carpena (2013), Moriasi et al. (2012), Pushpalatha et al. (2012), Bennett et al. (2013), Black et al. (2014), and Harmel et al. (2014) focused on various aspects of performance of H/WQ models. Biondi et al. (2012) performed a literature review and provided general model validation guidelines that cover several topics discussed in this special collection. Black et al. (2014) provided general guidance on the implementation and application of water resource management models focused on scenario analysis. Bennett et al. (2013) reviewed and provided methods available across different fields for describing the performance of environmental models focusing on model PMs. Pushpalatha et al. (2012) analyzed several forms of NSE to determine the form that was suitable for flows. Ritter and Muñoz-Carpena (2013) presented a unified framework for determining model PEC in a statistically rigorous way and for the evaluation of bias, outliers, and repeated data focused on RMSE and NSE. Harmel et al. (2014) reviewed literature and recommended a broad methodology that takes into account intended use to establish model performance expectations. The methodology provides a brief summary of several topics, including model valuation, interpretation, and communication of model results.

Moriasi et al. (2012) summarized the results of 25 H/WQ models in a special collection of 22 articles, each focusing on individual model calibration and validation strategies. The special collection provided a good source of model-specific calibration and validation examples, performance evaluation examples, and references. However, there is need for consistent model calibration and validation guidelines (Moriasi et al., 2012), including PMs and PEC.

Recognizing the good work done by others, in this article we: (1) synthesize the special collection articles (Moriasi et al., 2012) with respect to PMs and PEC; (2) perform a meta-analysis of performance data as reported in peer-reviewed literature by considering the effects of calibration and validation periods, simulated components, and spatial and temporal scales; and (3) establish guidelines for model performance evaluation based on information from the synthesis (objective 1) and meta-analysis (objective 2). Further, we present an example case study illustrating the application of our recommendations in model calibration and validation.

In summary, this article is one of nine topic-specific articles in a special collection whose main goal is to provide recommendations, which together with information from other literature will be used to develop model calibration and validation engineering practices for H/WQ models. These articles extensively cover critical issues related to the calibration and validation of H/WQ models. This article focuses on model PMs and the corresponding PEC related to models in the Moriasi et al. (2012) special collection and provides a more rigorous framework than Moriasi et al. (2007, 2012) for determining PEC, involving a meta-analysis of the performance data collected in this study and using the results to guide PEC development.

METHODS

SYNTHESIS OF PERFORMANCE MEASURES AND EVALUATION CRITERIA

As a starting point, the articles in the Moriasi et al. (2012) special collection were reviewed to determine the statistical and graphical PMs used for each of the models. The models in the special collection were grouped into three spatial categories (point to plot, field, and watershed; table 1). PMs and PEC reported outside of the special collection were helpful in broadening the outlook on PEC and providing additional materials useful for establishing guidelines. Commonly used PMs and PEC within and outside the special collection (Moriasi et al., 2012) for each model were recorded for in-depth analyses.

Although there are several ways in which statistical PMs can be categorized (Moriasi et al., 2007; Bennett et al., 2013), in this article statistical PMs are discussed and divided into three broad categories: (1) standard regression, (2) dimensionless, and (3) error index based on Moriasi et al. (2007). Standard regression measures determine the strength of the linear relationship between simulated and measured data. Dimensionless measures provide a relative model evaluation assessment, and error index measures quantify the deviation in the units of the data of interest (Legates and McCabe, 1999). Graphical PMs are divided into two categories (direct and derived comparison), and information about the strengths and weaknesses of each of the measures was obtained from the literature. In this article, we define direct comparison graphical PMs as graphical PMs in which original measured and simulated data are compared with each other, for instance, with time series graphs. Derived graphical PMs are those in which meas-

Table 1. Models in the Moriasi et al. (2012) special collection grouped by spatial scale.

Model	Simulated Processes (Components)	Reference
Point to plot scale		
COUPMODEL	Hydrology, N, carbon, plant growth, heat, tracer, chloride	Jansson (2012)
HYDRUS	Water flow, solute transport, heat transfer, carbon dioxide	Šimůnek et al. (2012)
MACRO	Macropore flow, pesticides	Jarvis and Larsbo (2012)
MT3DMS	Multispecies solute transport, groundwater	Zheng et al. (2012)
SHAW	Hydrology, heat transfer	Flerchinger et al. (2012)
STANMOD	Solute transport in soils and groundwater	van Genuchten et al. (2012)
SWIM3	Water and solute movement	Huth et al. (2012)
TOUGH2	Multiphase, multicomponent fluids in porous and fractured geologic media	Finsterle et al. (2012)
VS2DI	Water, solute, heat transport	Healy and Essaid (2012)
Field scale		
ADAPT	Hydrology, erosion, nutrients, pesticides, subsurface tile drainage	Gowda et al. (2012)
CREAMS/GLEAMS	Hydrology, erosion, pesticides, sediments, nutrients, plant growth	Knisel and Douglas-Mankin (2012)
DAISY	Water, snowmelt, carbon cycle, energy balance, N cycle, crop production, pesticides	Hansen et al. (2012)
DRAINMOD	Hydrology (water table depth, tile flow, surface runoff, depth of irrigation water applied, wetland hydrology), plant growth (crop yield)	Skaggs et al. (2012
EPIC/APEX	Hydrology (surface runoff, stream flow, tile flow), plant growth, erosion, sediments, nutrients, pesticides	Wang et al. (2012)
RZWQM2	Hydrology, plant growth, nutrients, pesticides	Ma et al. (2012)
WEPP Hillslope	Hydrology, soil erosion	Flanagan et al. (2012)
Watershed scale		
BASINS/HSPF	Hydrology, snowmelt, pollutant loadings, erosion, fate and transport	Duda et al. (2012)
KINEROS2/AGWA	Runoff, erosion, sediments	Goodrich et al. (2012)
MIKE-SHE	Surface and subsurface water dynamics, interception, evapotranspiration, overland flow, channel flow, unsaturated flow, saturated zone flow, water levels, surface and groundwater quality	Jaber and Shukla (2012)
SWAT	Hydrology, plant growth, sediments, nutrients, pesticides	Arnold et al. (2012)
WAM	Hydrology, sediments, nutrients	Bottcher et al. (2012)
WARMF	Hydrology, sediments, nutrients, acid mine, carbon, bacteria	Herr and Chen (2012)
WEPP Watershed	Hydrology, soil erosion	Flanagan et al. (2012)

ured or simulated data are first transformed into another form before they are displayed in a comparative graph, for example, frequency duration curves.

A comparative analysis of the reported PMs was performed to evaluate (1) how they compare across the models, (2) their advantages and disadvantages, and (3) their usability (ease of and suitability for use) from a user or non-developer perspective. Additional considerations for PMs included their suitability for event-based vs. continuous models and their use with missing and/or discrete observed data. Based on this analysis, recommendations are made for suitable PMs.

META-ANALYSIS OF PERFORMANCE DATA

A statistical meta-analysis was performed on the model performance data to guide the development of the PEC. Simply stated, a meta-analysis (Glass, 1976; Hunter et al., 1982; Hunt, 1997; Lyons, 1998; among others) is the accumulation and analysis of data from separate but similar studies for the purpose of obtaining insights from the pooled data that are not discernible from the individual studies. The methodology provides an avenue for bringing together information from various related studies in search of common patterns and conclusions. It can also be used to reconcile data from disparate studies. Since its inception in the 1970s, meta-analysis has been applied successfully in various fields, including medical research and social studies (Egger and Smith, 1997; Lyons, 1998; Bland, 2000). The methodology has also been used successfully in natural resources and environmental systems for the development of a Best Management Practice (BMP) tool (Gitau et al., 2005).

The accumulation of data from existing studies is the most involved part of a meta-analysis, as it requires considerable attention to some key considerations, as described in ensuing subsections.

Kinds of Articles to Include

It is necessary that articles be relevant to the study at hand (Light and Smith, 1971; Hunt, 1997) and that the articles contain the information needed to achieve study goals. As materials may be subject to re-interpretation, it is preferable that the articles contain original material and include a detailed account of the study. Further, given a common tendency toward selecting articles that favor an author's viewpoint and/or that align with prevailing opinion (Egger and Smith, 1997), it is important that article selection follows an objective procedure. For example, in this article, the articles included are primary sources that provided performance data for the various PMs. Additional criteria included the presence of details such as models used, evaluation time step, components evaluated, and whether data reported were for calibration or validation.

Whether or Not to Use Only Published Material

Generally, published material is deemed to have more reliable data and is afforded more credibility than unpublished material. However, published material is often preferential in nature, favoring research works based on reported significance (Lipsey and Wilson, 2001). For example, in regard to model performance, articles reporting higher values of NSE may be preferentially published, whereas those with lower values (albeit with better parameter representations) may take a while longer or may not be published at all. Including only published material may result in a publication bias (Light and Smith, 1971; Hunter et al., 1982; Light and Pillemer, 1984; Bland, 2000); thus, we recommend that both published and unpublished material be included. The challenge lies in being able to find unpublished information, as this is not generally available. Thus, the dataset developed for this article only contains data from published material (peer-reviewed journal articles after 1990).

Rejection of Articles on the Basis of Perceived Inadequacies in the Methodology

Another important consideration is the determination of article suitability for inclusion based on methodologies used. This is especially so for unpublished information, as a work may be unpublished due to unsuitable methodologies. However, it is important to note that flaws can be identified in almost any article (Hunter et al., 1982; Lipsey and Wilson, 2001) given that opinions tend to differ among researchers. The use of methodology as a basis for article inclusion would thus introduce elements of subjectivity into the analysis (Light and Smith, 1971) and would result in a reduced dataset (Glass, 1976; Hunter et al., 1982), which would then impact the analysis. In this study, no judgements were made as to the adequacy or inadequacy of the methodologies used once an article was deemed suitable for inclusion based on study goals.

Amount of Data Necessary for Analyses

The ideal case would be to have all existing data; in this case, the details and results of all studies in which model calibration and validation have been conducted and performance values have been reported. However, this is generally not practical, due to limited access to unpublished material, if nothing else, and thus the need for a representative sample arises. In addition, it is necessary to consider the study goals. For example, in this article, the goal was to capture recent advances in modeling (in the 1990s and later) for commonly used H/WQ models published in a recent special collection (Moriasi et al., 2012) when establishing performance criteria. For this work, the target was to review a minimum of 20 articles (outside the Moriasi et al. (2012) special collection) per model for the most commonly simulated output responses (flow, sediment, and nutrients) to be reviewed. To enable meta-analysis, each reported entry of performance data was extracted and tabulated along with size of the study area (supplemental material tables S1-1 through S1-22, available at http://bit.ly/NRES_SW10715). Exceptions were permitted for models for which the available peer-reviewed articles numbered less than 20, in which case all available articles were reviewed. Data on stream flow, surface runoff, base flow, and tile flow model performance values were combined as appropriate and referred to as flow for the watershed-scale and ADAPT models to ensure that there were sufficient data for analyses. Where stream flow was the only component used in the analysis and/or discussion, the term "stream flow" was used to distinguish it from the combined flow component. Data were commonly reported in the literature at annual, monthly, and daily temporal scales for watershed-scale models and at a monthly temporal scale for field-scale models. In addition, there was a substantial amount of seasonal data associated with PBIAS.

Handling of Extreme Values

Values showing up as extreme values, once all data are assembled, may reflect extreme site or study characteristics; thus, their exclusion would mask the existence of extremes. Therefore, extreme values such as values of other PMs for studies in which there were negative NSE values were not excluded from the primary analysis. However, negative NSE values were not included in criteria development, as such values represent unacceptable model performance. Further description is provided under the "Meta-Analysis of Performance Data" subheading within the "Results and Discussion" section.

Data Analyses

Once all data are assembled, the most basic analysis involves determining an average for each data component (Hunter et al., 1982; Light and Pillimer, 1984; Hunt, 1997), for example, an average of all NSE values. More detailed approaches involve the computation of standardized metrics to account for differences in the amounts of data among studies (Light and Pillimer, 1984; Lipsey and Wilson, 2001). In either case, this would mask the variability in the data, so more in-depth analysis allowing the examination of factors that could affect results (Hunter et al., 1982; Light and Pillimer, 1984; Hunt, 1997) and extraction of other pertinent information are necessary.

In this study, descriptive statistics such as mean, median, minimum, and maximum were computed for the performance data, and the associated distributions were plotted in order to make a determination on subsequent analysis. Following these preliminary diagnostics, significant differences in reported values were determined based on (1) calibration or validation; (2) scale (specifically watershed-scale studies based on Hydrologic Unit Code (HUC; https://pubs.er.usgs.gov/publication/ofr84708; direct comparisons were not made between watershed and field scales due to the large difference in available data); and (3) model components (e.g., flow, sediment, and nutrients). The analysis was conducted using the median test, a non-parametric (typically distribution-free) test based on median rank scores (SAS, 2007; Sheskin, 2003; Brown and Mood, 1951). The test considers all observations and ranks them as 0 or 1 based on their location around (above or below) the median. Resulting rank scores are then used for the comparisons based on the chi-square statistic and associated probabilities. In addition, the performance data were plotted on a common axis to provide a visual comparison. All analyses were carried out using JMP statistical software (SAS, 2008).

DEVELOPMENT OF GUIDELINES FOR MODEL PERFORMANCE EVALUATION

The median test on reported performance data was used to determine whether separate PEC were needed for calibration and validation periods, spatial and temporal scales, and for different simulated response outputs. Following the median test, thresholds for model PEC ratings were established by computing percentiles or quartiles of model PM data collected from peer-reviewed articles outside the Moriasi et al. (2012) special collection. The thresholds obtained for the defined ratings formed the initial PEC, which along with the results of the synthesis of the PEC and the modeling experience of the authors were used to develop final PEC guidelines for identified separate categories. A similar approach was used by USEPA (2010) as part of an evaluation of the potential benefits of numeric nutrient criteria for Florida's flowing waters. The guidelines are in the form of recommended PMs and PEC. Brief descriptions are provided for (1) the importance of following proper calibration and validation procedures (Zeckoski et al., 2015; Arnold et al., 2015; Baffaut et al., 2015; Malone et al., 2015; Daggupati et al., 2015b; Guzman et al., 2015; and Yuan et al., 2015) prior to using these general guidelines; (2) additional considerations for adjusting the general recommendations because of the variety of modeling applications; and (3) a framework for determining recommended model PMs and their corresponding PEC.

RESULTS AND DISCUSSION

SYNTHESIS OF PERFORMANCE MEASURES AND EVALUATION CRITERIA

The most commonly used graphical PMs in the special collection articles were time series charts (table 2; e.g., WARMF, DAISY, VS2DI, SWIM3, and SWAT). Other graphical PMs included scatter plots (e.g., APEX/EPIC, CREAMS/GLEAMS, DAISY, WARMF, and SWAT), cumulative frequency curves (e.g., WARMF, SWAT), contour maps (e.g., MT3DMS), depth profile plots (e.g., SWIM3), thermographs in which heat is used as a surrogate for water movement (e.g., VS2DI), and bar charts (e.g., EPIC/APEX). Thermographs are quite common in soil/water-solute transport applications.

The most commonly used statistical PMs were NSE, RMSE (also called root mean square deviation, RMSD), and R^2 (table 2). Other reported statistical PMs included *d* (Willmott, 1981), PBIAS (Gupta et al., 1999), mean absolute error, R, absolute error, relative error, standard error of estimate, non-parametric tests, RSR (Moriasi et al., 2007), 95% confidence intervals (to account for uncertainty, mean, and standard deviation), autocorrelation, and cross-correlation (table 2). Brief descriptions as well as discussions of the strengths, weaknesses, and usage of the commonly used measures are presented in ensuing subsections. The abbreviations of the models in the Moriasi et al. (2012) special collection are provided in the Appendix, while the statistical PMs and associated equations are provided in table 5. Detailed accounts of these and other measures can be obtained from model-specific articles and in the literature (e.g., Wilmott, 1984; Legates and McCabe, 1999; Krause et al., 2005; Moriasi et al., 2007; Ritter and Muñoz-Carpena, 2013; Bennett et al., 2013; Harmel et al., 2014).

Of the models within the Moriasi et al. (2012) special collection, only a few provided PEC (table 3), including

Table 2. Summary of performance measures and evaluation criteria for H/WQ models in the Moriasi et al. (2012) special collection.

	Suggested Performance Measures and Evaluation Criteria							
	Statistical Performance Measures[a]						Performance	Graphical Performance
Model	NSE	R^2	RMSE	*d*	PBIAS	Other	Evaluation Criteria[b]	Measures[c]
Point to plot scale								
COUPMODEL	X	X	-	-	-	-	n.p.	Time series
HYDRUS	-	X	-	-	-	X	n.p.	Time series
MACRO	X	-	X	-	-	-	n.p.	-
MT3DMS	-	-	-	-	-	X	n.p.	Contour maps, time series
SHAW	-	-	X	-	-	-	n.p.	Time series
STANMOD	-	-	-	-	-	X	n.p.	Time series
SWIM3	X	-	-	-	-	X	Moriasi et al. (2007)	Time series
TOUGH2	-	-	-	-	-	X	n.p.	-
VS2DI	-	-	-	-	-	X	n.p.	Time series
Field scale								
ADAPT	X	-	X	X	-	X	n.p.	Time series, scatter plots
CREAMS/GLEAMS	X	X	-	X	-	X	n.p.	Time series
DAISY	-	-	X	X	-	-	n.p.	Scatter plots
DRAINMOD	X	X	-	-	-	X	Table 3	Time series
EPIC/APEX	X	X	X	-	X	X	Table 3	Time series, scatter plots, bar charts
RZWQM2	-	-	X	-	-	-	Table 3	Time series
WEPP Hillslope	X	-	X	-	X	X	Moriasi et al. (2007)	-
Watershed scale								
BASINS/HSPF	-	X	-	-	-	X	Table 3	Time series, scatter plots, CFC
KINEROS2/AGWA	X	-	-	-	-	X	Table 3	Time series
MIKE-SHE	-	-	X	X	-	-	n.p.	Time series
SWAT	X	X	X	-	X	X	Moriasi et al. (2007)	Time series, scatter plots, CFC
WAM	X	-	X	-	-	-	n.p.	Time series
WARMF	-	-	-	-	-	X	Table 3	Time series, scatter plots, CFC
WEPP Watershed	X	-	X	-	X	X	Moriasi et al. (2007)	-

[a] NSE = Nash Sutcliffe efficiency/coefficient, R^2 = coefficient of determination, RMSE = root mean square error/deviation, *d* = index of agreement, PBIAS = percent bias/deviation. “Other” includes root mean square error to standard deviation ratio, linear or weighted correlation coefficient, mean error, mean absolute error, standard error of estimate, 95% confidence interval, comparison between observed and predicted means and standard deviations, mean and variance of weighted residuals, autocorrelation, cross-correlation, nonparametric tests, t-tests, and objective functions.

[b] n.p. = not provided and user-defined.

[c] CFC = cumulative frequency curves.

BASINS/HSPF (Duda et al., 2012), DRAINMOD (Skaggs et al., 2012), EPIC/APEX (Wang et al., 2012), KINEROS/AGWA (Goodrich et al., 2012), RZWQM2 (Ma et al., 2012), and WARMF (Herr and Chen, 2012). PEC from Moriasi et al. (2007) were cited for SWAT (Arnold et al., 2012), SWIM3 (Huth et al., 2012), and WEPP (Flanagan et al., 2012). With the exception of SWIM3 (Huth et al., 2012), all point and plot scale models (table 3) employed user-defined objective function thresholds with autocalibration algorithms (Moriasi et al., 2012). The MIKE-SHE (Jaber and Shukla, 2012) and WAM (Bottcher et al., 2012) articles do not provide any PEC.

GRAPHICAL PERFORMANCE MEASURES

Graphical PMs provide an important complementary tool for modelers to support the calibration and validation of H/WQ models (Daggupati et al., 2015a). Graphical PMs allow visual comparison of simulated and measured output response data, help identify model bias, identify differences in timing and magnitude of peaks (e.g., peak flows) and shape of recession curves, incorporate measurement (Harmel and Smith, 2007) and model (Shirmohammadi et al., 2006) uncertainty, and illustrate how well the model reproduces the frequency of measured daily values (Pfannerstill et al., 2014). The disadvantage of graphical PMs is that model performance can be obtained only qualitatively through them. In addition, graphical PMs can easily be manipulated to look good by scaling.

Table 4 lists a variety of graphical PMs used commonly to support and present results of H/WQ model calibration and validation. The graphical PMs are grouped into two broad categories (direct and derived) to enable users to determine appropriate graphical PMs for their study.

The spatial and temporal scale of simulation could be used to determine graphical performance measures that will be effective in communicating model performance to end users. The most effective graphical measures are ones that highlight specific predictive capabilities of the model. For shorter-term modeling (<1 year), a time series plot can be an effective tool. The performance of models for longer-duration datasets (≥10 years of daily data) is better understood by using either a scatter plot or a duration curve. For instance, when Duda et al. (2012) presented the daily-scale five-year calibration results for an HSPF model application, they provided both a time series graph and a duration curve. The time series graph, which contained approximately 1825 data points, gave the impression that the model sometimes overestimated or underestimated peak flows, depending on the peak. This presented a confusing picture of model performance. The authors then presented the same data in the form of a flow duration curve. The flow duration curve not only indicated that, in general, the model-simulated values were close to the observed values (similar to what was understood from the time series plot), but it also showed that the model overestimated higher flows and underestimated medium and lower flows during the validation period. Thus, the duration curve was a more effective tool for understanding and communicating daily model

Table 3. Reported performance evaluation criteria for models in the Moriasi et al. (2012) special collection.

Model (and Reference)	Response Output	Performance Evaluation Criteria				
BASINS/HSPF (Duda et al., 2012)		Difference between Simulated and Recorded Values (%)				
		Very Good	Good	Fair		
	Hydrology/flow	<10	10 to 15	15 to 25		
	Sediment	<20	20 to 30	30 to 45		
	Water temperature	<7	8 to 12	13 to 18		
	Water quality/nutrients	<15	15 to 25	25 to 35		
	Pesticides/toxics	<20	20 to 30	30 to 40		
		Statistical Evaluation Criteria				
	Hydrology/flow	Statistic	Very Good	Good	Fair	Poor
	Daily	R	≥0.89[a]	≥0.84	≥0.77	<0.77
	Monthly	R	≥0.92	≥0.87	≥0.81	<0.81
	Daily	R^2	≥0.80	≥0.70	≥0.60	<0.60
	Monthly	R^2	≥0.85	≥0.75	≥0.65	<0.65
DRAINMOD (Skaggs et al., 2012)		Statistical Evaluation Criteria				
		Statistic	Excellent	Good	Acceptable	
	Water table depth (daily)	MAE (cm)	<10	<15	<20	
		NSE	>0.75	>0.60	>0.40	
	Drainage volume (cm^3 cm^{-2})					
	Daily	NSE	>0.75	>0.60	>0.40	
	Monthly	NSE	>0.80	>0.70	>0.50	
	Annual	NSE	>0.85	>0.75	>0.60	
		NPE	<5%	<15%	<25%	
EPIC/APEX (Wang et al., 2012)		Satisfactory Calibration Criteria				
		R^2	NSE	PBIAS	Mean and SD	Graphical
	Runoff or water yield	≥0.60	≥0.55	Within 20%	-	Simulated time-series flow captures the trend or pattern of measured data.
	Crop yield	≥0.60	-	Within 25%	-	Simulated time-series crop yield captures the trend or pattern of measured data.
	Sediment yield	≥0.60	≥0.50	Within 35%	Simulated mean and SD compare closely with measured values	Simulated time-series sediment yield captures the trend or pattern of measured data.
	Nutrient loss	≥0.60	≥0.50	Within 50%	-	Simulated time-series nutrient loss captures the trend or pattern of measured data.
KINEROS/AGWA (Goodrich et al., 2012)		Acceptable Model Performance				
	Runoff, erosion, sediments	Simulated values within 30% of observed (Al-Qurashi et al., 2008)				
RZWQM2 (Ma et al., 2012)		Acceptable Model Simulation				
		R^2	NSE	*d*	PBIAS	
	Hydrology, plant growth, nutrients, pesticides	≥0.80	≥0.70	≥0.70	Within 15%	
WARMF (Herr and Chen, 2012)		Good Model Performance				
	Hydrology/flow	<20% absolute error				
	Nutrients	<30% absolute error				
	Phytoplankton and suspended sediment	<50% absolute error				

[a] Values estimated from figure 4 (Duda et al., 2012).

performance for their case study. The effectiveness of using a duration curve is also demonstrated in a case study presented later in this article.

As discussed in table 4, certain derived graphical PMs, such as cumulative plots and maps, can provide a misleading picture of model performance. For instance, a combination of cumulative and daily time series plot was used by Bottcher et al. (2012) to present results of the WAM model (fig. 1). The presentation of these two plots was essential because the cumulative plot gives the impression that the model overpredicts initially and underpredicts in the latter part of simulation but has reasonable overall performance. On the other hand, the time series plot shows that certain important flow peaks were completed missed. The time series plot allows the modeler to find temporal mismatches that could go unnoticed by using only a cumulative plot.

Maps are also effective tools for presenting key results and meeting the objectives of watershed models. For example, to build confidence in an uncalibrated SWAT model, Srinivasan et al. (2010) used maps to show that SWAT-simulated annual corn and soybean yields for each subbasin were consistent with USDA-NASS estimates. Pai et al. (2011) and Daggupati et al. (2011) used maps of sediment, total P, and nitrate-N outputs to prioritize subwatersheds and fields in SWAT model applications in Arkansas and Kansas. Such maps could be used to assess spatial model performance.

STATISTICAL PERFORMANCE MEASURES

Statistical PMs are widely used to quantify the performance of H/WQ models in describing the "closeness" of the simulated behavior to observations. Table 5 summarizes commonly used statistical PMs based on the Moriasi et al. (2012) special collection, along with their demonstrated advantages/disadvantages, ranges, optimal values, and the equations used to compute them. Harmel et al. (2014), Bennett et al. (2013), Krause et al. (2005), and Coffey (2004) also provide a comprehensive list of statistical PMs. Although there are different ways to categorize PMs (Moriasi et al., 2007; Bennett et al., 2013), the PMs in this article

Table 4. Summary of graphical performance measures for H/WQ model calibration and validation.

	Purpose	Advantages/Disadvantages
Direct comparison		
Scatter plots	Compare observed and simulated data with no dependent variable. A least square regression line can be fitted to observe deviation from the 1:1 line.	**Advantages:** Divergence from the 1:1 line provides a visual understanding of the underlying behavior of the model, including any bias or systematic variance. **Disadvantages:** Data points clumped in the low intensity, high frequency range and few in the high intensity, low frequency range can artificially make a model's performance look good.
Time-series plots	Compare observed and simulated data with time as a dependent variable.	**Advantages:** Helps inspect and support troubleshooting event-specific prediction issues, including mismatches in magnitude of peaks and shape of recession curve, and outliers. Time series plots can also guide selection of parameters to be used for calibration. **Disadvantages:** Time series plots become cluttered with too many data points.
Derived comparison		
Cumulative plots	Compare cumulative observed and simulated values with time as dependent variable.	**Advantages:** Allows identification of any systematic temporal divergence between observed and simulated values. **Disadvantages:** Cumulative plots may still converge, with major temporal mismatches. They should be used as a preliminary model performance-screening tool.
Flow and load duration curves	Compare observed and simulated values with probability as a dependent variable.	**Advantages:** Provides insight into model performance over different flow/load regimes (i.e., low, medium, high; Pfannerstill et al., 2014). **Disadvantages:** Needs a larger number of data points to derive meaningful conclusions. Duration curves are most useful for long-term monthly, daily, or subdaily calibrations.
Maps	Map showing the output of interest at the desired spatial scale. Examples include showing annual sediment loss for each subwatershed.	**Advantages:** Useful for presenting field-scale to watershed-scale model results for understanding the spatial performance of the model. Pollutant hotspots within a watershed can be quickly identified using color-codes. **Disadvantages:** Choices of color-coding and grouping within a map can sometimes be misleading. For example, red colored areas may or may not represent critical areas depending on actual values plotted.

are grouped as standard regression, dimensionless, and error index, as discussed below.

Standard Regression

Pearson's correlation coefficient (r) and coefficient of determination (R^2) describe the degree of collinearity between simulated and measured data. The correlation coefficient is an index that is used to investigate the degree of linear relationship between observed and simulated data. R^2 is the squared value of r, although it can also be expressed as the squared ratio between the covariance and the multiplied standard deviations of the observed and predicted values (Krause et al., 2005).

Dimensionless

The Nash-Sutcliffe efficiency (NSE) is a normalized statistic that determines the relative magnitude of the residual variance ("noise") compared to the measured data variance ("information"; Nash and Sutcliffe, 1970). NSE indicates how well the plot of observed versus simulated data fits the 1:1 line. Many studies (e.g., Santhi et al., 2001; Vazquez-Amabile and Engel, 2005; Reungsang et al., 2010; Pai et al., 2011; Douglas-Mankin et al., 2013) have used NSE to evaluate model performances for various output responses (e.g., flow, sediment, N, P, crop yields, etc.) using different models (MIKE-SHE, ADAPT, SWAT, WARMF, HSPF, etc.).

The index of agreement (*d*) was developed by Willmott (1981) as a standardized measure of the degree of model prediction error. The index of agreement represents the ratio between the mean square error and the "potential error" (Willmott, 1984). The potential error (denominator in index of agreement equation in table 5) represents the largest value that the squared difference of each pair can attain. The index of agreement can detect additive and proportional differences in the observed and simulated means and variances.

Error Index

The root mean square error (RMSE) is the square root of mean square error (MSE). The MSE is also known as standard error of the estimate in regression analysis. The RMSE is measured in the same units as the model output response of interest and is representative of the size of a typical error.

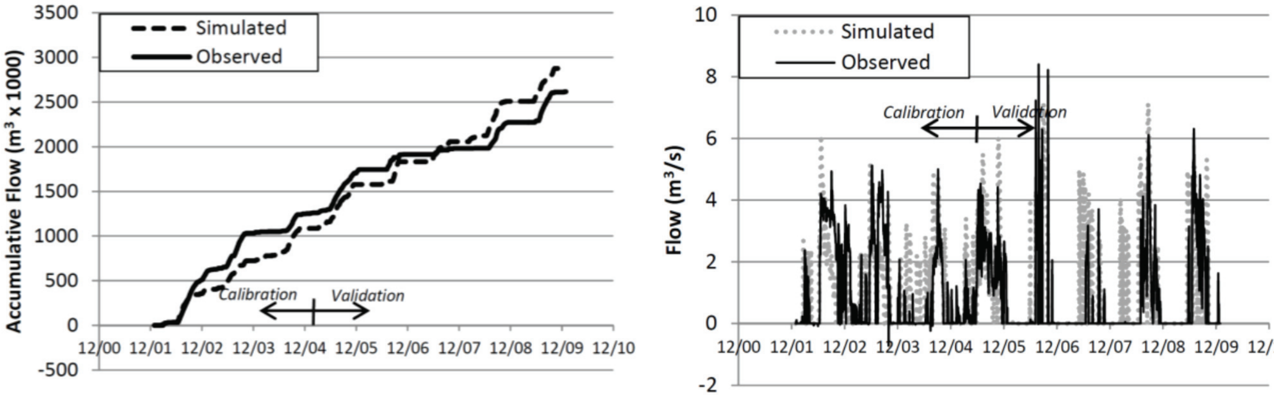


Figure 1. Calibrated daily flow using the WAM model (reproduced from Bottcher et al., 2012).

Table 5. Equations, ranges, optimal values, and advantages and disadvantages for statistical performance measures in the Moriasi et al. (2012) special collection (*O* and *P* are observed and predicted values, respectively).

Statistic	Equation	Range	Optimal Value	Advantages/Disadvantages
r	$\frac{\sum_{i=1}^{n}(O_i-\bar{O})(P_i-\bar{P})}{\sqrt{\sum_{i=1}^{n}(O_i-\bar{O})^2}\sqrt{\sum_{i=1}^{n}(P_i-\bar{P})^2}}$	-1.0 to 1.0	-1.0 (negative slope) or 1.0 (positive slope)	**Advantages:** R^2 and r are widely used in hydrological modeling studies, thus serving as a benchmark for performance evaluation. **Disadvantages:** R^2 and r are oversensitive to high extreme values (Krause et al., 2005) and insensitive to additive and proportional differences between model predictions and measured data (Legates and McCabe, 1999). **Notes:** We recommend that the regression line gradient and intercept be reported when R^2 is used as a performance measure. For a good agreement, the intercept should be close to zero and the gradient should be close to one (Krause et al., 2005).
R^2	$\left[\frac{\sum_{i=1}^{n}(O_i-\bar{O})(P_i-\bar{P})}{\sqrt{\sum_{i=1}^{n}(O_i-\bar{O})^2}\sqrt{\sum_{i=1}^{n}(P_i-\bar{P})^2}}\right]^2$	0.0 to 1.0	1.0	
NSE	$1-\frac{\sum_{i=1}^{n}(O_i-P_i)^2}{\sum_{i=1}^{n}(O_i-\bar{O})^2}$	-∞ to 1.0	1.0	**Advantages:** NSE is: (1) a quantitative measure conducive to development of PEC; (2) good for use with continuous long-term simulations and can be used to determine how well the model simulates trends for the output response of concern; (3) robust and can be used to evaluate model performance for several output responses (e.g., stream flow, sediments, nutrients, pesticides) and temporal scales; and (4) commonly used, which means that there is extensive information on reported values, which can be used for comparison purposes. Further, it can incorporate measurement uncertainty (Harmel and Smith, 2007; Harmel et al., 2010). **Disadvantages:** NSE cannot help identify model bias and cannot be used to identify differences in timing and magnitude of peak flows and shape of recession curves; in other words, it cannot be used for single-event simulations. **Notes:** NSE is sensitive to extreme values due to the squared differences (Krause et al., 2005). To overcome extreme-value cases and increase sensitivity to lower measured and simulated values, Krause et al. (2005) recommended the use of logarithmic and relative derivatives forms of NSE and *d*. In cases where the measured data are bi-modal with high and low distributions in the same study area, such as the measured flows in Cho and Olivera (2009), it is recommended that the two data categories be separated to avoid the bias toward simulation of lower values.
d	$1-\frac{\sum_{i=1}^{n}(O_i-P_i)^2}{\sum_{i=1}^{n}\left(\lvert P_i-\bar{O}\rvert+\lvert O_i-\bar{O}\rvert\right)^2}$	0.0 to 1.0	1.0	**Advantages:** The index of agreement (1) detects additive and proportional differences in the observed and simulated means and variances and (2) is widely used, and thus there is comprehensive information on reported values in the literature. **Disadvantages:** Overly sensitive to extreme values due to the squared differences (Legates and McCabe, 1999). High values of *d* were reported even for poor model fits (Krause et al., 2005). **Notes:** *d* should be evaluated based on the phenomenon studied, measurement accuracy, and the model employed. It can also be used as a substitute for R^2 to identify the degree to which model predictions are error-free (Legates and McCabe, 1999). Further, it can incorporate measurement uncertainty (Harmel and Smith, 2007; Harmel et al., 2010).
RMSE or RMSD	$\sqrt{\frac{1}{n}\sum_{i=1}^{n}(O_i-P_i)^2}$	0.0 to ∞	0.0	**Advantages:** RMSE and MAE are: (1) computed and reported in the same units as the model output of concern and are hence easy for readers to interpret; (2) work well for continuous long-term simulations; and (3) commonly used in model performance evaluation. **Disadvantages:** Error indices are measured in the same unit as the model output being investigated, so they cannot be used by themselves to gauge model performance for values other than zero. **Notes:** RMSE and MAE can be used to determine confidence intervals in model predictions, and it is possible to incorporate measurement uncertainty (Harmel and Smith, 2007; Harmel et al., 2010).
MAE	$\frac{1}{n}\sum_{i=1}^{n}\lvert O_i-P_i\rvert$	0.0 to ∞	0.0	
RSR	$\frac{\sqrt{\sum_{i=1}^{n}(O_i-P_i)^2}}{\sqrt{\sum_{i=1}^{n}(O_i-\bar{P})^2}}$	0.0 to ∞	0.0	**Advantages:** RSR incorporates the benefits of error index statistics and includes a scaling/normalization factor, so the resulting statistics and reported values can apply to various output responses. **Disadvantages:** RSR gives more weight to high values when compared with low values because errors in high values are usually greater in absolute value than errors in low values due to the squared difference values in the denominator. **Notes:** RSR has not been widely used in the H/WQ modeling literature since it is a relatively new statistical performance measure.

Table 5 (continued). Equations, ranges, optimal values, and advantages and disadvantages for statistical performance measures in the Moriasi et al. (2012) special collection (O and P are observed and predicted values, respectively).

Statistic	Equation	Range	Optimal Value	Advantages/Disadvantages
RE or PE	$\left\lvert\frac{O_i - P_i}{O_i}\right\rvert \times 100$	0.0 ∞ to ∞	0.0	**Advantages:** (1) RE facilitates comparison of model performance between different output responses, and (2) differences between observed and predicted values are quantified as relative deviations. This significantly reduces the influence of absolute differences during high flows. **Disadvantages:** The absolute lower differences during low flow periods are enhanced because they are significant if looked at in a relative sense. As a result, there might be a systematic over- or underprediction during low flow periods. **Notes:** RE can be used along with other statistics to quantify low flow simulations
PBIAS	$\frac{\sum_{i=1}^{n} O_i - P_i}{\sum_{i=1}^{n} O_i} \times 100$	-∞ to ∞	0.0	**Advantages:** PBIAS: (1) can be used to determine how well the model simulates the average magnitudes for the output response of interest; (2) is useful for continuous long-term simulations; (3) is robust and commonly used, which means that there is extensive information on reported values; (4) can help identify average model simulation bias (overprediction vs. underprediction); and (5) can incorporate measurement uncertainty (Harmel et al., 2010). **Disadvantages:** PBIAS cannot be used (1) for single-event simulations to identify differences in timing and magnitude of peak flows and the shape of recession curves nor (2) to determine how well the model simulates residual variations and/or trends for the output response of interest. **Notes:** PBIAS can give a deceiving rating of model performance if the model overpredicts as much as it underpredicts, in which case PBIAS will be close to zero even though the model simulation is poor. It is therefore recommended that PBIAS be used with other statistical and graphical PMs to determine model performance.

The mean absolute error (MAE) is also measured in the same units as the model output response of interest. It is usually similar in magnitude but slightly smaller than the RMSE. The RMSE also tends to give more weight to high values than low values because errors in high values are usually greater in absolute value than errors in low values (Gan et al., 1997; Gan and Biftu, 1996; Eckhardt and Arnold, 2001; van Griensven and Bauwens, 2003; Huisman et al., 2003; Cho and Olivera, 2009). To get around this limitation, Moriasi et al. (2007) recommended that RMSE be normalized using the observations standard deviation, giving a measure referred to as the RMSE-observations standard deviation ratio (RSR).

Although it is commonly accepted that the lower the RMSE, the better the model performance, only Singh et al. (2004) published a guideline to qualify what is considered a low RMSE based on the observations standard deviation (SD). Singh et al. (2004) stated that RMSE values of less than half of the SD of the observations may be considered low. Based on the recommendation by Singh et al. (2004), Moriasi et al. (2007) developed the RSR.

Relative error (RE), absolute relative error, or absolute relative deviation is the ratio of absolute error of the simulated data to the observed data. It indicates the mismatch that occurs between the observed and modeled values, expressed in terms of ratios and percentages. Krause et al. (2005) recommended relative efficiency criteria for NSE and d in which relative deviations are derived for NSE and d. These can be used to quantify low flow simulations. Relative bias (RB), relative volume error (RVE), and many other bias-based statistics are derived based on RE to report statistical PMs in evaluating hydrological model performances.

Percent bias (PBIAS) measures the average tendency of the simulated data to be larger or smaller than observed counterparts (Gupta et al., 1999). It also measures over- and underestimation of bias and expresses it as a percentage. Percent stream flow volume error (PVE; Singh et al., 2004), prediction error (PE; Fernandez et al., 2005), and percent deviation of stream flow volume (D_v; ASCE, 1993; Moriasi et al., 2007) are calculated in a similar manner as PBIAS.

META-ANALYSIS OF PERFORMANCE DATA

Reported Value Ranges for Performance Measures

For each model included in the Moriasi et al. (2012) special collection, approximately 20 available peer-reviewed articles were collected. Performance data for case studies in the Moriasi et al. (2012) special collection and for articles reviewed by Moriasi et al. (2007) were not considered in this study. While this effort was by no means exhaustive, it yielded a sizeable dataset including 312 data points for R^2 and 435 data points for NSE that were used in the meta-analysis. Due to the volume of material involved, reported performance data for each simulated component during calibration and validation were recorded (supplemental material tables S1-1 through S1-22, available at http://bit.ly/NRES_SW10715). These data were collected from articles published from 1992 to 2013; 93% were published in 2000 or later, and 53% were published after 2007. Most of the reported parameters are for field-scale (tables S1-2 to S1-10) and watershed-scale (tables S1-11 to S1-22) models that utilize both manual and autocalibration methods. Of the reviewed articles, most reported model calibration and validation on flow-related components (tables S1-2 to S1-5 and S1-11 to S1-15), and most are based on the

SWAT model. The least reported model calibration and validation PM values were those associated with point to plot scale models (table S1-1). Most of the models in this category utilize autocalibration algorithms that select all possible combinations of solutions that meet the set threshold for the selected objective function.

Of the models examined (table 1), only SWAT, HSPF, WARMF (watershed-scale), and ADAPT (field-scale) had sufficient model performance data for meaningful analyses. The total numbers of reviewed articles from which data were obtained for analyses of SWAT, HSPF, WARMF, and ADAPT models were 33, 17, 2, and 16, respectively. For each of the aforementioned models, values for R^2, NSE, and PBIAS were reported most frequently, but there was also an appreciable amount of data on the index of agreement (*d*) at field scale. Based on reviewed literature, point to plot (and to some extent field-scale) models used different simulated response outputs to evaluate model performance. For instance, Essaid et al. (2008) and Healy and Essaid (2012) used streambed water flux and temperature to evaluate VS2DI performance, while Huth et al. (2012) used soil water content to evaluate SWIM3. Krobel et al. (2010) and Diekkruger et al. (1995) also used soil water content to evaluate the performance of the DAISY model. The use of different simulated response outputs and the limited amount of reported peer-reviewed model performance data made it difficult to conduct statistical comparisons for these smaller spatial scale models, so they were excluded from the analysis and PEC development.

Preliminary Diagnostics of Data Used for Meta-Analysis

Table 6 summarizes the data used for the meta-analysis. Based on a preliminary analysis, reported performance data values for watershed-scale models, irrespective of output response and temporal scale, varied from 0.02 to 1.00 for R^2, from -10.30 to 0.99 for NSE, and from -81.1% to 167% for PBIAS (table 4). Reported R^2 values for field-scale models for flow at a monthly temporal scale varied from 0.18 to 0.91, while *d* values varied from 0.60 to 0.99 (table 6).

Table 6. Summary of the performance data used for detailed statistical analyses.

		Temporal Scale[a]			
Performance Measure		Annual	Monthly	Daily	Seasonal
Watershed scale					
R^2	Entries	89	196	27	-
	Mean	0.67	0.63	0.63	-
	Median	0.67	0.72	0.70	-
	Minimum	0.32	0.18	0.02	-
	Maximum	1.00	0.99	0.97	-
NSE	Entries	87	233	115	-
	Mean	0.58	0.44	0.13	-
	Median	0.60	0.59	0.53	-
	Minimum	-0.91	-7.89	-10.3	-
	Maximum	0.99	0.96	0.96	-
PBIAS	Entries	26	57	-	29
	Mean	-14.92	7.51	-	20.4
	Median	0	6.4	-	8
	Minimum	-81.1	-38.4	-	-46.4
	Maximum	35.3	53.1	-	167
Field scale					
R^2	Entries	-	29	-	-
	Mean	-	0.74	-	-
	Median	-	0.75	-	-
	Minimum	-	0.18	-	-
	Maximum	-	0.91	-	-
d	Entries	-	33	-	-
	Mean	-	0.88	-	-
	Median	-	0.91	-	-
	Minimum	-	0.60	-	-
	Maximum	-	0.99	-	-

[a] Blank entries mean that either there were no data or that available data were insufficient for meaningful statistical analyses. All available raw data are presented in the supplemental material tables (available at http://bit.ly/NRES_SW10715).

Further analysis of the distributions of the combined datasets (regardless of whether they pertained to calibration or validation, watershed size, and/or the components) showed that most tended to be skewed toward the higher values of the specific PMs (table 6 and fig. 2). This was expected because calibration and validation efforts are usually geared toward finding the best suitable values, which are the highest values for measures such as R^2, NSE, and *d*. Exceptions to this trend were values of PBIAS, which were more centrally located. Again, this is not surprising, as

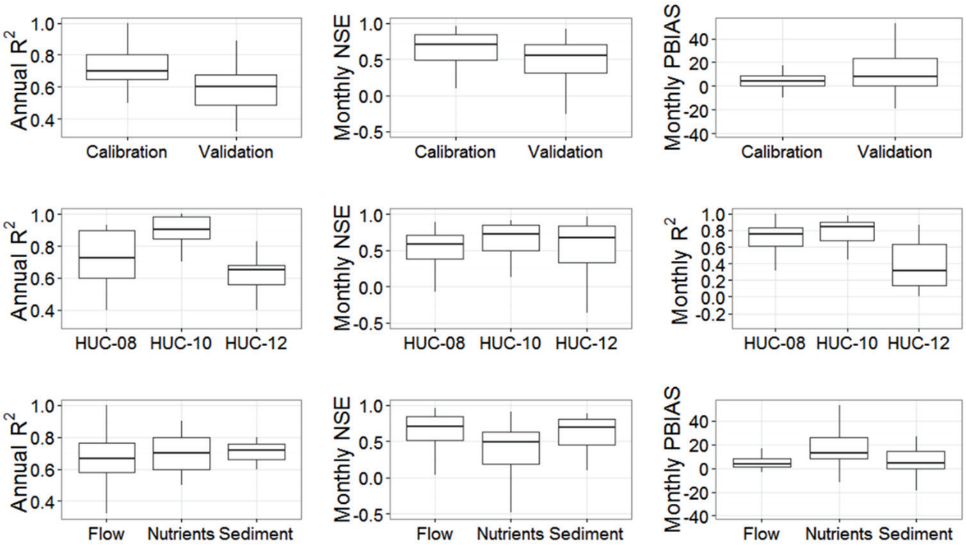


Figure 2. Box and whisker plots showing comparisons of performance data considering: (top row) calibration and validation, (middle row) watershed size (HUC-08 includes data for watersheds at HUC 8 and larger), and (bottom row) simulated component.

PBIAS can vary between small and large values, both negative and positive, and by definition PBIAS values close to zero indicate better model performance and are thus more desirable. The other exception was R^2 values, for which the data were approximately normally distributed. At this point, it is unclear why this was the case. Based on the approximate distributions of the performance data, the nonparametric median test was used to test whether there were significant differences among reported performance values data (table 7) among the various categories to warrant development of separate PEC.

For most of the watershed-scale analyses performance data, values for calibration were significantly different (table 7) from those reported for validation, with those for calibration being better (fig. 2). This was not the case for the field-scale data, for which the performance data values were not significantly different between the calibration and validation periods. Ideally, performance values obtained for validation need to be close to those obtained during calibration; a discrepancy between these values is evidence of model divergence (Sorooshian and Gupta, 1995; Duda et al., 2012; Zheng et al., 2012), suggesting calibrated model inaccuracies in process representation (Sorooshian, 1983). Since calibration efforts rely on comparisons between observed and measured data, it is possible to make parameter adjustments simply to suit this kind of comparison while ignoring the accuracy of the process simulation. Thus, in recommending guidelines, we do not make a distinction between calibration and validation periods.

Significant differences were also observed in reported performance data values at the watershed scale, with the exception of monthly NSE values (table 7 and fig. 2). Although no clear patterns were discernible, the models seemed to perform better for HUC-10 watersheds than for HUC-08+ and HUC-12 watersheds. Similarly, at each temporal scale, there were significant differences among PMs based on the response output being simulated and the available data for reported model PM values (table 7). For example, data analysis indicated better simulation of flow than all other response outputs. This was expected, given that hydrologic processes are the primary drivers within a watershed; thus, associated simulated response outputs are calibrated first and more extensively. In addition, more observed data are available to calibrate models for flow than for sediments or nutrients.

Further analyses based on both simulated response output and temporal scale (e.g., annual flow, monthly flow, etc.) also showed significant differences for R^2 and NSE ($p = 0.0002$ and 0.0001, respectively), although no significant differences were observed among the temporal scales when all data were grouped together and analyzed solely by temporal scale ($p = 0.0661$, 0.1957, and 0.0811 for R^2, NSE, and PBIAS, respectively). Due to the difficulties in duplicating the timing of flow, and given the uncertainties in the timing of model inputs (mainly precipitation; Duda et al., 2012), model calibration is considered to be simpler at the annual temporal scale and is progressively more difficult as the temporal scale resolutions becomes finer (Engel et al., 2007; Moriasi et al., 2007; Duda et al., 2012). Thus, this latter finding was somewhat surprising. However, the art of model calibration has greatly improved in recent years due to model autocalibration tools and techniques. These are designed to find optimal parameters based on PMs, hence increasing the likelihood that resulting model PM values will be comparable regardless of the temporal scale.

Based on the meta-analysis results, we determined that there was a need for separate PEC for each of the commonly simulated response outputs, watershed- and field-scale models, temporal scales, and for the recommended PMs.

Table 7. Summary of results of the statistical analyses on the performance data.

	Temporal Scale and Performance Measure						
	Annual			Monthly			Daily
Comparisons	R^2	NSE	PBIAS	R^2	NSE	PBIAS	NSE
Watershed scale							
Calibration vs. validation							
Calibration entries	57	53	8	106	127	27	66
Validation entries	32	34	18	90	106	30	49
p-value[a]	0.0047*	0.0112*	0.0401*	0.5674	0.0131*	0.0249*	<0.0001*
Comparison by HUC							
HUC-08+ entries	26	4	10	138	118	56	5
HUC-10 entries	7	6	16	14	54	1	62
HUC-12 entries	56	76	0	44	61	0	40
p-value	0.0002*	-	0.0123*	<0.0001*	0.2330	-	0.0158*
Comparison by component							
Flow entries[b]	84	72	26	88	119	32	88
Sediment entries	3	4	0	46	31	15	3
N entries	2	0	0	31	49	10	18
P entries	0	11	0	31	34		6
p-value	-	0.0453*	-	<0.0004*	<0.0001*	0.1281	<0.0001*
Field scale				R^2	*d*		
Calibration entries				17	18		
Validation entries				12	15		
p-value				0.5799	0.3499		

[a] Probability that observed differences in reported performance data values are attributable to error or chance given an α level of significance ($\alpha = 0.05$ in this case). Values $<\alpha$ indicate that the reported performance data values (e.g., for calibration vs. validation) are significantly different at that level of significance, with smaller values indicating higher significance (i.e., probability that observed differences were due to error or chance is very small). Asterisks (*) indicate significant differences in performance data values for calibration vs. validation, HUC, and modeled component.

[b] Combines data for stream flow, surface runoff, and base flow as reported.

However, there was also the need for general PEC that could be used across temporal scales. The final recommended PEC for the identified separate categories are based primarily on the results of computed percentiles of reported performance data to determine thresholds for the different qualitative ratings used in this article, existing PEC (Al-Qurashi et al., 2008; Moriasi et al., 2007; Duda et al., 2012; Herr and Chen, 2012; Ma et al., 2012; Skaggs et al., 2012; Wang et al., 2012), and our modeling experience.

Development of Criteria for Selected Statistical Performance Measures

The final step of the meta-analysis was to compute percentiles of available performance data to develop separate PEC for R^2, NSE, PBIAS, and *d* for the spatial and temporal scales and simulated response outputs identified by the median test in the previous subsection. There were 57 negative NSE values reported for watershed-scale models (supplemental material tables S1-11 to S1-20). However, by definition, NSE < 0.0 indicates that the mean observed value is a better predictor than the simulated value, which indicates unacceptable performance. Therefore, all negative values for NSE were excluded. While we agree that NSE is more stringent than R^2 or *d*, we did not exclude any reported performance data for R^2 and *d* corresponding to the studies that reported negative NSE. This is because different PMs have varied strengths that aid in determining the performance of a given model during the calibration and validation periods. Therefore, the reported performance data for each PM were analyzed independently.

To be consistent with model PEC previously recommended by Moriasi et al. (2007), "very good," "good," "satisfactory," and "not satisfactory" ratings were defined. Initial PEC were then developed for each of the ratings based on different data distributions at spatial and temporal scales and simulated response outputs for the recommended criteria. Even though percentile is used to measure spread, we also found it appropriate to use as an initial step in determining the thresholds for the defined ratings due to the fact that the calibration process seeks to optimize PMs for response outputs of interest. Considering the ranges of model PM data obtained (table 6) and expected reasonable PM data values, model performance values at and below the 25th percentile were considered "not satisfactory," model performance values between the 25th to 50th percentiles were considered "satisfactory," model performance values within and including the 50th to 75th percentiles were considered "good," and those above the 75th percentile were considered "very good." Values obtained based on percentiles were adjusted accordingly (e.g., rounded off) to produce meaningful intervals for these initial PEC. Figure 3 shows an example of the PEC development process. To facilitate PEC development for PBIAS, all related entries were converted into absolute values (fig. 3b). Because of the nature of this statistic, the rating and corresponding percentile ranges were reversed.

Analysis of the initial PEC based on data distributions resulted in several noteworthy differences (table 8). For example, with NSE, the resulting PEC for flow were different from those for N and P, with the former PEC being stricter. This was expected due to the large amount of observed flow calibration data, which is not the case for sediment and nutrient data. It is also critical that flow simulation be accurate, as flow is the primary driver of watershed processes. Sediment seemed to exhibit a similar response to flow, possibly for the same reasons. This explains why PEC were stricter for flow than for N and P.

(a) NSE - General

100.0%	maximum	0.99
99.5%		0.99
97.5%		0.94525
90.0%		0.88
75.0%	quartile	0.8
50.0%	median	0.64
25.0%	quartile	0.4875
10.0%		0.269
2.5%		0.09475
0.5%		0.03895
0.0%	minimum	0.03

(b) Monthly Flow PBIAS (absolute)

100.0%	maximum	38.39
99.5%		38.39
97.5%		38.39
90.0%		25.087
75.0%	quartile	13.5825
50.0%	median	7.325
25.0%	quartile	2.8175
10.0%		1.773
2.5%		0.19
0.5%		0.19
0.0%	minimum	0.19

Resulting Initial criteria

	V. Good	Good	Satisfactory	Not Satisfactory
NSE	>0.80	0.60≤NSE≤0.80	0.50<NSE<0.60	≤0.50
PBIAS	≤3.0	3.0<PBIAS<10	10≤PBIAS≤15	>15

Figure 3. Example of initial performance evaluation criteria development for flow: (a) annual NSE and (b) monthly PBIAS.

Table 8. Initial performance evaluation criteria for recommended statistical performance measures for watershed- and field-scale models based on the distribution of existing data.

Measure	Component	Temporal Scale	*n*	Very Good	Good	Satisfactory	Not Satisfactory
Watershed scale							
R^2	Flow	Annual	84	>0.75	$0.70 \le R^2 \le 0.75$	$0.60 < R^2 < 0.70$	≤0.60
		Monthly	87	>0.85	$0.80 \le R^2 \le 0.85$	$0.70 < R^2 < 0.80$	≤0.70
		Daily	27	>0.85	$0.70 \le R^2 \le 0.85$	$0.50 < R^2 < 0.70$	≤0.50
	Sediment	Annual	3	-	-	-	-
		Monthly	46	>0.80	$0.65 \le R^2 \le 0.80$	$0.40 < R^2 < 0.65$	≤0.40
		Daily	0	-	-	-	-
	N	Annual	2	-	-	-	-
		Monthly	31	>0.70	$0.60 \le R^2 \le 0.70$	$0.30 < R^2 < 0.60$	≤0.30
		Daily	0	-	-	-	-
	P	Annual	0	-	-	-	-
		Monthly	31	>0.80	$0.65 \le R^2 \le 0.80$	$0.40 < R^2 < 0.65$	≤0.40
		Daily	0	-	-	-	-
	General		311	>0.80	$0.70 \le R^2 \le 0.80$	$0.50 < R^2 < 0.70$	≤0.50
NSE	Flow	Annual	71	>0.75	0.60 ≤ NSE ≤ 0.75	0.50 < NSE < 0.60	≤0.50
		Monthly	109	>0.85	0.70 ≤ NSE ≤ 0.85	0.55 < NSE < 0.70	≤0.55
		Daily	79	>0.80	0.70 ≤ NSE ≤ 0.80	0.50 < NSE < 0.70	≤0.50
	Sediment	Annual	4	-	-	-	-
		Monthly	31	>0.80	0.70 ≤ NSE ≤ 0.80	0.45 < NSE < 0.70	≤0.45
		Daily	3	-	-	-	-
	N	Annual	0	-	-	-	-
		Monthly	31	>0.70	0.60 ≤ NSE ≤ 0.70	0.35 < NSE < 0.60	≤0.35
		Daily	6	>0.55	0.40 ≤ NSE ≤ 0.55	0.25 < NSE < 0.40	≤0.25
	P	Annual	10	>0.65	0.60 ≤ NSE ≤ 0.65	0.50 < NSE < 0.60	≤0.50
		Monthly	33	>0.65	0.50 ≤ NSE ≤ 0.65	0.40 < NSE < 0.50	≤0.40
		Daily	1	-	-	-	-
	General		378	>0.80	0.60 ≤ NSE ≤ 0.80	0.50 < NSE < 0.60	≤0.50
PBIAS (%)[a]	Flow	Annual	26	≤±2.5	±2.5 < PBIAS < ±15	±15 ≤ PBIAS ≤ ±35	>±35
		Monthly	32	≤±3.0	±3.0 < PBIAS < ±10	±10 ≤ PBIAS ≤ ±15	>±15
		Seasonal	29	≤±10	±10 < PBIAS < ±15	±15 ≤ PBIAS ≤ ±45	>±45
	Sediment	Annual	0	-	-	-	-
		Monthly	15	≤±1	±1 < PBIAS < ±10	±10 ≤ PBIAS ≤ ±20	>±20
		Seasonal	0	-	-	-	-
	Nutrients	Annual	0	-	-	-	-
		Monthly	10	≤±10	±10 < PBIAS < ±15	±15 ≤ PBIAS ≤ ±30	>±30
		Seasonal	0	-	-	-	-
	General		112	≤±5	±5 < PBIAS < ±10	±10 ≤ PBIAS ≤ ±25	>±25
Field scale							
R^2		Monthly	29	>0.85	$0.75 \le R^2 \le 0.85$	$0.70 < R^2 < 0.75$	≤0.70
d		Monthly	33	>0.90	$0.85 \le d \le 0.90$	$0.75 < d < 0.85$	≤0.75

[a] Values are absolute.

With regard to temporal scale, however, the distinctions were not as clear. While data were not always sufficient to allow comparisons for each component, in some instances the resulting PEC were contradictory, e.g., initial PEC were stricter for monthly flow than for annual flow. This was in contrast to Moriasi et al. (2007), who suggested more relaxed PEC for a daily temporal scale and progressively higher thresholds for subsequent coarser temporal scales. As previously discussed, our data did not show significant differences on the basis of temporal scale alone, which could possibly explain these discrepancies. For each of the PMs, general initial PEC (table 8) were also derived independent of either component or temporal scale and seemed to offer more unifying values that could be used as alternates where contradictions were encountered.

As a final step, the initial PEC were reviewed and revised based on previous PEC as reported in the literature (Al-Qurashi et al., 2008; Moriasi et al., 2007; Duda et al., 2012; Herr and Chen, 2012; Ma et al., 2012; Skaggs et al., 2012; Wang et al., 2012) and on our modeling experience. The final PEC developed are reported under the "Guidelines for Model Performance Evaluation: Recommended Measures and Criteria" subheading.

Guidelines for Model Performance Evaluation: Recommended Measures and Criteria

Prior to providing any general recommendations for model PMs and their corresponding PEC, we note that it is critical that model users follow proper calibration and validation procedures to obtain the correct model performance for the right reasons (Kirchner, 2006; Arnold et al., 2015). In this regard, we recommend that model users should consider recommendations for all other key calibration and validation topics covered in this special collection. These include (1) ensuring that terminology is clearly defined (Zeckoski et al., 2015), (2) selecting an appropriate model based on the study goals and ensuring that the model and fluxes are well represented (Arnold et al., 2015), (3) considering appropriate spatial and temporal scales (Baffaut et al., 2015), (4) parameterizing the model appropriately

(Malone et al., 2015), and (5) employing appropriate calibration and validation strategies (Daggupati et al., 2015b), including sensitivity (Yuan et al., 2015) and uncertainty (Guzman et al., 2015) analyses. Having taken all these important modeling aspects into consideration, model users should then use appropriate PMs along with the corresponding general PEC recommended in this article. Finally, we recommend that all these aspects of modeling be properly documented and reported (Saraswat et al., 2015) with sufficient detail to ensure repeatability.

The first step in evaluating model performance is to use recommended graphical PMs because they provide a visual indication of model performance. The next step is to compute values for the recommended statistical PMs. The computed values are then compared with recommended PEC to assess model performance with respect to statistical PMs.

Recommended Performance Measures

Due to varied strengths of the different PMs described in this article, we recommend the use of multiple graphical and statistical PMs. Both direct and derived graphical PMs are recommended in determining model calibration and validation performance. For shorter periods and coarse temporal resolutions (e.g., monthly calibration for one to three years), time series and scatter plots are most effective for data visualization and demonstration of model performance. With increasing data points, an inconsistent understanding of model performance may result from direct graphical PMs. Under such circumstances, derived measures such as cumulative distributions or duration curves should be employed. For field- and watershed-scale models, where calibration and validation are done at the outlet, we recommend using maps to ensure that non-calibrated locations provide reasonable values for outputs of interest such as soil erosion or nutrient loss. This will ensure a more comprehensive evaluation of model performance and confidence in model outputs.

The most commonly used statistical PMs with varied complementary strengths are recommended. These include R^2 (in conjunction with the gradient b and the intercept a of the corresponding regression line), NSE, d, RMSE alongside RSR, and PBIAS. These statistics can be used for daily, monthly, and yearly temporal scales and for all major output responses. During low flow simulations, logarithmic or relative derivatives of NSE or d need to be used, as recommended by Krause et al. (2005). We also recommend that RSR be reported alongside RMSE, with RMSE providing model performance in the units of the output response of interest and RSR providing a normalized value for comparison of model performance for various studies.

Recommended Performance Criteria

The recommended PEC for the statistical PMs NSE, R^2, d, and PBIAS for different output responses at different spatial and temporal scales are presented in table 9. The PEC in table 9 result from a combination of previous PEC as reported in the literature (Al-Qurashi et al., 2008; Moriasi et al., 2007; Duda et al., 2012; Herr and Chen, 2012; Ma et al., 2012; Skaggs et al., 2012; Wang et al., 2012), meta-analysis conducted in this study, and our modeling experience. For a given study, the same PBIAS PEC are recommended for the three temporal scales because PBIAS is computed based on observed daily, monthly, and annual values derived from data collected or measured at a finer temporal scale, such as hourly or sub-hourly. These PEC apply to both model calibration and validation periods. For example, based on table 9, model performance can be judged as "satisfactory" for flow simulations if monthly $R^2 > 0.70$ and $d > 0.75$ for field-scale models and daily, monthly, or annual $R^2 > 0.60$, NSE > 0.50, and PBIAS ≤ ±15% for watershed-scale models. Although we recommend RMSE (with RSR) and the logarithmic or relative derivative of d or NSE statistical PMs, no PEC were developed for them because the available data were not sufficient for meta-analysis and thus for PEC development. However, for RSR, we recommend that the PEC proposed by Moriasi et al. (2007) be used until new PEC can be developed. The intent of this study was to develop generalizable PEC for all models. However, sufficient data for meta-analysis were available only for SWAT, HSPF, WARMF, and ADAPT, as mentioned earlier. Therefore, we also recommend that the PEC developed in this study be used primarily for these models and used only with caution for other models. For example, in the absence of spatial-specific model criteria, the stated watershed PMs and corresponding criteria can be adopted and/or modified for oth-

Table 9. Final performance evaluation criteria for recommended statistical performance measures for watershed- and field-scale models.

Measure	Output Response	Temporal Scale[a]	Performance Evaluation Criteria: Very Good	Good	Satisfactory	Not Satisfactory
Watershed scale						
R^2	Flow[b]	D-M-A	$R^2 > 0.85$	$0.75 < R^2 \leq 0.85$	$0.60 < R^2 \leq 0.75$	$R^2 \leq 0.60$
	Sediment/P[c]	M	$R^2 > 0.80$	$0.65 < R^2 \leq 0.80$	$0.40 < R^2 \leq 0.65$	$R^2 \leq 0.40$
	N	M	$R^2 > 0.70$	$0.60 < R^2 \leq 0.70$	$0.30 < R^2 \leq 0.60$	$R^2 \leq 0.30$
NSE	Flow	D-M-A	NSE > 0.80	0.70 < NSE ≤ 0.80	0.50 < NSE ≤ 0.70	NSE ≤ 0.50
	Sediment	M	NSE > 0.80	0.70 < NSE ≤ 0.80	0.45< NSE ≤ 0.70	NSE ≤ 0.45
	N/P[c]	M	NSE > 0.65	0.50 < NSE ≤ 0.65	0.35< NSE ≤ 0.50	NSE ≤ 0.35
PBIAS (%)	Flow	D-M-A	PBIAS < ±5	±5 ≤ PBIAS < ±10	±10 ≤ PBIAS < ±15	PBIAS ≥ ±15
	Sediment	D-M-A	PBIAS < ±10	±10 ≤ PBIAS < ±15	±15 ≤ PBIAS < ±20	PBIAS ≥ ±20
	N/P[c]	D-M-A	PBIAS < ±15	±15 ≤ PBIAS < ±20	±20 ≤ PBIAS < ±30	PBIAS ≥ ±30
Field scale						
R^2	Flow	M	$R^2 > 0.85$	$0.75 < R^2 \leq 0.85$	$0.70 < R^2 < 0.75$	$R^2 \leq 0.70$
d	Flow	M	$d > 0.90$	$0.85 < d \leq 0.90$	$0.75 < d < 0.85$	$d \leq 0.75$

[a] D, M, and A denote daily, monthly, and annual temporal scales, respectively.

[b] Includes stream flow, surface runoff, base flow, and tile flow, as appropriate, for watershed- and field-scale models.

[c] Where there were no differences, PEC were grouped for the output responses.

er spatial scale models.

The PEC recommended in this study are general and can be adjusted as appropriate. However, we consider some values of the recommended PMs to be unacceptable beyond certain reasonable ranges. For example, as explained earlier, we consider negative values of NSE to indicate unacceptable model performance. Unacceptable values of PBIAS can be derived from Harmel et al. (2006), with maximum measurement uncertainties under typical measurement scenarios considered to be ±19% for stream flow, ±69% for nitrate-N (NO_3-N), ±100% for ammonium-N (NH_4-N), ±70% for total N, ±104% for dissolved P, ±110% for total P, and ±53% for total suspended sediments (TSS). Al-Qurashi et al. (2008) defined acceptable performance for flow simulations as being within 30% of observed values for KINEROS/AGWA (Goodrich et al., 2012). For performance measure *d*, Krause et al. (2005) stated that high values of *d* (over 0.65) were reported even for poor model fits. In this article, the minimum *d* value obtained as reported in literature was 0.60, and the overall minimum R^2 value reported in literature and used in the meta-analysis in this article was 0.18. Such low values do not provide much information about model performance and, similar to NSE < 0.0, can indicate that the mean observed value is a better predictor than the simulated value.

Thus, in this article, $R^2 < 0.18$, NSE < 0.0, PBIAS $\geq \pm 30\%$ for flow, PBIAS $\geq \pm 55\%$ for sediments, PBIAS $\geq \pm 70\%$ for nutrients, and $d < 0.60$ represent unacceptable model performance.

ADDITIONAL CONSIDERATIONS

The recommendations for model PMs and their corresponding PEC presented in the previous section apply to the typical case of continuous, long-term simulation for the given output responses at specified spatial and temporal scales (table 9). However, because of the diversity of modeling applications, these recommendations may be adjusted based on the quality and quantity of available measured data, spatial and temporal scales, and project scope and magnitude. It is also important to note that the recommended PMs are based only on the measures reported primarily in the Moriasi et al. (2012) special collection. Therefore, we have provided some additional considerations in this subsection to assist users in their calibration and validation efforts.

The PEC results presented herein are based on a meta-analysis of a selection of published data. As mentioned earlier, this body of data is not all-inclusive; this work can be extended by including data from a more extensive body of literature. However, in order to maintain the integrity of the database, article selection and data collection must be subject to the same considerations and follow the same procedures as outlined in this work. It is also important to note that substantial advances have been made in model calibration and validation such that it is now possible to obtain far better model performance and parameter representation than was possible at its nascence. Thus, we do not recommend the inclusion of historical and early development and application works, as resulting criteria may not be representative of the current state-of-the-art. We suggest using works only from the last 20 years.

A major limitation of the meta-analysis is the exclusion of unpublished data. In further extending the analysis, we recommend, inasmuch as is possible, identification and inclusion of unpublished material that fit all other criteria as outlined under key considerations in the "Meta-analysis of Performance Data" subsection. The use of only published material in this work has its strengths and weaknesses; while the results are based on data that has undergone a thorough quality assurance and quality review via the peer-review process, a weakness is that typically only good results (with the best performance data values) are published, likely contributing to the lack of distinction among temporal scales. This effect might not be discernible at other levels of analysis since the datasets at those levels are much smaller.

Finally, we recommend presenting summary statistics such as the mean, median, percentiles, and standard deviation of the observed and simulated response outputs. This information is useful and can provide benchmarks for follow up studies.

Residual Analysis

The residual (or error) is the difference between individual observed and simulated values; these values represent the uncertainty of the simulation. Ideally, the residuals should be close to zero and normally distributed. Any skew indicates a systematic bias, which could be potentially resolved by further calibration. Bennett et al. (2013) observed that residual analysis was an important part of model evaluation. They recommended using residual or QQ plots to examine any systematic divergence from zero. Residual plots are graphs of the residuals against time or space, which are useful in identifying any systematic bias. In a QQ plot, quantiles of the residuals are plotted against Gaussian quantiles. This is helpful in determining if the distribution of residuals is normal. Jain and Sudheer (2008) demonstrated that residual analysis, such as checking for homoscedasticity (unsystematic variance), could result in additional insight and improved model evaluations. In addition to graphical analysis, Bennett et al. (2013) recommended calculating the MSE or RMSE of the residuals for a quantitative evaluation.

Despite its documented advantages, residual analysis continues to be a rarely used and/or sparsely reported practice in the modeling literature. Guidelines are needed for simplifying and integrating residual analysis into H/WQ model performance evaluation.

Quality and Quantity of Measured Data

The quality of measured data should be considered in evaluating model calibration and validation performance whenever such information is available (Harmel et al., 2006). According to Harmel et al. (2006), measured data are obtained under best-case, typical, and worst-case data quality scenarios. The best-case scenario represents procedures used with a concentrated effort in quality assurance/quality control (QA/QC), unconstrained by financial and personnel resource limitations, and in ideal hydrologic conditions. The typical scenario represents procedures conducted with a moderate effort at QA/QC and under typical hydrologic conditions. The worst-case scenario represents data measurements conducted with minimal attention to QA/QC, with limited financial and personnel resources, and in difficult hydrologic conditions. Harmel and Smith (2007) provide modified NSE, *d*, RMSE, and MAE statistics that account for measurement uncertainty. The recommended model PEC presented herein are for data of typical scenario quality. PEC should be stricter when data of best-case scenario quality are available and more relaxed where uncertainty is high (Moriasi et al., 2007). In such cases, however, users should not over-calibrate their models to obtain values of statistical performance measures better than the uncertainty of the available measured data. Harmel et al. (2010) provide adjustments that can be made to statistical PMs based on uncertainty in measured and simulated data. Alternative measures, such as comparison of means and other graphical PMs such as percentiles and frequency distributions, may be more appropriate for measured datasets derived from either incomplete or low-frequency sampling (Moriasi et al., 2007).

Spatial and Temporal Scale of Study

The recommended PEC are intended for field- to watershed-scale modeling studies and mainly for one or more temporal scales (daily, monthly, and annual) depending on the statistical PMs used and the model output response. More strict PEC are recommended for point to plot scale studies in which there is less complexity of the processes involved and less uncertainty in model inputs (Guzman et al., 2015) due to the small spatial scale (Baffaut et al., 2015. For example, Ma et al. (2012) defined NSE > 0.70 and $R^2 > 0.80$ as acceptable model performance values for RZWQM2. It is also necessary to adjust the PEC as the temporal scale changes, utilizing stricter PEC as the evaluation temporal scale decreases from hourly to daily to annual (Moriasi et al., 2007).

Project Scope, Magnitude, and Intended Purpose

Moriasi et al. (2007) discussed the effects of scope and magnitude of the modeling project on model PEC, which should be taken into account when assessing model performance. More stringent PEC are recommended for projects that involve potentially large consequences, while the PEC may be relaxed for proof-of-concept studies. Similarly, Harmel et al. (2014) provided criteria for interpreting model results considering general intended use categories, which include exploratory, planning, and regulatory/legal.

Calibration vs. Validation Performance Criteria

Although prior studies have recommended different PEC for calibration and validation periods (e.g., Moriasi et al., 2007), and our analyses showed significant differences in reported values, this should not be the case. Based on discussions in Sorooshian and Gupta (1995) and Sorooshian (1983), this occurrence in some cases points to inaccuracies in process representation. In other cases, differences in performance during the calibration and validation periods may indicate substantially different climate (Van Liew and Garbrecht, 2003) and land use data (Pai and Saraswat, 2011) and/or the need for further calibration. Thus, the recommended model PEC in this article apply for both the calibration and validation periods. It is also essential to use observed calibration and validation data at spatial and temporal scales that are consistent with the model computations; otherwise, a justification should be provided (Baffaut et al., 2015; Daggupati et al., 2015b).

FRAMEWORK FOR UPDATING RECOMMENDED MODEL PERFORMANCE MEASURES AND EVALUATION CRITERIA

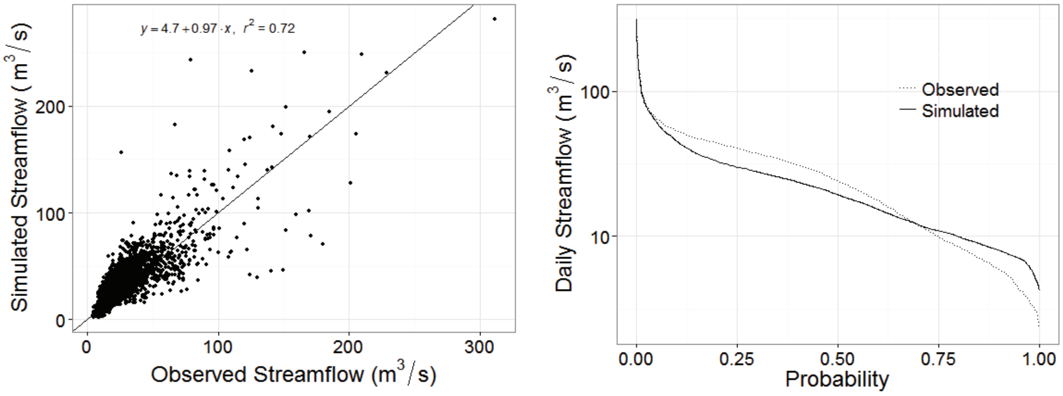
This initial meta-analysis sets the stage for a more comprehensive meta-analysis including a broader range of articles (including unpublished material) and covering a larger suite of models. To assist with this future endeavor, we present a framework for determining recommended model PMs and their corresponding PEC. The framework consists of (1) reviewing current modeling literature to determine the PMs used and collect study-specific calibration and validation data as reported and (2) developing PEC for the recommended PMs based on a meta-analysis of a comprehensive dataset collected from published and unpublished sources while taking into account all key considerations described herein. The scope and limitations of the recommended PEC in this article have been clearly defined in prior sections but can be updated as more information becomes available. For future work, we recommend using performance data values reported for other models, for different output responses, and at various spatial and temporal scales both from published and unpublished literature. In addition, reported study-specific graphical PMs need to be recorded and discussed in depth.

We have established a database with an inventory of reported model performance values and respective study details (e.g., spatial scales, outputs, objective functions) to enable modelers to query and develop custom model PEC better suited to their study goals. This database can be extended frequently as H/WQ model PMs and related PEC continue to evolve and when new understandings of modeling science arise. We intend to make this database available in an open and user-friendly format to provide opportunities for updates through crowd-sourcing. The analysis framework and the developed database will enable modifications of the recommended PMs and PEC as more information is obtained.

DEMONSTRATION OF RECOMMENDED MODEL PERFORMANCE MEASURES AND CRITERIA

An example case study was conducted with a hypothetical watershed-scale H/WQ model. The model was calibrated at the outlet for stream flow on a daily temporal scale for ten years (2001 to 2010). The model name and the study location are not mentioned here to emphasize the generic nature of the guidelines. Figure 4 and table 10 show the graphical and statistical performance of the model based on the recommended PMs.

Since this is a daily temporal scale, ten-year evaluation, the recommended graphical PMs are the scatter plot and flow duration curves (fig. 4). Note that a time series graph was not recommended in this case because of the large dataset. The slope and intercept values are provided on the



(a) **(b)**

Figure 4. Graphical performance measures of a hypothetical model: (a) scatter plot and (b) flow duration curve.

Table 10. Statistical performance evaluation criteria of a hypothetical model.

Average		Standard Deviation		Statistics				
Measured	Simulated	Measured	Simulated	R^2	PBIAS (%)	NSE	RSR	RMSE
24.4	28.3	21.0	23.9	0.72 (slope 0.97, intercept 4.7) (Satisfactory)	-16 (Not satisfactory)	0.60 (Satisfactory)	0.63 (Satisfactory; Moriasi et al., 2007)	13.26

scatter plot based on the least square regression line. The slope of the line is close to a value of one, while the intercept is close to a value of zero, indicating good model performance. The flow duration curve shows that model predictions were close to the observed data for all flow regimes, although the model tended to underestimate the observed data during low flows (>80% probability), slightly overestimate during medium flows (>20% and <50% probability), and had a good agreement during high flows (>10%). By using this figure, a modeler and end user can easily visualize model performance and further identify parameters that can be tweaked to improve performance. For instance, in this case, parameters related to base flow can be adjusted, allowing the model to simulate slightly higher low flows.

Based on the statistical PMs, we can say that the model adequately captured the mean and standard deviation of the daily flow rates. Using the performance values in table 9, we can say that model performance was "satisfactory" based on R^2 and NSE, "not satisfactory" based on the PBIAS of -16%, and satisfactory based on the RSR of 0.63 (Moriasi et al., 2007). Adjustments can be made to model parameters to obtain better agreement among the PMs.

Although H/WQ models provide outputs in various file formats, performance evaluation is typically performed using a spreadsheet. However, setting up a spreadsheet to calculate the numerous graphical and statistical PMs can be a tedious task and prone to errors. Therefore, to support the task of model performance evaluation, a Microsoft Excel spreadsheet was developed (available at http://bit.ly/NRES_SW10715). The objectives of the spreadsheet are to (1) demonstrate the various statistical and graphical PMs discussed in the case study and (2) provide a starting point for H/WQ model users to conduct model performance evaluation.

In situations with conflicting performance ratings, we recommend that those differences be clearly described. For example, if simulation for one output variable in one watershed produces unbalanced performance ratings of "satisfactory" for R^2 and "unsatisfactory" for *d* for field-scale flow simulation, then the overall performance should be described conservatively as "unsatisfactory" for that one study area and that one model response output. However, we recommend that users describe model performance with respect to the degree of collinearity between simulated and measured data (R^2) as "satisfactory" and with respect to prediction error (*d*) as "unsatisfactory." Similarly, if performance ratings differ for various field- and watershed-scale studies and/or response outputs, then those differences need to be clearly described.

SUMMARY AND CONCLUSIONS

This is one of nine topic-specific articles in a special collection whose main goal is to provide recommendations that, together with recommendations by Harmel et al. (2014), will contribute toward the development of ASABE engineering practices for calibration and validation of H/WQ models. In this research, articles in the Moriasi et al. (2012) special collection were synthesized with respect to performance measures (PMs) and performance evaluation criteria (PEC). In addition, a detailed literature review centered on graphical and statistical PMs used by models described in the special collection was carried out to determine PMs to recommend for use. Further, an initial meta-analysis of performance data reported in literature (outside of the special collection) was performed to establish PEC for various PMs. Data were collected from articles published from 1992 to 2013; 93% were published in and after 2000, and 53% were published after 2007. Finally, specific guidelines for model performance evaluation were established based on the synthesis and results of the meta-analysis. Additional considerations were also presented to allow users to adjust recommended PMs and/or associated PEC to their specific needs. A framework for determining recommended model PMs and their corresponding PEC, based on a more comprehensive meta-analysis, was presented.

Based on the synthesis, we recommend that a combination of multiple graphical and statistical PMs be used for evaluating model performance. Recommended graphical PMs include time series, scatter plots, cumulative distribution, flow and load duration, and maps, while the recommended statistical PMs include R^2 (in conjunction with slope and intercept of the pertinent regression line), NSE, *d*, RMSE (together with RSR), and PBIAS.

In this study, we do not go further into specifying PEC based on watershed size, although further work would be needed in this regard. However, the results strongly suggest the need to provide PEC at different scales; therefore, we provide separate PEC for the watershed scale and the field scale. We do not provide (or even recommend) separate PEC for calibration and validation periods. Based on the meta-analysis results, previous PEC reported in the literature, and our modeling experience, recommended PEC are presented in table 9. In general, model performance can be judged "satisfactory" for flow simulations if monthly $R^2 > 0.70$ and $d > 0.75$ for field-scale models and daily, monthly, or annual $R^2 > 0.60$, NSE > 0.50, and PBIAS ≤ ±15% for watershed-scale models. Additionally, model performance can be judged "satisfactory" if monthly $R^2 > 0.40$ and NSE > 0.45 and daily, monthly, or annual PBIAS ≤ ±20% for sediment; monthly $R^2 > 0.40$ and NSE > 0.35 and daily, monthly, or annual PBIAS ≤ ±30% for P; and monthly $R^2 > 0.30$ and NSE > 0.35 and daily, monthly, or annual PBIAS ≤ ±30% for N. For RSR, we recommend that the PEC proposed by Moriasi et al. (2007) be used until new PEC are developed. These PEC, which apply to calibration and validation periods, may be adjusted to be more or less strict based on considerations of the quality and quantity of available measured data, spatial and temporal scales, and project scope, magnitude, and intended purpose. As more data become available and as new PMs are developed and used more frequently, the recommended PMs and their corresponding general PEC can be adjusted based on the framework developed in this study.

However, we consider some values of the recommended statistical PMs to be unacceptable beyond certain reasonable ranges. Thus, in this article, $R^2 < 0.18$, NSE < 0.0, PBIAS ≥ ±30% for flow, PBIAS ≥ ±55% for sediment, PBIAS ≥ ±70% for nutrients, and $d < 0.60$ represent unacceptable model performance. An example case study and an Excel spreadsheet are provided to illustrate the application of the recommended PMs and the corresponding developed PEC guidelines.

The guidelines developed in this study go beyond the scope of those provided by Moriasi et al. (2007), which were limited to NSE, PBIAS (Gupta et al., 1999), and RSR for stream flow, sediment, and nutrient (N and P) simulations at a monthly temporal scale and watershed spatial scale. In this study, PEC for R^2 were added and PEC for NSE were disaggregated by output parameter (flow, sediment, N/P), and limits were adjusted based on current data. Limits were also adjusted for PBIAS for each output parameter, and some PEC were explicitly extended to daily and annual scales. In addition, PEC for R^2 and *d* were added for ADAPT. These current results provide updated guidance on performance measures and corresponding performance evaluation criteria for calibrating and validating hydrologic and water quality models.

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APPENDIX

ABBREVIATIONS FOR MODEL NAMES

ADAPT	Agricultural Drainage and Pesticide Transport
AGWA	ArcGIS-based Automated Geospatial Watershed Assessment
APEX	Agricultural Policy/Environmental eXtender
BASINS	Better Assessment Science Integrating Point and Nonpoint Sources
COUPMODEL	Coupled Heat and Mass Transfer model
CREAMS	Chemicals, Runoff, and Erosion from Agricultural Management Systems
DAISY	Danish Simulation Model
EPIC	Erosion Productivity Impact Calculator
GLEAMS	Groundwater Loading Effects of Agricultural Management Systems
HSPF	Hydrological Simulation Program - Fortran
H/WQ	Hydrologic and water quality (models)
HYDRUS	-
KINEROS	KINematic runoff and EROSion
MIKE SHE	MIKE System Hydrologique European (SHE)
MT3DMS	Modular 3-Dimensional Multispecies Transport Model
RZWQM	Root Zone Water Quality Model
SHAW	Simultaneous Heat and Water
STANMOD	STudio of ANalytical MODels
SWAT	Soil and Water Assessment Tool
SWIM	Soil Water Infiltration and Movement
TOUGH	Transport of Unsaturated Groundwater and Heat
VS2DI	-
WAM	Watershed Assessment Model
WARMF	Watershed Analysis Risk Management Framework
WEPP	Water Erosion Prediction Project

STATISTICAL TERMS AND PERFORMANCE MEASURES

d	Index of agreement
D_v	Deviation volume
HUC	Hydrologic unit code
MAE	Mean absolute error
ME	Mean error
MSE	Mean square error
NSE	Nash-Sutcliffe efficiency
PBIAS	Percent bias
PE	Prediction error
PPS	Point to plot scale
PVE	Percent volume error
r	Pearson’s correlation coefficient
R^2	Coefficient of determination
RB	Relative bias
RE	Relative error
RMSD	Root mean square deviation
RMSE	Root mean square error
RSR	RMSE-observations standard deviation ratio
RVE	Relative volume error
SD	Standard deviation

Appendix 30A

Specifications for Runs 15 – 18

and

Specifications for Simulated WWTP Discharges and Urban Deep Percolation

ILRG Model

Early EPCWID Ops (WWTP & Fabens Drains) (Run 15)

Early EPCWID Ops (WWTP) (Run 15a)
Early EPCWID Ops (Fabens Drains) (Run 15b)
Early EPCWID Ops (TX Hueco Pumping Off) (Run 15c)

Irrigation Pumping

- Supplemental pumping to meet unmet demand after use of surface water.
    - **Run 15c**: Texas Hueco pumping off.
- Pumping on NM primary ground water acres to meet crop demand.

Non-Irrigation Pumping and Returns

- Historical non-irrigation pumping and returns.
    - **Run 15c**: Texas Hueco pumping off.

Irrigated Area

Project Acres:	Historical
HCCRD and MX Acres:	Historical
NM Primary GW Acres:	Historical

Crop Evapotranspiration

- Historical.

Irrigation Infrastructure and Irrigation Practices

- EBID: Historical
- HCCRD: Historical
- Mexico: Historical
- EPCWID
    - **Run 15 & 15c**:
        - Charge EPCWID for use of EPW WWTP returns.
        - No ACE or Haskell credits for EPCWID.
        - Simulate EPCWID (EPV) increased use of Fabens drain flows*.
        - Charge EPCWID for use of Fabens drain flows.
    - **Run 15a**:
        - Charge EPCWID for use of EPW WWTP returns.
        - No ACE or Haskell credits for EPCWID.
    - **Run 15b**:
        - Simulate EPCWID (EPV) increased use of Fabens drain flows*.
        - Charge EPCWID for use of Fabens drain flows.

* Starting in July 1945, use 70% of simulated Fabens drain flow up to 6,000 af/month for irrigation in EPCWID.

Project Allocation Rules

1951-2005:	D1/D2 Project allocation rules.
2006-2007:	D3 Project allocation rules without carryover accounting.
2008-2017:	D3 Project allocation rules with carryover accounting.

Conj Use 1: Hist All Acres D1/D2 (Hist M&I) (Run 16)

Conj Use 1a: Hist All Acres D1/D2 (1978 M&I) (Run 16a)

Irrigation Pumping

- Supplemental pumping to meet unmet demand after use of surface water.
- Pumping on NM primary ground water acres to meet crop demand.
- Limit 10-year average irrigation pumping to 1951-1978 averages:
    - NM: 166,866 AF (includes primary GW pumping)
    - TX: 81,971 AF (limit EPCWID+HCCRD)
        - EPCWID: 70,783 AF
        - HCCRD : 11,188 AF
    - MX: No limit

Non-Irrigation Pumping and Returns

- **Run 16 (Hist M&I):**
    - Historical non-irrigation pumping and returns.
    - Set Las Cruces returns from use of Jornada wells to zero (results in a simulated offset from return flows attributed to this imported water source).
- **Run 16a (1978 M&I):**
    - Limit annual M&I pumping to 1951-1978 maximums:
        - NM: 20,993 AF
        - TX (Hueco): 89,979 AF
        - TX (Mesilla): 30,264 AF
        - MX: No limit
    - Reduce M&I returns by same percentage as M&I pumping reduced:
        - For Las Cruces, this reduction applies to their use of Mesilla wells (not to their Jornada wells).
        - Don’t reduce EPW returns from use of Project water.
    - Set Las Cruces returns from use of Jornada wells to zero (results in a simulated offset from return flows attributed to this imported water source).

Irrigated Area

- Project Acres: Historical
- HCCRD and MX Acres: Historical
- NM Primary GW Acres: Historical

Crop Evapotranspiration

- Historical.

Irrigation Infrastructure and Irrigation Practices

- EBID: Historical
- HCCRD: Historical
- Mexico: Historical
- EPCWID (Run 15 Conditions):
    - Charge EPCWID for use of EPW WWTP returns.
    - No ACE or Haskell credits for EPCWID.
    - Simulate EPCWID (EPV) increased use of Fabens drain flows*.
    - Charge EPCWID for use of Fabens drain flows.

* Starting in July 1945, use 70% of simulated Fabens drain flow up to 6,000 af/month for irrigation in EPCWID.

Project Allocation Rules

- D1/D2 Project allocation rules from 1951-2017.

Conj Use 2: Hist Proj Acres (Hist M&I) (Run 17)

Conj Use 2a: Hist Proj Acres (Pre-Comp M&I) (Run 17a)

Irrigation Pumping

- Supplemental pumping to meet unmet demand after use of surface water (same as Historical Base Run).
- No pumping on NM primary ground water acres.

Non-Irrigation Pumping and Returns

- **Run 17 (Hist M&I)**:
  - Historical non-irrigation pumping and returns.
  - Set Las Cruces returns from use of Jornada wells to zero (results in a simulated offset from return flows attributed to this imported water source).
- **Run 17a (Pre-Comp M&I)**:
  - Limit M&I pumping to pre-Compact levels:
    - NM: 736 AF
    - TX: 13,744 AF
  - Reduce M&I returns by same percentage as M&I pumping reduced
    - For Las Cruces, this reduction applies to their use of Mesilla wells (not to their Jornada wells).
    - Don’t reduce EPW returns from use of Project water.
  - Set Las Cruces returns from use of Jornada wells to zero (results in a simulated offset from return flows attributed to this imported water source).

Irrigated Area

- Project Acres: Historical
- HCCRD and Mexico Acres: Historical
- NM Primary GW Acres: None

Crop Evapotranspiration

- Historical

Irrigation Infrastructure and Irrigation Practices

- EBID: Historical
- HCCRD: Historical
- Mexico: Historical
- EPCWID (Run 15 Conditions):
  - Charge EPCWID for use of EPW WWTP returns.
  - No ACE or Haskell credits for EPCWID.
  - Simulate EPCWID (EPV) increased use of Fabens drain flows*.
  - Charge EPCWID for use of Fabens drain flows*.

* Starting in July 1945, use 70% of simulated Fabens drain flow up to 6,000 af/month for irrigation in EPCWID.

Project Allocation Rules

- D1/D2 Project allocation rules from 1951-2017.

Conj Use 3: Auth Proj Acres (Pre-Comp M&I) (Run 18)

Irrigation Pumping

- Supplemental pumping to meet unmet demand after use of surface water (same as Historical Base Run).
- No pumping on primary ground water acres in EBID.

Non-Irrigation Pumping and Returns

- Limit M&I pumping to pre-Compact levels:
  - NM: 736 AF
  - TX: 13,744 AF
- Reduce M&I returns by same percentage as M&I pumping reduced
  - For Las Cruces, this reduction applies to their use of Mesilla wells (not to their Jornada wells).
- Set Las Cruces returns from use of Jornada wells to zero (results in a simulated offset from return flows attributed to this imported water source).
- No EPW use of Project water and no returns from EPW use of Project water.

Irrigated Area

- Project Acres: Set irrigated area to the original authorized Project acres in every year of the study period from 1940 – 2017:
  - EBID: 88,000 acres
  - EPCWID: 67,000 acres
- Other Acres: Set the irrigated area for HCCRD to the maximum historical acres which occurred in 1951, and use the actual historical acres that vary through time for Mexico:
  - HCCRD: 17,750 acres
  - MX: Historical acres (same as Base Run)
- NM Primary GW Acres: None

Crop Evapotranspiration

- Simulate the historical crop-weighted average unit crop irrigation requirement (CIR) for each irrigation district (EBID, EPCWID, HCCRD, Mexico); this reflects the historical changes in cropping pattern through time (same as Base Run).

Irrigation Infrastructure and Irrigation Practices

- Simulate the historical infrastructure as it evolved through time (same as Base Run).
- For all areas, simulate the historical water distribution losses, irrigation efficiency, deep percolation/surface runoff split, etc. as these changed through time (same as Base Run).
- EPCWID (Run 15 Conditions):
  - Charge EPCWID for use of EPW WWTP returns.
  - No ACE or Haskell credits for EPCWID.
  - Simulate EPCWID (EPV) increased use of Fabens drain flows*.
  - Charge EPCWID for use of Fabens drain flows*.

* Starting in July 1945, use 70% of simulated Fabens drain flow up to 6,000 af/month for irrigation in EPCWID.

Project Allocation Rules

- D1/D2 Project allocation rules from 1951-2017.

Simulated WWTP Discharges and Urban Deep Percolation for ILRG Model Runs

			WWTP Discharge (2)	**Urban Deep Percolation (3)**
Run	**Base Run Volume 1940 - 2017 Avg (AF/y)**		**75,649**	**11,436**
No.	**Run Name**	**Description (1)**	**Volume Turned Off 1940 - 2017 Avg (AF/y)**	
0	Historical Calibration Run	Base	0	0
1	Historical Base Run (All Pumping On)	Base	0	0
2	All Pumping Off	All Off	65,814	9,083
3	NM Pumping Off	NM Off	7,327	2,648
4	TX Pumping Off	TX Off	27,641	6,435
5	MX Pumping Off	MX Off	30,847	0
6	R-M Pumping Off	R-M Off	16,229	4,493
7	TX Mesilla Pumping Off	TX Mesilla Off	7,505	1,846
8	TX Non-Irrigation Pumping Off	TX Off	27,641	6,435
9	NM Non-Irrigation Pumping Off	NM Off	7,327	2,648
10	MX Non-Irrigation Pumping Off	MX Off	30,847	0
11	D1/D2 Allocation (All Pumping On)	Base	0	0
12	D3+Carryover Allocation (All Pumping On)	Base	0	0
13	Reduced Waste	Base	0	0
14	All Hueco Pumping Off	All Hueco Off	49,591	4,666
14a	TX Hueco Pumping Off	TX Hueco Off	20,142	4,666
14b	MX Hueco Pumping Off	MX Hueco Off	29,449	0
14c	TX WWTP Discharges Off	TX WWTP Off	27,641	0
14d	TX Hueco Pumping Off (Returns Left On)	Base	0	0
15	Early EPCWID Ops (WWTP & Fabens Drains)	Base	0	0
15a	Early EPCWID Ops (WWTP)	Base	0	0
15b	Early EPCWID Ops (Fabens Drains)	Base	0	0
15c	Early EPCWID Ops (TX Hueco Pumping Off)	TX Hueco Off	20,142	4,666
16	Conj Use 1: Hist All Acres D1/D2 (Hist M&I)	Base-Jornada	479	186
16a	Conj Use 1a: Hist All Acres D1/D2 (1978 M&I)	1978 Max	2,779	961
17	Conj Use 2: Hist Proj Acres (Hist M&I)	Base-Jornada	479	186
17a	Conj Use 2a: Hist Proj Acres (Pre-Comp M&I)	PreComp GW	29,907	8,282
18	Conj Use 3: Auth Proj Acres (Pre-Comp M&I)	PreComp	39,742	10,634

Notes:

(1) See detail for description on Page 2.
(2) "2020-06-17 WWTP Returns for Model Runs Rev.xlsx"
(3) "UrbanDeepPerc_Summary_ProposedUpdate_20200625 with Monthly Updates.xlsx"

Key to Simulated WWTP Discharges and Urban Deep Percolation for ILRG Model Runs

Description	WWTP Discharges ("WWTP")	Urban Deep Percolation ("UDP")
Base	All WWTP on.	All UDP on.
All Off	Turn off WWTP from NM Off, TX Off, and MX Off. Leave on WWTP from Haskell and Bustamante from EPW surface water diversions.	Turn off UDP from NM Off and TX Off.
NM Off	Turn off WWTP from Las Cruces, Salem, Hatch, Anthony NM, Gadsden School District, South Central Regional, Sunland Park and Santa Teresa, and El Paso Electric.	Turn off UDP from pumping from Las Cruces, Santa Teresa, Anthony NM, Mesquite, Berino, Garfield, and Radium Springs.
TX Off	Turn off WWTP from Anthony TX, Northwest, Socorro, and Fabens. Turn off WWTP from Haskell and Bustamante from EPW Mesilla and Hueco pumping. Leave on WWTP from Haskell and Bustamante from EPW surface water diversions.	Turn off UDP from Mesilla and Hueco pumping. Leave on UDP from EPW surface water diversions.
MX Off	Turn off WWTP from Juarez.	No MX UDP simulated in runs.
R-M Off	Turn off WWTP from NM Off and TX Mesilla Off. Turn off WWTP from Juarez Mesilla (Conjeos Medanos) pumping.	Turn off UDP from NM Off and TX Mesilla Off.
TX Mesilla Off	Turn off WWTP from Anthony TX and Northwest and WWTP from Haskell from EPW Mesilla pumping.	Turn off UDP from EPW Mesilla pumping. Computed as total EPW UDP multiplied by EPW Mesilla pumping divided by total EPW use.
All Hueco Off	Turn off WWTP from TX Hueco Off and MX Hueco Off.	Turn off UDP from TX Hueco Off.
TX Hueco Off	Turn off WWTP from include Socorro and Fabens. Turn off WWTP from of Haskell and Bustamante from EPW Hueco pumping. Leave on Haskell and Bustamante WWTP from EPW surface water diversions. Leave on Haskell WWTP from EPW Mesilla pumping.	Turn off UDP from EPW Hueco pumping. Computed as total EPW UDP multiplied by EPW Hueco pumping divided by total EPW use.
MX Hueco Off	Turn off WWTP from Juarez Hueco pumping. Leave on WWTP from Juarez Mesilla (Conejos Medanos) pumping.	All UDP on.
TX WWTP Off	Turn off WWTP from Anthony TX, Northwest, Haskell, Bustamante, Socorro, and Fabens.	All UDP on.
Base-Jornada	Turn off WWTP from Las Cruces from Jornada pumping. Computed as total Las Cruces WWTP multiplied by Jornada pumping divided by total Las Cruces pumping.	Turn off UDP from Las Cruces Jornada pumping. Computed as total Las Cruces UDP multiplied by Jornada pumping divided by total Las Cruces pumping .
1978 Max	For NM and TX, turn off WWTP from pumping that exceeds the maximum annual 1951-1978 pumping. Computed as WWTP multiplied by pumping reduction percentages.	For NM and TX, turn off UDP from pumping that exceeds the maximum annual 1951-1978 pumping. Computed as UDP multiplied by pumping reduction percentages.
PreComp GW	For NM and TX, set WWTP to pre-compact amounts. NM pre-compact WWTP is equal to the 1940 Hatch and Las Cruces amounts. TX pre-compact WWTP is equal to the 1938 Haskell amount. Leave on Haskell and Bustamante WWTP from EPW surface water diversions.	For NM and TX, set UDP to pre-compact amounts. NM pre-compact UDP is equal to the 1940 UDP from Hatch and Las Cruces pumping. TX pre-compact UDP is equal to the 1938 UDP from Haskell pumping. Leave on UDP from EPW surface water diversions.
PreComp	For NM and TX, set WWTP to pre-compact amounts. NM pre-compact WWTP is equal to the 1940 Hatch and Las Cruces amounts. TX pre-compact WWTP is equal to the 1938 Haskell amount.	For NM and TX, set UDP to pre-compact amounts. NM pre-compact UDP is equal to the 1940 UDP from Hatch and Las Cruces pumping. TX pre-compact UDP is equal to the 1938 UDP from Haskell pumping.

Appendix 30B - 30AA

Comparison of ILRG Model Runs

Appendix 30B

Comparison of ILRG Model Runs
Run 2 v. Run 1

Model Run Specifications

Model Version: LRG_v116

Name: **Run 2 - All Pumping Off**

Run ID: LRG_v116_Operational_Run2
Date: 8/24/2020

Name: **Run 1 - Historical Base Run**

Run ID: LRG_v116_Operational_Run1
Date: 8/23/2020

Selected Model Inputs

Pumping and Returns	Run 2	Run 1
Irrigation Pumping	All Off	On
Irrigated Area	Hist	Hist
Non-Irrigation Pumping	All Off	On
Non-Irrigation Pumping Returns	All Off	On
Las Cruces Jornada Pumping Returns	Off	On

Project Allocation Rules		
1950-2005	D1/D2	D1/D2
2006-2007	D3	D3
2008-2017	D3 + CO	D3 + CO

EPCWID Operations		
Charge EPCWID for Use of WWTP Returns	Off	Off
ACE and Haskell Credits for EPCWID	On	On
Increased EPCWID Use of Fabens Drain Flows	Off	Off
Charge EPCWID for Fabens Drain Flow Use	Off	Off

Run 2 - All Pumping Off

Comparison of ILRG Model Runs

Run 2 v. Run 1

1951 - 2017 Annual Average

(1,000 acre-feet)

Run No.	**1**	**2**	**2 - 1**		
Simulated Input or Output	**Run 1**	**Run 2**	**Run 2 minus Run 1**		
Pumping Stress					
Irrigation Pumping	254.9	0.0	-254.9		
Non-Irrigation Pumping	181.0	0.0	-181.0		
WWTP Flows	58.0	11.1	-46.9		
Urban Deep Percolation	13.1	2.7	-10.4		
Total Stress	364.8	-13.8	-378.6		
	Stress is Pumping minus WWTP and Urban Deep Perc				
Effects of Pumping Stress				***% Chg***	
FHG Deliveries (Mar - Oct)				***Stress***	***% Diff.***
EBID	167.6	202.2	34.6	*-9%*	*21%*
EPCWID (incl. EPW)	139.9	152.1	12.3	*-3%*	*9%*
HCCRD	32.8	35.5	2.6	*-1%*	*8%*
Total	340.3	389.8	49.5	*-13%*	*15%*
FHG Deliveries (Nov - Feb)					
EBID	0.0	0.1	0.1	*0%*	*991%*
EPCWID (incl. EPW)	0.2	0.2	0.0	*0%*	*-11%*
HCCRD	2.4	2.2	-0.2	*0%*	*-8%*
Total	2.6	2.4	-0.2	*0%*	*-6%*
Irrigation Pumping					
EBID	140.4	0.0			
EPCWID (Mesilla Valley)	7.4	0.0			
EPCWID (El Paso Valley)	40.1	0.0			
HCCRD	4.2	0.0			
	Pumping turned off.	*Other values are simulated responses and are totaled.*			
Other Inflows/Outflows					
Net Reservoir Evaporation	125.3	143.7	18.4	*-5%*	*15%*
Riparian ET	70.9	83.9	13.0	*-3%*	*18%*
River Evaporation + Incidental Canal Loss	30.3	31.5	1.2	*0%*	*4%*
Total	226.6	259.2	32.6	*-9%*	*14%*
Rio Grande at Fort Quitman					
Reservoir Spills	33.3	50.7	17.4	*-5%*	*52%*
Nov-Feb Flows	21.4	60.3	38.9	*-10%*	*182%*
Mar - Oct Flows	41.1	85.1	44.0	*-12%*	*107%*
Underflow (GW Model)	0.2	0.3	0.1	*0%*	*32%*
Total	96.0	196.3	100.4	*-27%*	*105%*

Run 2 - All Pumping Off

Comparison of ILRG Model Runs

Run 2 v. Run 1

1951 - 2017 Annual Average

(1,000 acre-feet)

Run No.	1	2	2 - 1		
Simulated Input or Output	**Run 1**	**Run 2**	**Run 2 minus Run 1**		
Effects of Pumping Stress (continued)				***% Chg***	
Change in Storage				***Stress***	***% Diff.***
Reservoir Storage	-4.7	-3.6	1.1	*0%*	*-23%*
Alluvial GW Storage (RW Model)	-23.6	-0.4	23.2	*-6%*	*-98%*
Non-alluvial GW Storage (GW Models)	-96.4	-0.3	96.1	*-25%*	*-100%*
Soil Moisture Storage	0.6	0.7	0.1	*0%*	*17%*
Total	-124.0	-3.6	120.4	*-32%*	*-97%*
Summary of Effects					
FHG Deliveries (Mar-Oct)	340.3	389.8	49.5	*-13%*	*15%*
FHG Deliveries (Nov-Feb)	2.6	2.4	-0.2	*0%*	*-6%*
Irrigation Pumping	0.0	0.0	0.0	*0%*	*0%*
Riparian ET + Evaporation	226.6	259.2	32.6	*-9%*	*14%*
Fort Quitman Flow	96.0	196.3	100.4	*-27%*	*105%*
Change in Storage	-124.0	-3.6	120.4	*-32%*	*-97%*
Total	541.5	844.2	302.8	*-80%*	*56%*
Other Effects of Pumping Stress				***% Chg***	
Rio Grande at El Paso				***Stress***	***% Diff.***
Reservoir Spills	49.4	66.8	17.4	*-5%*	*35%*
Nov-Feb Flows	22.8	51.3	28.5	*-8%*	*125%*
Mar - Oct Flows	263.8	296.8	33.1	*-9%*	*13%*
Total	336.0	414.9	79.0	*-21%*	*24%*
Rio Grande below Caballo					
Reservoir Spills	65.9	83.9	18.0	*-5%*	*27%*
Nov-Feb Flows	0.5	0.5	0.0	*0%*	*5%*
Mar - Oct Flows	541.3	504.3	-37.0	*10%*	*-7%*
Total	607.6	588.7	-19.0	*5%*	*-3%*
Surface Water Diversions (Mar - Oct)					
EBID	366.5	416.8	50.3	*-13%*	*14%*
EPCWID (incl. EPW)	236.8	258.1	21.3	*-6%*	*9%*
HCCRD	67.5	80.5	13.0	*-3%*	*19%*
Total	670.8	755.4	84.5	*-22%*	*13%*
Surface Water Diversions (Nov - Feb)					
EBID	0.0	0.0	0.0	*0%*	*0%*
EPCWID (incl. EPW)	14.3	15.7	1.3	*0%*	*9%*
HCCRD	14.2	17.8	3.6	*-1%*	*25%*
Total	28.5	33.5	4.9	*-1%*	*17%*

Run 2 - All Pumping Off
Annual Differences in ILRG Model Outputs
Run 2 minus Run 1
1940 - 2017 (acre-feet)

	Net River Headgate Diversions						Farm Headgate Deliveries						Annual Flows		
	EBID		EPCWID (incl. EPW)		HCCRD		EBID		EPCWID (incl. EPW)		HCCRD				
Year	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Caballo Releases	Rio Grande at El Paso	Rio Grande at Fort Quitman
1940	-70	-70	-825	537	-406	703	-8	24	848	898	-320	-320	-7,706	-7,295	7,168
1941	-273	-273	-769	-1,275	-2	85	-41	-3	-39	-105	12	-23	6,848	5,472	8,000
1942	-232	-232	-304	-2,114	-90	-108	26	65	282	-178	-114	-123	936	2,541	3,756
1943	-250	-250	-344	-1,474	-96	-115	43	83	325	135	-89	-310	2,294	2,670	2,949
1944	-282	-282	-732	-2,062	-15	-235	-2	39	-81	-293	-38	-202	-452	-67	2,246
1945	-284	-284	-485	-2,095	53	-481	27	65	-91	-383	47	109	479	977	2,679
1946	-220	-220	-361	-2,293	141	-542	52	94	68	-406	97	29	339	940	2,836
1947	-263	-263	-125	-1,484	-24	-321	23	67	638	181	-51	-33	-1,017	-296	3,190
1948	-1,035	-1,035	-1,436	-2,563	373	220	472	520	513	359	380	157	-4,281	-3,101	8,191
1949	-2,145	-2,145	-2,855	-4,130	1,432	1,710	155	209	-109	-136	-138	-281	-6,174	-3,209	13,441
1950	-265	-265	-4,038	-4,768	1,631	2,075	2,268	2,322	-104	-80	-27	-48	-5,582	6,827	17,603
1951	439	439	-4,566	-5,138	1,704	2,497	3,387	3,443	85	115	1,786	1,313	-30,442	9,452	37,549
1952	-177	-177	-6,838	-7,399	2,004	3,004	7,775	7,831	-471	-424	1,848	1,114	-48,835	18,961	45,519
1953	-652	-652	-8,384	-8,970	3,528	5,115	7,329	7,383	-560	-508	3,606	4,094	-55,975	22,853	64,328
1954	48,884	48,884	36,956	43,264	5,129	9,314	31,475	31,513	33,479	33,550	6,177	9,147	16,237	105,775	72,212
1955	51,927	51,927	40,655	53,567	16,005	22,896	32,174	32,200	31,941	31,797	13,241	18,435	-4,453	115,421	78,887
1956	25,255	25,255	26,205	40,191	12,388	18,390	23,556	23,579	24,793	24,071	10,760	13,776	-46,688	103,442	63,607
1957	68,024	68,024	27,490	39,122	14,263	21,385	25,034	25,072	11,377	11,036	10,045	12,060	-48,359	91,894	60,524
1958	-1,222	-1,222	-28,014	-20,277	9,184	17,320	11,228	11,270	-2,195	-2,206	-1,396	1,082	-176,116	11,292	102,747
1959	-1,327	-1,327	-16,145	-14,012	6,454	11,495	7,294	7,342	-783	-706	403	682	-102,822	12,862	89,989
1960	-1,394	-1,394	-13,565	-11,820	5,478	9,077	7,469	7,518	-1,415	-1,333	0	0	-96,553	18,727	84,004
1961	-1,305	-1,305	-12,947	-11,473	5,694	9,097	7,106	7,155	169	248	1,543	-351	-84,485	20,007	82,956
1962	-1,322	-1,322	-12,003	-10,630	5,281	8,498	7,011	7,060	-611	-530	822	1,280	-86,794	25,639	82,205
1963	7,457	7,457	-12,507	-10,602	5,421	8,905	13,003	13,052	-1,206	-1,121	2,506	1,991	-78,348	32,635	82,913
1964	268,545	268,545	139,372	146,153	18,356	24,923	147,941	147,989	95,054	94,800	13,409	15,769	252,583	230,861	114,047
1965	84,909	84,909	10,109	16,861	12,030	20,091	67,032	67,081	26,168	25,856	12,629	15,184	-109,023	85,445	107,640
1966	-86	-86	20,567	23,861	17,130	22,964	-2,219	-2,172	16,126	16,221	-2,697	-4,654	-80,608	68,626	111,070
1967	186,249	186,249	100,548	106,797	20,226	29,634	106,970	107,018	71,490	71,080	10,339	12,266	122,722	167,392	106,571
1968	38,137	38,137	24,995	30,862	22,887	32,934	25,765	25,819	18,479	18,185	12,093	9,482	-74,236	97,208	123,196
1969	729	729	26,295	28,330	24,401	30,943	-2,565	-2,513	19,087	19,162	3,056	-1,594	-78,806	61,865	114,201
1970	-1,480	-1,480	-10,573	-9,807	8,942	13,479	8,470	8,521	-1,134	-1,066	-1,274	-2,725	-110,118	22,344	96,250
1971	117,695	117,695	36,716	40,045	20,158	26,567	67,799	67,852	20,409	20,513	13,777	14,722	815	111,601	114,869
1972	201,568	201,568	122,379	132,400	26,645	35,584	98,954	99,002	74,881	74,734	12,888	11,452	151,754	208,136	135,030
1973	-418	-418	25,660	32,614	34,384	43,619	350	401	15,956	15,813	18,401	15,966	-133,161	77,120	121,431
1974	-1,803	-1,803	-5,006	-2,705	20,666	29,092	13,151	13,207	1,409	1,491	-3,923	-6,152	-91,360	41,630	123,924
1975	-77	-77	35,374	36,390	28,064	35,560	-1,596	-1,548	18,628	18,703	8,101	3,486	-66,046	74,422	111,651
1976	-2,200	-2,200	2,664	3,835	17,671	25,472	9,158	9,189	438	485	-1,658	-5,752	-88,026	36,272	90,297
1977	153,118	153,118	43,238	48,034	21,636	29,039	90,338	90,389	18,795	18,895	16,781	15,626	45,124	118,358	107,462
1978	222,302	222,302	62,020	69,188	19,285	28,464	135,551	135,604	36,845	36,968	16,117	14,160	78,581	157,338	122,364

Run 2 - All Pumping Off

Annual Differences in ILRG Model Outputs

Run 2 minus Run 1

1940 - 2017 (acre-feet)

	Net River Headgate Diversions						Farm Headgate Deliveries						Annual Flows		
	EBID		EPCWID (incl. EPW)		HCCRD		EBID		EPCWID (incl. EPW)		HCCRD				
Year	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Caballo Releases	Rio Grande at El Paso	Rio Grande at Fort Quitman
1979	1,249	1,249	26,261	30,157	15,032	22,930	11,025	11,080	17,638	17,740	2,378	-604	-107,349	59,625	107,575
1980	-1,428	-1,428	4,552	4,497	10,320	14,227	9,365	9,424	921	999	-4,644	-9,127	-71,658	37,280	116,711
1981	-1,289	-1,289	8,038	9,716	8,948	11,684	9,005	9,051	825	907	-56	-412	-69,531	45,743	95,599
1982	-1,384	-1,384	7,165	8,908	8,453	10,979	8,614	8,669	852	936	-2,057	-4,030	-76,875	45,692	108,357
1983	-983	-983	10,423	11,757	11,716	14,224	7,828	7,883	726	804	0	0	-62,373	43,307	84,378
1984	-1,232	-1,232	12,253	13,225	18,360	20,184	7,875	7,921	715	781	0	0	-36,011	43,290	82,420
1985	1,570	1,570	82,844	82,225	44,447	45,705	-5,291	-5,233	28,626	28,581	0	0	357,218	410,939	410,830
1986	-654	-654	13,088	12,546	12,174	12,561	7,248	7,322	-4,044	-3,987	0	0	87,233	151,523	319,143
1987	-1,560	-1,560	22,282	21,721	9,938	8,932	4,511	4,579	546	595	0	0	45	56,591	120,743
1988	-1,163	-1,163	23,489	22,926	9,867	8,325	5,557	5,622	413	458	0	0	-16,512	42,066	80,214
1989	-952	-952	25,371	24,547	10,892	9,556	6,947	7,002	883	551	0	0	-16,847	51,784	72,871
1990	-701	-701	23,899	23,014	14,149	13,059	6,794	6,854	637	174	0	0	-15,214	45,839	62,361
1991	-2,704	-2,704	11,299	10,301	6,379	5,812	3,112	3,179	357	-379	0	0	-24,404	28,113	61,145
1992	1,422	1,422	88,132	87,313	41,134	41,711	-5,917	-5,855	34,442	34,145	0	0	55,449	116,855	126,465
1993	-558	-558	-6,039	-6,640	2,220	1,962	7,055	7,125	-2,428	-2,382	0	0	-20,360	39,184	79,937
1994	-979	-979	289	-333	3,890	3,754	9,204	9,290	3,149	3,209	0	0	-15,559	74,034	111,168
1995	-959	-959	-276	-954	3,580	3,222	11,344	11,424	3,581	3,609	0	0	38,068	147,652	178,364
1996	-1,506	-1,506	-1,730	-2,352	2,789	2,552	11,766	11,851	786	869	0	0	-80,076	47,656	83,942
1997	-881	-881	-6,571	-7,795	5,072	4,514	8,400	8,461	-1,146	-2,095	0	0	-45,934	38,457	76,532
1998	-1,112	-1,112	314	-414	4,309	3,428	8,974	9,056	1,070	1,131	0	0	-14,547	72,684	113,140
1999	-1,958	-1,958	-13,233	-15,859	30,845	31,505	-2,465	-2,405	-16,558	-16,518	0	0	8,718	95,774	137,493
2000	-887	-887	21,833	18,772	5,930	6,775	-1,246	-1,195	-2,043	-2,013	0	0	-20,510	68,670	86,516
2001	-399	-399	17,537	13,546	6,797	8,042	7,663	7,708	8,080	8,131	0	0	-23,365	51,715	59,673
2002	-767	-767	-257	-2,335	2,653	4,197	8,562	8,605	498	555	0	0	-50,325	33,784	53,692
2003	112,776	112,776	65,045	62,586	19,471	20,877	68,685	68,747	20,334	20,409	0	0	95,568	134,394	96,715
2004	29,520	29,520	16,712	15,138	5,954	8,291	26,603	26,654	5,972	6,045	0	0	-45,119	78,246	74,919
2005	1,140	1,140	9,543	6,603	6,246	8,557	13,955	14,017	7,008	7,086	0	0	-78,994	39,229	62,967
2006	113,465	113,465	77,838	74,778	21,144	23,813	69,488	69,538	37,585	37,646	0	0	93,952	134,426	102,339
2007	116,138	116,138	8,314	6,131	5,104	7,409	82,171	82,220	9,827	9,911	0	0	-35,966	54,073	65,691
2008	184,221	184,221	1,667	-498	4,367	5,933	127,155	127,271	3,225	3,422	0	0	19,896	64,318	89,612
2009	169,956	169,956	1,140	-968	3,022	4,940	116,446	116,603	516	718	0	0	26,377	80,304	109,576
2010	186,430	186,430	4,267	2,307	4,209	6,038	127,637	127,745	2,490	2,662	0	0	6,683	65,750	90,960
2011	111,519	111,519	63,776	63,134	28,695	37,880	55,719	55,763	43,893	44,005	0	0	13,047	127,832	100,518
2012	103,391	103,391	46,169	44,525	27,677	34,751	55,402	55,434	23,637	23,741	0	0	-33,111	106,308	84,433
2013	63,297	63,297	34,132	33,249	13,693	17,203	37,131	37,162	11,688	11,775	5,985	7,791	20,923	114,891	75,575
2014	75,601	75,601	26,931	24,985	15,010	20,636	36,426	36,447	14,946	15,030	902	2,237	-30,070	87,072	71,172
2015	172,196	172,196	22,987	21,518	9,788	13,538	96,285	96,316	12,082	12,186	-4,382	-3,770	-37,547	66,916	74,512
2016	171,041	171,041	17,834	16,499	5,641	8,561	105,374	105,404	13,939	14,054	0	0	-60,762	72,316	64,623
2017	317,337	317,337	6,667	6,157	4,714	7,163	202,857	202,953	8,423	8,594	0	0	19,442	68,703	84,679
Averages															
1951-2017	50,298	50,298	21,264	22,587	12,980	16,579	34,570	34,626	12,259	12,238	2,649	2,447	-18,953	78,964	100,373
1951-1978	52,206	52,206	23,239	27,810	14,465	20,549	33,891	33,938	18,830	18,780	6,406	6,138	-36,551	76,699	94,551
1979-2005	4,579	4,579	17,121	16,401	11,910	12,873	9,451	9,512	4,142	4,087	-162	-525	-9,232	77,782	113,477
2006-2017	148,716	148,716	25,977	24,318	11,922	15,655	92,674	92,738	15,188	15,312	209	521	239	86,909	84,474
1985-2017	57,978	57,978	21,373	19,890	11,873	13,370	39,805	39,869	8,255	8,240	76	190	5,376	86,912	105,531
1985-2005	6,128	6,128	18,741	17,360	11,845	12,064	9,593	9,657	4,293	4,199	0	0	8,311	86,914	117,563

Notes:

EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).

EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

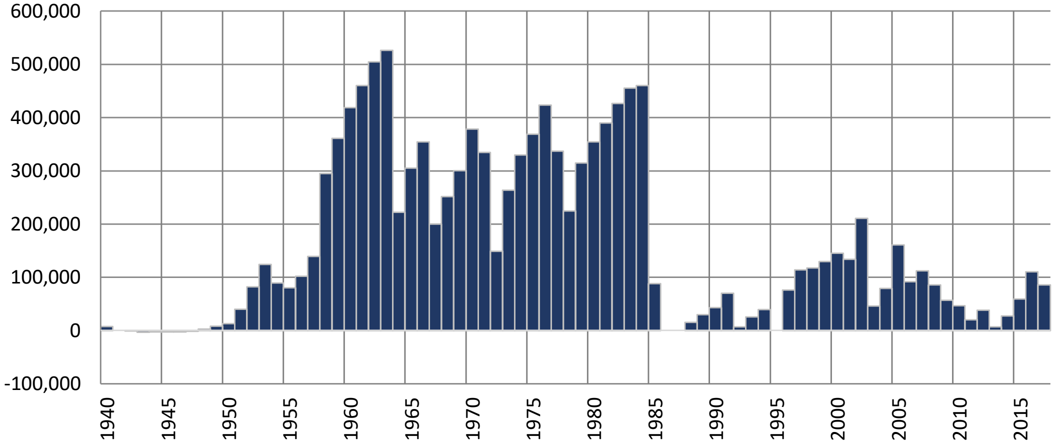
Run 2 - All Pumping Off

Simulated Differences in ILRG Model Outputs

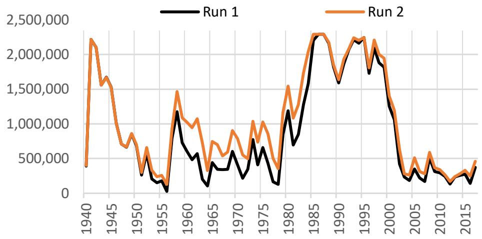
Run 2 minus Run 1

1940 - 2017 (acre-feet)

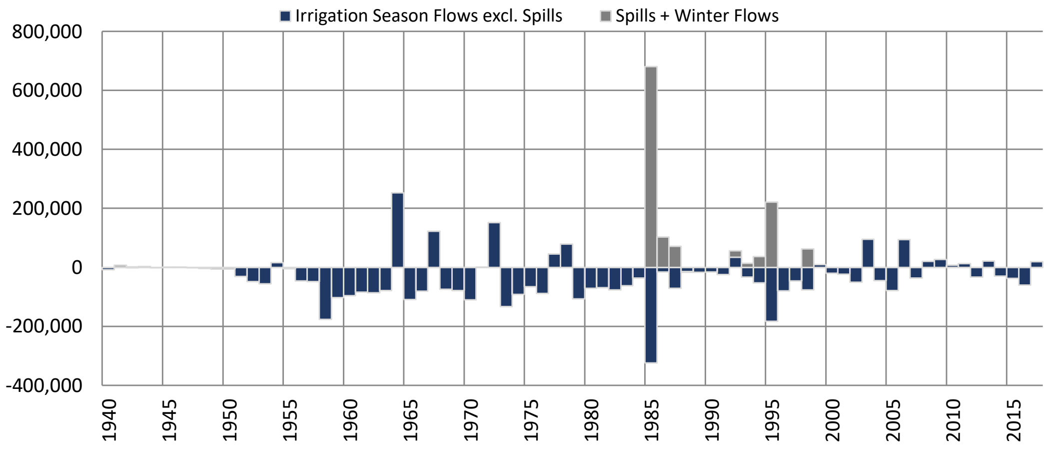
Total Project Storage (Year End)



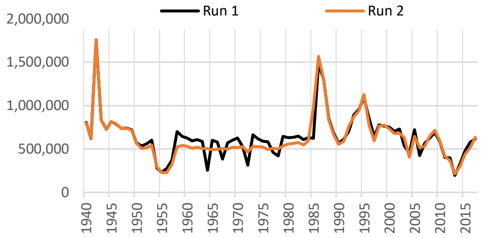
Period	Average Difference
1951-2017	1,087
1951-1978	7,562
1979-2005	-2,360
2006-2017	-6,267
1985-2017	-11,345
1985-2005	-14,246



Caballo Reservoir Outflows (Annual)



	Average Difference		
Period	Irr Season (excl. Spills)	Nov-Feb and Spills	Annual
1951-2017	-36,983	18,030	-18,953
1951-1978	-36,551	0	-36,551
1979-2005	-53,973	44,741	-9,232
2006-2017	239	0	239
1985-2017	-31,231	36,607	5,376
1985-2005	-49,214	57,525	8,311



Notes:

Reservoir storage does not include storage attributed to SJC, CO, or NM credit waters.

Average differences calculated as (Final Storage - Initial Storage)/(no. years).

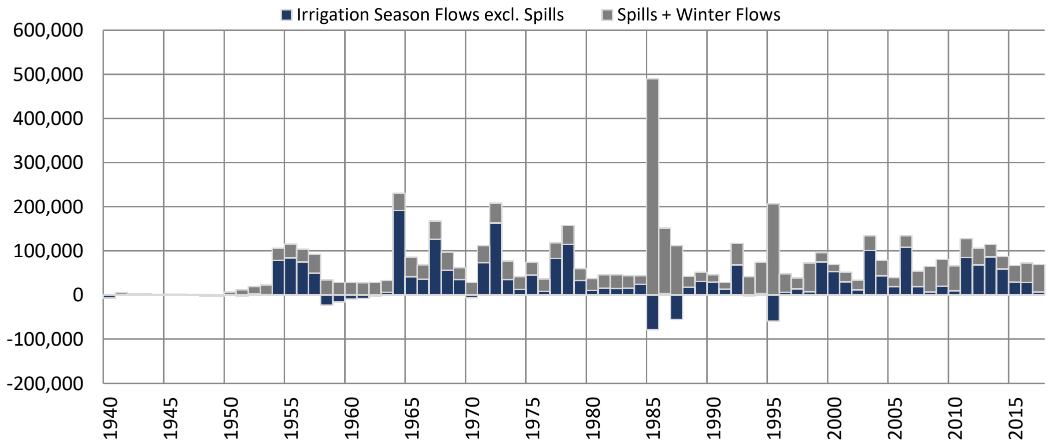
Run 2 - All Pumping Off

Simulated Differences in ILRG Model Outputs

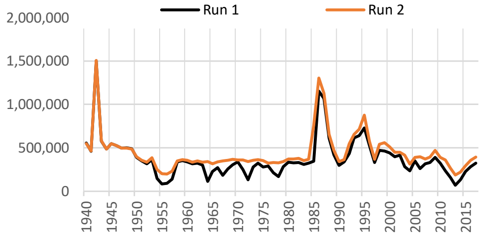
Run 2 minus Run 1

1940 - 2017 (acre-feet)

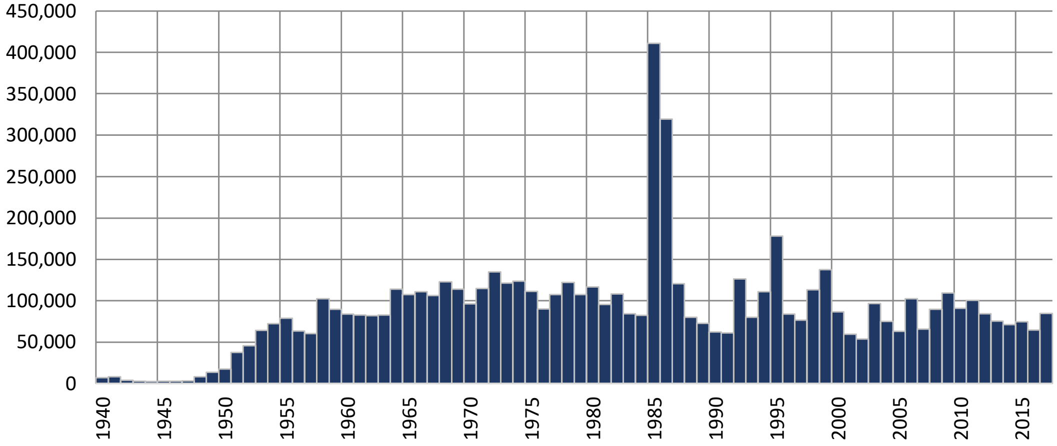
Rio Grande at El Paso (Annual)



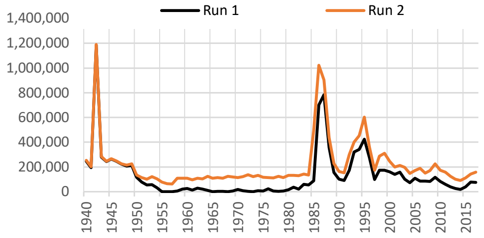
	Average Difference		
Period	Irr Season (excl. Spills)	Nov-Feb and Spills	Annual
1951-2017	33,065	45,900	78,964
1951-1978	44,593	32,106	76,699
1979-2005	16,339	61,443	77,782
2006-2017	43,798	43,111	86,909
1985-2017	25,891	61,021	86,912
1985-2005	15,659	71,255	86,914



Rio Grande at Fort Quitman (Annual)



Period	Average Difference
1951-2017	100,304
1951-1978	94,449
1979-2005	113,419
2006-2017	84,456
1985-2017	105,499
1985-2005	117,524



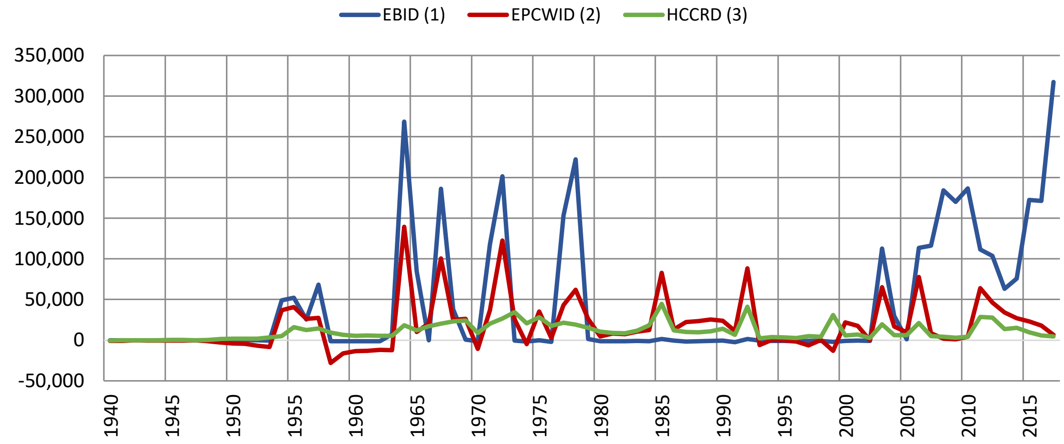
Run 2 - All Pumping Off

Simulated Differences in ILRG Model Outputs

Run 2 minus Run 1

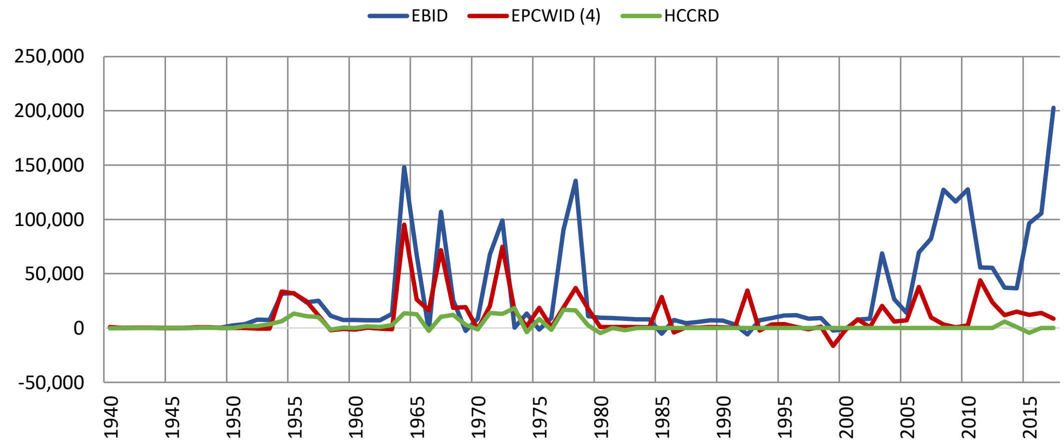
1940 - 2017 (acre-feet)

River Headgate (RHG) Diversions (Irrigation Season)



	Average Difference		
Period	EBID	EPCWID	HCCRD
1951-2017	50,298	21,264	12,980
1951-1978	52,206	23,239	14,465
1979-2005	4,579	17,121	11,910
2006-2017	148,716	25,977	11,922
1985-2017	57,978	21,373	11,873
1985-2005	6,128	18,741	11,845

Farm Headgate (FHG) Deliveries (Irrigation Season)



	Average Difference		
Period	EBID	EPCWID	HCCRD
1951-2017	34,570	12,259	2,649
1951-1978	33,891	18,830	6,406
1979-2005	9,451	4,142	-162
2006-2017	92,674	15,188	209
1985-2017	39,805	8,255	76
1985-2005	9,593	4,293	0

Notes:

(1) EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).

(2) EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

(3) HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

(4) EPCWID FHG values include deliveries to Rogers WTP and R/U WTP.

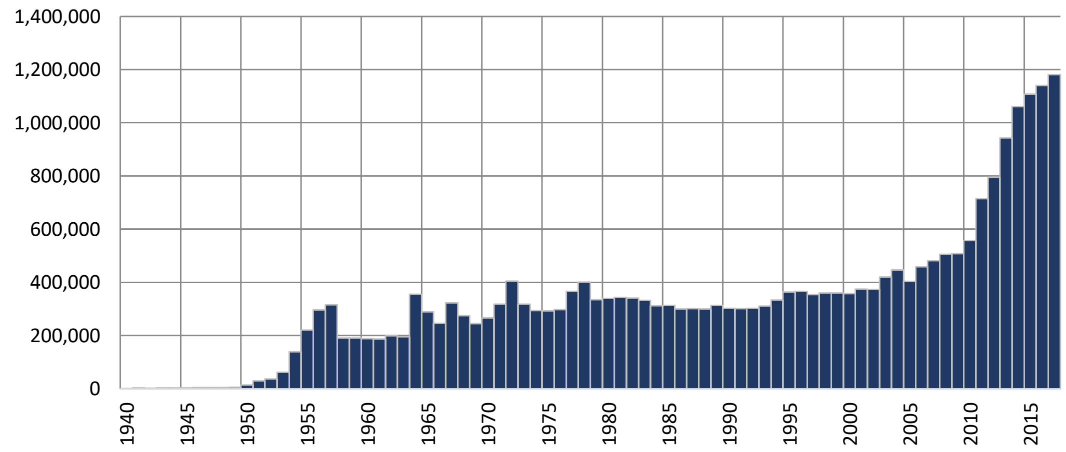
Run 2 - All Pumping Off

Simulated Differences in ILRG Model Outputs

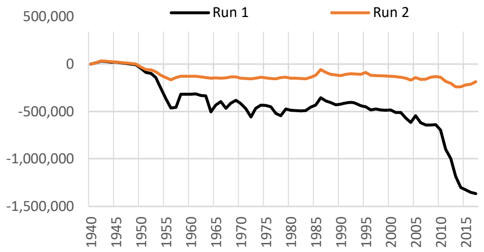
Run 2 minus Run 1

1940 - 2017 (acre-feet)

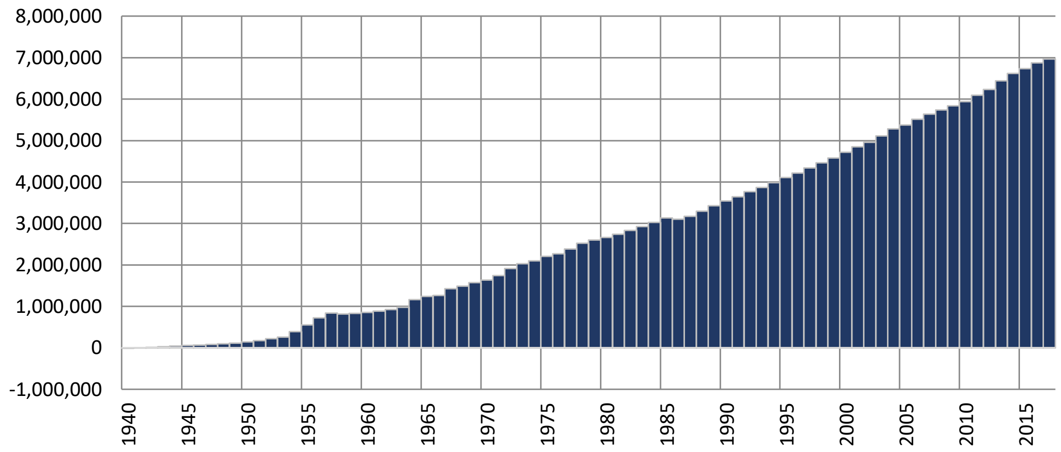
Cumulative Annual Rincon-Mesilla Groundwater Storage



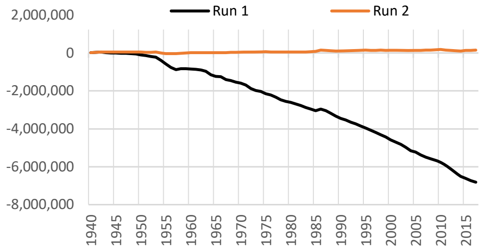
Period	Average Difference
1951-2017	17,417
1951-1978	13,807
1979-2005	96
2006-2017	64,812
1985-2017	26,339
1985-2005	4,354



Cumulative Annual Hueco Groundwater Storage



Period	Average Difference
1951-2017	101,839
1951-1978	84,954
1979-2005	105,574
2006-2017	132,836
1985-2017	119,492
1985-2005	111,867



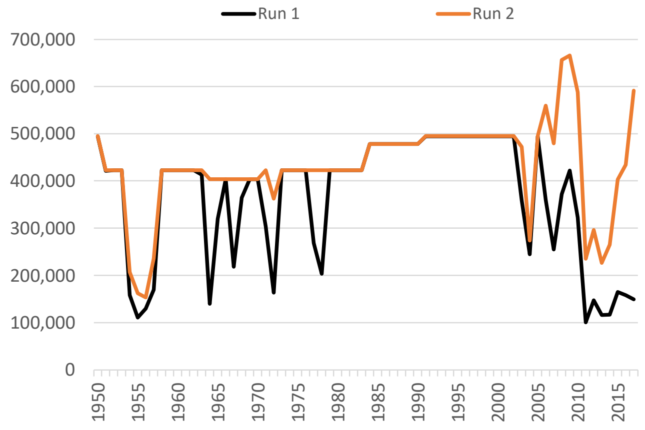
Notes:

Cumulative storage change in alluvial and non-alluvial aquifers.

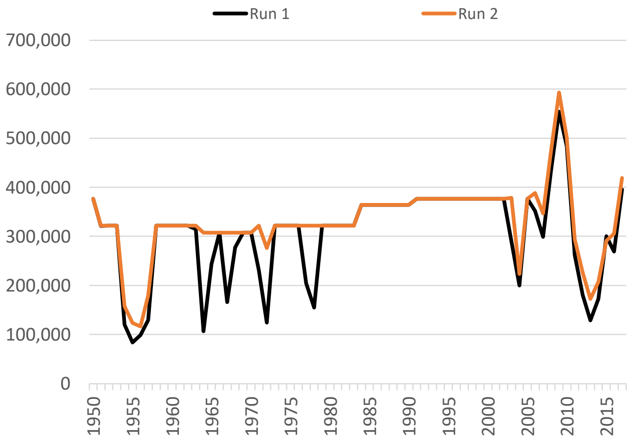
Average differences calculated as (Final Storage - Initial Storage)/(no. years).

Run 2 - All Pumping Off
Annual Allocation and Charges
Run 2 v. Run 1
ILRG Model
1950 - 2017 (acre-feet)

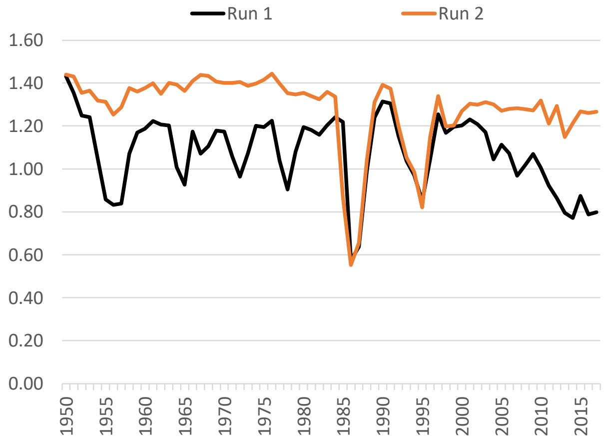
Total Allocation - EBID



Total Allocation - EPCWID

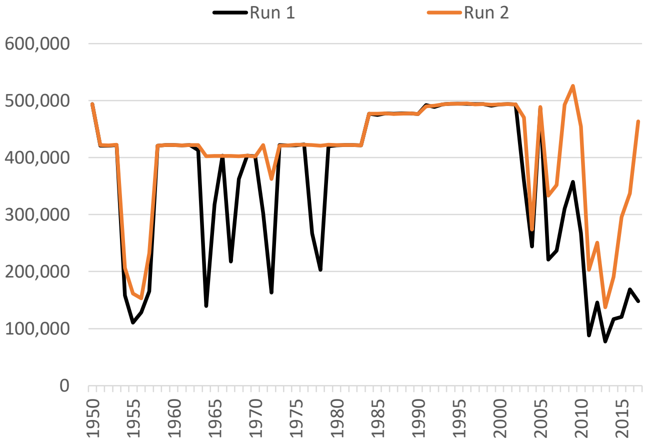


Diversion Ratio

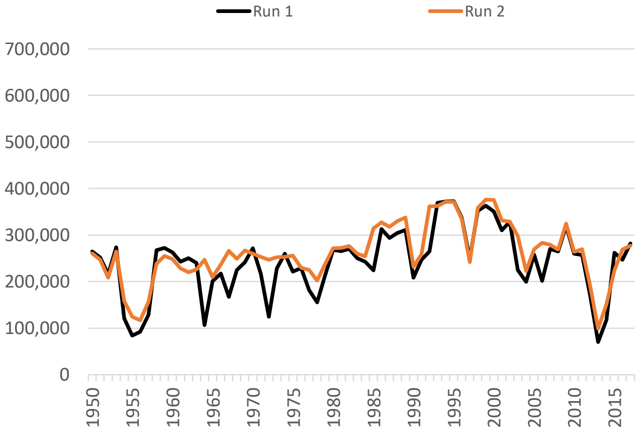


Note:
Computed as Total Charges/Caballo Release.

Annual Delivery Charges - EBID



Annual Delivery Charges - EPCWID



Run 2 - All Pumping Off

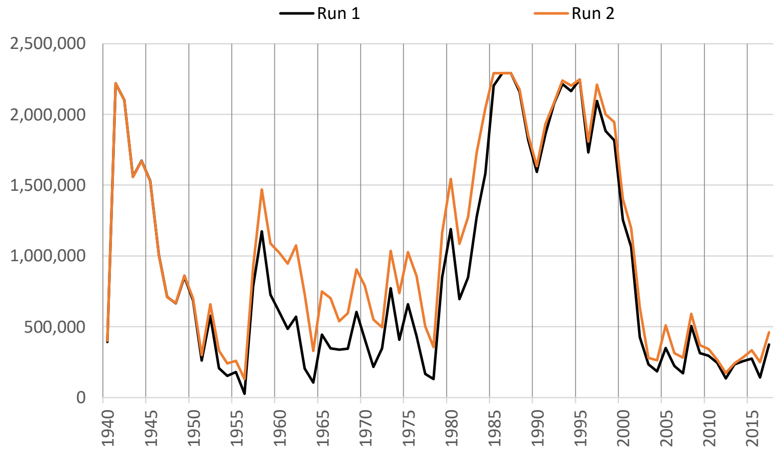
Annual Summary of Project Storage and Rio Grande Flows

Run 2 v. Run 1

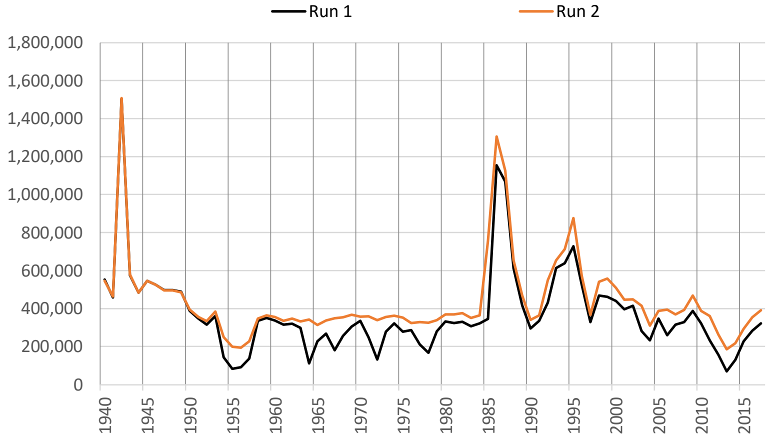
ILRG Model

1940 - 2017 (acre-feet)

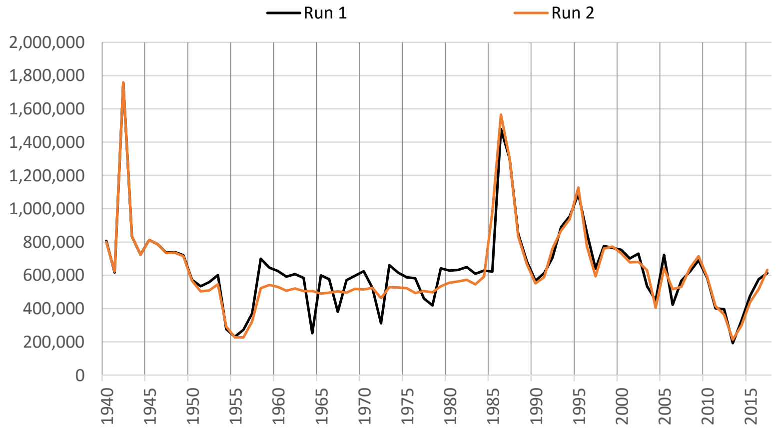
Total Year-End Project Reservoir Storage



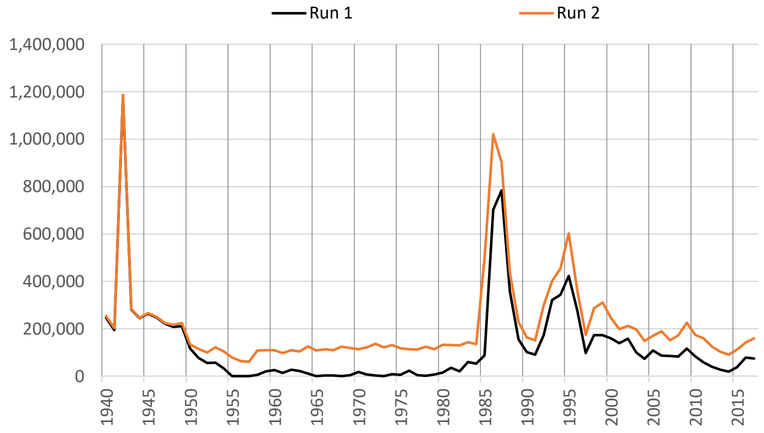
Rio Grande at El Paso



Rio Grande Below Caballo



Rio Grande at Fort Quitman

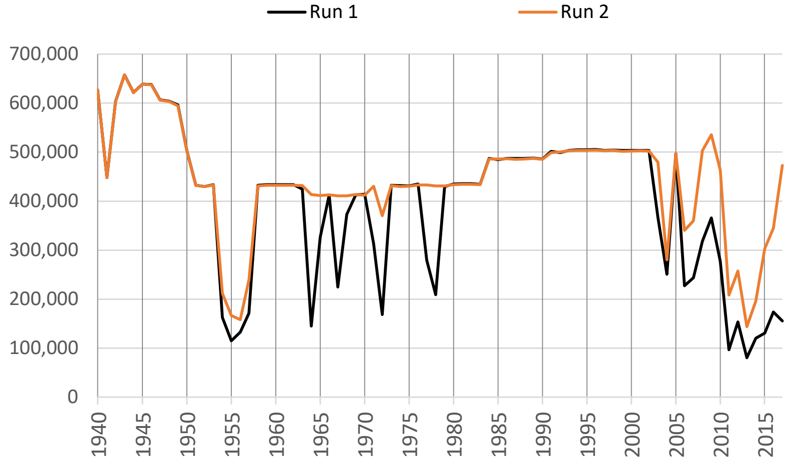


***Note different scales.**

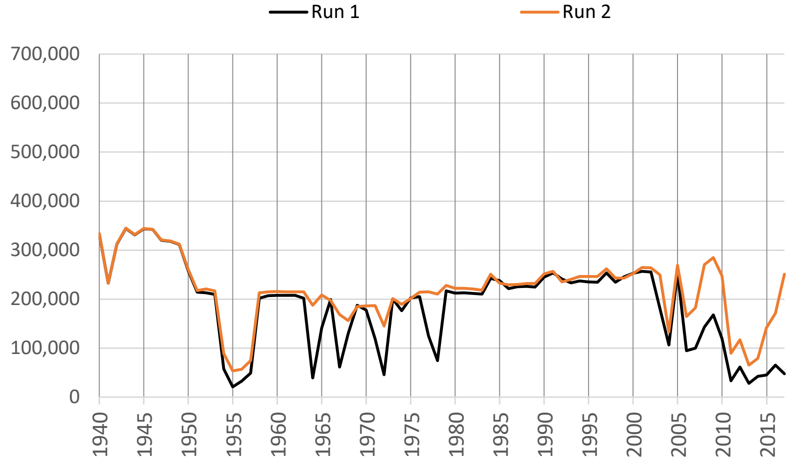
Run 2 - All Pumping Off
Irrigation Season Summary of Irrigation Operations
Run 2 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

EBID Total

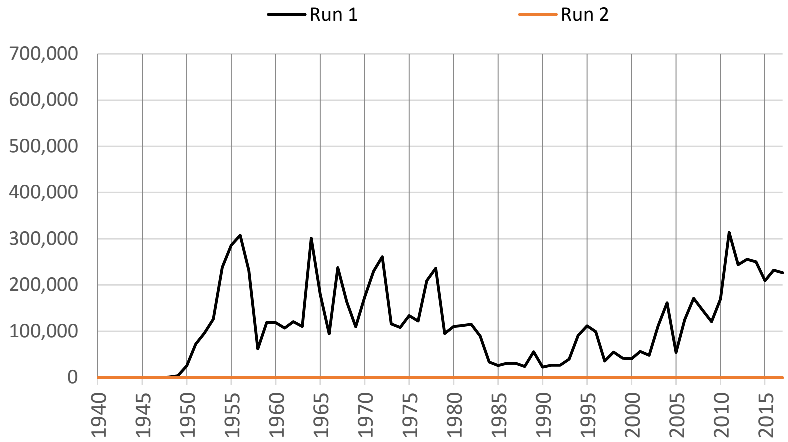
Net River Headgate Diversions



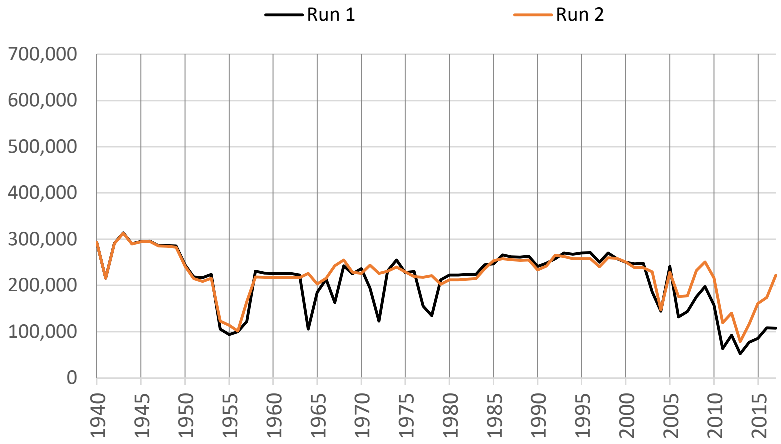
Farm Headgate Deliveries



Pumping



RHG Diversions - FHG Deliveries



Notes: EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).
Pumping includes Supplemental and Primary groundwater pumping.

Run 2 - All Pumping Off

Irrigation Season Summary of Irrigation Operations

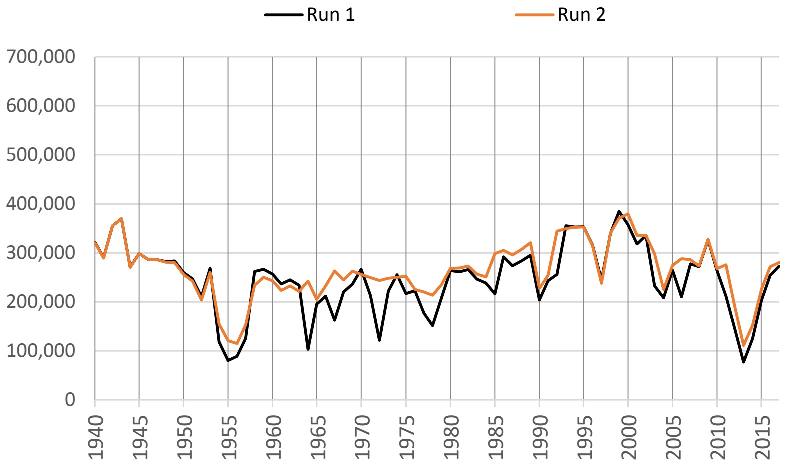
Run 2 v. Run 1

ILRG Model

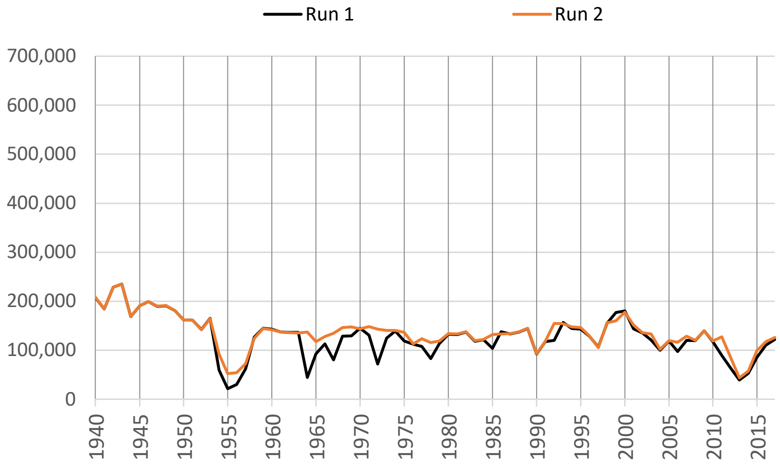
1940 - 2017 (acre-feet)

EPCWID Total

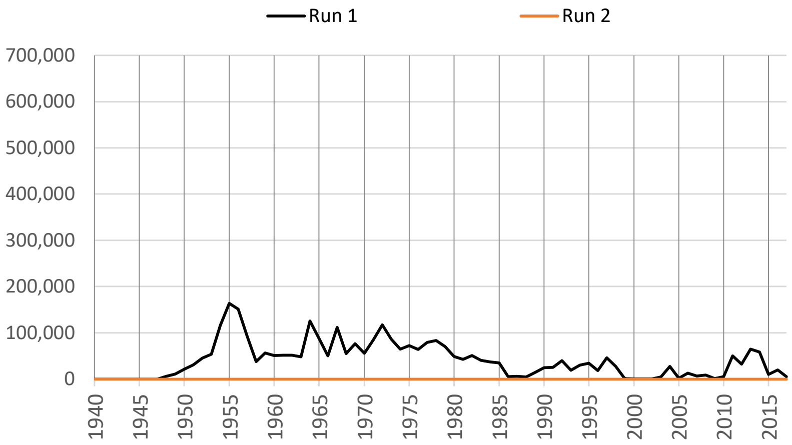
Net River Headgate Diversions



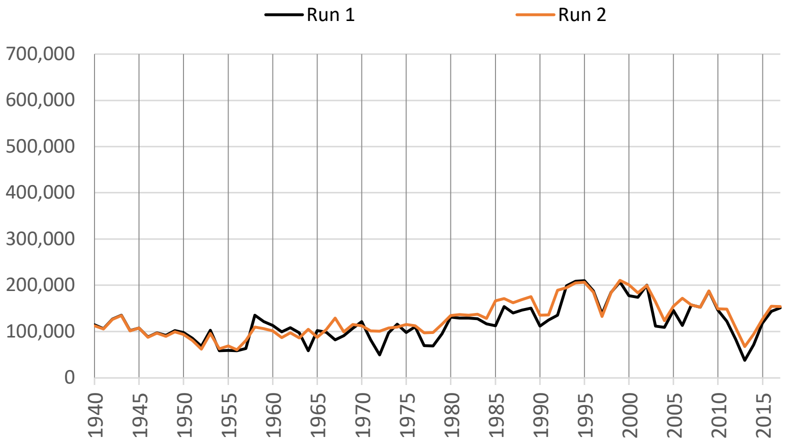
Farm Headgate Deliveries



Pumping



RHG Diversions - FHG Deliveries

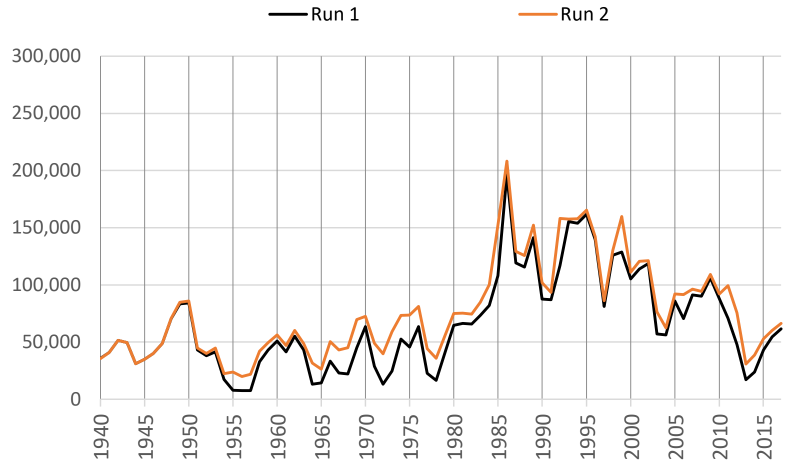


Note: EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

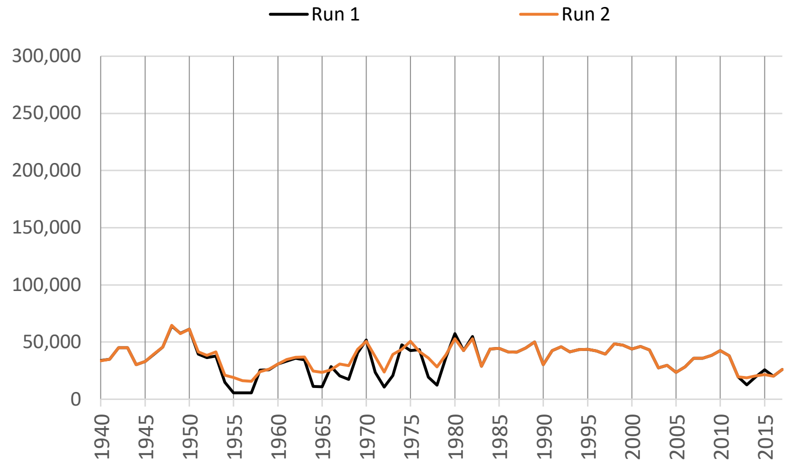
Run 2 - All Pumping Off
Irrigation Season Summary of Irrigation Operations
Run 2 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

HCCRD Total

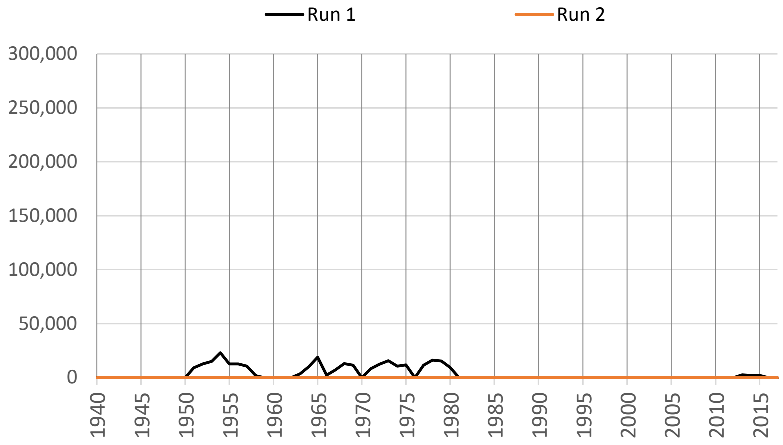
Net River Headgate Diversions



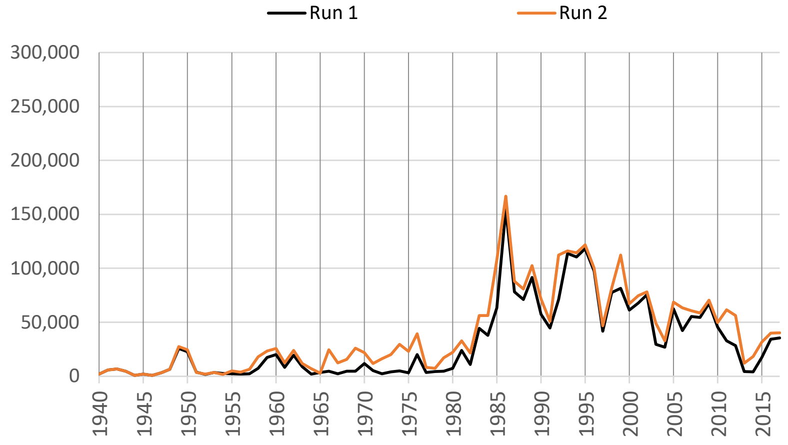
Farm Headgate Deliveries



Pumping



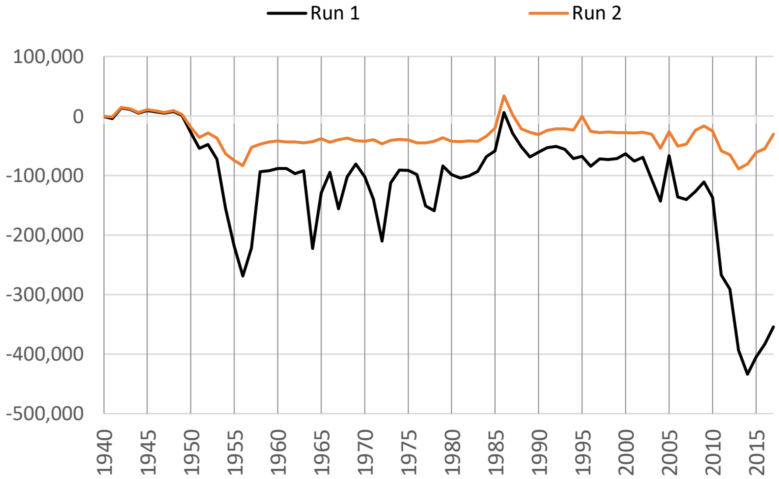
RHG Diversions - FHG Deliveries



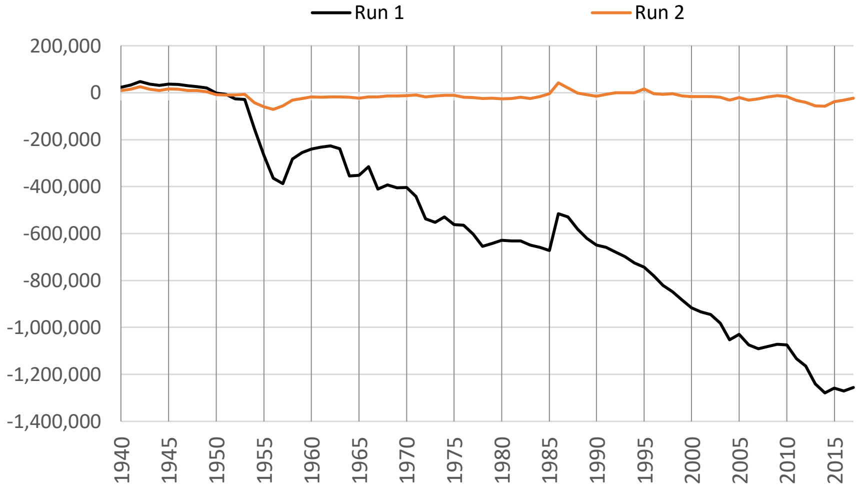
Note: HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

Run 2 - All Pumping Off
Cumulative Change in Ground Water Storage
Run 2 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

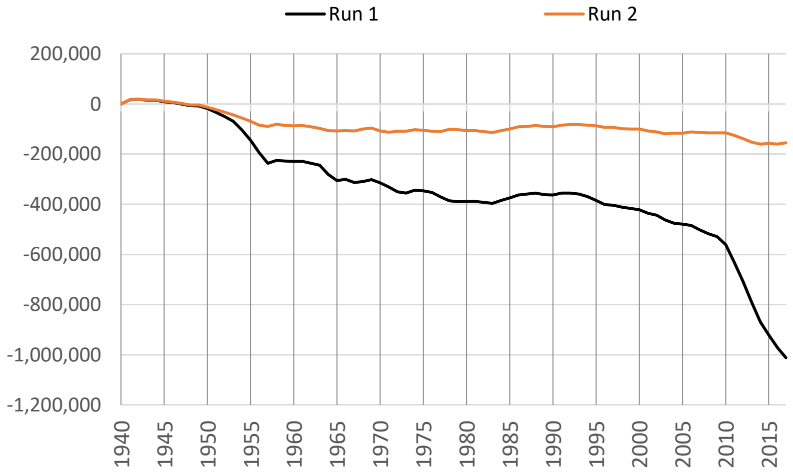
Rincon-Mesilla Alluvial Aquifer



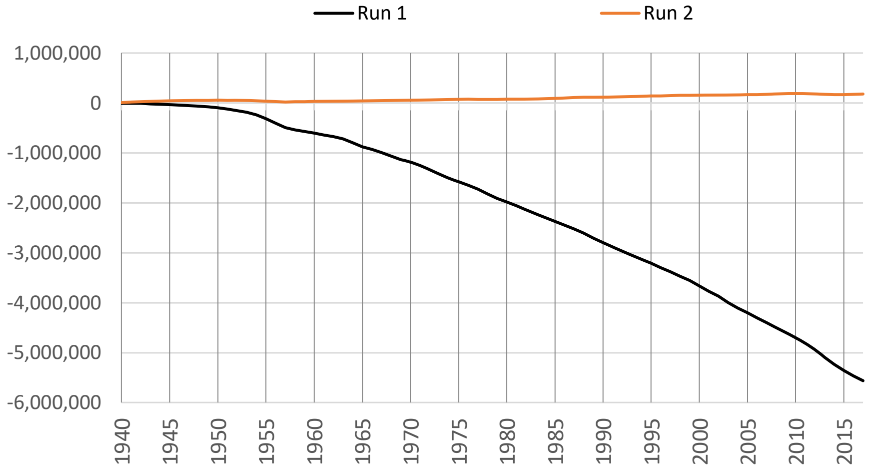
Hueco Alluvial Aquifer



Rincon-Mesilla Non-Alluvial Aquifer

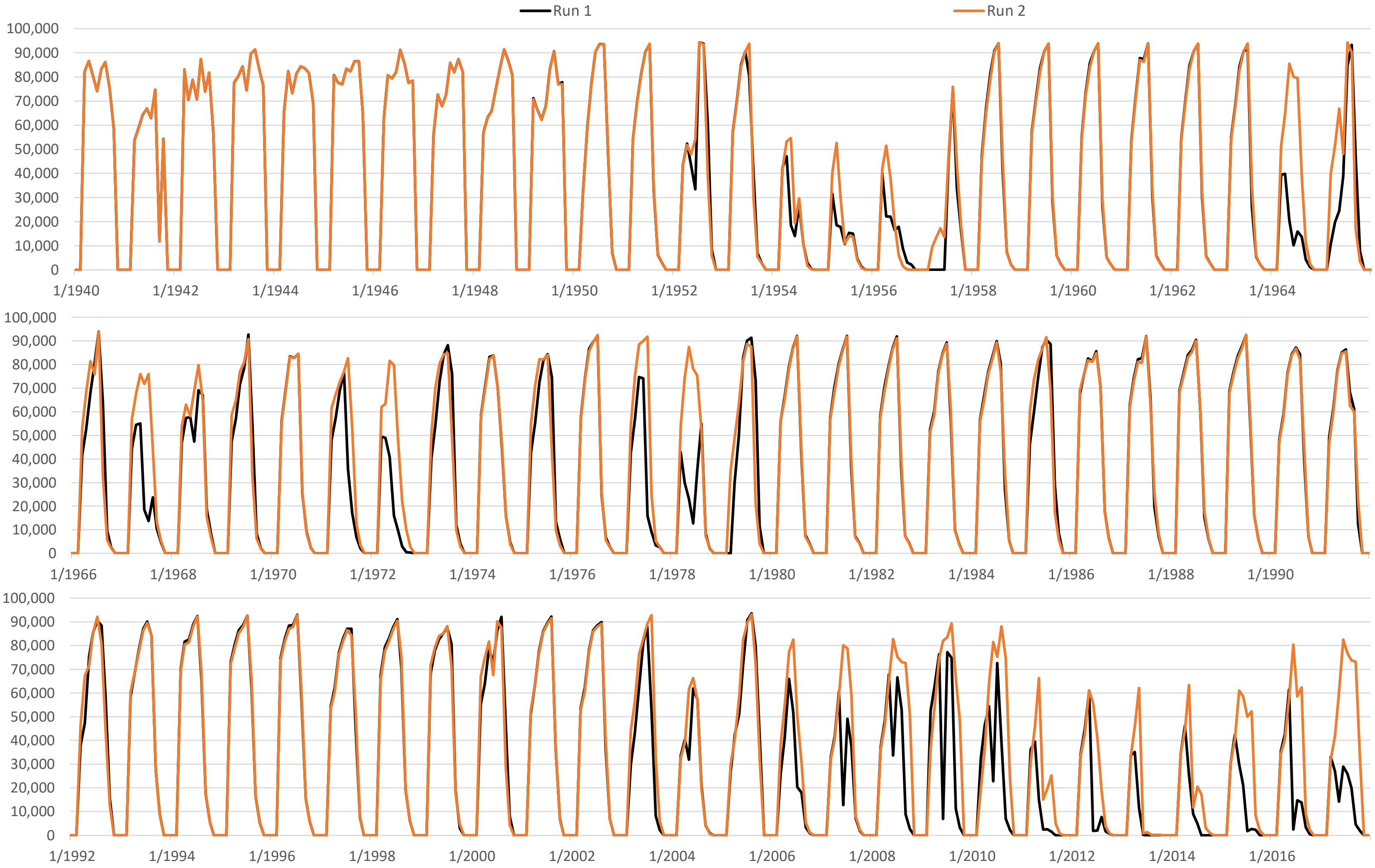


Hueco Non-Alluvial Aquifer



***Note different scales.**

Run 2 - All Pumping Off
Monthly Net RHG Diversions
Run 2 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)
EBID Total



Note: EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).

Run 2 - All Pumping Off
Monthly Net RHG Diversions
Run 2 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)
EPCWID Total

Note: EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

Run 2 - All Pumping Off

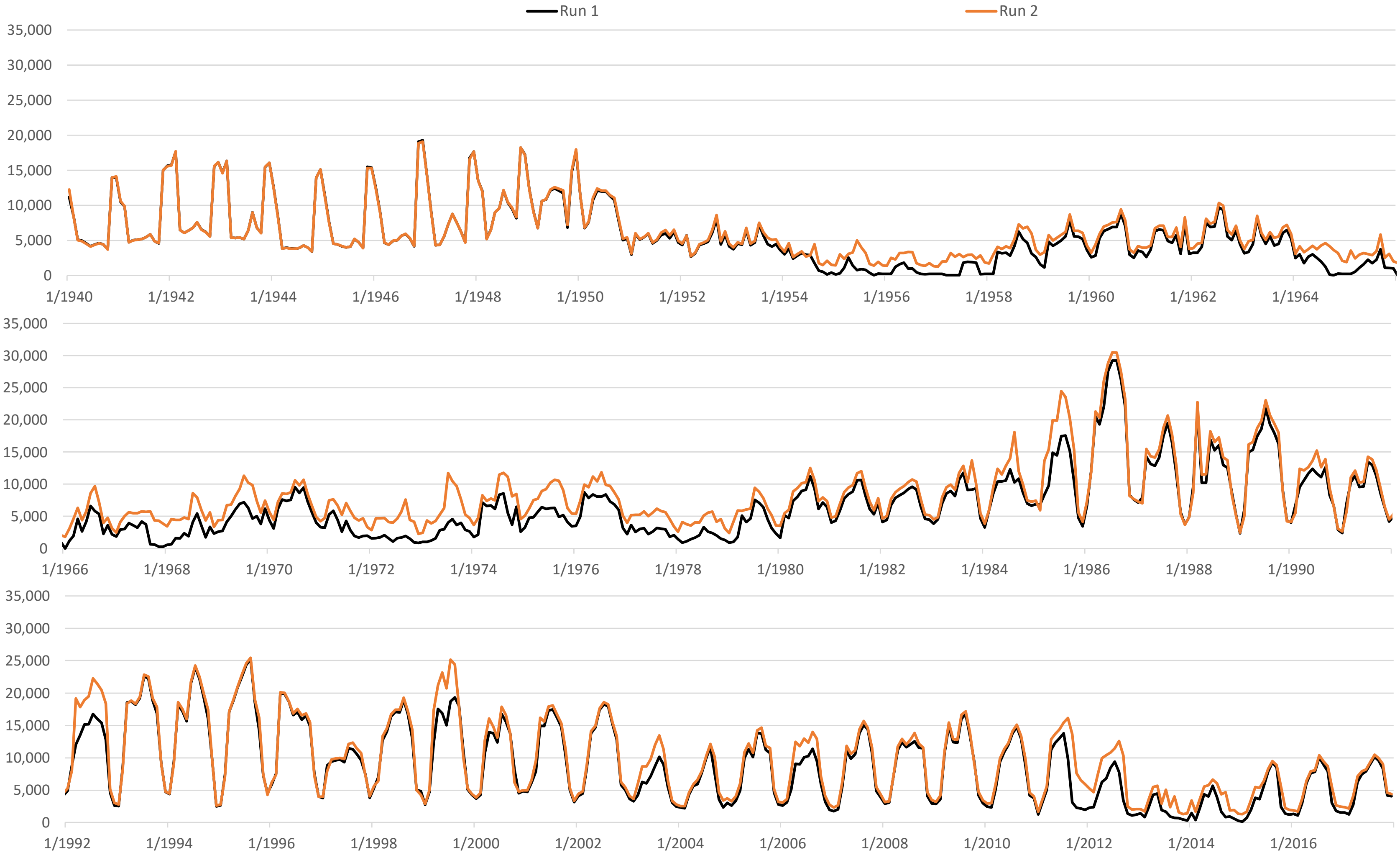
Monthly Net RHG Diversions

Run 2 v. Run 1

ILRG Model

1940 - 2017 (acre-feet)

HCCRD Total



Note: HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

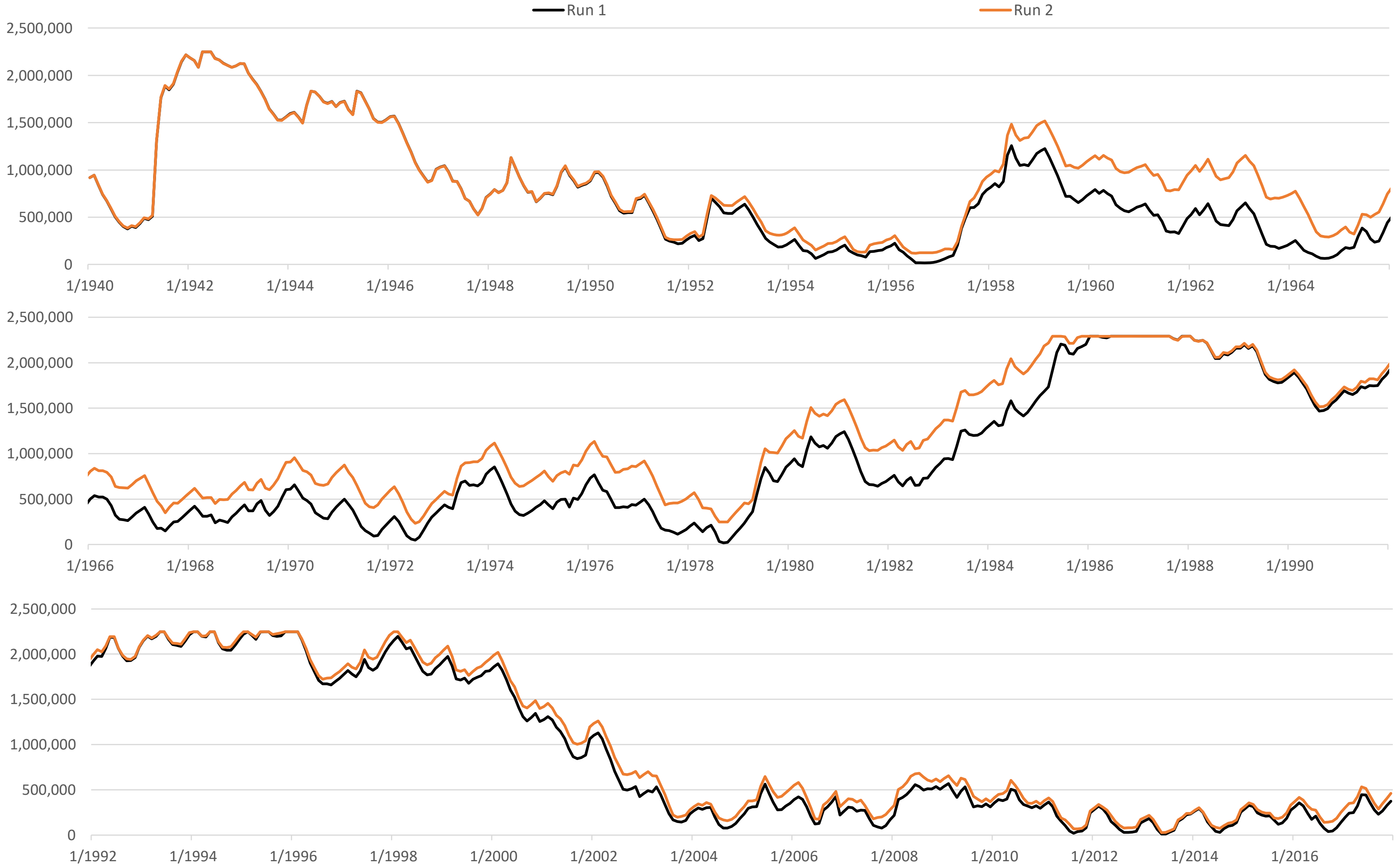
Run 2 - All Pumping Off

End of Month Reservoir Storage (Elephant Butte + Caballo)

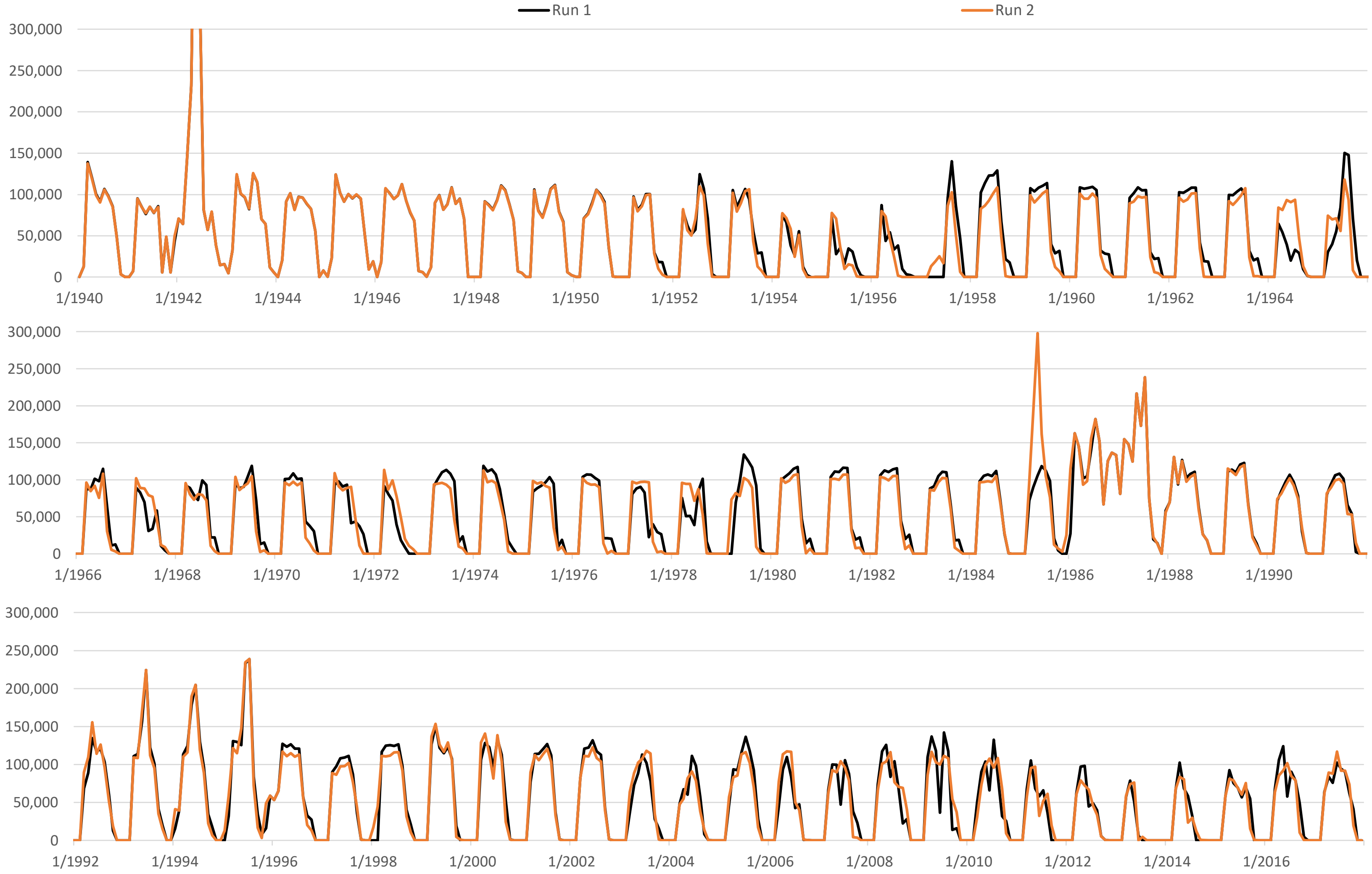
Run 2 v. Run 1

ILRG Model

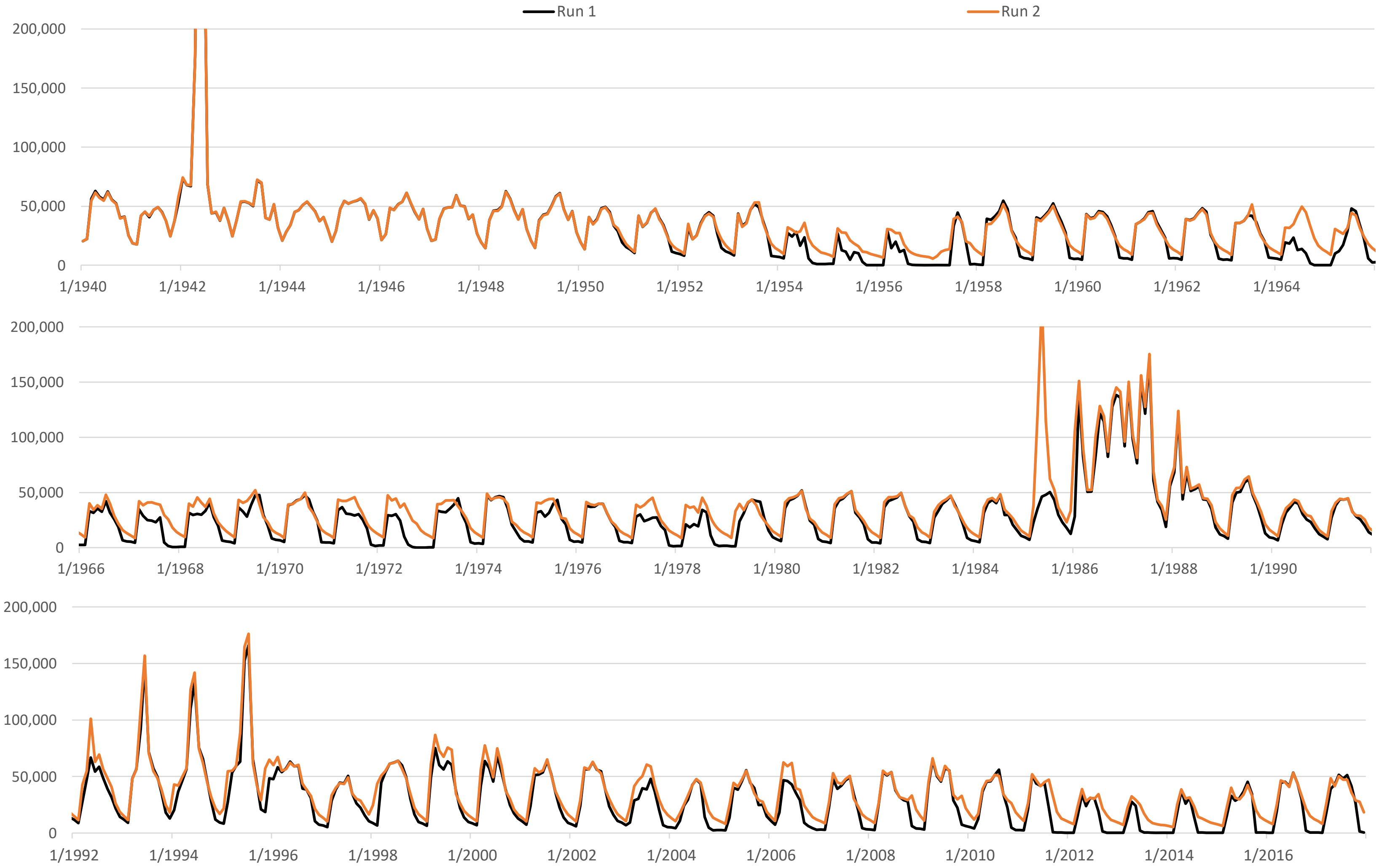
1940 - 2017 (acre-feet)



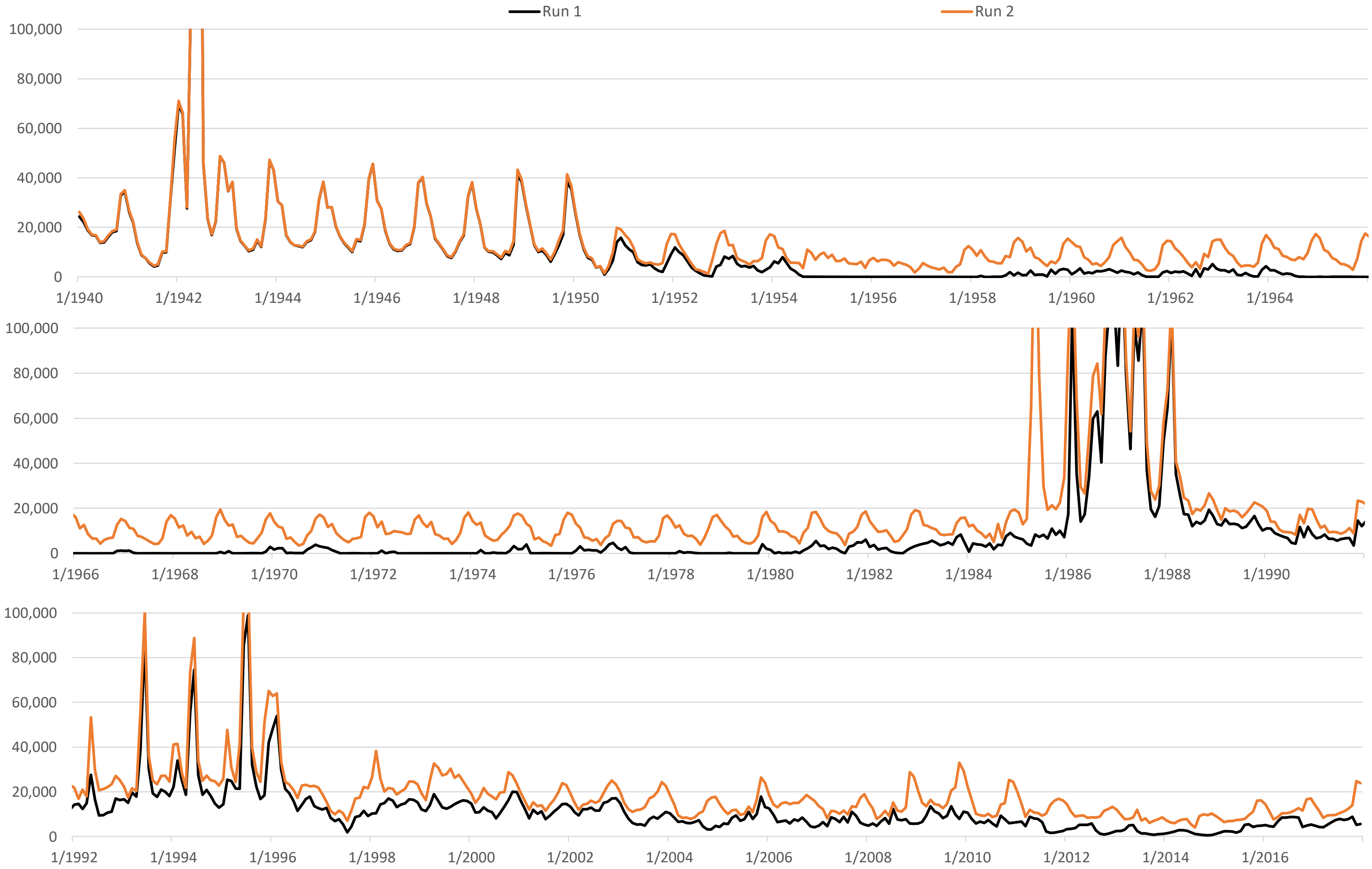
Run 2 - All Pumping Off
Monthly Caballo Releases
Run 2 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)



Run 2 - All Pumping Off
Monthly Rio Grande at El Paso Flow
Run 2 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)



Run 2 - All Pumping Off
Monthly Rio Grande at Fort Quitman Flow
Run 2 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)



Appendix 30C

Comparison of ILRG Model Runs
Run 3 v. Run 1

Model Run Specifications

Model Version: LRG_v116

Name: **Run 3 - NM Pumping Off**

Run ID: LRG_v116_Operational_Run3
Date: 8/24/2020

Name: **Run 1 - Historical Base Run**

Run ID: LRG_v116_Operational_Run1
Date: 8/23/2020

Selected Model Inputs

Pumping and Returns	Run 3	Run 1
Irrigation Pumping	NM Off	On
Irrigated Area	Hist	Hist
Non-Irrigation Pumping	NM Off	On
Non-Irrigation Pumping Returns	NM Off	On
Las Cruces Jornada Pumping Returns	Off	On

Project Allocation Rules		
1950-2005	D1/D2	D1/D2
2006-2007	D3	D3
2008-2017	D3 + CO	D3 + CO

EPCWID Operations		
Charge EPCWID for Use of WWTP Returns	Off	Off
ACE and Haskell Credits for EPCWID	On	On
Increased EPCWID Use of Fabens Drain Flows	Off	Off
Charge EPCWID for Fabens Drain Flow Use	Off	Off

Run 3 - NM Pumping Off

Comparison of ILRG Model Runs

Run 3 v. Run 1

1951 - 2017 Annual Average

(1,000 acre-feet)

Run No.	1	3	3 - 1		
Simulated Input or Output	**Run 1**	**Run 3**	**Run 3 minus Run 1**		
Pumping Stress					
Irrigation Pumping	140.4	0.0	-140.4		
Non-Irrigation Pumping	181.0	153.9	-27.1		
WWTP Flows	58.0	52.3	-5.7		
Urban Deep Percolation	13.1	10.0	-3.0		
Total Stress	250.3	91.5	-158.8		
	Stress is Pumping minus WWTP and Urban Deep Perc				
Effects of Pumping Stress				***% Chg***	
FHG Deliveries (Mar - Oct)				***Stress***	***% Diff.***
EBID	167.6	198.8	31.2	*-20%*	*19%*
EPCWID (incl. EPW)	139.9	151.6	11.7	*-7%*	*8%*
HCCRD	32.8	34.5	1.6	*-1%*	*5%*
Total	340.3	384.9	44.6	*-28%*	*13%*
FHG Deliveries (Nov - Feb)					
EBID	0.0	0.1	0.1	*0%*	*950%*
EPCWID (incl. EPW)	0.2	0.2	0.0	*0%*	*-1%*
HCCRD	2.4	2.3	-0.1	*0%*	*-5%*
Total	2.6	2.5	-0.1	*0%*	*-3%*
Irrigation Pumping					
EBID	140.4	0.0			
EPCWID (Mesilla Valley)	7.4	5.8	-1.5	*1%*	*-21%*
EPCWID (El Paso Valley)	40.1	31.9	-8.2	*5%*	*-20%*
HCCRD	4.2	2.1	-2.1	*1%*	*-51%*
	51.7	39.8	-11.9	*7%*	*-23%*
	Pumping turned off.	*Other values are simulated responses and are totaled.*			
Other Inflows/Outflows					
Net Reservoir Evaporation	125.3	141.2	15.9	*-10%*	*13%*
Riparian ET	70.9	76.8	5.9	*-4%*	*8%*
River Evaporation + Incidental Canal Loss	30.3	32.1	1.8	*-1%*	*6%*
Total	226.6	250.2	23.6	*-15%*	*10%*
Rio Grande at Fort Quitman					
Reservoir Spills	33.3	47.0	13.7	*-9%*	*41%*
Nov-Feb Flows	21.4	41.3	19.9	*-13%*	*93%*
Mar - Oct Flows	41.1	56.4	15.4	*-10%*	*37%*
Underflow (GW Model)	0.2	0.3	0.1	*0%*	*24%*
Total	96.0	145.0	49.0	*-31%*	*51%*

Run 3 - NM Pumping Off

Comparison of ILRG Model Runs

Run 3 v. Run 1
1951 - 2017 Annual Average
(1,000 acre-feet)

Run No.	1	3	3 - 1		
Simulated Input or Output	**Run 1**	**Run 3**	**Run 3 minus Run 1**		
Effects of Pumping Stress (continued)				***% Chg***	
Change in Storage				***Stress***	***% Diff.***
Reservoir Storage	-4.7	-3.5	1.2	*-1%*	*-25%*
Alluvial GW Storage (RW Model)	-23.6	-17.4	6.2	*-4%*	*-26%*
Non-alluvial GW Storage (GW Models)	-96.4	-82.8	13.5	*-9%*	*-14%*
Soil Moisture Storage	0.6	0.7	0.1	*0%*	*24%*
Total	-124.0	-103.0	21.0	*-13%*	*-17%*
Summary of Effects					
FHG Deliveries (Mar-Oct)	340.3	384.9	44.6	*-28%*	*13%*
FHG Deliveries (Nov-Feb)	2.6	2.5	-0.1	*0%*	*-3%*
Irrigation Pumping	51.7	39.8	-11.9	*7%*	*-23%*
Riparian ET + Evaporation	226.6	250.2	23.6	*-15%*	*10%*
Fort Quitman Flow	96.0	145.0	49.0	*-31%*	*51%*
Change in Storage	-124.0	-103.0	21.0	*-13%*	*-17%*
Total	593.1	719.4	126.3	*-80%*	*21%*
Other Effects of Pumping Stress				***% Chg***	
Rio Grande at El Paso				***Stress***	***% Diff.***
Reservoir Spills	49.4	64.6	15.2	*-10%*	*31%*
Nov-Feb Flows	22.8	45.7	23.0	*-14%*	*101%*
Mar - Oct Flows	263.8	286.7	22.9	*-14%*	*9%*
Total	336.0	397.1	61.1	*-38%*	*18%*
Rio Grande below Caballo					
Reservoir Spills	65.9	82.7	16.9	*-11%*	*26%*
Nov-Feb Flows	0.5	0.2	-0.3	*0%*	*-57%*
Mar - Oct Flows	541.3	508.1	-33.2	*21%*	*-6%*
Total	607.6	591.0	-16.6	*10%*	*-3%*
Surface Water Diversions (Mar - Oct)					
EBID	366.5	412.8	46.3	*-29%*	*13%*
EPCWID (incl. EPW)	236.8	255.3	18.5	*-12%*	*8%*
HCCRD	67.5	74.1	6.5	*-4%*	*10%*
Total	670.8	742.1	71.3	*-45%*	*11%*
Surface Water Diversions (Nov - Feb)					
EBID	0.0	0.0	0.0	*0%*	*0%*
EPCWID (incl. EPW)	14.3	17.4	3.0	*-2%*	*21%*
HCCRD	14.2	16.8	2.6	*-2%*	*18%*
Total	28.5	34.2	5.6	*-4%*	*20%*

Run 3 - NM Pumping Off

Annual Differences in ILRG Model Outputs

Run 3 minus Run 1

1940 - 2017 (acre-feet)

	Net River Headgate Diversions						Farm Headgate Deliveries						Annual Flows		
	EBID		EPCWID (incl. EPW)		HCCRD		EBID		EPCWID (incl. EPW)		HCCRD				
Year	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Caballo Releases	Rio Grande at El Paso	Rio Grande at Fort Quitman
1940	-96	-96	5	3	1	1	17	49	3	2	1	1	-127	-29	-53
1941	-306	-306	-2	-4	-1	-2	-47	-10	-1	0	-1	-4	105	276	169
1942	-193	-193	-1	-5	1	4	14	52	2	8	1	0	-268	153	129
1943	-235	-235	0	-5	3	5	25	65	-8	-9	2	-1	-270	120	36
1944	-272	-272	-153	-138	-107	-85	5	46	9	-10	-97	-98	-418	-73	17
1945	-269	-269	-3	39	-104	-32	23	60	-5	-32	-102	30	-367	89	41
1946	-212	-212	20	53	12	40	41	82	17	18	-5	-66	-316	169	183
1947	-252	-252	-8	61	-34	19	24	68	-5	-15	-38	-38	-386	143	171
1948	-1,032	-1,032	80	103	2	19	484	532	85	77	3	3	-891	17	31
1949	-2,151	-2,151	-89	-86	-19	-8	164	217	-48	-52	0	0	-2,873	-107	-91
1950	63	63	146	212	5	89	2,057	2,112	94	111	0	-1	-1,052	8,896	6,073
1951	984	984	218	245	93	192	3,071	3,127	180	203	69	115	-23,154	11,765	10,030
1952	464	464	500	539	165	264	6,543	6,600	375	411	170	255	-38,896	21,167	15,711
1953	230	230	-315	-276	278	380	6,725	6,780	-222	-181	83	-135	-41,209	25,263	19,770
1954	27,222	27,222	20,902	27,845	1,754	3,303	22,016	22,053	16,881	16,933	2,042	3,333	-9,023	80,958	23,834
1955	50,004	50,004	38,972	51,943	7,071	9,585	31,143	31,168	28,094	27,930	6,474	8,628	805	104,717	17,517
1956	20,506	20,506	21,680	36,034	5,143	5,636	20,194	20,216	18,706	17,961	5,400	5,305	-49,829	85,890	9,140
1957	65,790	65,790	37,242	49,284	4,239	6,640	22,227	22,264	8,752	8,392	2,481	3,693	-35,030	87,893	8,097
1958	-540	-540	-14,306	-5,889	6,079	11,895	10,303	10,346	-1,296	-1,322	-1,397	859	-153,702	17,395	30,809
1959	-239	-239	-3,317	-502	2,905	6,066	6,117	6,166	261	318	403	682	-74,571	20,578	32,468
1960	-207	-207	-1,677	768	1,466	3,085	6,151	6,201	219	277	0	0	-72,303	21,215	30,000
1961	-211	-211	-1,175	978	1,797	3,418	5,600	5,649	1,722	1,777	1,098	-817	-62,295	20,960	33,969
1962	-163	-163	-419	1,627	1,383	2,651	5,621	5,670	518	572	213	81	-67,197	21,798	31,310
1963	8,731	8,731	-797	1,768	1,179	2,792	10,909	10,958	276	331	461	478	-52,618	31,524	29,514
1964	244,624	244,624	147,016	154,459	14,276	18,915	130,791	130,838	94,769	94,480	12,381	14,864	244,864	213,207	58,632
1965	84,431	84,431	22,016	29,434	8,880	15,292	61,208	61,267	26,208	25,872	9,304	13,121	-79,686	82,850	62,843
1966	830	830	30,383	34,337	14,218	18,424	-3,212	-3,163	16,726	16,796	-3,642	-5,539	-62,202	66,650	66,393
1967	156,007	156,007	106,422	113,405	15,880	23,907	85,106	85,152	69,471	69,043	10,090	11,522	117,433	156,512	52,632
1968	37,794	37,794	-6,061	559	10,249	18,542	39,685	39,742	1,376	1,057	9,160	7,979	-89,278	47,784	48,304
1969	1,383	1,383	36,190	38,918	18,861	23,219	-3,554	-3,501	20,308	20,364	3,024	-1,398	-55,149	65,290	57,437
1970	-459	-459	-3,230	-1,795	3,269	5,594	7,066	7,118	-666	-618	-1,274	-2,725	-89,289	19,994	34,270
1971	119,074	119,074	42,198	46,146	11,645	15,288	65,995	66,049	21,958	22,032	8,859	10,869	17,297	99,727	38,480
1972	126,680	126,680	81,097	91,811	8,090	14,773	69,289	69,331	55,286	55,205	7,506	7,072	76,423	139,434	40,277
1973	-1,366	-1,366	-6,402	1,194	12,696	18,411	11,357	11,407	1,364	1,194	14,006	14,423	-137,569	27,897	30,985
1974	-762	-762	-506	2,417	7,524	12,499	11,821	11,876	1,616	1,678	-754	-1,878	-79,620	32,131	39,185
1975	947	947	34,627	36,263	18,953	23,752	-3,882	-3,835	18,523	18,578	8,209	3,692	-53,214	64,767	43,868
1976	-245	-245	-627	1,195	5,246	10,623	6,726	6,757	461	494	-1,658	-5,752	-74,903	20,948	33,379
1977	154,691	154,691	40,116	45,490	13,096	18,707	87,670	87,721	19,996	20,065	11,515	11,912	56,467	97,052	30,458
1978	187,071	187,071	25,593	33,315	3,934	11,483	123,344	123,393	22,464	22,554	5,317	6,255	40,744	93,976	36,844

Run 3 - NM Pumping Off

Annual Differences in ILRG Model Outputs

Run 3 minus Run 1

1940 - 2017 (acre-feet)

	Net River Headgate Diversions						Farm Headgate Deliveries						Annual Flows		
	EBID		EPCWID (incl. EPW)		HCCRD		EBID		EPCWID (incl. EPW)		HCCRD				
Year	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Caballo Releases	Rio Grande at El Paso	Rio Grande at Fort Quitman
1979	2,325	2,325	22,848	27,297	8,484	14,190	9,253	9,305	17,922	17,986	2,729	311	-99,403	38,741	42,062
1980	-518	-518	-124	448	3,524	6,039	7,108	7,166	768	844	-3,189	-6,812	-65,715	19,381	47,745
1981	-447	-447	-82	2,176	2,029	3,952	7,440	7,485	645	704	-56	-242	-68,802	24,057	36,777
1982	-431	-431	-24	2,446	1,634	3,289	6,943	6,998	613	795	-375	-1,153	-75,243	24,800	44,604
1983	-337	-337	26	2,124	1,721	3,179	6,384	6,439	465	608	0	0	-64,570	21,884	35,745
1984	-531	-531	170	1,759	4,988	6,209	6,071	6,116	503	615	0	0	-37,267	21,321	28,654
1985	2,185	2,185	64,010	64,067	34,844	36,264	-6,670	-6,613	28,516	28,602	0	0	335,686	371,925	333,193
1986	-35	-35	-7,601	-7,600	1,089	2,593	5,995	6,068	-4,139	-4,102	0	0	87,161	133,112	262,461
1987	-762	-762	-15	-7	981	1,587	3,573	3,640	446	471	0	0	-11	37,803	62,024
1988	-405	-405	-30	-19	834	1,329	4,215	4,281	312	336	0	0	-20,029	19,834	27,113
1989	-154	-154	185	209	714	1,049	5,156	5,210	377	408	0	0	-34,986	14,188	17,830
1990	-212	-212	221	318	2,187	2,436	5,221	5,279	241	299	0	0	-24,168	18,131	19,583
1991	-1,613	-1,613	6	50	673	919	2,849	2,914	210	336	0	0	-25,721	9,902	21,469
1992	1,917	1,917	75,564	75,272	35,308	36,697	-6,929	-6,868	34,244	33,917	0	0	84,039	128,281	116,616
1993	157	157	-5,497	-5,533	-431	436	5,975	6,045	-2,678	-2,656	0	0	-15,695	26,977	40,058
1994	-223	-223	263	261	720	1,200	7,373	7,457	650	688	0	0	-14,434	54,486	55,234
1995	-328	-328	2,440	2,426	2,609	3,246	9,431	9,508	253	253	0	0	30,526	116,123	111,567
1996	-383	-383	443	479	728	1,320	9,866	9,951	624	682	0	0	-65,529	34,405	37,924
1997	-248	-248	-220	-383	818	1,264	6,573	6,634	103	-323	0	0	-35,739	24,246	23,788
1998	-353	-353	987	973	1,269	1,180	7,316	7,394	949	987	0	0	-18,411	44,048	47,460
1999	-122	-122	860	1,376	354	721	6,099	6,159	2,559	2,622	0	0	-27,342	28,082	28,222
2000	1,113	1,113	17,527	18,359	1,484	1,874	-2,866	-2,815	-2,095	-2,073	0	0	-33,557	30,945	34,218
2001	84	84	-665	-141	271	677	5,876	5,921	-182	-151	0	0	-33,968	19,011	19,539
2002	-248	-248	-232	818	490	1,075	6,757	6,798	243	279	0	0	-39,528	21,310	23,237
2003	121,481	121,481	47,140	48,153	13,026	14,159	71,509	71,574	21,247	21,309	0	0	92,835	104,794	62,568
2004	44,059	44,059	30,381	33,203	5,633	8,609	34,492	34,545	21,073	21,141	0	0	-27,876	63,431	40,608
2005	1,813	1,813	2,978	4,653	2,752	4,523	12,929	12,989	4,748	4,797	0	0	-77,608	21,106	32,475
2006	101,910	101,910	79,855	81,341	18,711	20,944	61,314	61,362	41,386	41,435	0	0	88,286	114,933	60,006
2007	106,680	106,680	6,212	8,450	2,463	4,583	74,196	74,244	7,263	7,335	0	0	-29,243	42,726	34,803
2008	186,956	186,956	2,838	4,983	2,222	3,749	127,019	127,135	3,726	3,872	0	0	34,982	54,062	53,783
2009	137,148	137,148	-1,548	917	857	2,603	94,648	94,743	-240	-130	0	0	1,113	54,879	58,304
2010	195,927	195,927	41,983	44,567	14,497	16,304	123,268	123,341	15,088	15,188	0	0	58,169	90,781	74,853
2011	86,109	86,109	49,649	53,427	17,696	25,020	44,335	44,373	34,204	34,292	0	0	-8,438	92,132	68,637
2012	88,948	88,948	40,370	43,986	18,139	25,464	45,362	45,392	29,152	29,236	0	0	-47,630	73,998	64,543
2013	63,296	63,296	46,089	49,210	13,038	16,253	33,291	33,321	28,292	28,363	5,864	6,279	22,632	90,050	53,761
2014	72,740	72,740	24,091	26,936	9,808	13,525	35,159	35,179	16,860	16,927	-189	-374	-31,236	62,525	45,328
2015	161,950	161,950	17,881	20,999	5,148	7,920	88,536	88,566	11,676	11,765	-4,340	-3,741	-38,008	45,959	50,621
2016	148,083	148,083	27,399	31,046	5,074	7,692	88,530	88,559	20,827	20,932	0	0	-55,273	66,691	47,677
2017	300,626	300,626	4,420	8,119	1,919	4,002	191,038	191,109	5,731	5,864	0	0	14,038	53,531	52,465
Averages															
1951-2017	46,290	46,290	18,465	21,473	6,547	9,155	31,204	31,257	11,745	11,744	1,642	1,510	-16,607	61,104	49,011
1951-1978	45,831	45,831	23,084	28,268	7,156	10,905	30,215	30,262	15,869	15,800	3,912	3,818	-30,239	63,548	34,506
1979-2005	6,214	6,214	9,317	10,118	4,768	5,926	8,812	8,873	4,764	4,792	-33	-292	-10,198	54,531	61,214
2006-2017	137,531	137,531	28,270	31,165	9,131	12,338	83,891	83,944	17,830	17,923	111	180	783	70,189	55,398
1985-2017	55,094	55,094	17,212	18,513	6,543	8,219	36,407	36,466	9,747	9,785	40	66	4,395	65,588	63,090
1985-2005	7,987	7,987	10,893	11,283	5,064	5,865	9,273	9,337	5,129	5,134	0	0	6,459	62,959	67,485

Notes:

EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).

EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

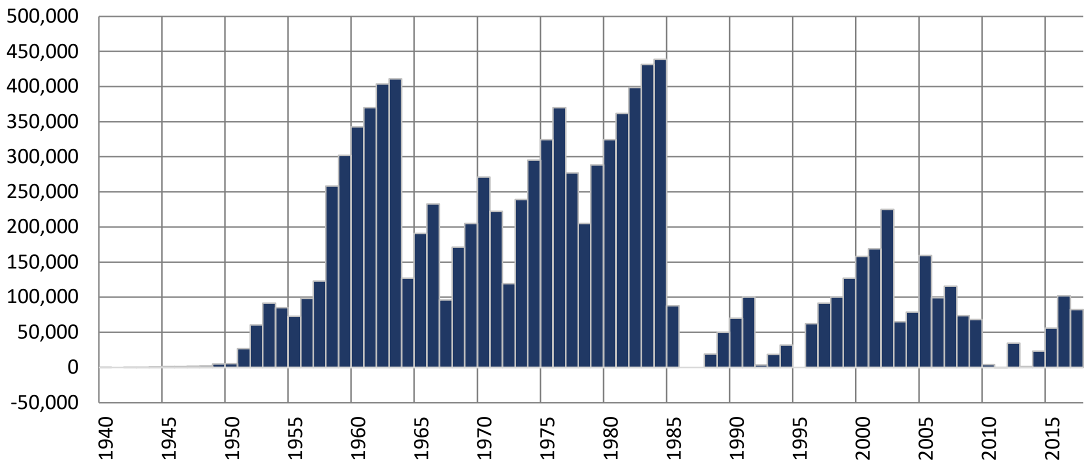
Run 3 - NM Pumping Off

Simulated Differences in ILRG Model Outputs

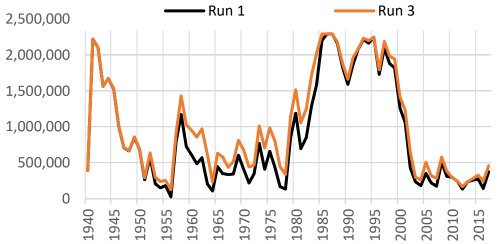
Run 3 minus Run 1

1940 - 2017 (acre-feet)

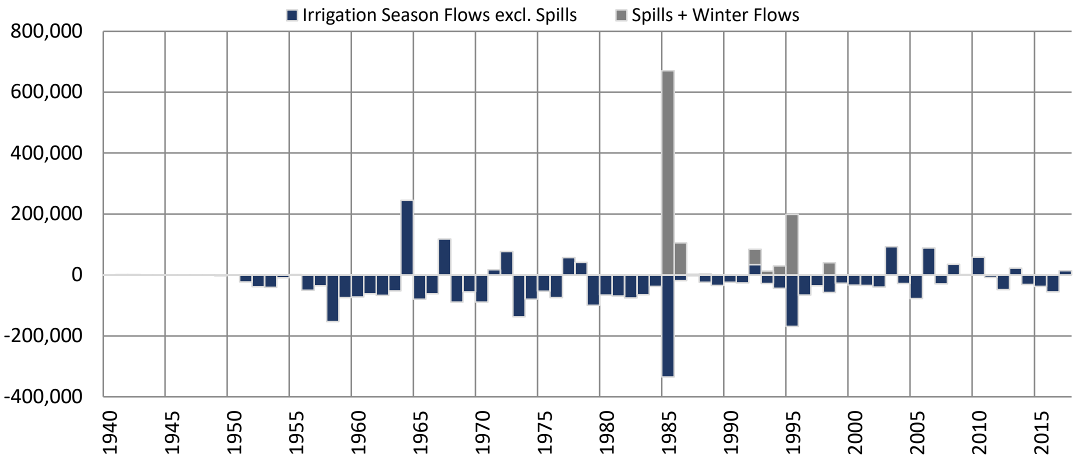
Total Project Storage (Year End)



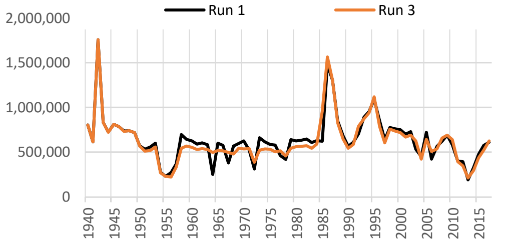
Period	Average Difference
1951-2017	1,151
1951-1978	7,128
1979-2005	-1,695
2006-2017	-6,390
1985-2017	-10,790
1985-2005	-13,305



Caballo Reservoir Outflows (Annual)



Period	Average Difference Irr Season (excl. Spills)	Nov-Feb and Spills	Annual
1951-2017	-33,225	16,618	-16,607
1951-1978	-30,239	0	-30,239
1979-2005	-51,435	41,237	-10,198
2006-2017	783	0	783
1985-2017	-29,344	33,740	4,395
1985-2005	-46,560	53,019	6,459



Notes:

Reservoir storage does not include storage attributed to SJC, CO, or NM credit waters.

Average differences calculated as (Final Storage - Initial Storage)/(no. years).

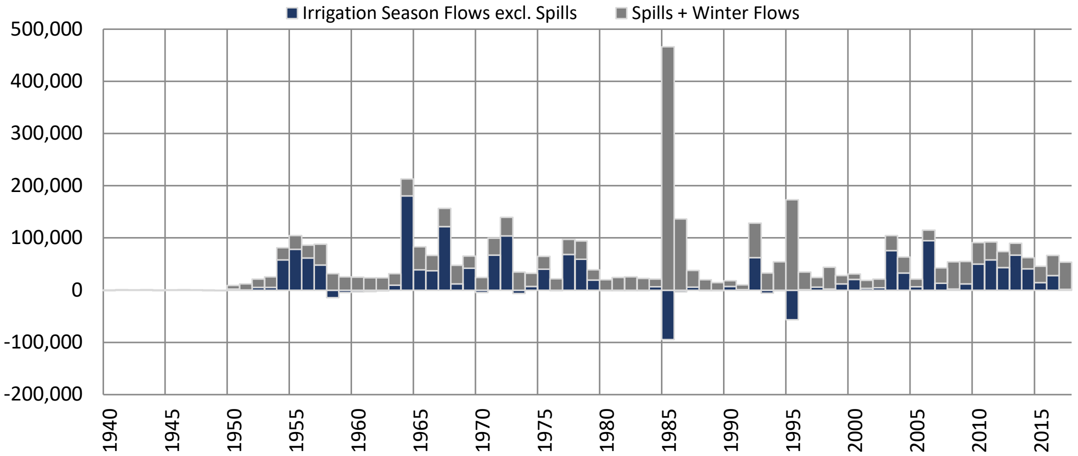
Run 3 - NM Pumping Off

Simulated Differences in ILRG Model Outputs

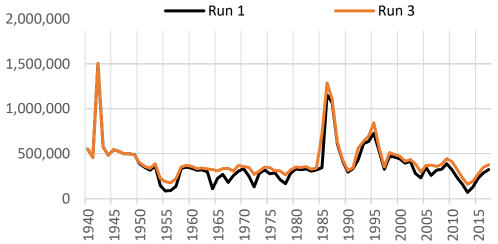
Run 3 minus Run 1

1940 - 2017 (acre-feet)

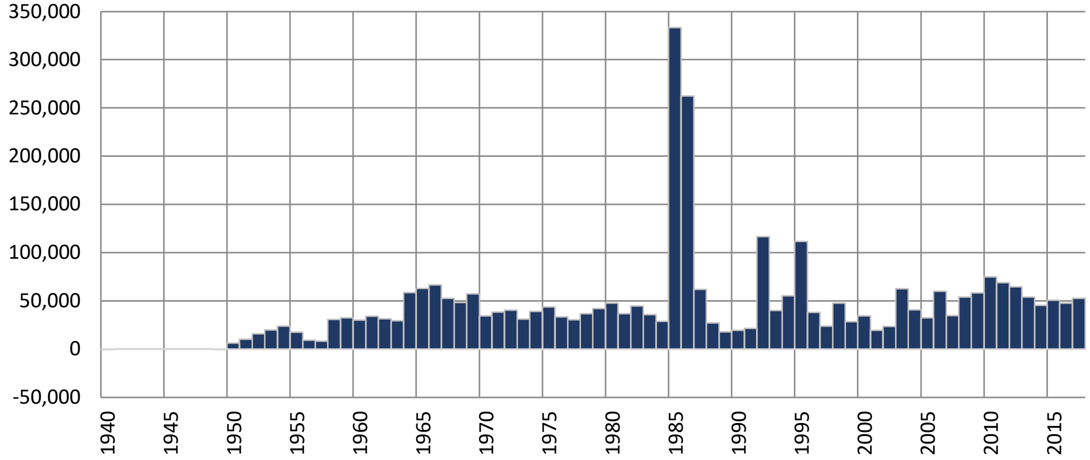
Rio Grande at El Paso (Annual)



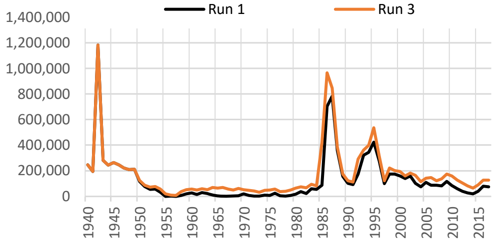
	Average Difference		
Period	Irr Season (excl. Spills)	Nov-Feb and Spills	Annual
1951-2017	22,907	38,197	61,104
1951-1978	35,942	27,606	63,548
1979-2005	3,827	50,704	54,531
2006-2017	35,419	34,770	70,189
1985-2017	15,288	50,300	65,588
1985-2005	3,785	59,174	62,959



Rio Grande at Fort Quitman (Annual)



Period	Average Difference
1951-2017	48,960
1951-1978	34,432
1979-2005	61,170
2006-2017	55,385
1985-2017	63,066
1985-2005	67,456



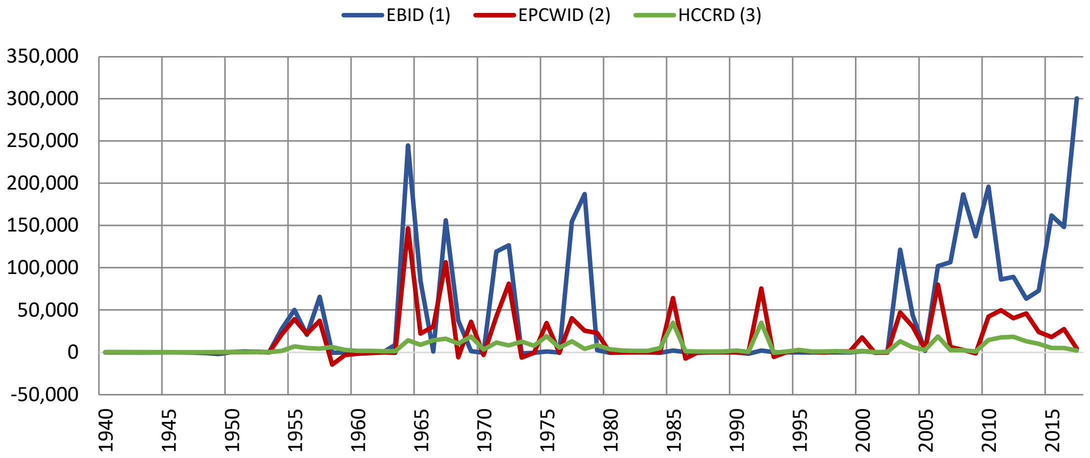
Run 3 - NM Pumping Off

Simulated Differences in ILRG Model Outputs

Run 3 minus Run 1

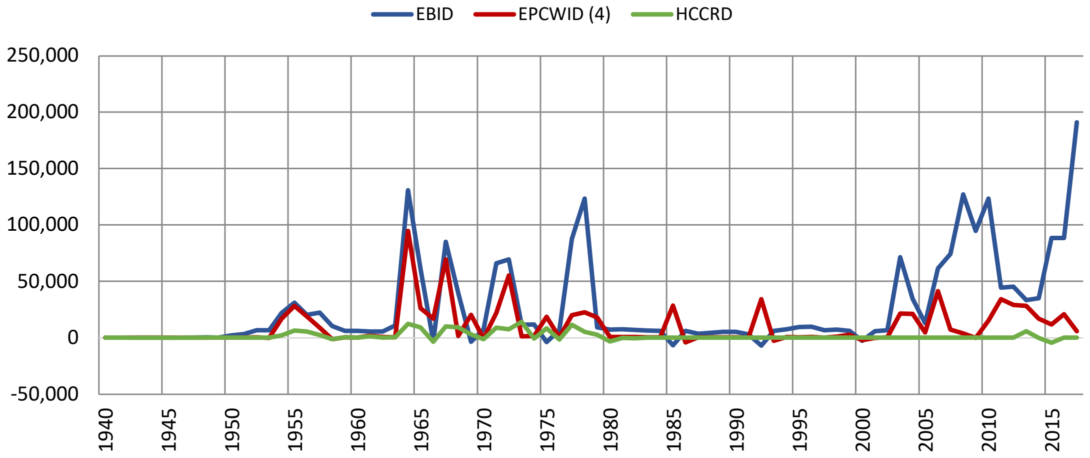
1940 - 2017 (acre-feet)

River Headgate (RHG) Diversions (Irrigation Season)



	Average Difference		
Period	EBID	EPCWID	HCCRD
1951-2017	46,290	18,465	6,547
1951-1978	45,831	23,084	7,156
1979-2005	6,214	9,317	4,768
2006-2017	137,531	28,270	9,131
1985-2017	55,094	17,212	6,543
1985-2005	7,987	10,893	5,064

Farm Headgate (FHG) Deliveries (Irrigation Season)



	Average Difference		
Period	EBID	EPCWID	HCCRD
1951-2017	31,204	11,745	1,642
1951-1978	30,215	15,869	3,912
1979-2005	8,812	4,764	-33
2006-2017	83,891	17,830	111
1985-2017	36,407	9,747	40
1985-2005	9,273	5,129	0

Notes:

(1) EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).

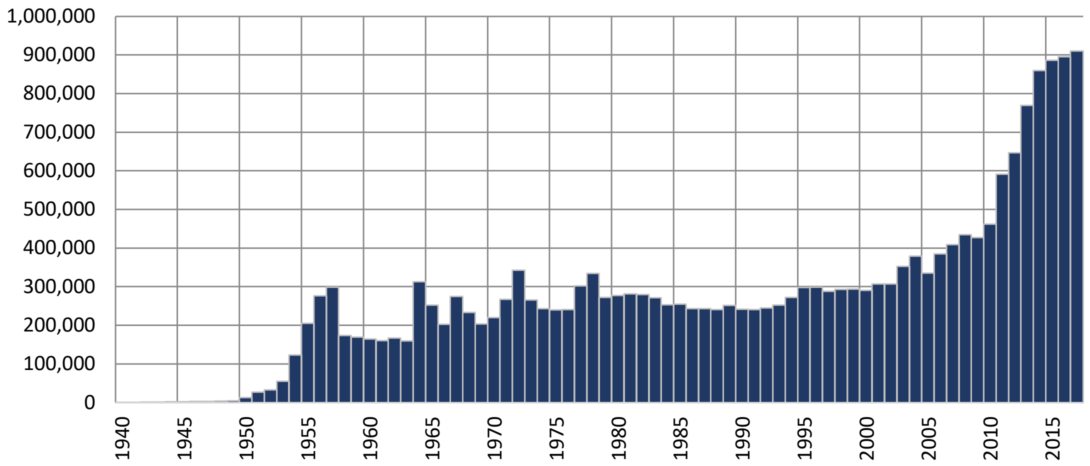
(2) EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

(3) HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

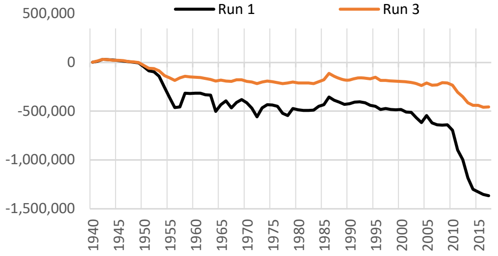
(4) EPCWID FHG values include deliveries to Rogers WTP and R/U WTP.

Run 3 - NM Pumping Off
Simulated Differences in ILRG Model Outputs
Run 3 minus Run 1
1940 - 2017 (acre-feet)

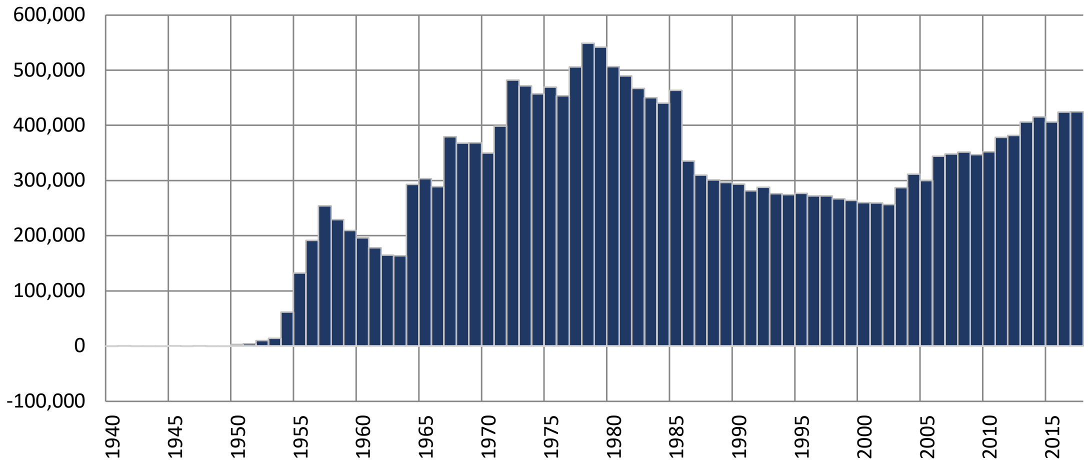
Cumulative Annual Rincon-Mesilla Groundwater Storage



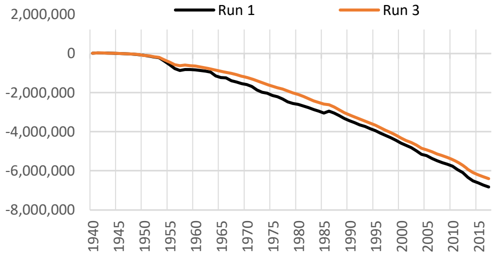
Period	Average Difference
1951-2017	13,394
1951-1978	11,472
1979-2005	36
2006-2017	47,933
1985-2017	19,917
1985-2005	3,908



Cumulative Annual Hueco Groundwater Storage



Period	Average Difference
1951-2017	6,296
1951-1978	19,498
1979-2005	-9,221
2006-2017	10,401
1985-2017	-473
1985-2005	-6,687



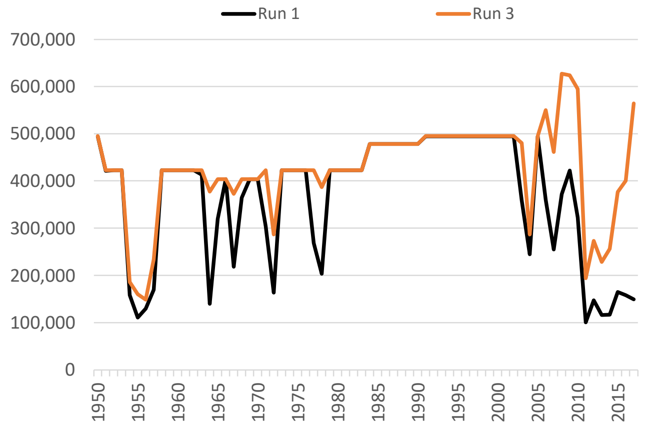
Notes:

Cumulative storage change in alluvial and non-alluvial aquifers.

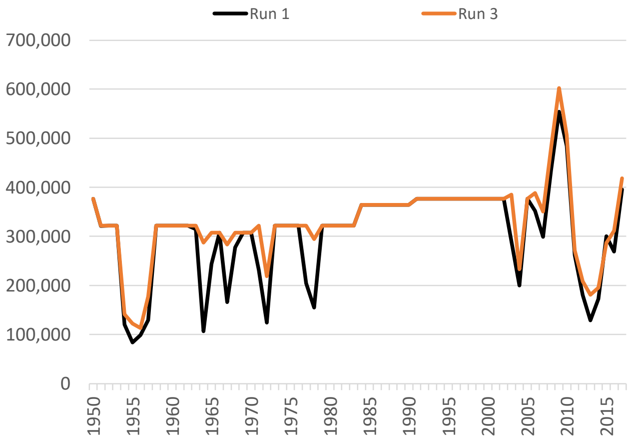
Average differences calculated as (Final Storage - Initial Storage)/(no. years).

Run 3 - NM Pumping Off
Annual Allocation and Charges
Run 3 v. Run 1
ILRG Model
1950 - 2017 (acre-feet)

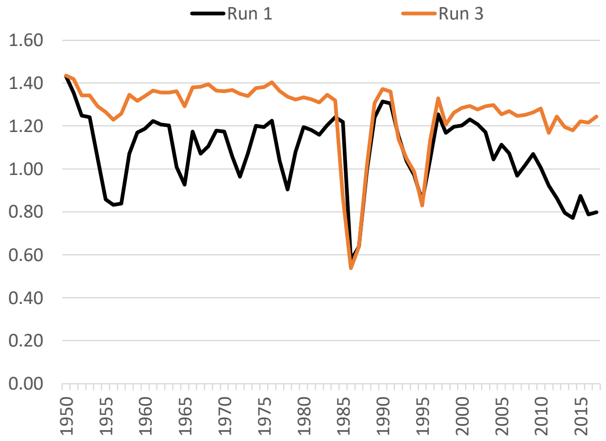
Total Allocation - EBID



Total Allocation - EPCWID

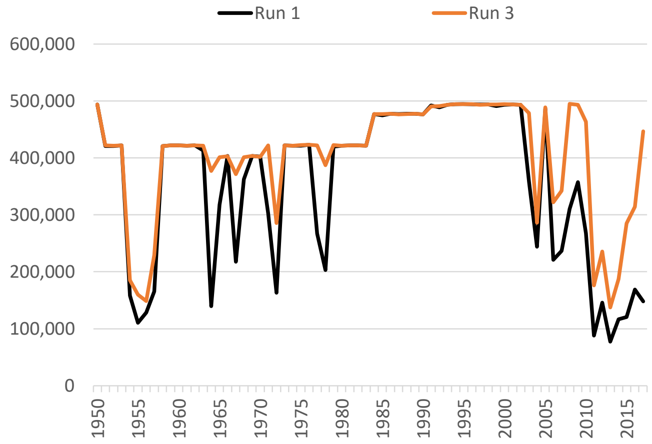


Diversion Ratio

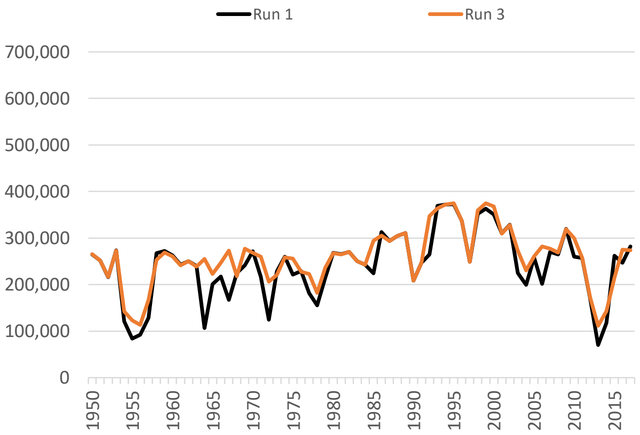


Note:
Computed as Total Charges/Caballo Release.

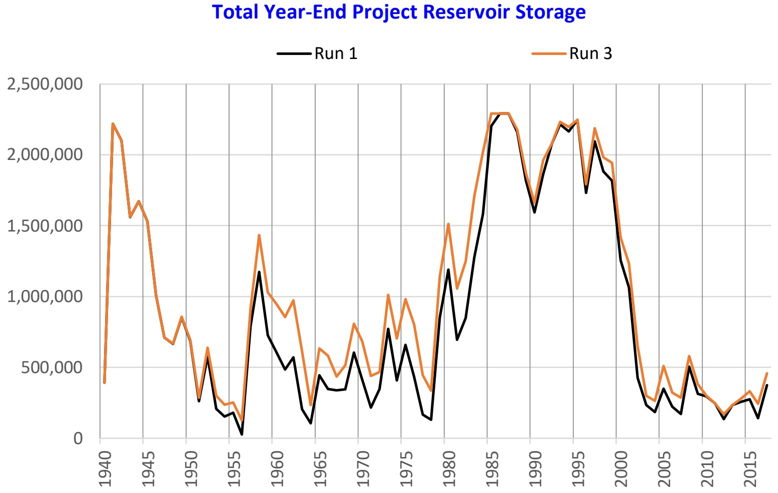
Annual Delivery Charges - EBID

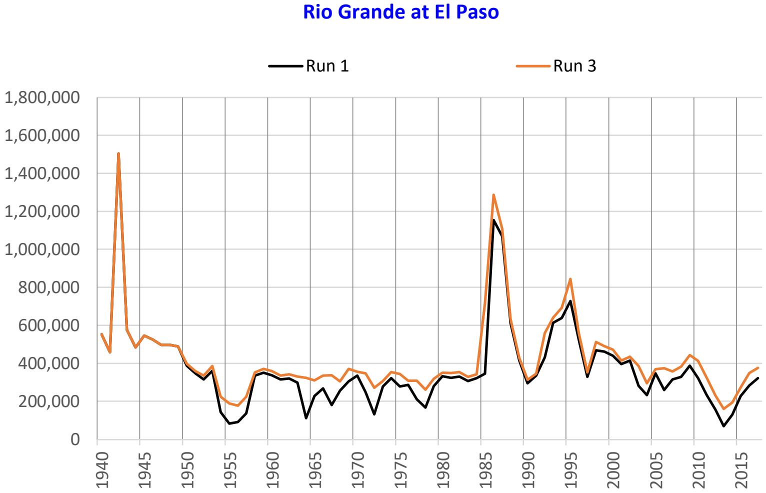


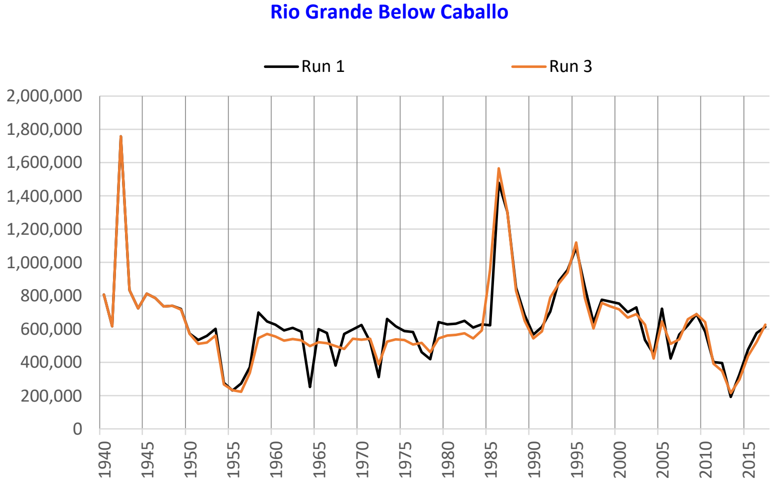
Annual Delivery Charges - EPCWID

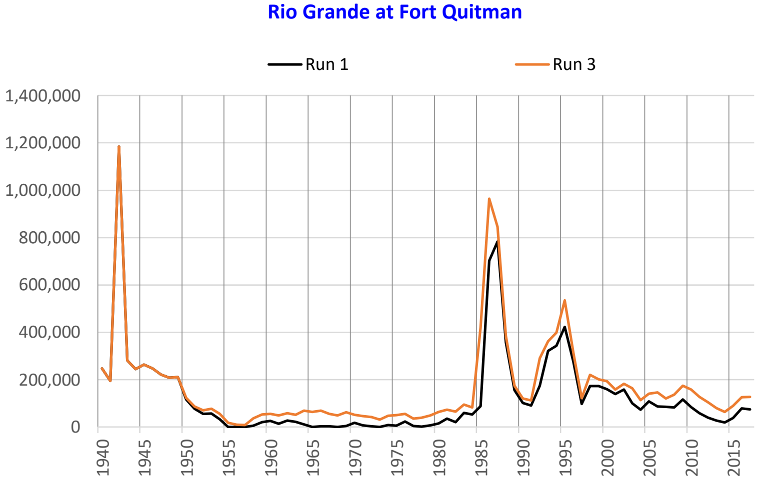


Run 3 - NM Pumping Off
Annual Summary of Project Storage and Rio Grande Flows
Run 3 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)







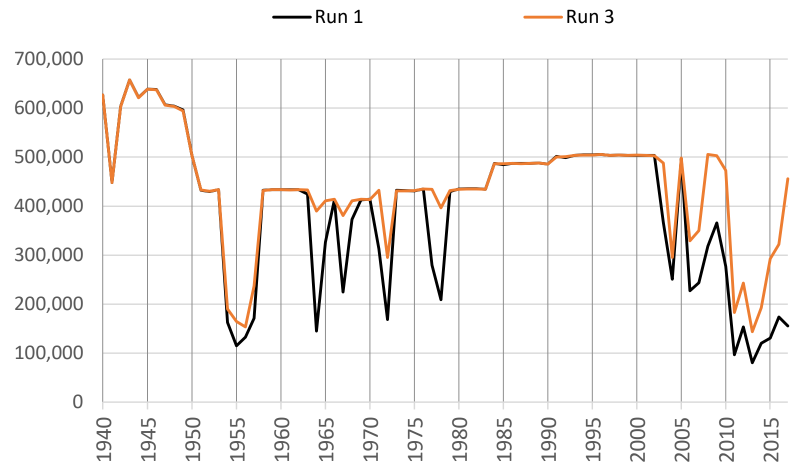


***Note different scales.**

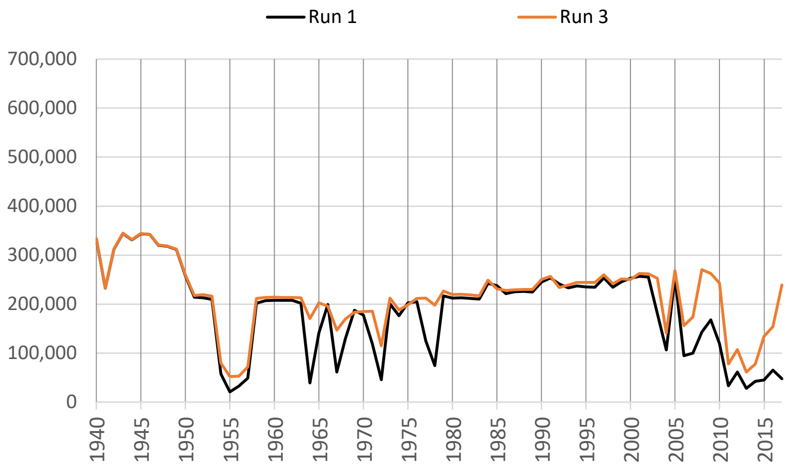
Run 3 - NM Pumping Off
Irrigation Season Summary of Irrigation Operations
Run 3 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

EBID Total

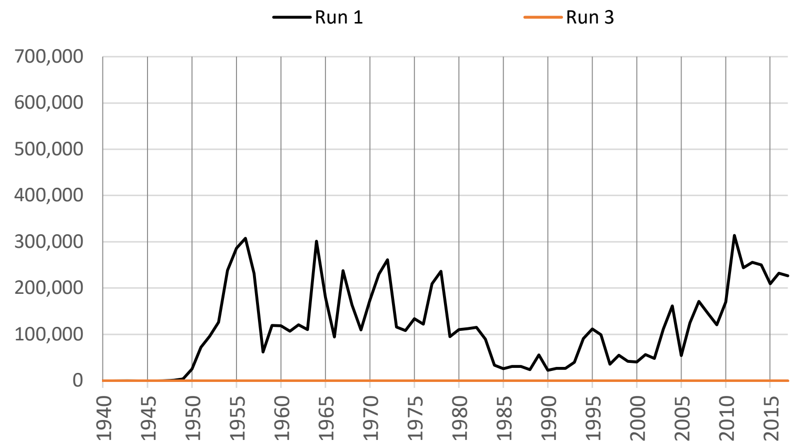
Net River Headgate Diversions



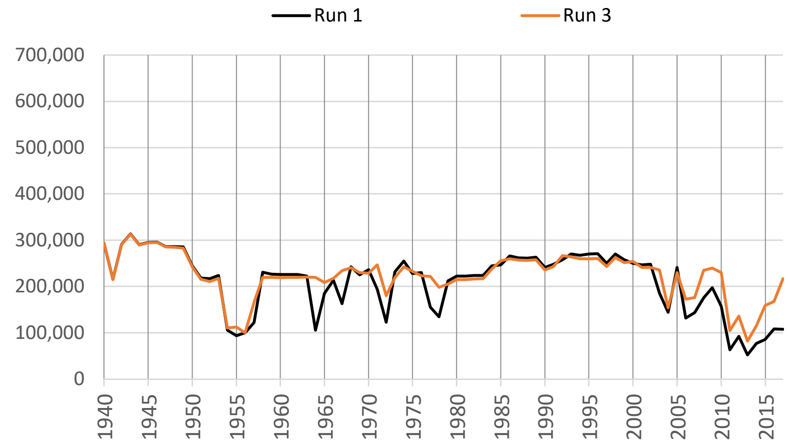
Farm Headgate Deliveries



Pumping



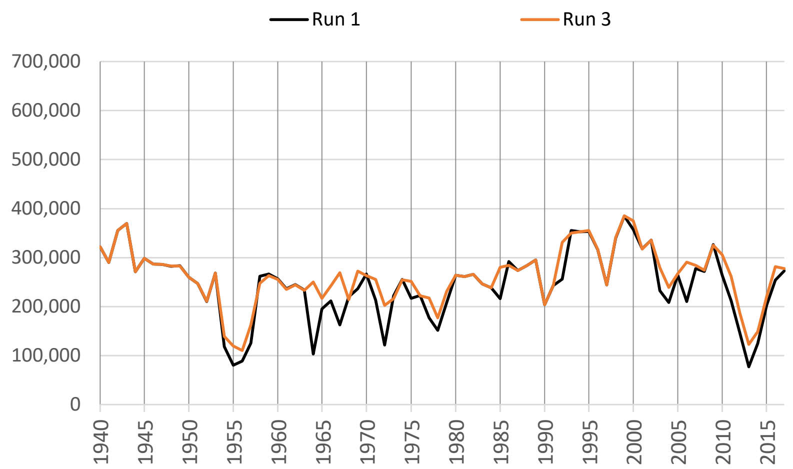
RHG Diversions - FHG Deliveries



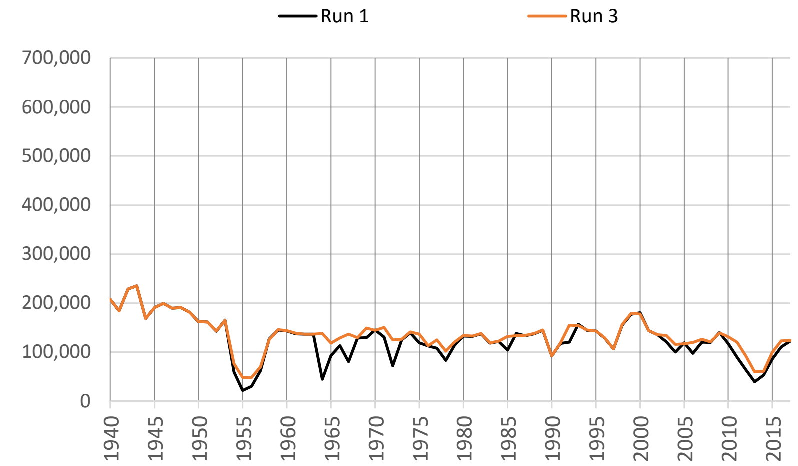
Notes: EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).
Pumping includes Supplemental and Primary groundwater pumping.

Run 3 - NM Pumping Off
Irrigation Season Summary of Irrigation Operations
Run 3 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

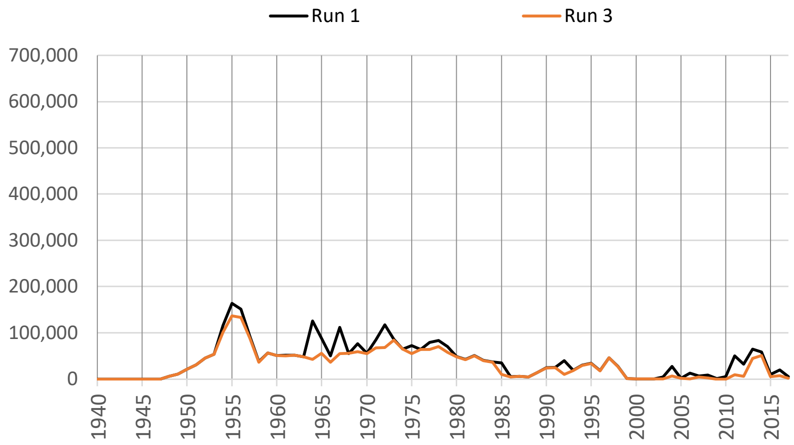
EPCWID Total



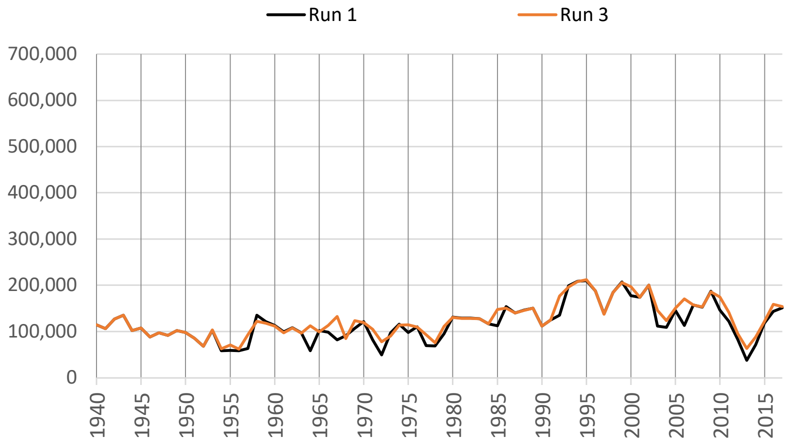
Net River Headgate Diversions



Farm Headgate Deliveries



Pumping



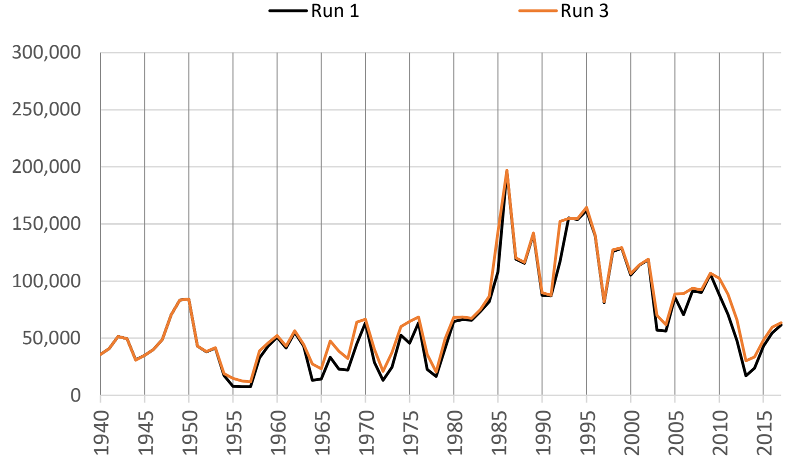
RHG Diversions - FHG Deliveries

Note: EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

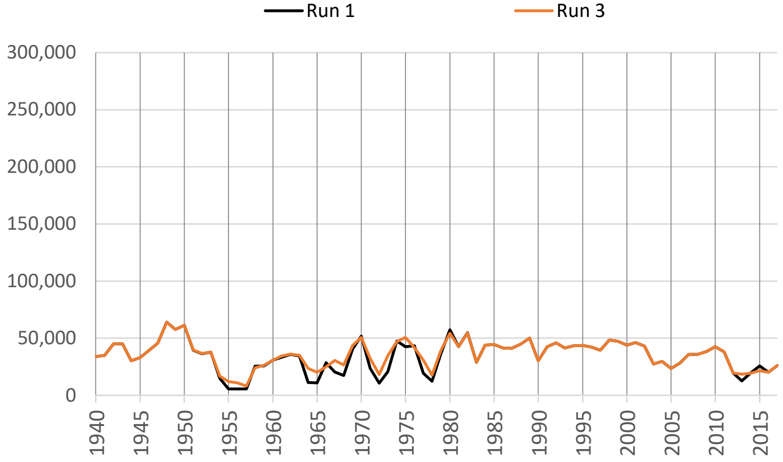
Run 3 - NM Pumping Off
Irrigation Season Summary of Irrigation Operations
Run 3 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

HCCRD Total

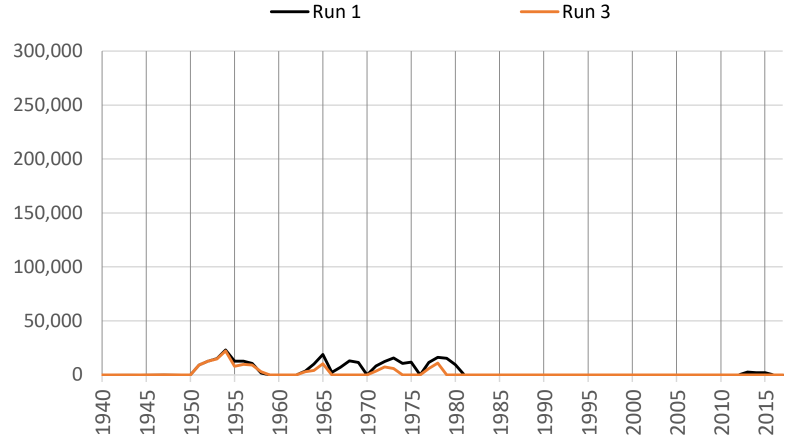
Net River Headgate Diversions



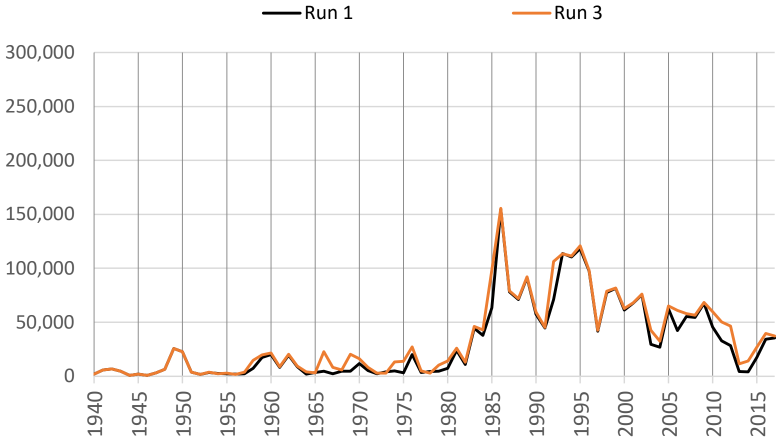
Farm Headgate Deliveries



Pumping

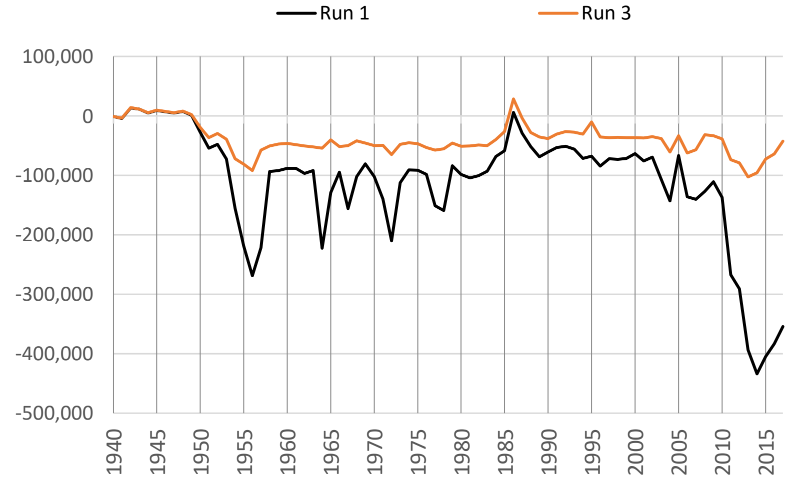


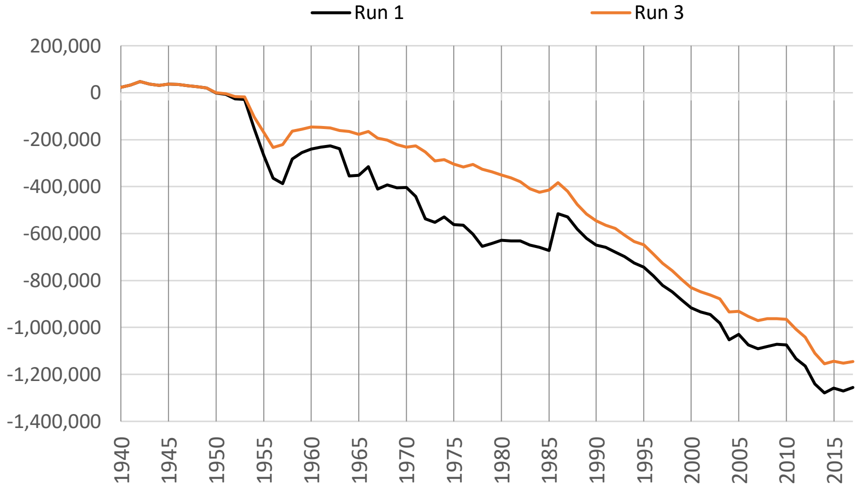
RHG Diversions - FHG Deliveries

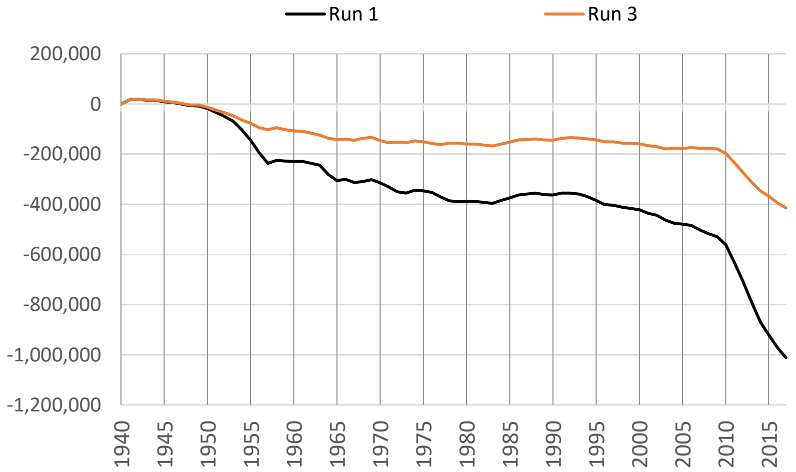


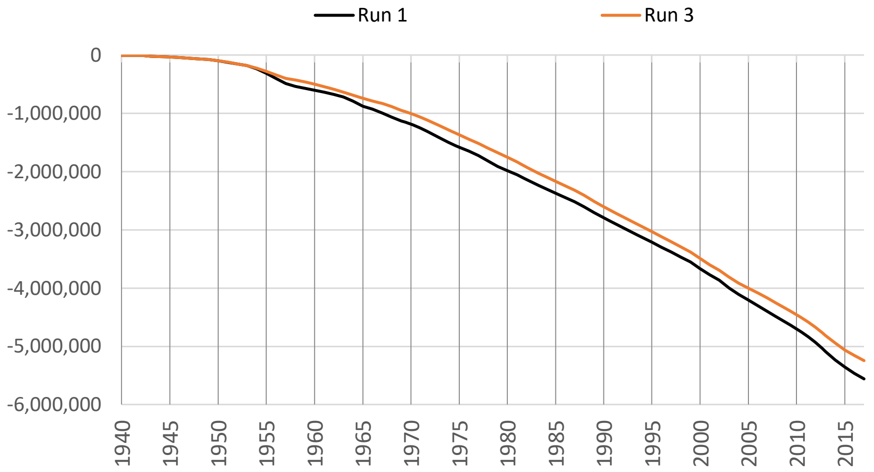
Note: HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

Run 3 - NM Pumping Off
Cumulative Change in Ground Water Storage
Run 3 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)


Rincon-Mesilla Alluvial Aquifer

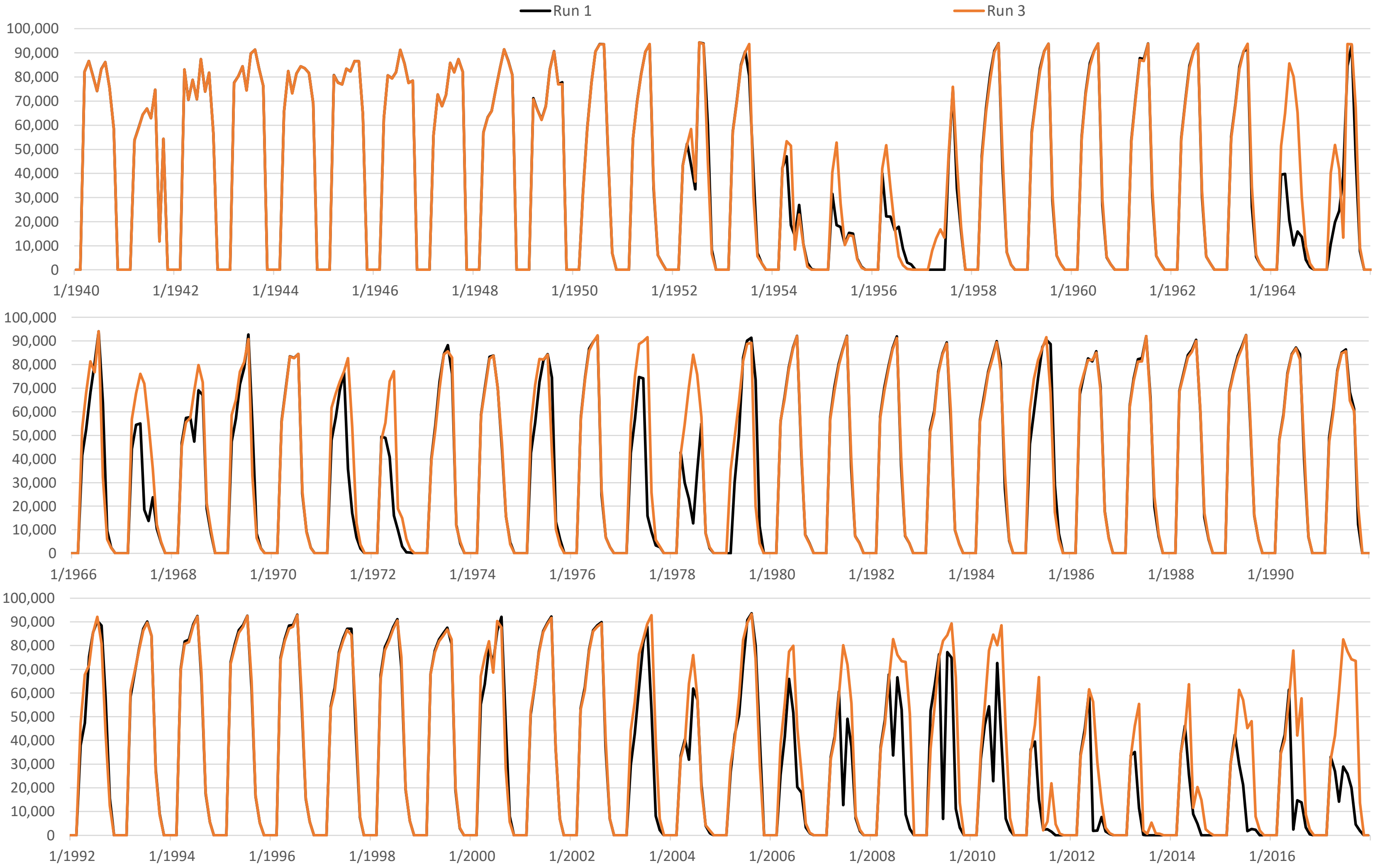

Hueco Alluvial Aquifer


Rincon-Mesilla Non-Alluvial Aquifer


Hueco Non-Alluvial Aquifer

***Note different scales.**

Run 3 - NM Pumping Off
Monthly Net RHG Diversions
Run 3 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)
EBID Total

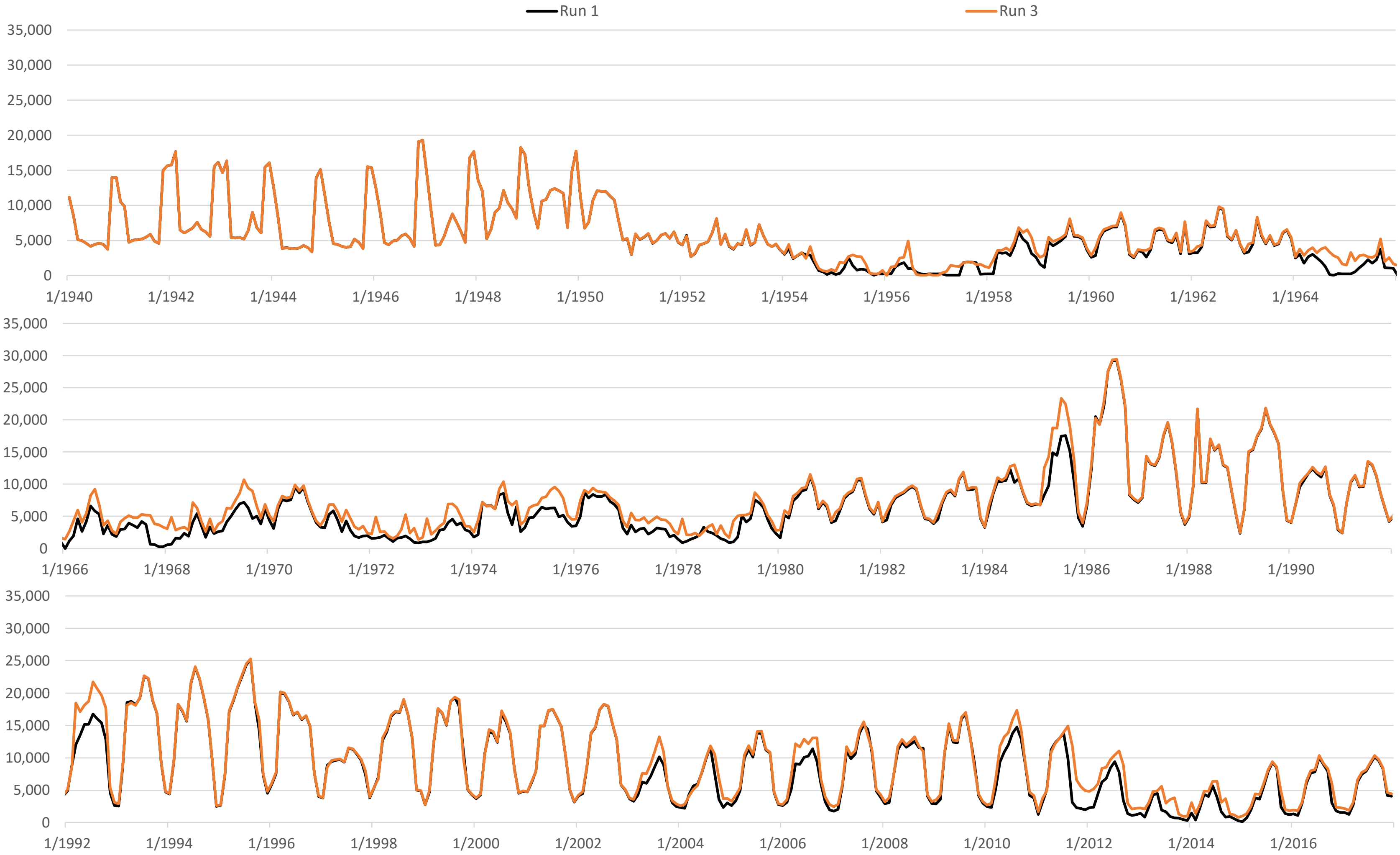


Note: EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).

Run 3 - NM Pumping Off
Monthly Net RHG Diversions
Run 3 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)
EPCWID Total

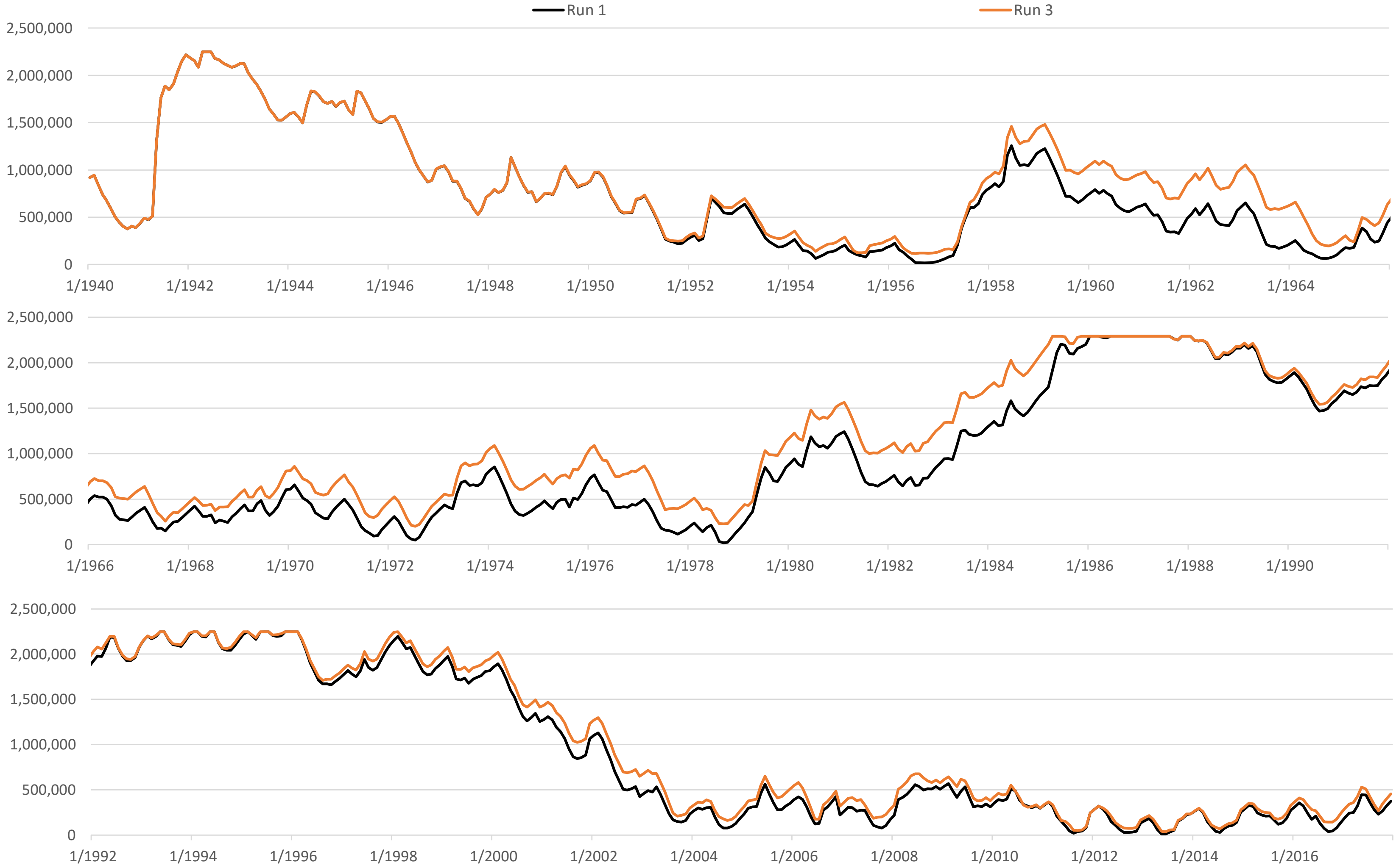
Note: EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

Run 3 - NM Pumping Off
Monthly Net RHG Diversions
Run 3 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)
HCCRD Total



Note: HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

Run 3 - NM Pumping Off
End of Month Reservoir Storage (Elephant Butte + Caballo)
Run 3 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)



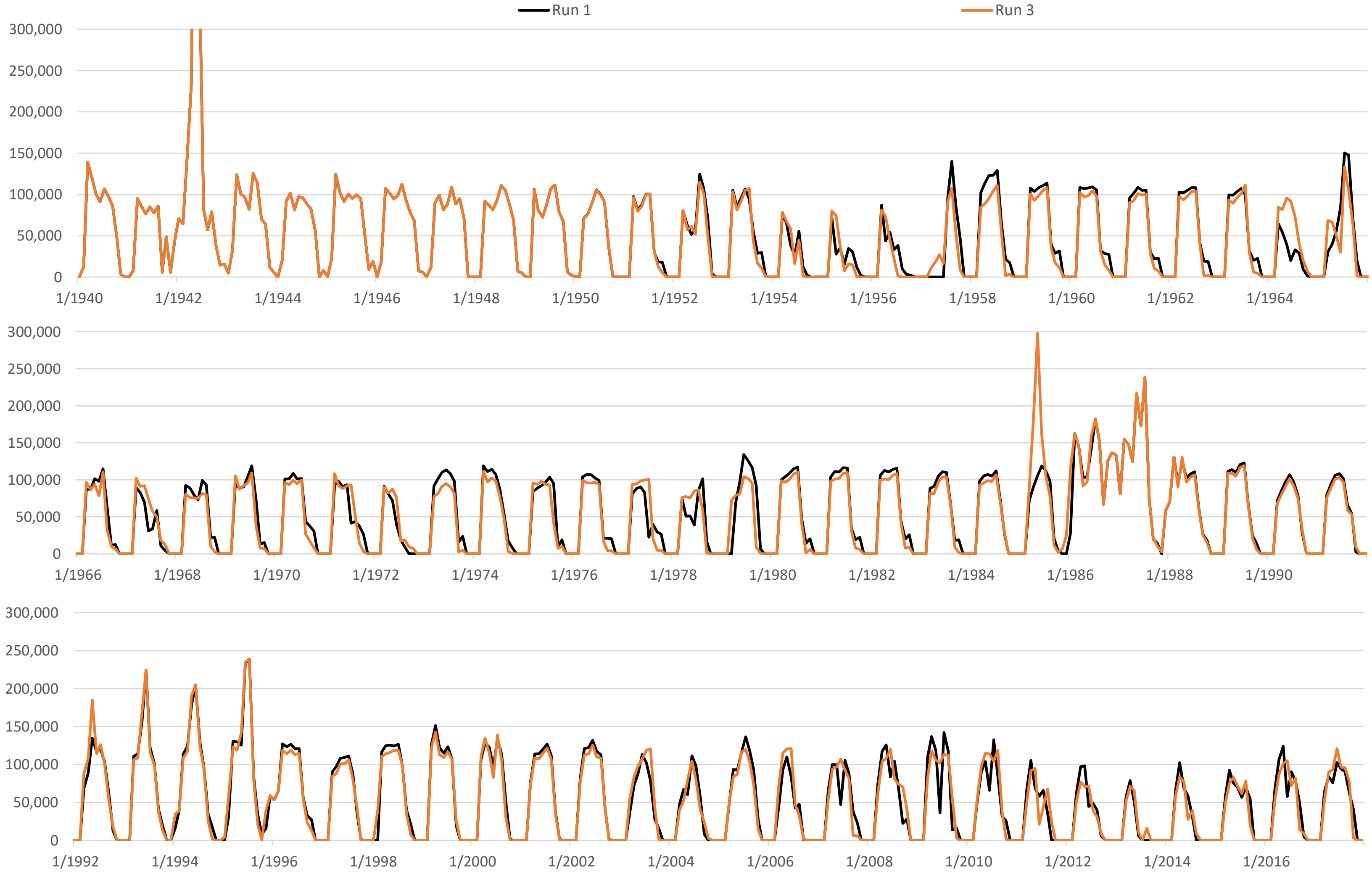
Run 3 - NM Pumping Off

Monthly Caballo Releases

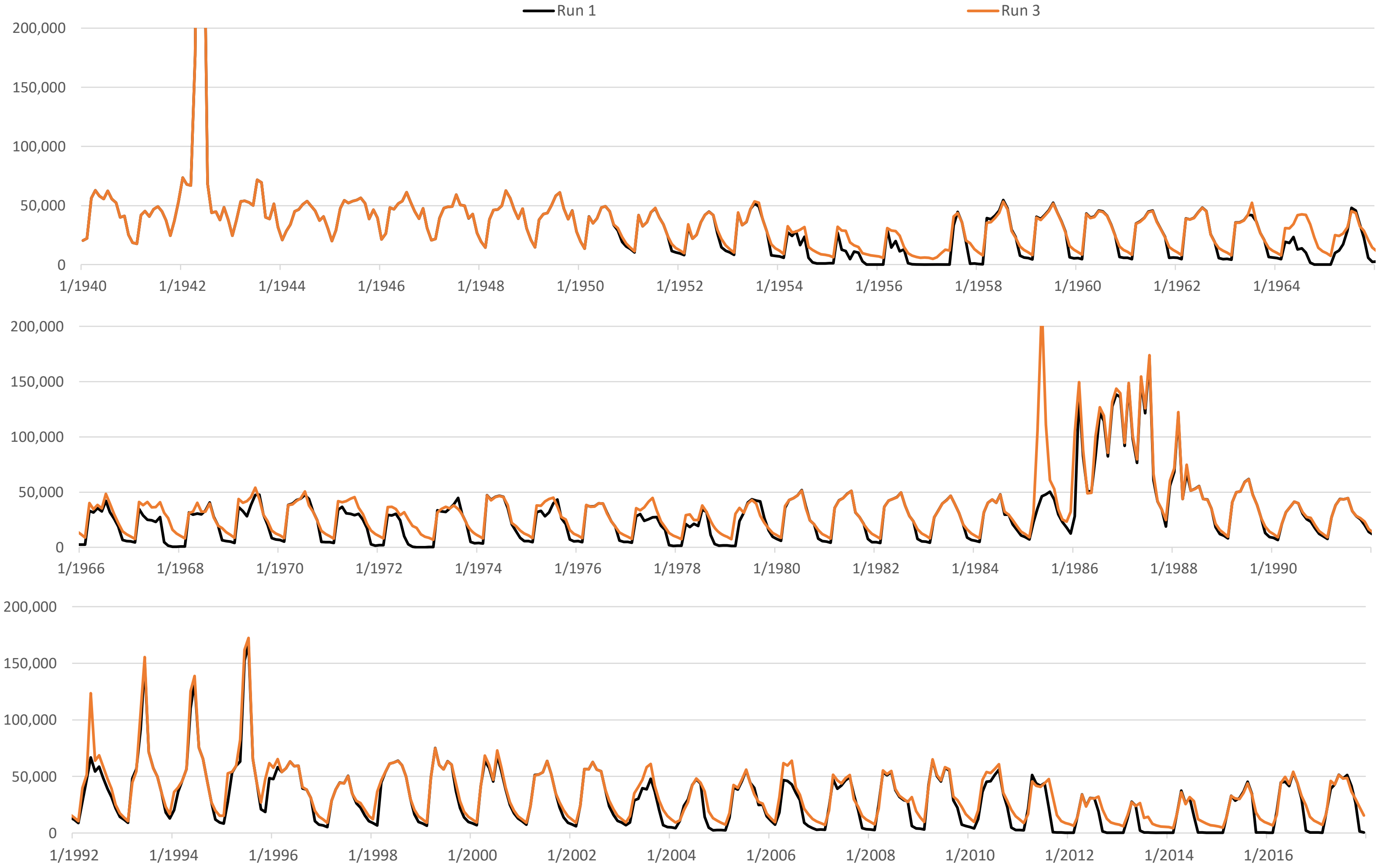
Run 3 v. Run 1

ILRG Model

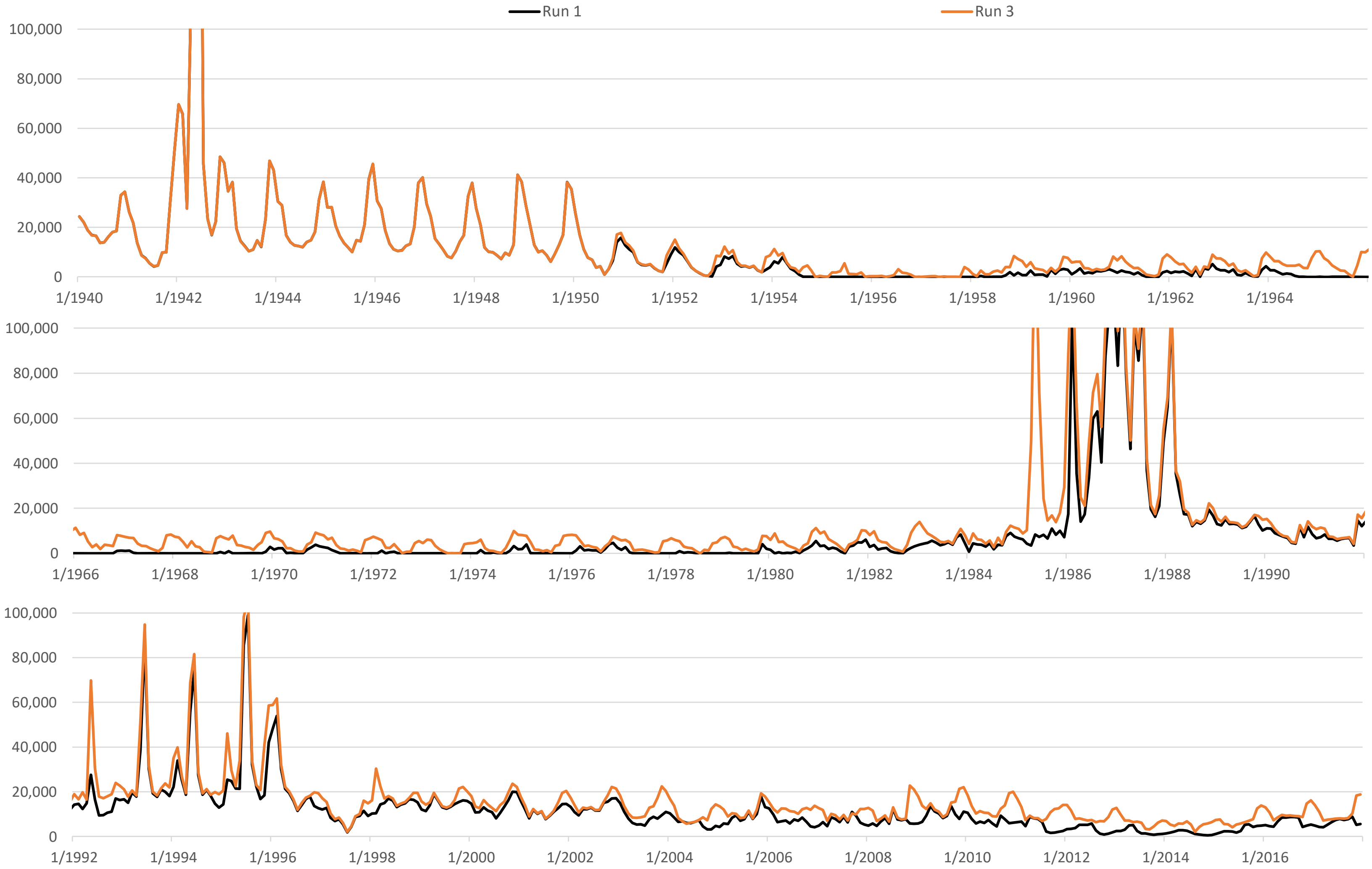
1940 - 2017 (acre-feet)



Run 3 - NM Pumping Off
Monthly Rio Grande at El Paso Flow
Run 3 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)



Run 3 - NM Pumping Off
Monthly Rio Grande at Fort Quitman Flow
Run 3 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)



Appendix 30D

Comparison of ILRG Model Runs
Run 4 v. Run 1

Model Run Specifications

Model Version: LRG_v116

Name: **Run 4 - TX Pumping Off**

Run ID: LRG_v116_Operational_Run4
Date: 8/28/2020

Name: **Run 1 - Historical Base Run**

Run ID: LRG_v116_Operational_Run1
Date: 8/23/2020

Selected Model Inputs

Pumping and Returns	**Run 4**	**Run 1**
Irrigation Pumping	TX Off	On
Irrigated Area	Hist	Hist
Non-Irrigation Pumping	TX Off	On
Non-Irrigation Pumping Returns	TX Off	On
Las Cruces Jornada Pumping Returns	On	On

Project Allocation Rules		
1950-2005	D1/D2	D1/D2
2006-2007	D3	D3
2008-2017	D3 + CO	D3 + CO

EPCWID Operations		
Charge EPCWID for Use of WWTP Returns	Off	Off
ACE and Haskell Credits for EPCWID	On	On
Increased EPCWID Use of Fabens Drain Flows	Off	Off
Charge EPCWID for Fabens Drain Flow Use	Off	Off

Run 4 - TX Pumping Off

Comparison of ILRG Model Runs

Run 4 v. Run 1

1951 - 2017 Annual Average

(1,000 acre-feet)

Run No.	1	4	4 - 1
Simulated Input or Output	**Run 1**	**Run 4**	**Run 4 minus Run 1**
Pumping Stress			
Irrigation Pumping	51.7	0.0	-51.7
Non-Irrigation Pumping	181.0	96.9	-84.1
WWTP Flows	58.0	40.6	-17.4
Urban Deep Percolation	13.1	5.7	-7.3
Total Stress	161.5	50.6	-111.0

Stress is Pumping minus WWTP and Urban Deep Perc

Effects of Pumping Stress	**Run 1**	**Run 4**	**Run 4 minus Run 1**	***% Chg Stress***	***% Diff.***
FHG Deliveries (Mar - Oct)					
EBID	167.6	171.7	4.1	*-4%*	*2%*
EPCWID (incl. EPW)	139.9	140.3	0.4	*0%*	*0%*
HCCRD	32.8	34.8	1.9	*-2%*	*6%*
Total	340.3	346.8	6.4	*-6%*	*2%*
FHG Deliveries (Nov - Feb)					
EBID	0.0	0.0	0.0	*0%*	*1%*
EPCWID (incl. EPW)	0.2	0.1	-0.1	*0%*	*-46%*
HCCRD	2.4	2.3	-0.1	*0%*	*-3%*
Total	2.6	2.4	-0.2	*0%*	*-6%*
Irrigation Pumping					
EBID	140.4	136.5	-4.0	*4%*	*-3%*
EPCWID (Mesilla Valley)	7.4	0.0			
EPCWID (El Paso Valley)	40.1	0.0			
HCCRD	4.2	0.0			
	140.4	136.5	-4.0	*4%*	*-3%*

Pumping turned off. *Other values are simulated responses and are totaled.*

Other Inflows/Outflows					
Net Reservoir Evaporation	125.3	126.6	1.3	*-1%*	*1%*
Riparian ET	70.9	76.4	5.5	*-5%*	*8%*
River Evaporation + Incidental Canal Loss	30.3	29.9	-0.4	*0%*	*-1%*
Total	226.6	232.9	6.4	*-6%*	*3%*
Rio Grande at Fort Quitman					
Reservoir Spills	33.3	32.8	-0.5	*0%*	*-1%*
Nov-Feb Flows	21.4	27.7	6.3	*-6%*	*29%*
Mar - Oct Flows	41.1	54.9	13.8	*-12%*	*34%*
Underflow (GW Model)	0.2	0.3	0.1	*0%*	*24%*
Total	96.0	115.6	19.7	*-18%*	*20%*

Run 4 - TX Pumping Off
Comparison of ILRG Model Runs
Run 4 v. Run 1
1951 - 2017 Annual Average
(1,000 acre-feet)

Run No.	**1**	**4**	**4 - 1**		
Simulated Input or Output	**Run 1**	**Run 4**	**Run 4 minus Run 1**		
Effects of Pumping Stress (continued)				***% Chg***	
Change in Storage				***Stress***	***% Diff.***
Reservoir Storage	-4.7	-4.7	0.0	*0%*	*0%*
Alluvial GW Storage (RW Model)	-23.6	-15.6	8.0	*-7%*	*-34%*
Non-alluvial GW Storage (GW Models)	-96.4	-49.4	46.9	*-42%*	*-49%*
Soil Moisture Storage	0.6	0.6	0.0	*0%*	*4%*
Total	-124.0	-69.1	54.9	*-49%*	*-44%*
Summary of Effects					
FHG Deliveries (Mar-Oct)	340.3	346.8	6.4	*-6%*	*2%*
FHG Deliveries (Nov-Feb)	2.6	2.4	-0.2	*0%*	*-6%*
Irrigation Pumping	140.4	136.5	-4.0	*4%*	*-3%*
Riparian ET + Evaporation	226.6	232.9	6.4	*-6%*	*3%*
Fort Quitman Flow	96.0	115.6	19.7	*-18%*	*20%*
Change in Storage	-124.0	-69.1	54.9	*-49%*	*-44%*
Total	681.9	765.1	83.2	*-75%*	*12%*
Other Effects of Pumping Stress				***% Chg***	
Rio Grande at El Paso				***Stress***	***% Diff.***
Reservoir Spills	49.4	45.9	-3.5	*3%*	*-7%*
Nov-Feb Flows	22.8	28.2	5.4	*-5%*	*24%*
Mar - Oct Flows	263.8	282.1	18.4	*-17%*	*7%*
Total	336.0	356.2	20.2	*-18%*	*6%*
Rio Grande below Caballo					
Reservoir Spills	65.9	58.8	-7.0	*6%*	*-11%*
Nov-Feb Flows	0.5	0.5	0.0	*0%*	*2%*
Mar - Oct Flows	541.3	547.1	5.8	*-5%*	*1%*
Total	607.6	606.4	-1.2	*1%*	*0%*
Surface Water Diversions (Mar - Oct)					
EBID	366.5	371.1	4.6	*-4%*	*1%*
EPCWID (incl. EPW)	236.8	241.3	4.5	*-4%*	*2%*
HCCRD	67.5	73.0	5.5	*-5%*	*8%*
Total	670.8	685.4	14.6	*-13%*	*2%*
Surface Water Diversions (Nov - Feb)					
EBID	0.0	0.0	0.0	*0%*	*0%*
EPCWID (incl. EPW)	14.3	12.7	-1.6	*1%*	*-11%*
HCCRD	14.2	14.9	0.7	*-1%*	*5%*
Total	28.5	27.6	-0.9	*1%*	*-3%*

Run 4 - TX Pumping Off

Annual Differences in ILRG Model Outputs

Run 4 minus Run 1

1940 - 2017 (acre-feet)

	Net River Headgate Diversions						Farm Headgate Deliveries						Annual Flows		
	EBID		EPCWID (incl. EPW)		HCCRD		EBID		EPCWID (incl. EPW)		HCCRD				
Year	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Caballo Releases	Rio Grande at El Paso	Rio Grande at Fort Quitman
1940	5	5	-620	68	-149	555	-12	-12	377	377	-94	-94	-3,500	-3,375	6,842
1941	0	0	-111	-1,249	219	51	3	4	-2	-199	200	110	3,200	2,930	3,444
1942	-32	-32	-49	-2,055	-175	-176	10	10	464	-154	-197	-220	1,886	1,888	-298
1943	-38	-38	-158	-1,659	-156	-294	23	23	433	189	-100	-403	4,298	4,215	2,293
1944	-41	-41	-488	-1,869	133	-167	0	0	-236	-448	82	-150	1,807	1,796	2,067
1945	-47	-47	-260	-2,172	217	-415	12	12	-299	-699	192	215	2,967	2,923	2,497
1946	-24	-24	51	-2,523	319	-529	25	26	-48	-860	257	180	2,979	3,078	2,615
1947	-43	-43	471	-1,544	175	-463	9	9	643	57	121	152	1,912	2,067	2,796
1948	-32	-32	-978	-2,388	568	295	-6	-6	306	-1	438	215	-756	-518	4,478
1949	-30	-30	-2,384	-4,199	1,613	1,573	0	0	-380	-403	-148	-299	-714	-553	6,967
1950	-325	-325	-3,690	-4,605	1,768	1,934	234	234	-423	-417	-35	-61	-2,267	223	6,980
1951	-4,090	-4,090	-4,432	-4,889	1,640	2,246	-1,756	-1,757	-430	-427	1,724	1,251	-6,894	-410	17,111
1952	-807	-807	-6,369	-6,938	1,729	2,505	842	841	-900	-893	1,560	844	-8,779	-590	17,084
1953	-752	-752	-7,667	-8,139	3,214	4,563	1,378	1,378	-853	-844	3,565	3,977	-12,289	81	29,454
1954	4,590	4,590	4,075	3,312	3,698	5,281	6,680	6,680	9,489	9,505	3,854	5,591	6,285	21,083	22,856
1955	7,789	7,789	5,955	5,122	8,498	11,356	3,945	3,945	6,710	6,504	7,888	10,495	10,809	17,526	15,618
1956	1,543	1,543	267	-1,457	7,526	9,895	-1,614	-1,614	3,456	2,674	6,980	8,587	250	10,632	8,182
1957	-392	-392	-8,108	-9,099	829	4,021	325	325	1,696	1,275	1,683	3,284	-11,115	2,548	5,452
1958	-869	-869	-21,576	-21,990	6,285	11,335	1,040	1,040	-2,326	-2,404	-1,655	-200	-39,572	-9,921	35,328
1959	-1,066	-1,066	-13,330	-13,813	5,121	7,976	1,150	1,150	-1,545	-1,525	403	682	-28,431	-2,377	38,073
1960	-1,144	-1,144	-11,147	-12,122	3,953	5,254	1,268	1,268	-2,298	-2,275	0	0	-19,091	3,953	31,983
1961	-1,045	-1,045	-10,119	-11,080	4,285	5,471	1,306	1,305	-818	-795	1,521	-425	-16,279	6,602	35,762
1962	-1,118	-1,118	-9,069	-10,106	3,868	4,964	1,324	1,324	-1,659	-1,633	793	1,223	-16,383	8,130	32,699
1963	7,662	7,662	-8,365	-9,214	4,015	5,016	6,388	6,389	-2,062	-2,031	2,444	2,238	-2,615	20,429	35,088
1964	27,627	27,627	19,031	17,291	5,588	7,290	26,689	26,689	15,569	15,229	5,763	7,278	25,870	45,367	26,012
1965	35,496	35,496	9,122	7,491	8,303	11,681	19,828	19,828	17,155	16,758	8,966	11,404	25,721	39,212	30,426
1966	255	255	23,623	23,836	14,933	18,306	-8,857	-8,857	14,803	14,834	-2,501	-4,764	-1,113	51,198	54,526
1967	15,109	15,109	13,348	13,023	7,333	11,936	9,555	9,555	15,226	14,736	6,074	9,637	17,069	29,689	24,895
1968	2,692	2,692	-7,010	-7,150	10,550	15,450	4,399	4,399	628	255	8,921	8,287	-14,076	13,762	24,132
1969	-646	-646	-6,827	-7,375	12,375	15,636	1,539	1,539	-280	-259	2,988	-1,539	-20,528	8,113	36,311
1970	-950	-950	-3,905	-4,765	5,640	7,152	1,348	1,348	-902	-883	-1,274	-2,725	-11,960	12,993	31,944
1971	27,296	27,296	-2,732	-3,091	6,647	9,173	18,260	18,260	-470	-443	5,995	8,477	9,362	22,538	25,269
1972	-3,103	-3,103	-1,510	-2,222	10,332	12,324	-4,188	-4,188	-7,715	-7,955	8,611	8,427	-9,499	16,257	22,052
1973	-1,493	-1,493	-1,679	-3,197	18,019	21,175	2,783	2,783	727	504	17,067	15,068	-20,233	15,751	15,521
1974	-1,282	-1,282	139	-471	16,045	20,248	2,106	2,106	255	277	-2,914	-4,687	-13,815	17,920	44,700
1975	-1,043	-1,043	2,765	1,473	15,344	19,054	2,460	2,460	98	117	10,065	6,626	-6,111	19,587	23,750
1976	-1,362	-1,362	6,620	5,320	12,502	16,449	2,676	2,676	-299	-285	-1,658	-5,716	-5,753	23,848	33,136
1977	42,138	42,138	42,434	43,227	17,454	20,915	18,377	18,377	14,387	14,414	15,176	14,379	55,885	76,182	36,947
1978	1,121	1,121	1,152	1,397	9,115	12,465	1,316	1,316	-4,990	-4,959	9,714	9,431	-5,769	24,721	23,254

Run 4 - TX Pumping Off
Annual Differences in ILRG Model Outputs
Run 4 minus Run 1
1940 - 2017 (acre-feet)

	Net River Headgate Diversions						Farm Headgate Deliveries						Annual Flows		
	EBID		EPCWID (incl. EPW)		HCCRD		EBID		EPCWID (incl. EPW)		HCCRD				
Year	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Caballo Releases	Rio Grande at El Paso	Rio Grande at Fort Quitman
1979	-882	-882	5,055	4,272	6,925	10,375	2,477	2,478	6	43	6,924	9,302	-10,854	30,973	28,965
1980	-936	-936	8,314	7,791	6,594	8,142	1,714	1,715	173	198	-1,599	-3,741	-1,382	30,294	57,931
1981	-892	-892	11,875	10,820	5,212	4,583	1,711	1,711	162	182	-56	-258	5,500	30,900	35,456
1982	-963	-963	11,051	9,639	4,847	4,086	1,576	1,576	152	170	-1,240	-2,706	7,385	32,246	46,225
1983	-677	-677	13,730	12,173	8,105	7,370	1,425	1,426	171	188	0	0	10,907	32,964	33,716
1984	-704	-704	15,090	13,835	10,879	9,754	1,541	1,541	154	173	0	0	8,811	31,725	26,430
1985	-560	-560	17,172	16,700	6,376	5,311	3,367	3,368	92	20	0	0	10,046	29,009	25,332
1986	-628	-628	22,680	22,502	8,134	5,975	1,157	1,155	98	109	0	0	-22,614	-970	91,807
1987	-855	-855	25,591	25,423	7,825	5,287	968	968	143	158	0	0	142	20,188	17,286
1988	-676	-676	27,109	26,941	8,279	5,389	1,715	1,716	84	98	0	0	18,649	36,823	12,579
1989	-813	-813	28,978	28,525	9,348	6,729	1,814	1,816	502	134	0	0	34,170	53,915	23,578
1990	-491	-491	25,495	24,744	10,187	7,735	1,545	1,545	345	-155	0	0	15,906	36,172	13,315
1991	-958	-958	12,416	11,754	4,158	2,529	-245	-244	-87	-860	0	0	11,581	28,593	19,556
1992	-803	-803	8,613	8,197	2,283	1,415	2,868	2,871	-131	-454	0	0	-21,871	-4,828	-3,876
1993	-795	-795	247	63	1,313	-238	1,098	1,099	-479	-469	0	0	-35,331	-16,200	-22,942
1994	-901	-901	618	431	1,987	599	1,616	1,615	1,127	1,133	0	0	-8,045	14,919	7,044
1995	-865	-865	164	-61	1,383	-381	1,710	1,710	1,854	1,807	0	0	3,411	29,014	16,042
1996	-1,159	-1,159	921	767	1,520	-7	1,907	1,907	174	191	0	0	-2,954	25,346	7,551
1997	-455	-455	-4,028	-6,595	3,776	1,402	1,327	1,327	-2,445	-3,452	0	0	-1,116	22,852	15,549
1998	-772	-772	4,359	3,994	2,676	746	1,644	1,644	772	782	0	0	3,025	29,636	21,710
1999	-823	-823	-2,358	-5,396	438	-458	1,602	1,602	-2,750	-2,743	0	0	-1,797	23,538	10,385
2000	-577	-577	15,645	11,727	3,444	3,077	1,807	1,808	2,178	2,188	0	0	10,235	33,937	1,056
2001	-560	-560	9,223	4,653	2,144	1,833	1,493	1,493	-188	-181	0	0	790	24,195	-2,037
2002	-533	-533	3,642	538	18	-369	1,685	1,685	251	260	0	0	-7,850	16,976	-6,028
2003	-106	-106	20,102	16,702	3,490	2,488	1,478	1,478	-275	-268	0	0	19,717	39,746	4,694
2004	-10,593	-10,593	-14,153	-18,299	-1,854	-2,652	-4,574	-4,574	-13,462	-13,452	0	0	-20,511	9,738	1,798
2005	72	72	7,244	2,737	824	398	1,773	1,770	284	302	0	0	-4,455	19,209	-203
2006	8,900	8,900	-272	-4,597	-482	-650	5,552	5,552	-4,611	-4,600	0	0	316	16,666	1,487
2007	13,874	13,874	3,568	-684	242	-42	8,208	8,208	771	788	0	0	-6,210	13,297	877
2008	27,738	27,738	3,398	-691	807	99	18,851	18,851	68	86	0	0	-793	16,772	1,760
2009	41,648	41,648	5,941	1,437	520	-198	23,919	23,919	-167	-147	0	0	4,289	21,118	5,566
2010	45,408	45,408	6,290	2,006	1,537	1,487	29,096	29,096	730	750	0	0	6,340	22,189	6,048
2011	23,513	23,513	4,790	858	6,035	7,970	12,925	12,925	2,622	2,640	0	0	11,062	20,408	11,284
2012	-8,158	-8,158	2,710	-1,589	5,540	5,610	-1,379	-1,379	-6,636	-6,624	0	0	-13,033	19,300	10,033
2013	5,073	5,073	-7,990	-11,179	2,246	2,420	2,791	2,791	-12,518	-12,507	2,838	3,112	2,398	13,871	2,666
2014	4,450	4,450	-3,970	-7,753	4,306	4,947	2,625	2,625	-6,063	-6,054	2,711	3,038	694	10,898	7,618
2015	2,749	2,749	1,588	-1,991	2,421	2,593	1,731	1,731	-4,883	-4,873	-1,935	-1,678	4,567	16,005	13,366
2016	1,682	1,682	-2,060	-6,058	-841	-1,202	630	630	-4,361	-4,351	0	0	-9,418	10,030	-4,540
2017	19,232	19,232	5,435	2,117	1,206	1,117	10,011	10,011	823	833	0	0	14,561	18,541	137
Averages															
1951-2017	4,617	4,617	4,461	2,848	5,503	6,185	4,085	4,086	408	321	1,931	1,854	-1,236	20,221	19,654
1951-1978	5,434	5,434	167	-558	8,030	10,684	4,306	4,306	2,595	2,481	4,348	4,183	-4,252	17,672	27,770
1979-2005	-1,071	-1,071	10,178	8,688	4,456	3,375	1,415	1,415	-411	-515	149	96	796	24,478	17,886
2006-2017	15,509	15,509	1,619	-2,344	1,961	2,012	9,580	9,580	-2,852	-2,838	301	373	1,231	16,591	4,692
1985-2017	4,917	4,917	6,943	4,483	3,069	2,150	4,325	4,325	-1,398	-1,482	109	136	482	20,330	9,409
1985-2005	-1,136	-1,136	9,985	8,383	3,702	2,229	1,322	1,322	-567	-707	0	0	54	22,467	12,105

Notes:

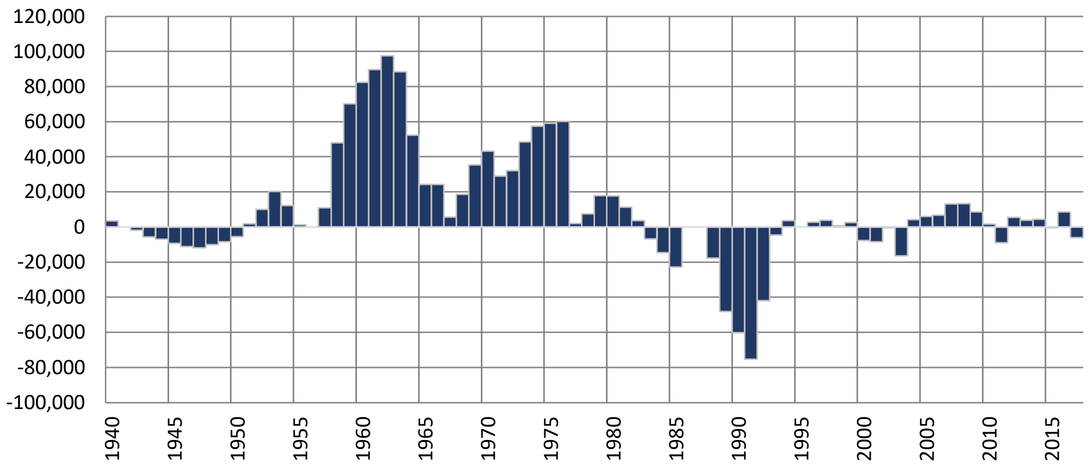
EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).

EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

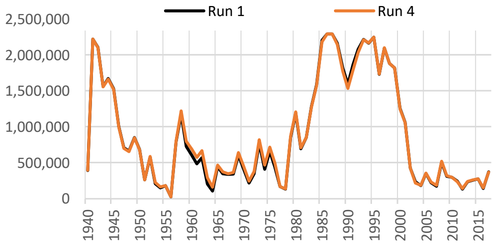
HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

Run 4 - TX Pumping Off
Simulated Differences in ILRG Model Outputs
Run 4 minus Run 1
1940 - 2017 (acre-feet)

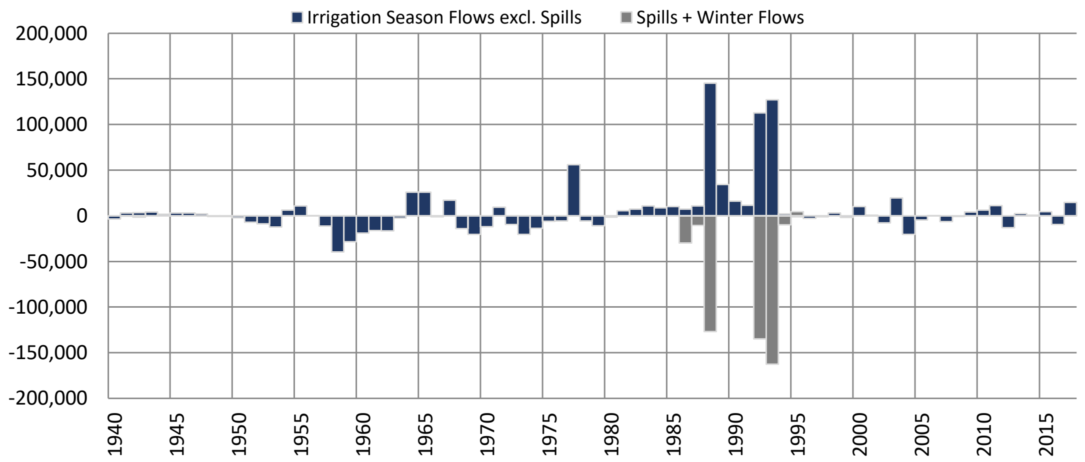
Total Project Storage (Year End)



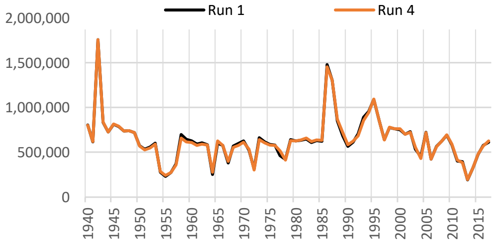
Period	Average Difference
1951-2017	-10
1951-1978	457
1979-2005	-50
2006-2017	-1,006
1985-2017	261
1985-2005	985



Caballo Reservoir Outflows (Annual)



	Average Difference		
Period	Irr Season (excl. Spills)	Nov-Feb and Spills	Annual
1951-2017	5,778	-7,013	-1,236
1951-1978	-4,252	0	-4,252
1979-2005	18,200	-17,404	796
2006-2017	1,231	0	1,231
1985-2017	14,721	-14,239	482
1985-2005	22,430	-22,376	54



Notes:

Reservoir storage does not include storage attributed to SJC, CO, or NM credit waters.

Average differences calculated as (Final Storage - Initial Storage)/(no. years).

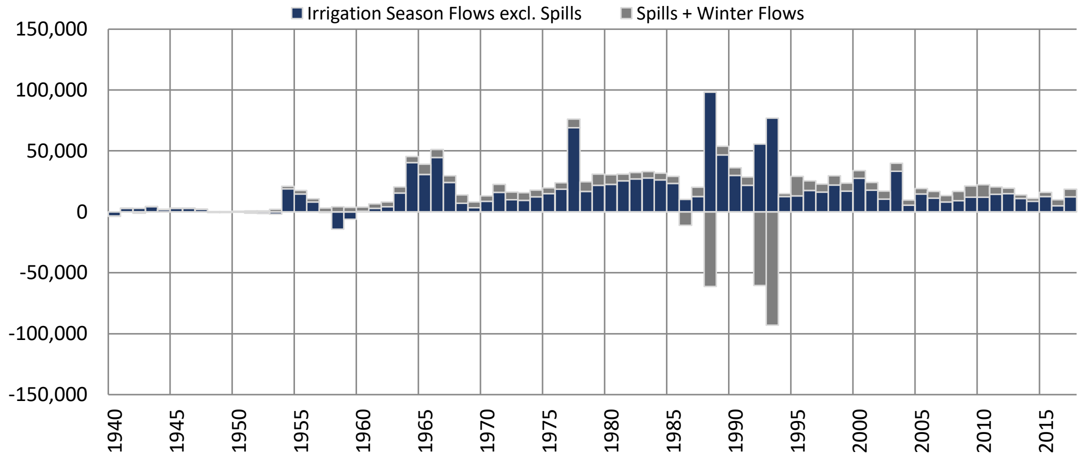
Run 4 - TX Pumping Off

Simulated Differences in ILRG Model Outputs

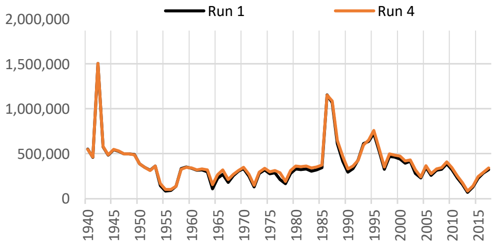
Run 4 minus Run 1

1940 - 2017 (acre-feet)

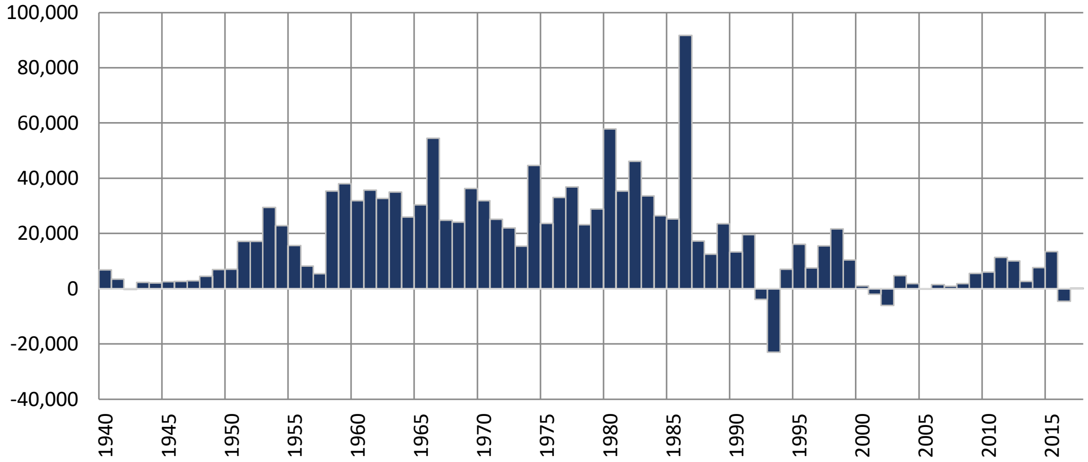
Rio Grande at El Paso (Annual)



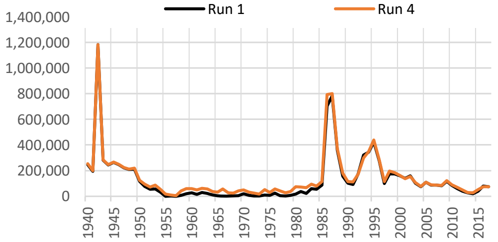
	Average Difference		
Period	Irr Season (excl. Spills)	Nov-Feb and Spills	Annual
1951-2017	18,357	1,864	20,221
1951-1978	13,037	4,635	17,672
1979-2005	27,171	-2,693	24,478
2006-2017	10,942	5,649	16,591
1985-2017	21,648	-1,317	20,330
1985-2005	27,765	-5,298	22,467



Rio Grande at Fort Quitman (Annual)



Period	Average Difference
1951-2017	19,602
1951-1978	27,695
1979-2005	17,839
2006-2017	4,682
1985-2017	9,386
1985-2005	12,074



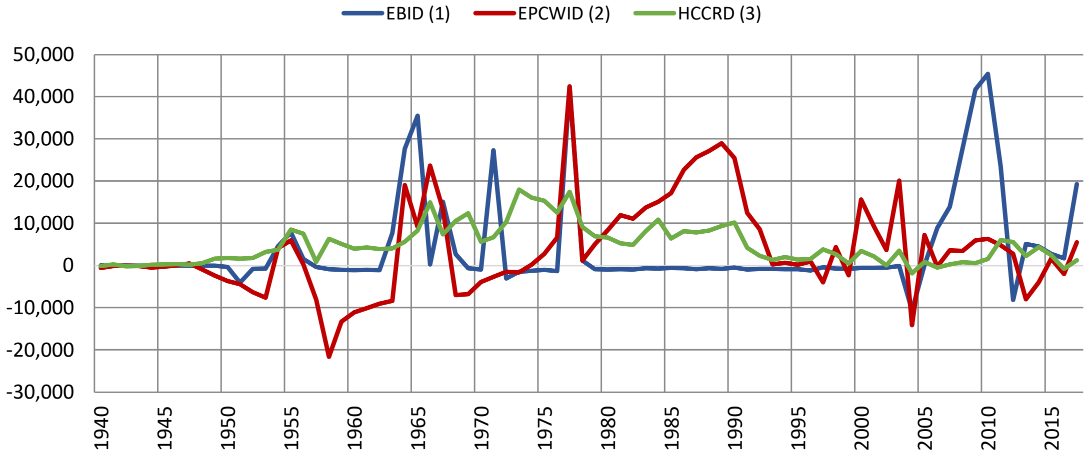
Run 4 - TX Pumping Off

Simulated Differences in ILRG Model Outputs

Run 4 minus Run 1

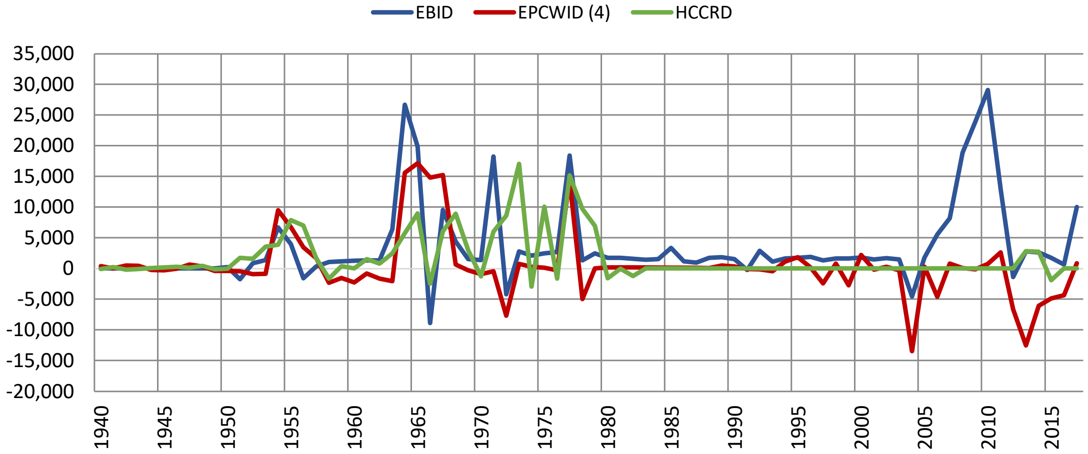
1940 - 2017 (acre-feet)

River Headgate (RHG) Diversions (Irrigation Season)



	Average Difference		
Period	EBID	EPCWID	HCCRD
1951-2017	4,617	4,461	5,503
1951-1978	5,434	167	8,030
1979-2005	-1,071	10,178	4,456
2006-2017	15,509	1,619	1,961
1985-2017	4,917	6,943	3,069
1985-2005	-1,136	9,985	3,702

Farm Headgate (FHG) Deliveries (Irrigation Season)



	Average Difference		
Period	EBID	EPCWID	HCCRD
1951-2017	4,085	408	1,931
1951-1978	4,306	2,595	4,348
1979-2005	1,415	-411	149
2006-2017	9,580	-2,852	301
1985-2017	4,325	-1,398	109
1985-2005	1,322	-567	0

Notes:

(1) EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).

(2) EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

(3) HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

(4) EPCWID FHG values include deliveries to Rogers WTP and R/U WTP.

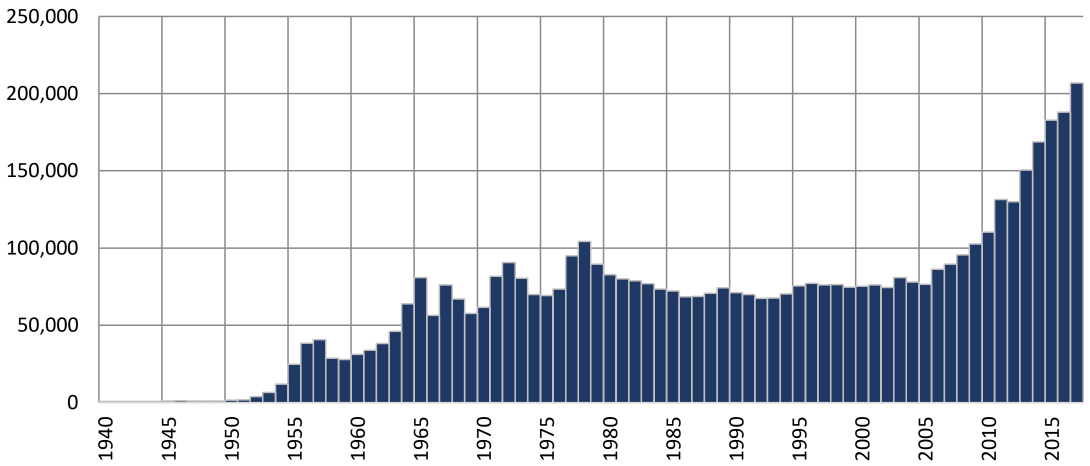
Run 4 - TX Pumping Off

Simulated Differences in ILRG Model Outputs

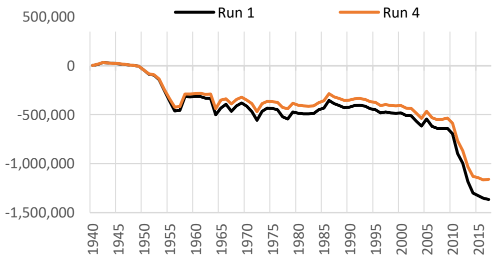
Run 4 minus Run 1

1940 - 2017 (acre-feet)

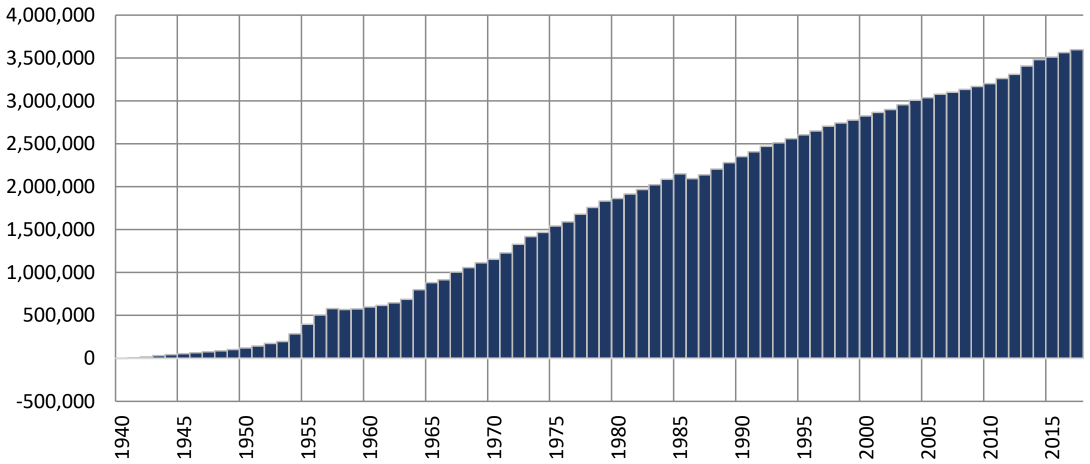
Cumulative Annual Rincon-Mesilla Groundwater Storage



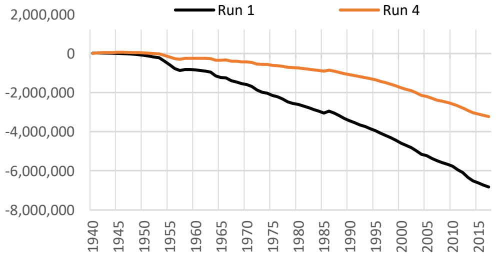
Period	Average Difference
1951-2017	3,063
1951-1978	3,666
1979-2005	-1,024
2006-2017	10,853
1985-2017	4,044
1985-2005	153



Cumulative Annual Hueco Groundwater Storage



Period	Average Difference
1951-2017	51,833
1951-1978	58,494
1979-2005	47,347
2006-2017	46,385
1985-2017	45,711
1985-2005	45,326

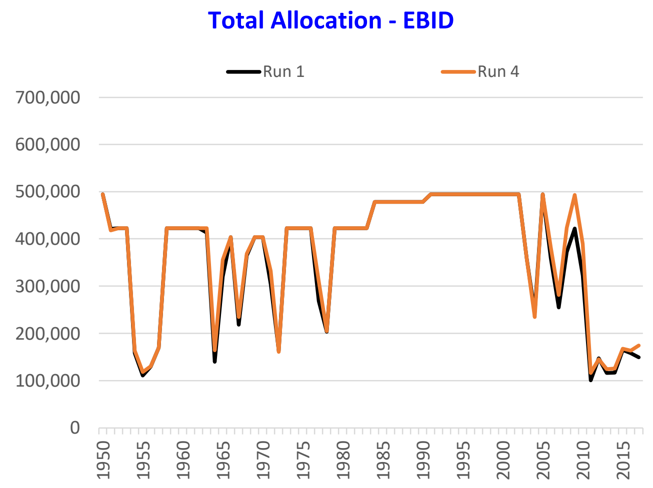


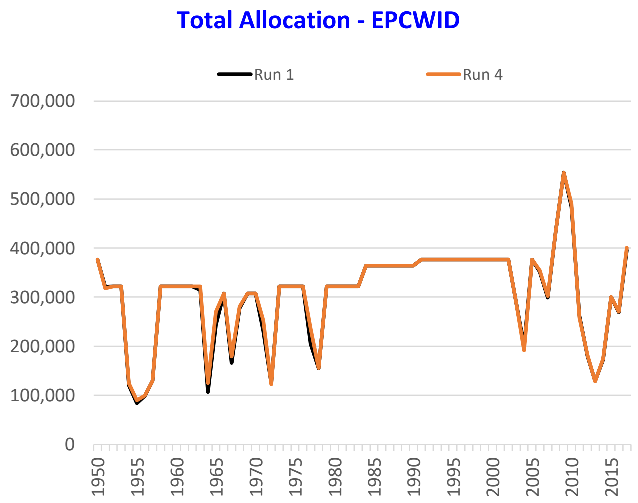
Notes:

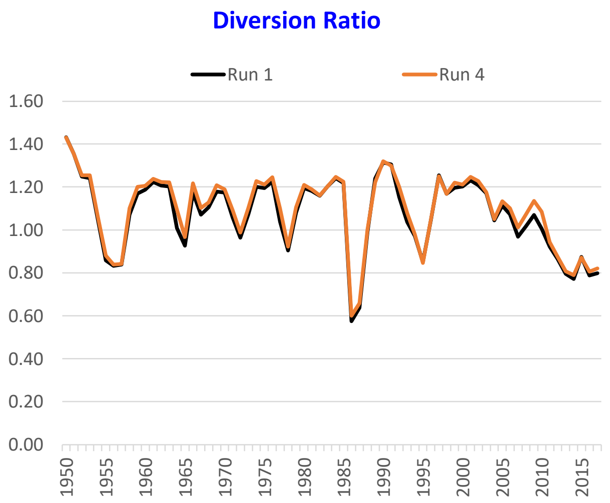
Cumulative storage change in alluvial and non-alluvial aquifers.

Average differences calculated as (Final Storage - Initial Storage)/(no. years).

Run 4 - TX Pumping Off
Annual Allocation and Charges
Run 4 v. Run 1
ILRG Model
1950 - 2017 (acre-feet)

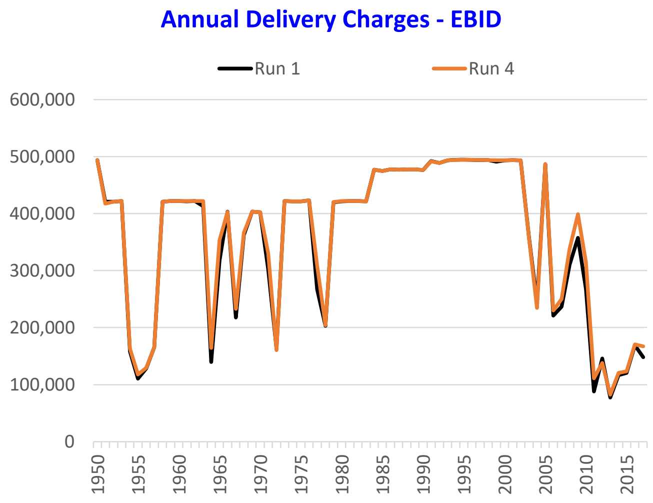

Total Allocation - EBID

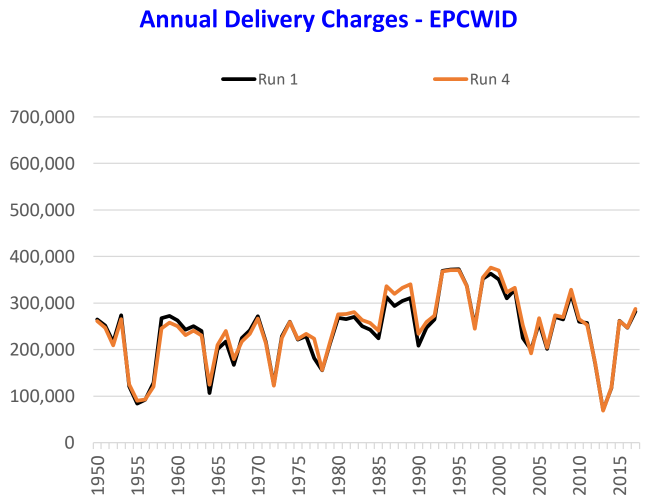

Total Allocation - EPCWID


Diversion Ratio

Note:

Computed as Total Charges/Caballo Release.


Annual Delivery Charges - EBID


Annual Delivery Charges - EPCWID

Run 4 - TX Pumping Off

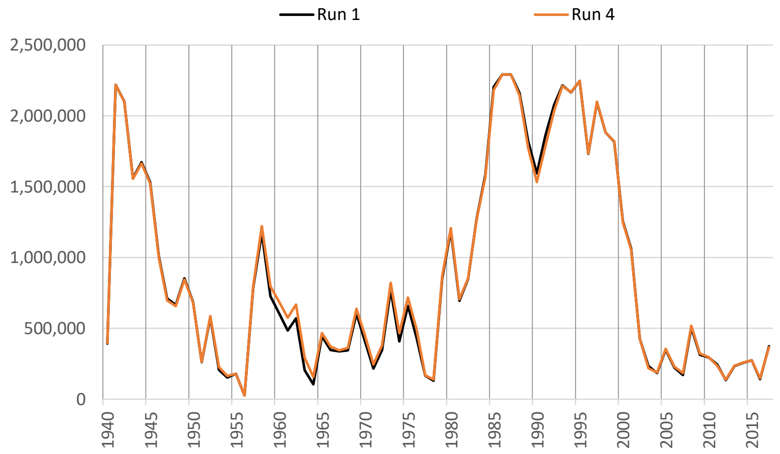
Annual Summary of Project Storage and Rio Grande Flows

Run 4 v. Run 1

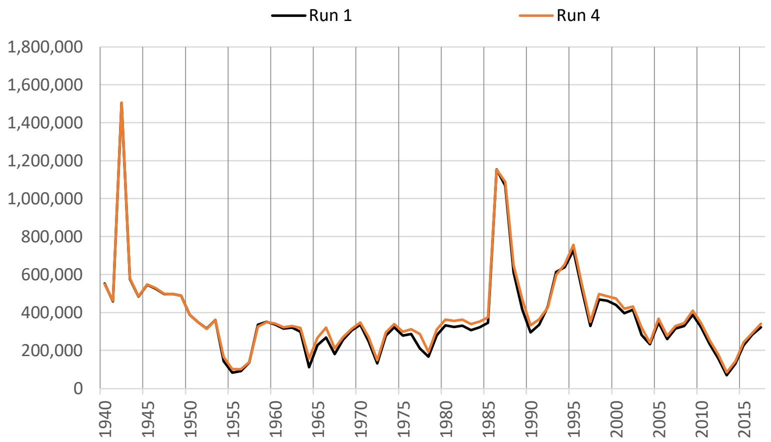
ILRG Model

1940 - 2017 (acre-feet)

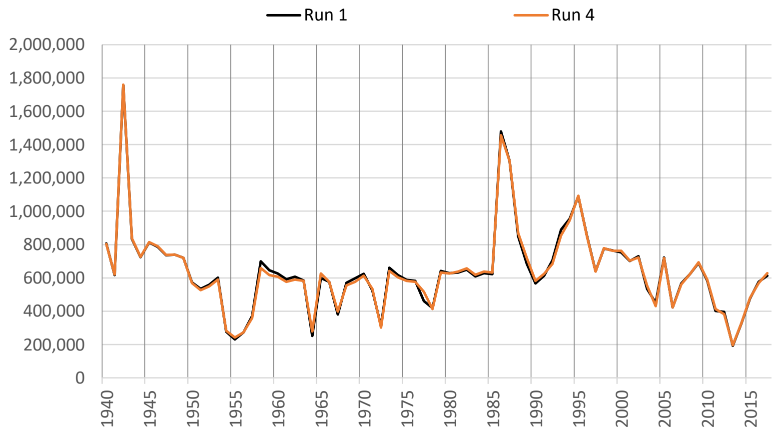
Total Year-End Project Reservoir Storage



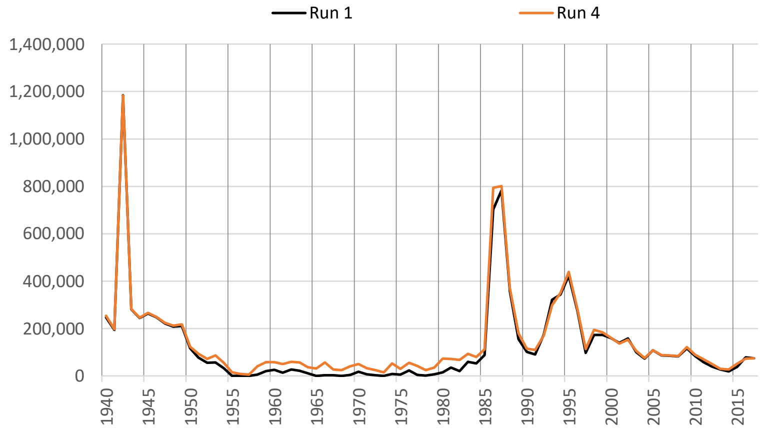
Rio Grande at El Paso



Rio Grande Below Caballo



Rio Grande at Fort Quitman

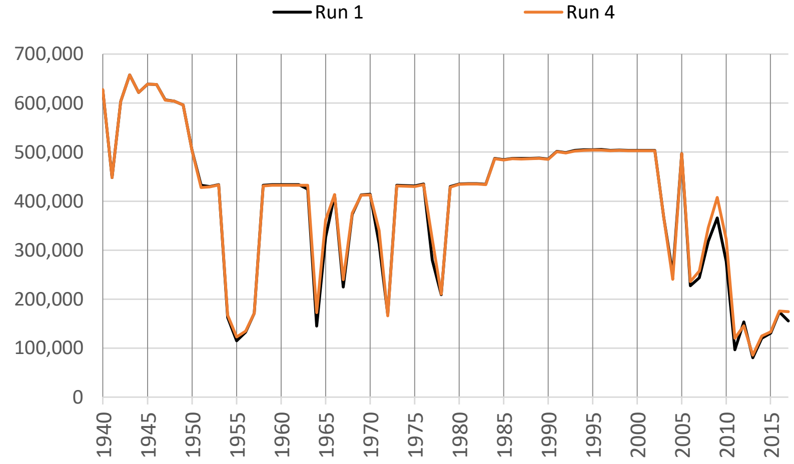


***Note different scales.**

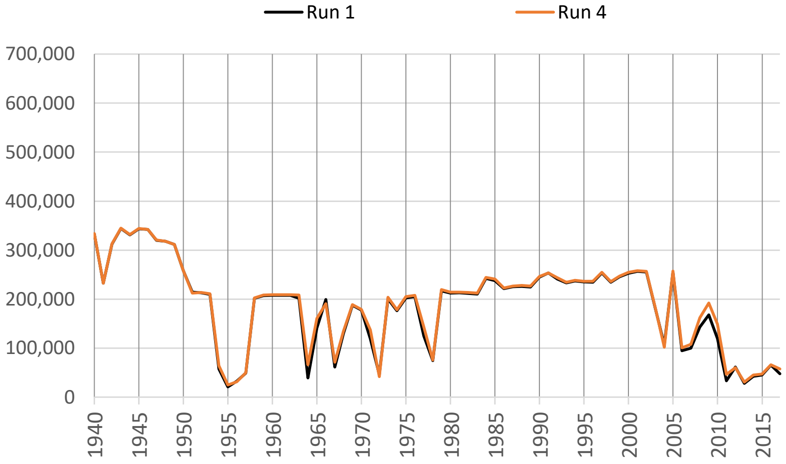
Run 4 - TX Pumping Off
Irrigation Season Summary of Irrigation Operations
Run 4 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

EBID Total

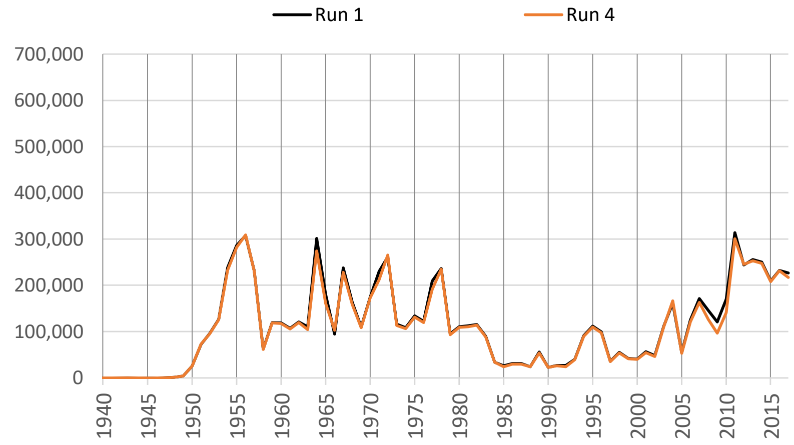
Net River Headgate Diversions



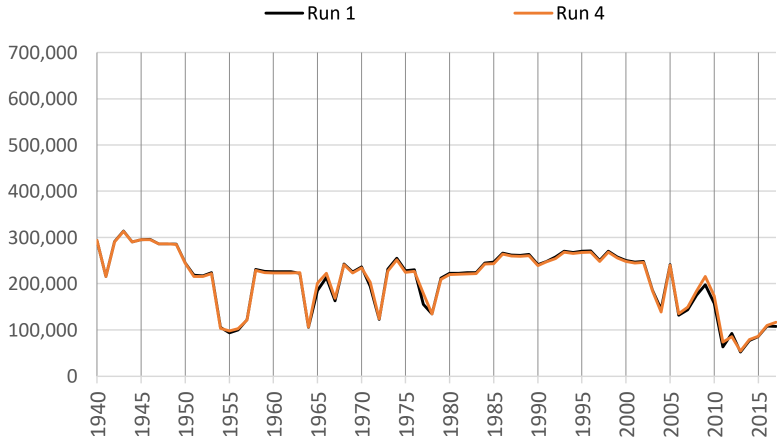
Farm Headgate Deliveries



Pumping



RHG Diversions - FHG Deliveries

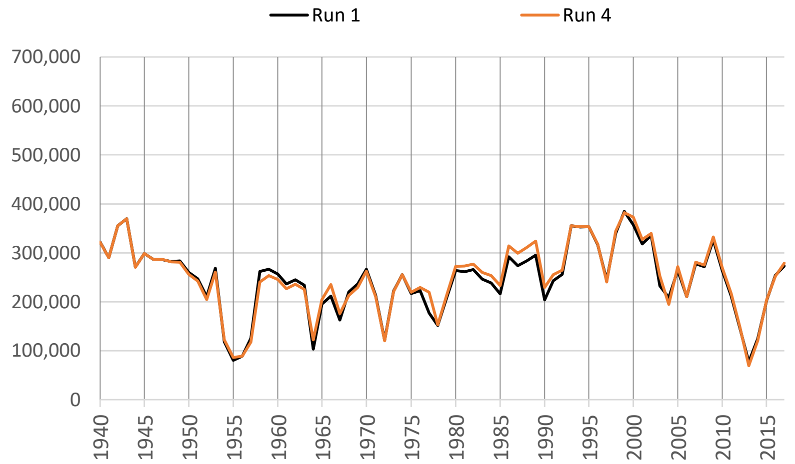


Notes: EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).
Pumping includes Supplemental and Primary groundwater pumping.

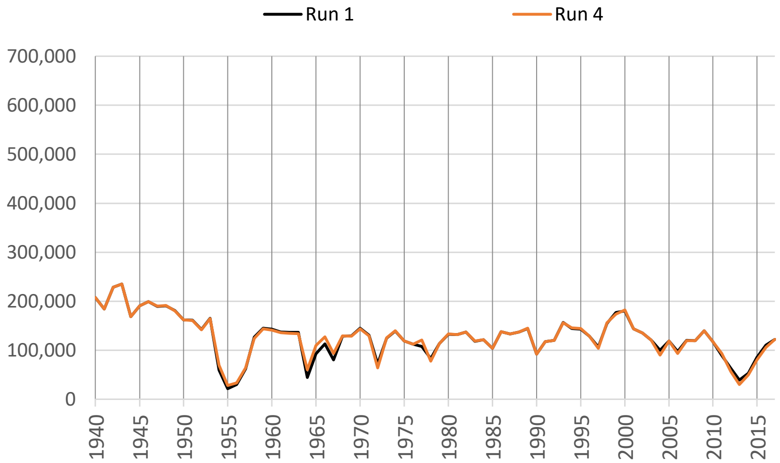
Run 4 - TX Pumping Off
Irrigation Season Summary of Irrigation Operations
Run 4 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

EPCWID Total

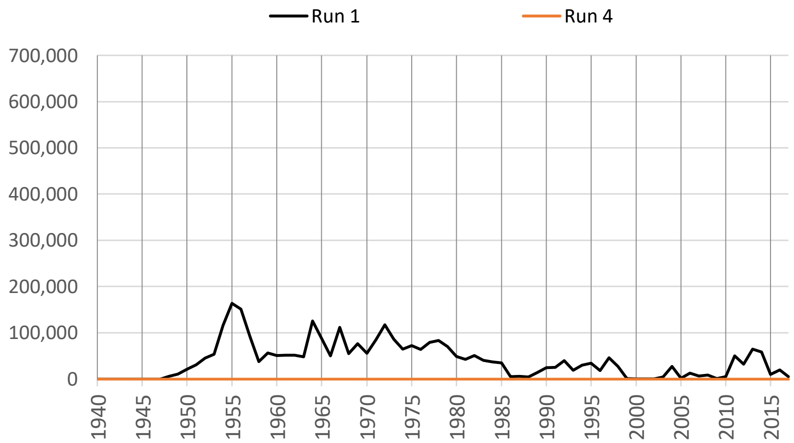
Net River Headgate Diversions



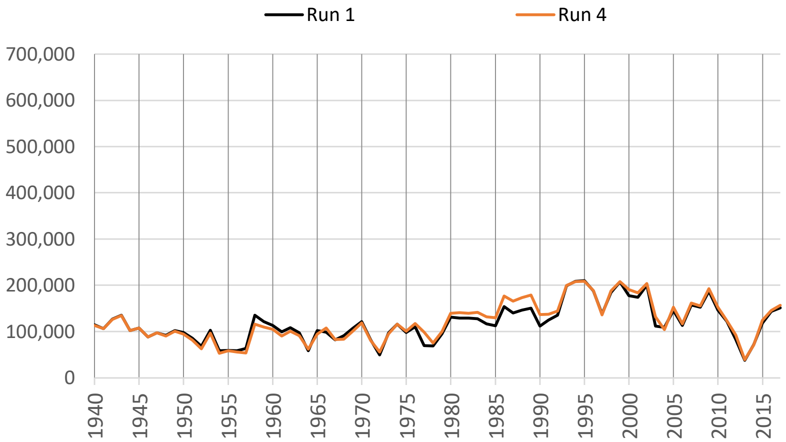
Farm Headgate Deliveries



Pumping



RHG Diversions - FHG Deliveries



Note: EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

Run 4 - TX Pumping Off

Irrigation Season Summary of Irrigation Operations

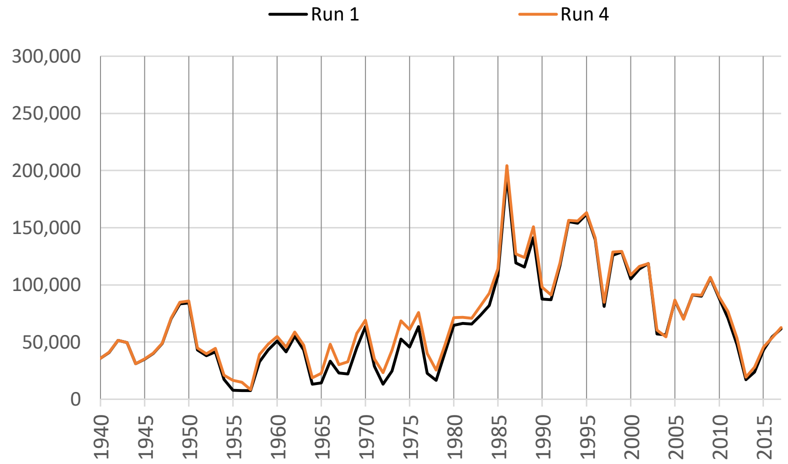
Run 4 v. Run 1

ILRG Model

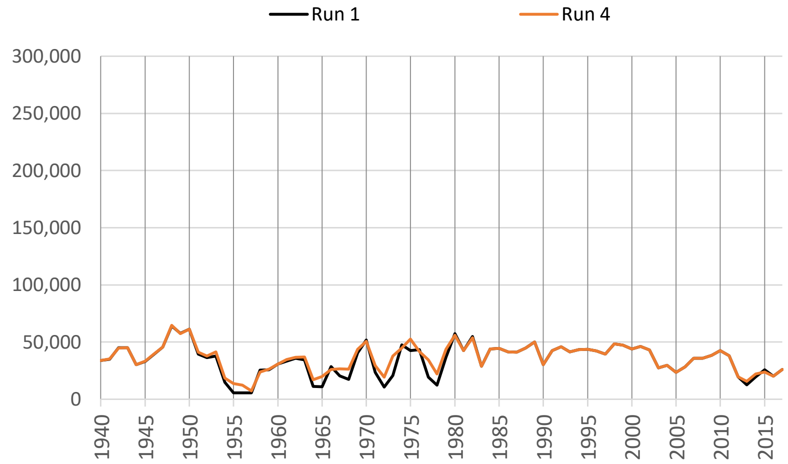
1940 - 2017 (acre-feet)

HCCRD Total

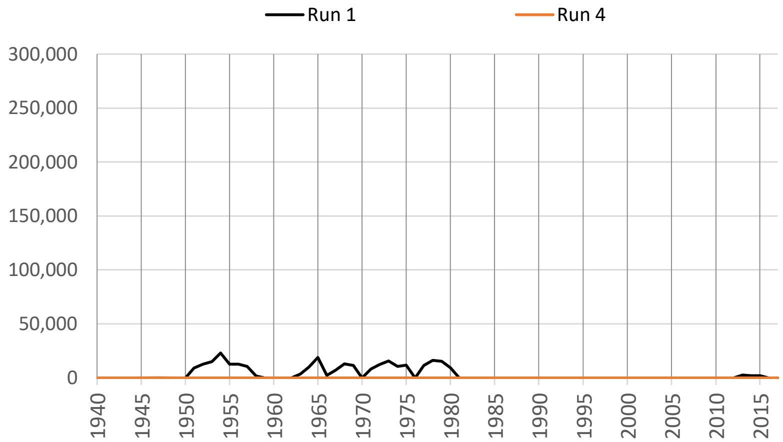
Net River Headgate Diversions



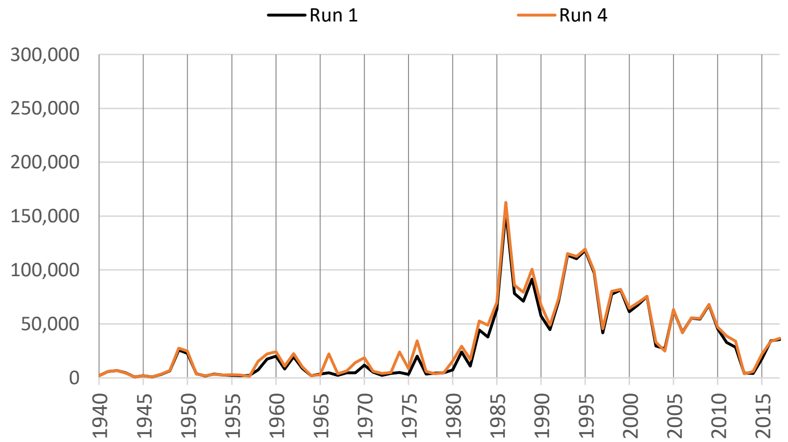
Farm Headgate Deliveries



Pumping



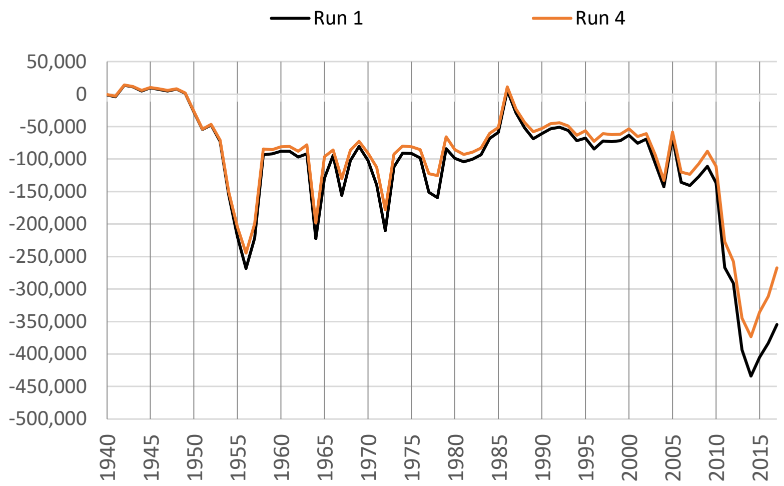
RHG Diversions - FHG Deliveries



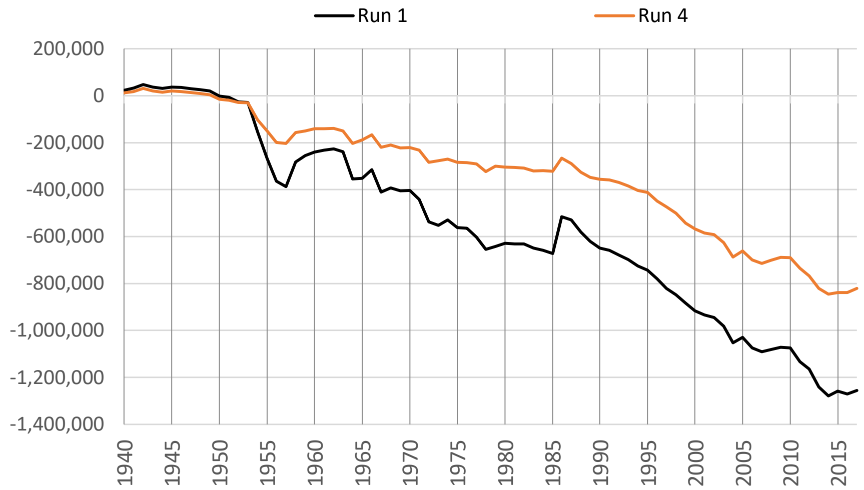
Note: HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

Run 4 - TX Pumping Off
Cumulative Change in Ground Water Storage
Run 4 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

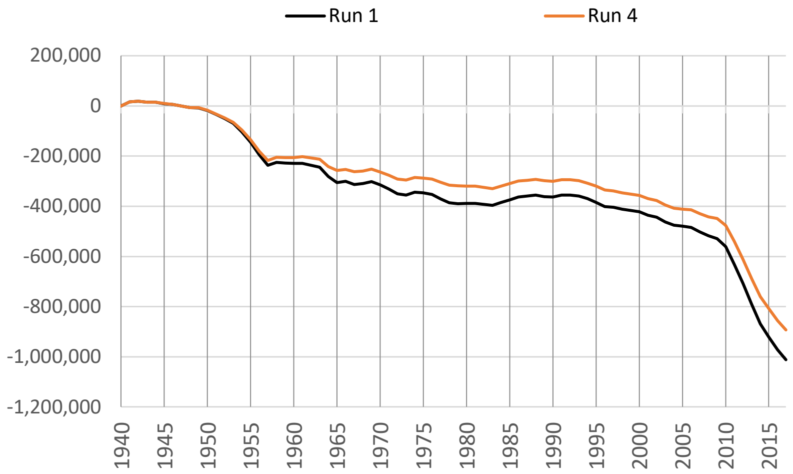
Rincon-Mesilla Alluvial Aquifer



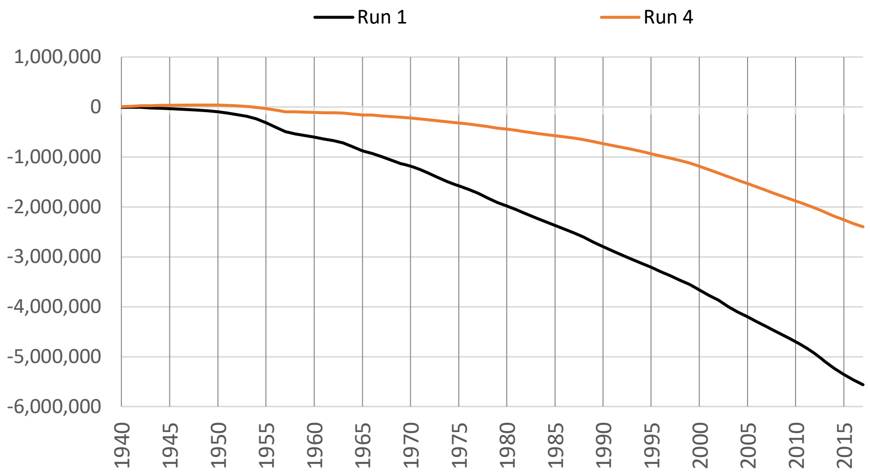
Hueco Alluvial Aquifer



Rincon-Mesilla Non-Alluvial Aquifer

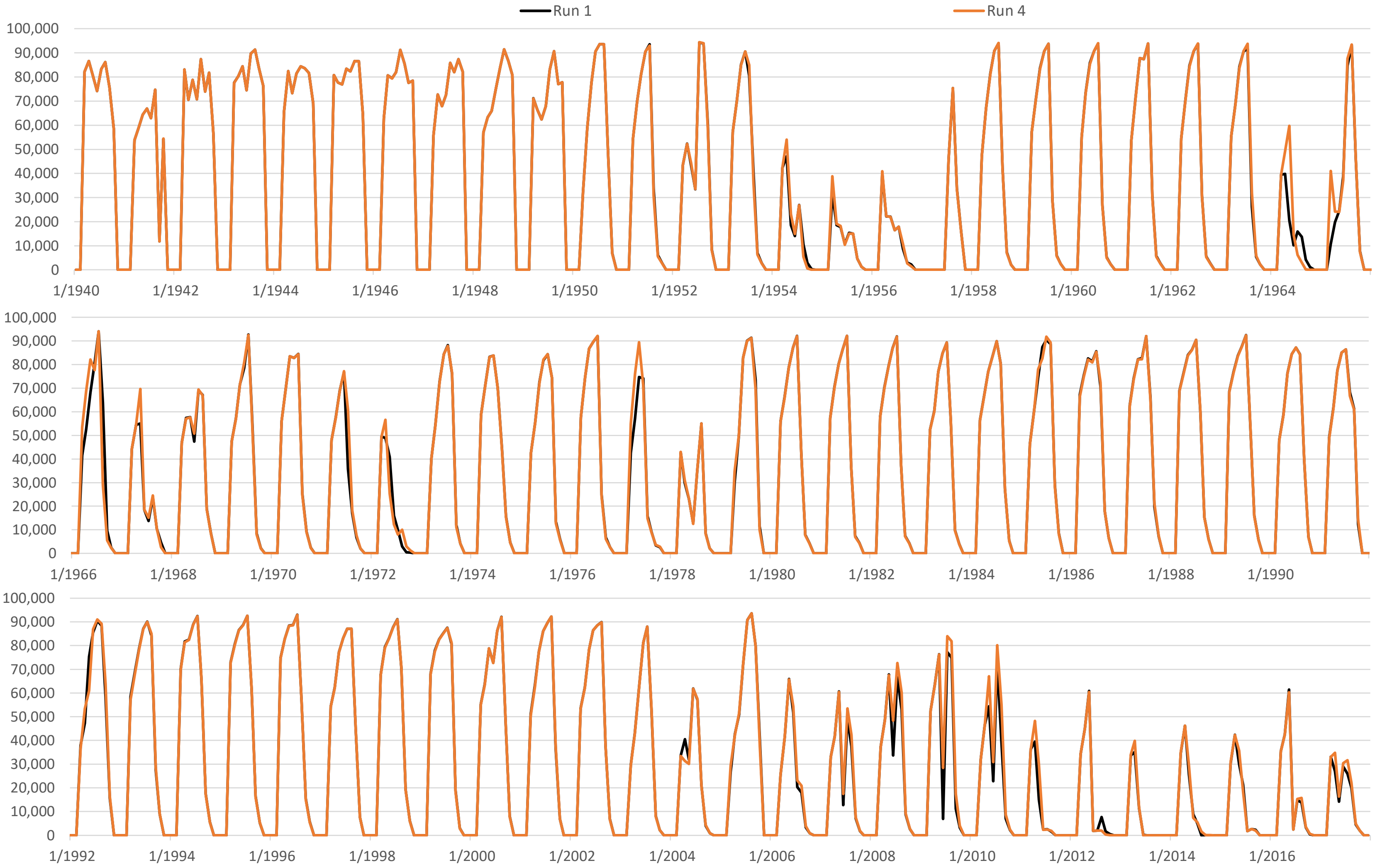


Hueco Non-Alluvial Aquifer



***Note different scales.**

Run 4 - TX Pumping Off
Monthly Net RHG Diversions
Run 4 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)
EBID Total

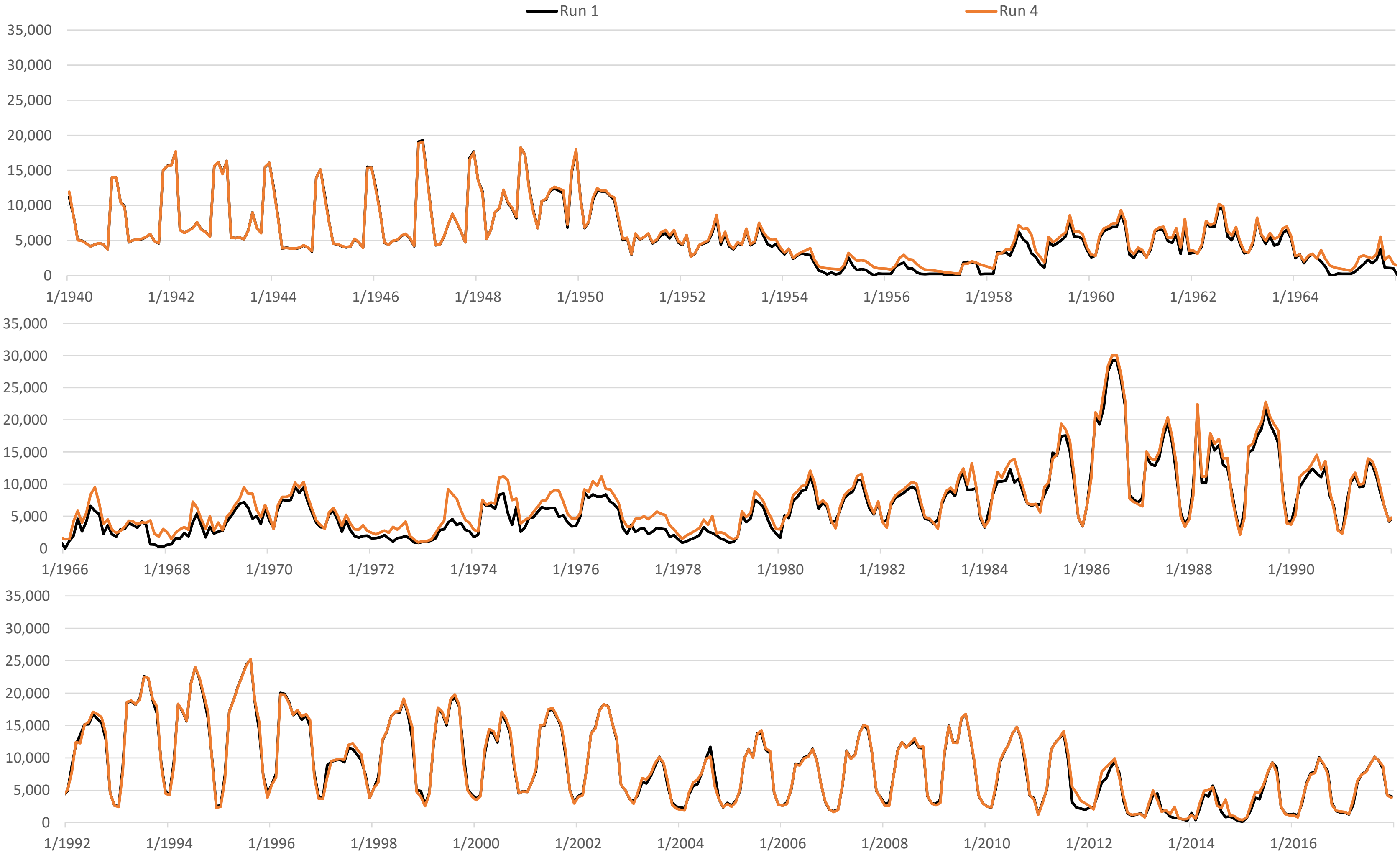


Note: EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).

Run 4 - TX Pumping Off
Monthly Net RHG Diversions
Run 4 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)
EPCWID Total

Note: EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

Run 4 - TX Pumping Off
Monthly Net RHG Diversions
Run 4 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)
HCCRD Total



Note: HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

Run 4 - TX Pumping Off

End of Month Reservoir Storage (Elephant Butte + Caballo)

Run 4 v. Run 1

ILRG Model

1940 - 2017 (acre-feet)

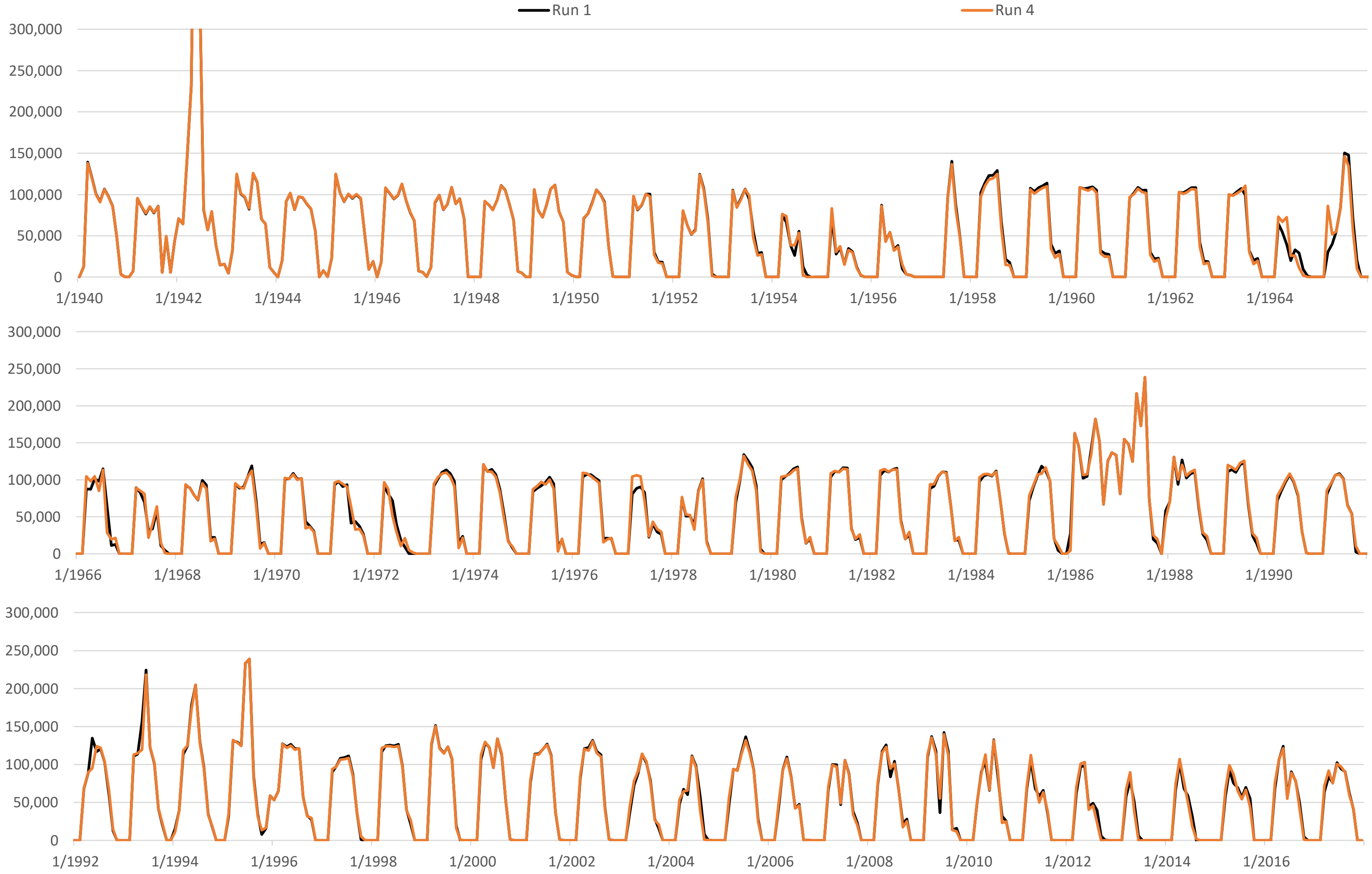
Run 4 - TX Pumping Off

Monthly Caballo Releases

Run 4 v. Run 1

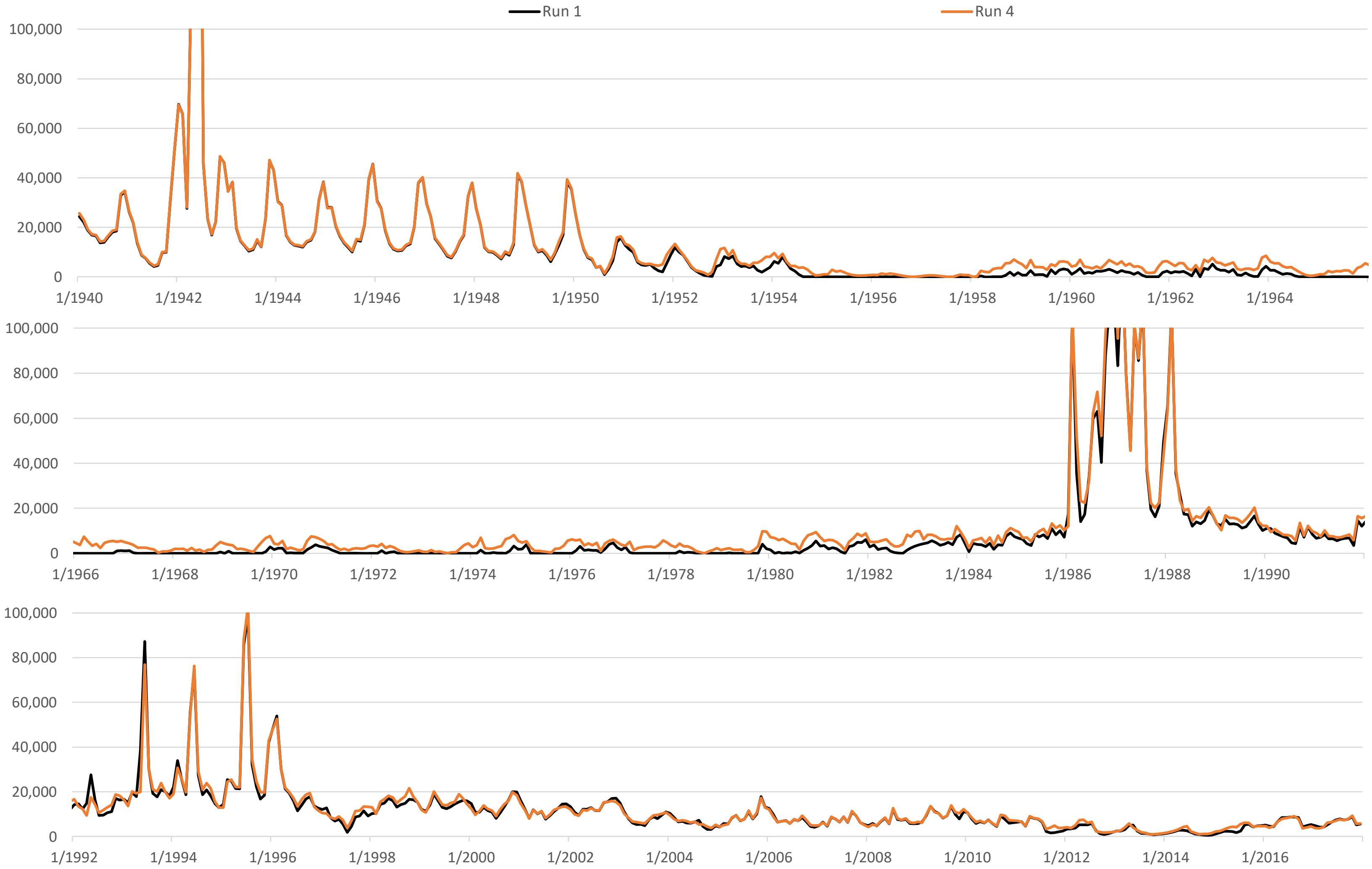
ILRG Model

1940 - 2017 (acre-feet)



Run 4 - TX Pumping Off
Monthly Rio Grande at El Paso Flow
Run 4 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

Run 4 - TX Pumping Off
Monthly Rio Grande at Fort Quitman Flow
Run 4 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)



Appendix 30E

Comparison of ILRG Model Runs
Run 5 v. Run 1

Model Run Specifications

Model Version: LRG_v116

Name: **Run 5 - MX Pumping Off**

Run ID: LRG_v116_Operational_Run5
Date: 8/25/2020

Name: **Run 1 - Historical Base Run**

Run ID: LRG_v116_Operational_Run1
Date: 8/23/2020

Selected Model Inputs

Pumping and Returns	**Run 5**	**Run 1**
Irrigation Pumping	MX Off	On
Irrigated Area	Hist	Hist
Non-Irrigation Pumping	MX Off	On
Non-Irrigation Pumping Returns	MX Off	On
Las Cruces Jornada Pumping Returns	On	On

Project Allocation Rules		
1950-2005	D1/D2	D1/D2
2006-2007	D3	D3
2008-2017	D3 + CO	D3 + CO

EPCWID Operations		
Charge EPCWID for Use of WWTP Returns	Off	Off
ACE and Haskell Credits for EPCWID	On	On
Increased EPCWID Use of Fabens Drain Flows	Off	Off
Charge EPCWID for Fabens Drain Flow Use	Off	Off

Run 5 - MX Pumping Off
Comparison of ILRG Model Runs
Run 5 v. Run 1
1951 - 2017 Annual Average
(1,000 acre-feet)

Run No.	1	5	5 - 1		
Simulated Input or Output	**Run 1**	**Run 5**	**Run 5 minus Run 1**		
Pumping Stress					
Irrigation Pumping	62.8	0.0	-62.8		
Non-Irrigation Pumping	181.0	109.2	-71.7		
WWTP Flows	58.0	34.3	-23.8		
Urban Deep Percolation	13.1	13.1	0.0		
Total Stress	172.7	61.9	-110.7		
	Stress is Pumping minus WWTP and Urban Deep Perc				
Effects of Pumping Stress				***% Chg***	
FHG Deliveries (Mar - Oct)				***Stress***	***% Diff.***
EBID	167.6	169.1	1.5	*-1%*	*1%*
EPCWID (incl. EPW)	139.9	141.4	1.5	*-1%*	*1%*
HCCRD	32.8	33.6	0.7	*-1%*	*2%*
Total	340.3	344.0	3.7	*-3%*	*1%*
FHG Deliveries (Nov - Feb)					
EBID	0.0	0.0	0.0	*0%*	*-2%*
EPCWID (incl. EPW)	0.2	0.2	0.0	*0%*	*-8%*
HCCRD	2.4	2.4	0.0	*0%*	*-1%*
Total	2.6	2.6	0.0	*0%*	*-1%*
Irrigation Pumping					
EBID	140.4	139.0	-1.5	*1%*	*-1%*
EPCWID (Mesilla Valley)	7.4	7.3	-0.1	*0%*	*-1%*
EPCWID (El Paso Valley)	40.1	38.9	-1.3	*1%*	*-3%*
HCCRD	4.2	2.9	-1.3	*1%*	*-31%*
	192.1	188.0	-4.1	*4%*	*-2%*
	Pumping turned off.	*Other values are simulated responses and are totaled.*			
Other Inflows/Outflows					
Net Reservoir Evaporation	125.3	126.4	1.1	*-1%*	*1%*
Riparian ET	70.9	77.0	6.1	*-5%*	*9%*
River Evaporation + Incidental Canal Loss	30.3	30.1	-0.2	*0%*	*-1%*
Total	226.6	233.5	7.0	*-6%*	*3%*
Rio Grande at Fort Quitman					
Reservoir Spills	33.3	36.3	3.0	*-3%*	*9%*
Nov-Feb Flows	21.4	30.4	9.0	*-8%*	*42%*
Mar - Oct Flows	41.1	54.2	13.1	*-12%*	*32%*
Underflow (GW Model)	0.2	0.2	0.0	*0%*	*16%*
Total	96.0	121.2	25.2	*-23%*	*26%*

Run 5 - MX Pumping Off
Comparison of ILRG Model Runs
Run 5 v. Run 1
1951 - 2017 Annual Average
(1,000 acre-feet)

Run No.	**1**	**5**	**5 - 1**		
Simulated Input or Output	**Run 1**	**Run 5**	**Run 5 minus Run 1**		
Effects of Pumping Stress (continued)				***% Chg***	
Change in Storage				***Stress***	***% Diff.***
Reservoir Storage	-4.7	-4.8	-0.1	*0%*	*3%*
Alluvial GW Storage (RW Model)	-23.6	-6.2	17.4	*-16%*	*-74%*
Non-alluvial GW Storage (GW Models)	-96.4	-51.2	45.1	*-41%*	*-47%*
Soil Moisture Storage	0.6	0.4	-0.2	*0%*	*-26%*
Total	-124.0	-61.8	62.2	*-56%*	*-50%*
Summary of Effects					
FHG Deliveries (Mar-Oct)	340.3	344.0	3.7	*-3%*	*1%*
FHG Deliveries (Nov-Feb)	2.6	2.6	0.0	*0%*	*-1%*
Irrigation Pumping	192.1	188.0	-4.1	*4%*	*-2%*
Riparian ET + Evaporation	226.6	233.5	7.0	*-6%*	*3%*
Fort Quitman Flow	96.0	121.2	25.2	*-23%*	*26%*
Change in Storage	-124.0	-61.8	62.2	*-56%*	*-50%*
Total	733.6	827.5	94.0	*-85%*	*13%*
Other Effects of Pumping Stress				***% Chg***	
Rio Grande at El Paso				***Stress***	***% Diff.***
Reservoir Spills	49.4	48.3	-1.1	*1%*	*-2%*
Nov-Feb Flows	22.8	23.0	0.2	*0%*	*1%*
Mar - Oct Flows	263.8	263.5	-0.2	*0%*	*0%*
Total	336.0	334.8	-1.2	*1%*	*0%*
Rio Grande below Caballo					
Reservoir Spills	65.9	63.5	-2.4	*2%*	*-4%*
Nov-Feb Flows	0.5	0.6	0.1	*0%*	*23%*
Mar - Oct Flows	541.3	542.6	1.3	*-1%*	*0%*
Total	607.6	606.7	-0.9	*1%*	*0%*
Surface Water Diversions (Mar - Oct)					
EBID	366.5	368.9	2.4	*-2%*	*1%*
EPCWID (incl. EPW)	236.8	236.5	-0.3	*0%*	*0%*
HCCRD	67.5	71.5	3.9	*-4%*	*6%*
Total	670.8	676.9	6.0	*-5%*	*1%*
Surface Water Diversions (Nov - Feb)					
EBID	0.0	0.0	0.0	*0%*	*0%*
EPCWID (incl. EPW)	14.3	14.4	0.1	*0%*	*0%*
HCCRD	14.2	16.3	2.1	*-2%*	*15%*
Total	28.5	30.7	2.1	*-2%*	*8%*

Run 5 - MX Pumping Off
Annual Differences in ILRG Model Outputs
Run 5 minus Run 1
1940 - 2017 (acre-feet)

	Net River Headgate Diversions						Farm Headgate Deliveries						Annual Flows		
	EBID		EPCWID (incl. EPW)		HCCRD		EBID		EPCWID (incl. EPW)		HCCRD				
Year	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Caballo Releases	Rio Grande at El Paso	Rio Grande at Fort Quitman
1940	3	3	-152	475	-246	83	-13	-13	464	517	-223	-223	-4,018	-3,818	157
1941	-113	-113	-693	71	-262	35	0	1	-37	99	-229	-161	3,487	2,229	4,518
1942	-4	-4	-312	485	111	101	3	4	-280	118	71	88	-690	494	4,058
1943	7	7	-330	266	44	161	-11	-11	-263	-158	78	242	-1,961	-1,899	277
1944	15	15	-310	81	-195	-100	-7	-7	156	247	-157	-45	-2,132	-2,065	110
1945	12	12	-249	248	-160	13	-8	-9	155	294	-141	-118	-2,154	-2,114	163
1946	6	6	-370	338	-180	18	-12	-12	96	443	-160	-144	-2,306	-2,263	132
1947	10	10	-674	-40	-210	-192	-11	-11	-131	300	-174	-187	-2,669	-2,619	6
1948	16	16	-597	63	-202	-7	-9	-9	36	346	-78	-50	-2,768	-2,717	3,623
1949	17	17	-424	270	-188	123	-7	-7	246	406	12	25	-2,719	-2,679	6,432
1950	1	1	-532	-333	-71	151	-8	-8	86	86	8	15	-2,414	-2,372	4,261
1951	1,018	1,018	-409	-441	17	149	553	553	236	236	39	110	-1,541	-1,815	8,870
1952	198	198	-689	-711	148	292	380	379	221	219	156	95	-6,625	-4,884	7,154
1953	180	180	-739	-753	104	317	1,159	1,158	207	205	135	99	-1,663	-2,733	12,700
1954	3,318	3,318	2,641	2,634	925	1,056	5,732	5,732	5,569	5,568	902	1,116	2,389	6,160	9,552
1955	8,708	8,708	6,244	6,133	-488	-757	4,497	4,497	4,387	4,202	-368	-532	18,975	9,243	352
1956	-3,077	-3,077	-1,740	-1,740	-559	-677	-2,347	-2,347	-1,786	-2,282	-824	-1,171	-5,292	-2,175	-87
1957	0	0	-9	-20	-12	35	-12	-12	11	-238	-149	-295	75	8	-82
1958	-3	-3	-3,096	-3,132	1,082	3,006	0	0	12	-87	-414	-765	-4,808	-3,260	3,296
1959	0	0	-1,801	-1,837	3,043	4,886	-1	-1	219	219	6	23	-4,509	-3,930	7,073
1960	1	1	-1,715	-1,615	2,365	3,678	-13	-13	247	247	0	0	-6,844	-6,385	7,011
1961	3	3	-2,674	-2,448	2,766	4,367	-21	-21	1,664	1,664	1,294	-874	-8,959	-8,411	15,046
1962	6	6	-2,681	-2,450	2,528	4,036	-15	-15	349	349	414	478	-8,874	-8,469	19,027
1963	8,877	8,877	-3,427	-3,199	2,228	3,698	4,798	4,798	423	424	948	976	-2,521	-5,887	19,745
1964	15,982	15,982	11,569	11,920	3,846	4,966	8,501	8,501	8,026	7,697	3,329	3,574	20,306	11,770	17,271
1965	2,819	2,819	-916	-952	2,580	4,816	1,357	1,357	914	596	2,464	4,819	-3,747	-200	1,003
1966	-20	-20	-2,612	-2,300	5,992	8,632	127	127	-22	-20	-3,351	-4,245	-7,744	-4,043	14,078
1967	9,251	9,251	7,253	8,001	4,985	7,348	5,760	5,760	6,583	6,089	4,090	4,926	11,094	6,899	12,048
1968	927	927	-4,611	-3,890	5,656	8,920	835	835	201	-200	6,001	7,379	-5,862	-2,877	5,253
1969	4	4	-4,606	-4,542	6,957	10,374	205	205	-100	-99	5,099	3,034	-7,695	-5,972	20,191
1970	1	1	-4,534	-4,525	5,297	8,058	5	5	33	33	-1,268	-2,376	-8,832	-7,917	26,348
1971	13,048	13,048	-2,715	-2,244	4,966	8,186	7,930	7,930	373	374	4,009	5,968	2,106	-3,397	13,122
1972	-1,070	-1,070	-1,178	-986	4,869	7,096	4,972	4,972	230	148	4,561	5,053	-6,112	64	10,548
1973	-72	-72	-3,871	-3,900	2,284	4,369	-102	-102	357	288	2,252	2,809	-2,861	-4,536	3,696
1974	-4	-4	-3,788	-3,822	5,214	10,399	-31	-31	460	460	1,165	1,064	-6,665	-5,957	18,325
1975	-219	-219	-3,459	-3,445	8,282	13,821	1,042	1,042	169	169	7,514	8,997	-8,014	-6,170	19,566
1976	-11	-11	-2,544	-2,554	7,513	13,869	356	356	58	58	-924	-3,065	-5,284	-5,371	31,149
1977	21,799	21,799	-2,322	-1,312	7,542	12,859	13,402	13,402	315	316	7,018	8,191	8,164	-497	14,261
1978	14,393	14,393	10,212	11,647	5,674	11,389	7,817	7,817	12,429	12,431	5,812	6,823	24,247	16,497	16,267

Run 5 - MX Pumping Off

Annual Differences in ILRG Model Outputs

Run 5 minus Run 1

1940 - 2017 (acre-feet)

	Net River Headgate Diversions						Farm Headgate Deliveries						Annual Flows		
	EBID		EPCWID (incl. EPW)		HCCRD		EBID		EPCWID (incl. EPW)		HCCRD				
Year	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Caballo Releases	Rio Grande at El Paso	Rio Grande at Fort Quitman
1979	-401	-401	-5,546	-5,178	7,839	12,970	130	130	-1,174	-1,169	3,114	737	-9,367	-3,303	27,004
1980	-56	-56	-3,423	-3,233	6,437	10,771	122	122	35	38	-3,919	-7,987	-7,496	-4,238	51,823
1981	-17	-17	-2,966	-2,987	4,772	7,511	183	183	13	13	-56	-339	-4,827	-3,718	39,921
1982	-6	-6	-3,009	-3,021	4,191	6,766	44	44	5	44	-1,041	-2,368	-4,306	-3,572	48,827
1983	-7	-7	-2,366	-2,414	4,372	6,825	37	37	-24	-23	0	0	-3,230	-2,674	36,176
1984	-10	-10	-2,032	-2,013	6,285	8,565	27	27	2	87	0	0	-980	-889	30,826
1985	-16	-16	-1,881	-1,830	4,757	6,960	13	13	-162	-3	0	0	-2,527	-2,054	33,767
1986	-12	-12	-1,950	-1,982	4,125	6,350	77	80	6	9	0	0	20,324	19,934	170,337
1987	-9	-9	-1,909	-1,960	2,719	4,728	10	11	1	2	0	0	-28	-119	70,007
1988	-3	-3	-1,812	-1,868	2,243	4,068	22	22	1	1	0	0	-3,899	-3,041	44,478
1989	-3	-3	-1,891	-1,845	2,230	3,898	10	10	-172	18	0	0	-2,670	-2,397	34,208
1990	-38	-38	-609	-486	4,535	5,946	149	149	-120	159	0	0	425	697	23,745
1991	-19	-19	-406	-416	2,439	3,700	80	80	-92	-4	0	0	-1,020	-737	34,355
1992	1,230	1,230	72,354	72,271	28,846	31,052	-8,171	-8,178	32,201	32,215	0	0	44,882	47,625	65,521
1993	497	497	-6,270	-6,374	260	1,917	632	628	-2,957	-2,963	0	0	-39,052	-39,186	4,230
1994	86	86	-98	-199	1,665	2,845	-175	-175	873	872	0	0	602	-1,043	31,205
1995	113	113	-287	-260	1,692	2,860	-13	-13	557	772	0	0	2,549	1,760	38,696
1996	-41	-41	-1,246	-1,347	1,537	2,772	321	321	31	31	0	0	-5,220	-3,667	36,759
1997	-4	-4	-1,934	-1,822	1,769	2,617	-42	-42	-100	243	0	0	-2,465	-2,483	27,331
1998	-3	-3	-2,281	-2,384	1,489	2,542	-9	-9	-156	-27	0	0	-5,396	-5,011	36,522
1999	124	124	-233	-296	2,415	3,716	4	4	1,823	1,903	0	0	0	-559	38,156
2000	-6	-6	-6,388	-6,457	1,778	3,235	-17	-17	-1,832	-1,832	0	0	-6,453	-6,064	36,192
2001	-8	-8	-2,717	-2,799	2,771	4,336	-10	-10	-4	-4	0	0	-2,423	-2,406	35,203
2002	-5	-5	-2,792	-2,874	2,754	4,291	-8	-8	3	3	0	0	-2,456	-2,417	34,585
2003	14,759	14,759	-1,642	-1,685	2,514	4,168	9,308	9,308	1,041	1,045	0	0	6,823	1,225	26,641
2004	2,563	2,563	1,861	1,897	3,503	5,266	1,714	1,714	2,888	2,891	0	0	2,428	3,395	27,833
2005	-3	-3	-3,900	-3,959	3,860	5,734	77	78	74	76	0	0	-5,346	-3,123	30,791
2006	4,758	4,758	6,444	6,400	4,333	6,234	2,923	2,923	5,585	5,587	0	0	5,397	3,659	33,521
2007	3,320	3,320	1,952	1,987	4,289	6,344	1,564	1,564	5,001	5,004	0	0	5,297	3,636	26,328
2008	6,575	6,575	-6,169	-6,205	3,758	5,673	4,250	4,250	-1,087	-1,085	0	0	-6,565	-5,716	33,811
2009	6,439	6,439	-4,284	-4,380	2,369	3,859	2,832	2,832	47	49	0	0	-3,400	-3,908	36,634
2010	17,893	17,893	-3,524	-3,583	2,230	3,689	11,206	11,206	243	248	0	0	882	-3,074	33,013
2011	12,006	12,006	1,386	1,312	8,303	9,739	6,518	6,518	3,497	3,499	0	0	8,690	2,477	22,728
2012	-573	-573	125	10	9,594	11,838	737	737	2,633	2,634	0	0	-1,749	48	10,732
2013	-3,329	-3,329	-1,169	-1,281	3,168	4,728	-1,715	-1,715	730	730	1,599	2,124	-4,349	-1,156	3,273
2014	42	42	-996	-1,109	4,626	7,331	-67	-67	1,369	1,370	54	2,827	-800	-1,136	-2,335
2015	-1,545	-1,545	-6,731	-6,852	3,945	6,104	-883	-883	12	12	-2,633	-1,437	-10,191	-6,830	9,156
2016	-1,065	-1,065	4,657	4,535	3,966	6,176	-777	-777	8,077	8,079	0	0	11,825	6,391	13,605
2017	4,321	4,321	-9,493	-9,601	2,474	4,378	2,099	2,099	-534	-533	0	0	-10,053	-9,726	20,271
Averages															
1951-2017	2,442	2,442	-319	-250	3,920	5,995	1,494	1,494	1,494	1,478	702	683	-944	-1,159	25,204
1951-1978	3,431	3,431	-651	-446	3,422	5,685	2,389	2,389	1,492	1,395	1,782	1,865	-968	-1,580	11,885
1979-2005	693	693	542	536	4,215	6,163	167	167	1,213	1,274	-70	-369	-1,153	-669	41,301
2006-2017	4,070	4,070	-1,483	-1,564	4,421	6,341	2,390	2,390	2,131	2,133	-82	293	-418	-1,278	20,061
1985-2017	2,062	2,062	490	441	4,029	5,730	990	989	1,802	1,848	-30	106	-180	-455	33,979
1985-2005	914	914	1,618	1,587	3,805	5,381	189	189	1,615	1,686	0	0	-44	16	41,932

Notes:

EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).

EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

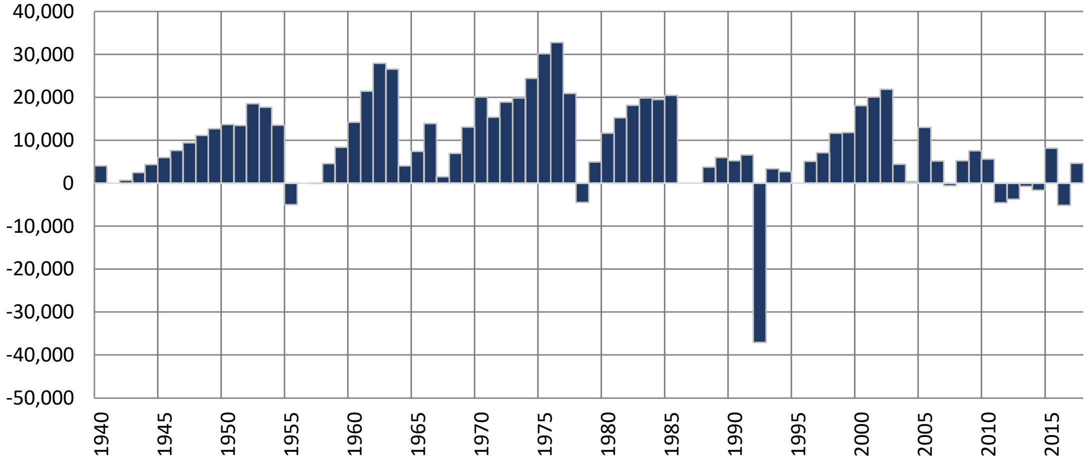
Run 5 - MX Pumping Off

Simulated Differences in ILRG Model Outputs

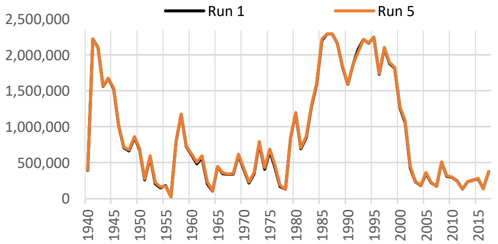
Run 5 minus Run 1

1940 - 2017 (acre-feet)

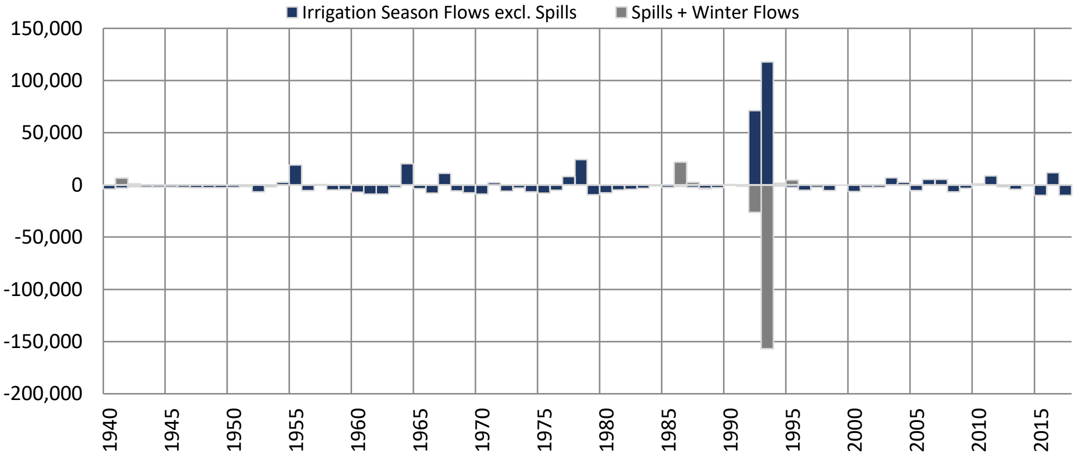
Total Project Storage (Year End)



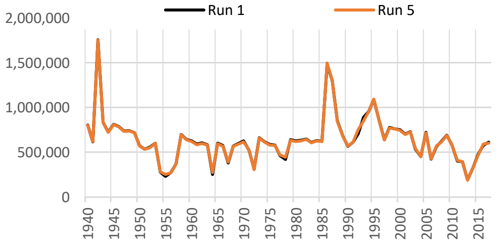
Period	Average Difference
1951-2017	-135
1951-1978	-648
1979-2005	646
2006-2017	-696
1985-2017	-451
1985-2005	-311



Caballo Reservoir Outflows (Annual)



	Average Difference		
Period	Irr Season (excl. Spills)	Nov-Feb and Spills	Annual
1951-2017	1,339	-2,283	-944
1951-1978	-968	0	-968
1979-2005	4,511	-5,664	-1,153
2006-2017	-418	0	-418
1985-2017	4,454	-4,634	-180
1985-2005	7,239	-7,282	-44



Notes:

Reservoir storage does not include storage attributed to SJC, CO, or NM credit waters.

Average differences calculated as (Final Storage - Initial Storage)/(no. years).

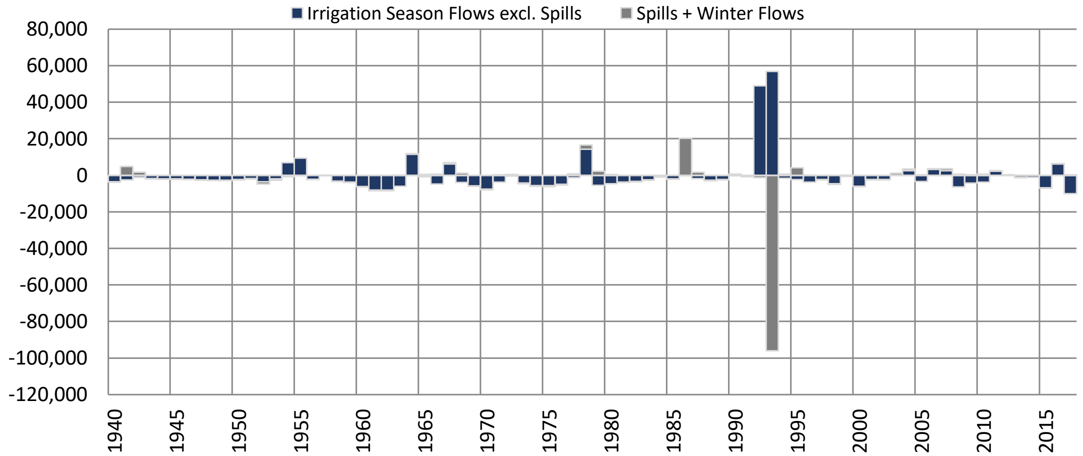
Run 5 - MX Pumping Off

Simulated Differences in ILRG Model Outputs

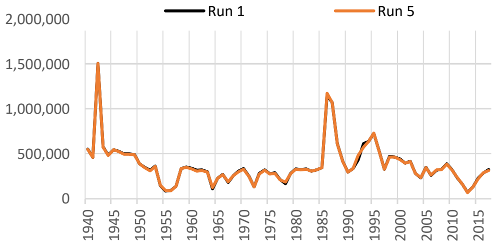
Run 5 minus Run 1

1940 - 2017 (acre-feet)

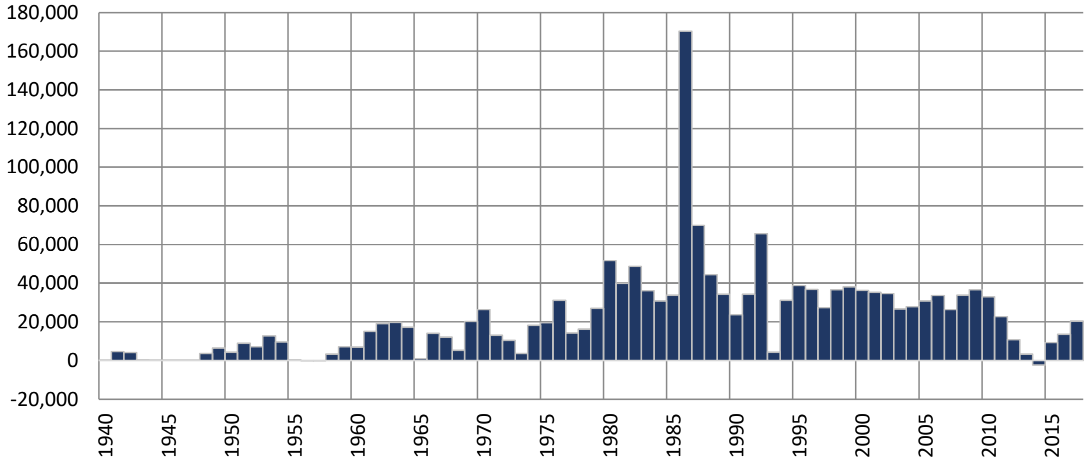
Rio Grande at El Paso (Annual)



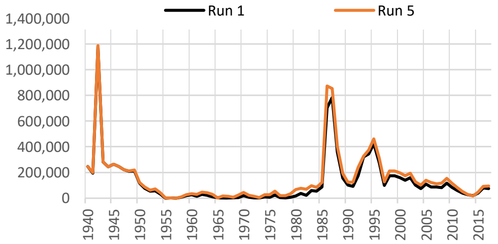
	Average Difference		
Period	Irr Season (excl. Spills)	Nov-Feb and Spills	Annual
1951-2017	-224	-935	-1,159
1951-1978	-1,617	37	-1,580
1979-2005	1,825	-2,494	-669
2006-2017	-1,582	304	-1,278
1985-2017	1,544	-1,999	-455
1985-2005	3,331	-3,315	16



Rio Grande at Fort Quitman (Annual)



Period	Average Difference
1951-2017	25,169
1951-1978	11,841
1979-2005	41,265
2006-2017	20,053
1985-2017	33,960
1985-2005	41,907



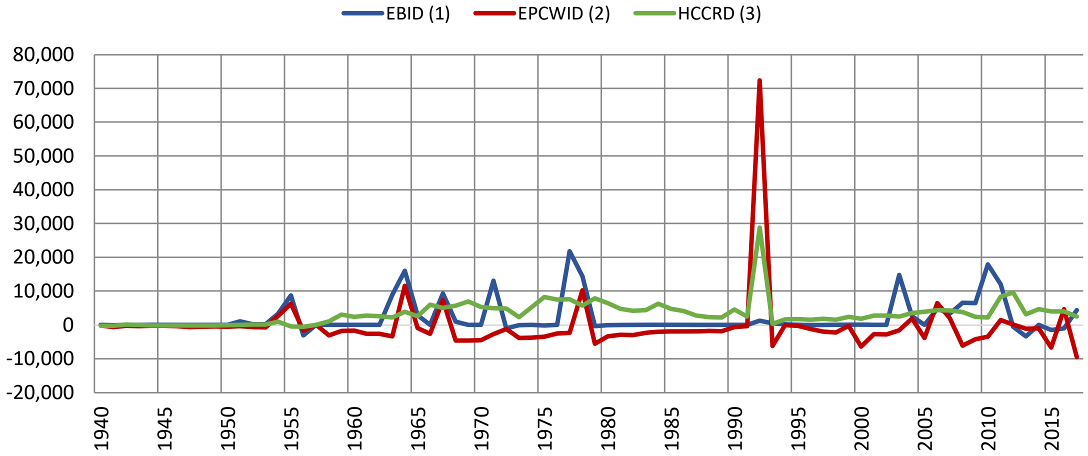
Run 5 - MX Pumping Off

Simulated Differences in ILRG Model Outputs

Run 5 minus Run 1

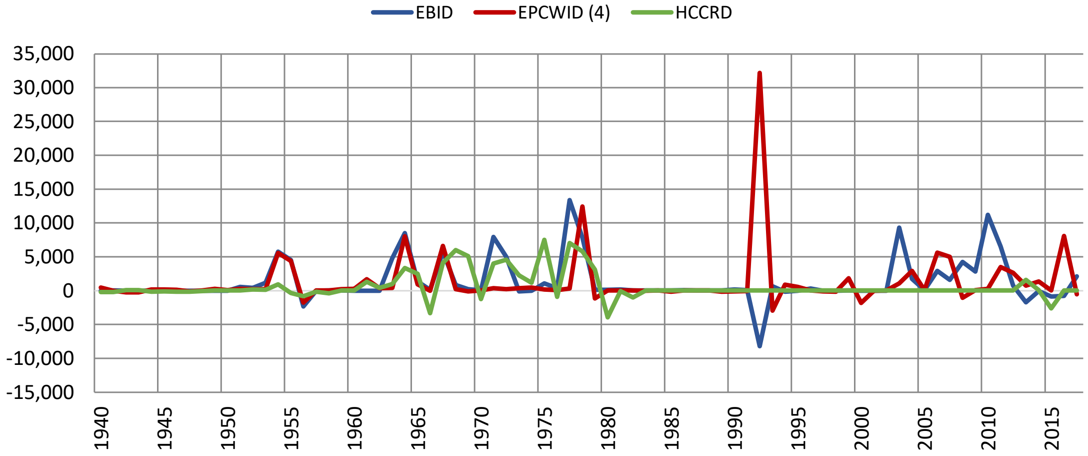
1940 - 2017 (acre-feet)

River Headgate (RHG) Diversions (Irrigation Season)



	Average Difference		
Period	EBID	EPCWID	HCCRD
1951-2017	2,442	-319	3,920
1951-1978	3,431	-651	3,422
1979-2005	693	542	4,215
2006-2017	4,070	-1,483	4,421
1985-2017	2,062	490	4,029
1985-2005	914	1,618	3,805

Farm Headgate (FHG) Deliveries (Irrigation Season)



	Average Difference		
Period	EBID	EPCWID	HCCRD
1951-2017	1,494	1,494	702
1951-1978	2,389	1,492	1,782
1979-2005	167	1,213	-70
2006-2017	2,390	2,131	-82
1985-2017	990	1,802	-30
1985-2005	189	1,615	0

Notes:

(1) EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).

(2) EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

(3) HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

(4) EPCWID FHG values include deliveries to Rogers WTP and R/U WTP.

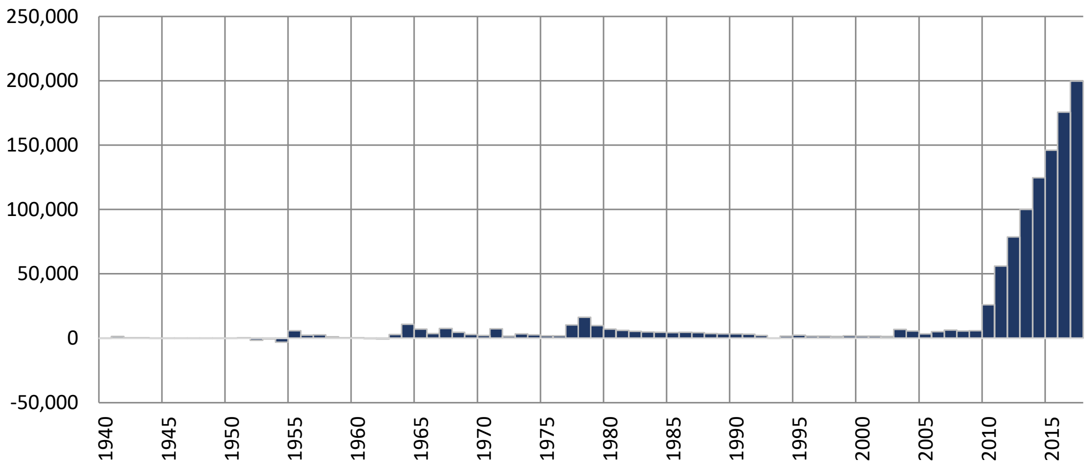
Run 5 - MX Pumping Off

Simulated Differences in ILRG Model Outputs

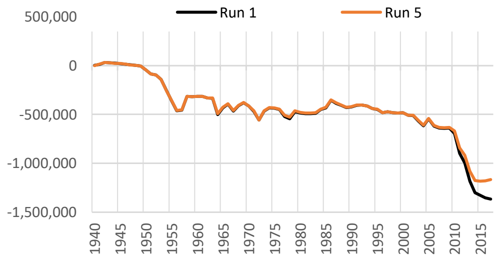
Run 5 minus Run 1

1940 - 2017 (acre-feet)

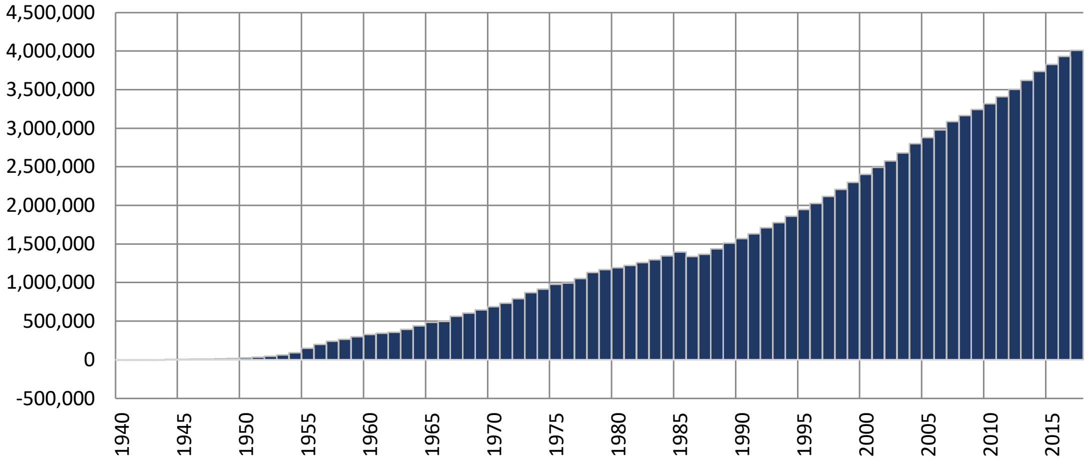
Cumulative Annual Rincon-Mesilla Groundwater Storage



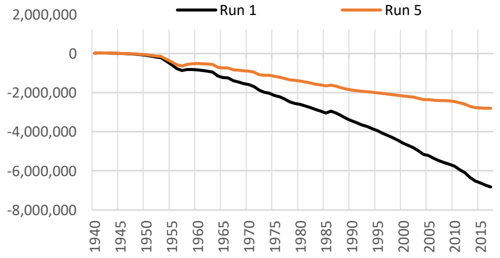
Period	Average Difference
1951-2017	2,980
1951-1978	584
1979-2005	-477
2006-2017	16,348
1985-2017	5,907
1985-2005	-60



Cumulative Annual Hueco Groundwater Storage



Period	Average Difference
1951-2017	59,524
1951-1978	39,524
1979-2005	64,726
2006-2017	94,489
1985-2017	80,745
1985-2005	72,892



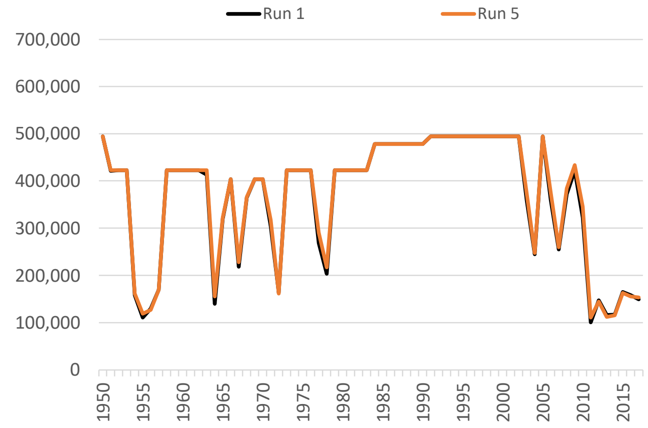
Notes:

Cumulative storage change in alluvial and non-alluvial aquifers.

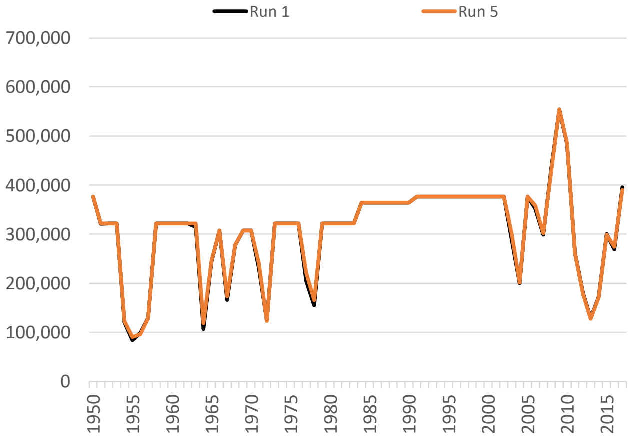
Average differences calculated as (Final Storage - Initial Storage)/(no. years).

Run 5 - MX Pumping Off
Annual Allocation and Charges
Run 5 v. Run 1
ILRG Model
1950 - 2017 (acre-feet)

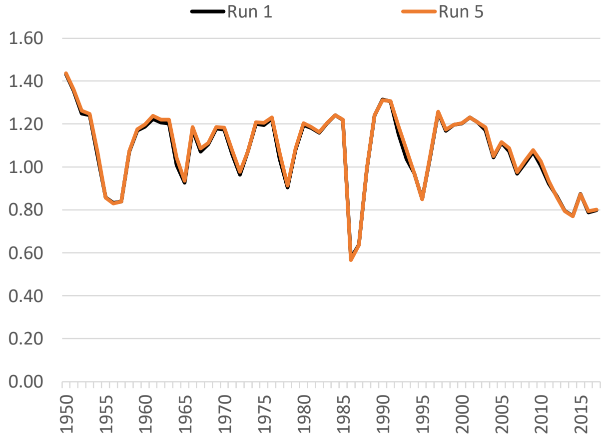
Total Allocation - EBID



Total Allocation - EPCWID



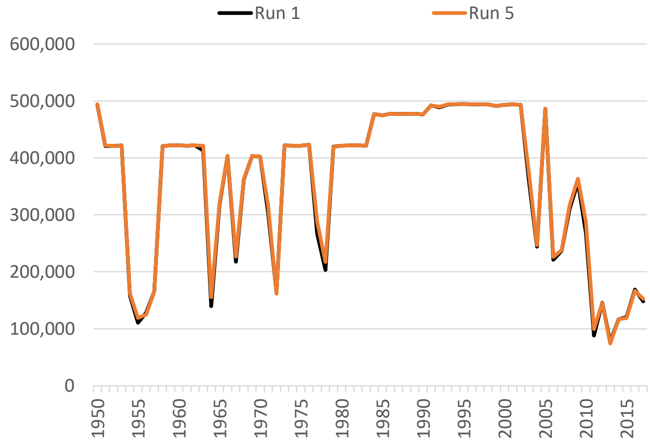
Diversion Ratio



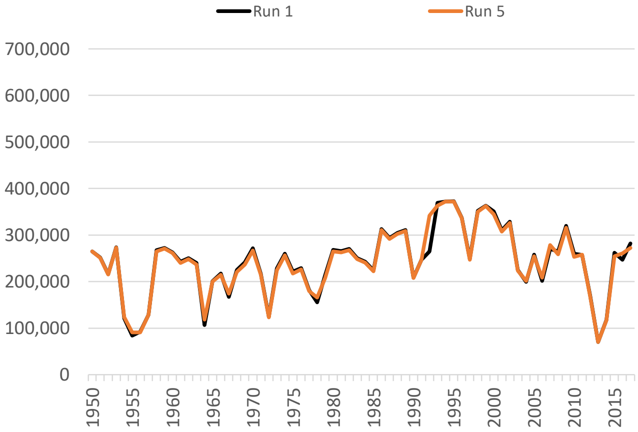
Note:

Computed as Total Charges/Caballo Release.

Annual Delivery Charges - EBID

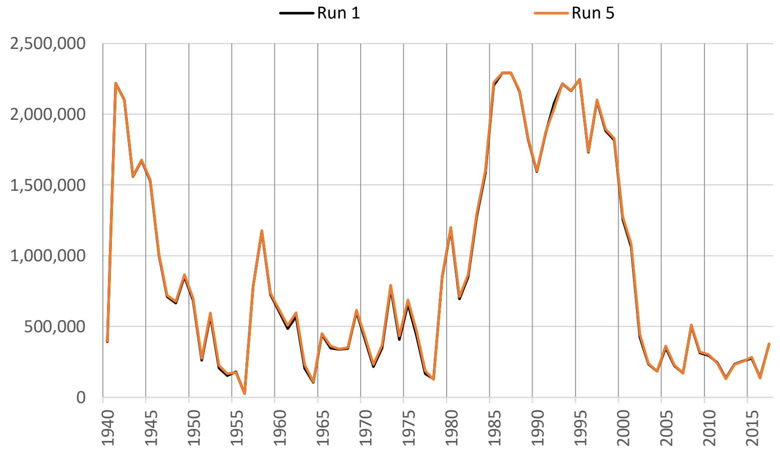


Annual Delivery Charges - EPCWID

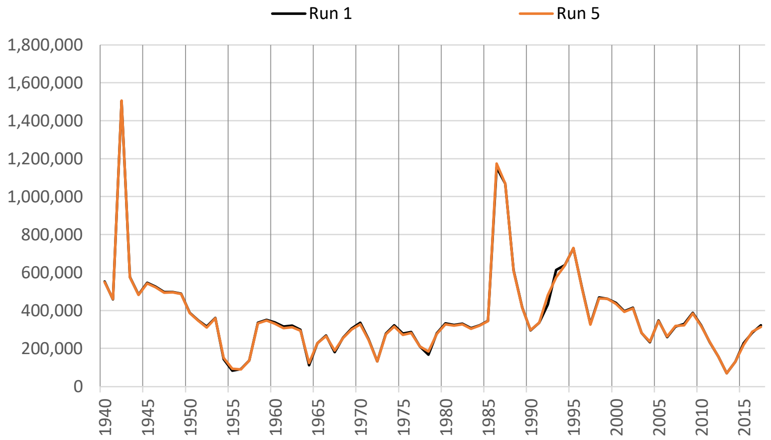


Run 5 - MX Pumping Off
Annual Summary of Project Storage and Rio Grande Flows
Run 5 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

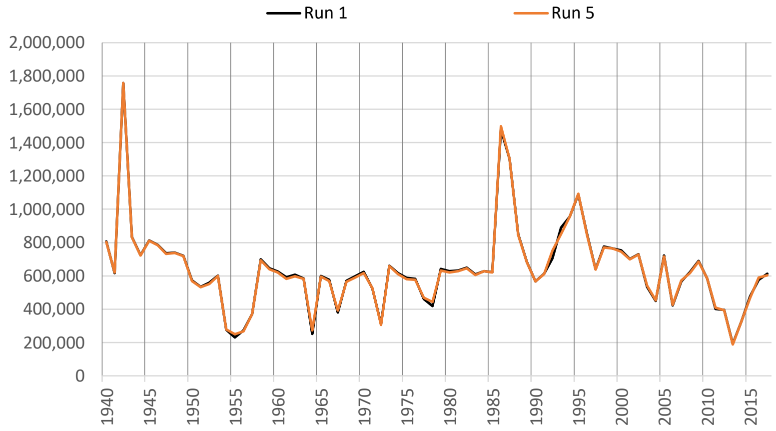
Total Year-End Project Reservoir Storage



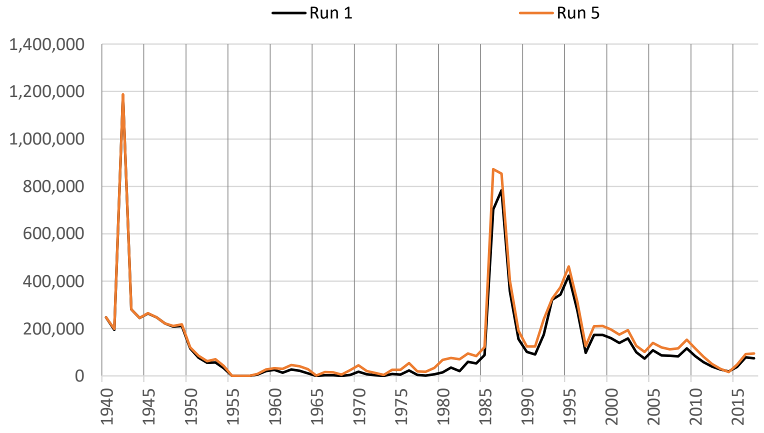
Rio Grande at El Paso



Rio Grande Below Caballo



Rio Grande at Fort Quitman



***Note different scales.**

Run 5 - MX Pumping Off

Irrigation Season Summary of Irrigation Operations

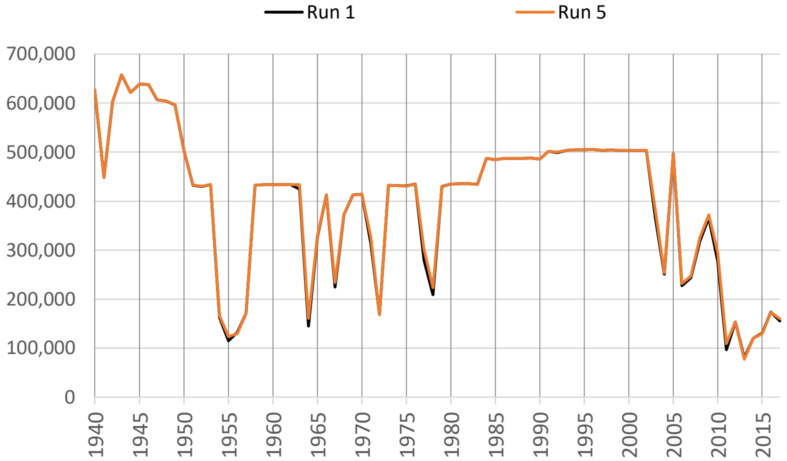
Run 5 v. Run 1

ILRG Model

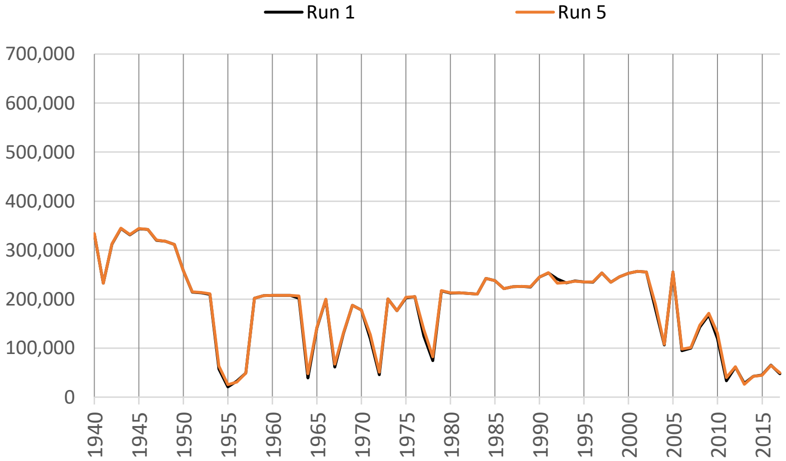
1940 - 2017 (acre-feet)

EBID Total

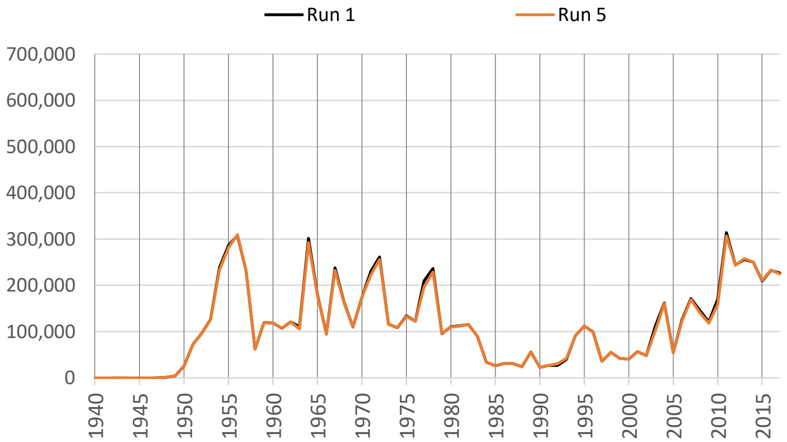
Net River Headgate Diversions



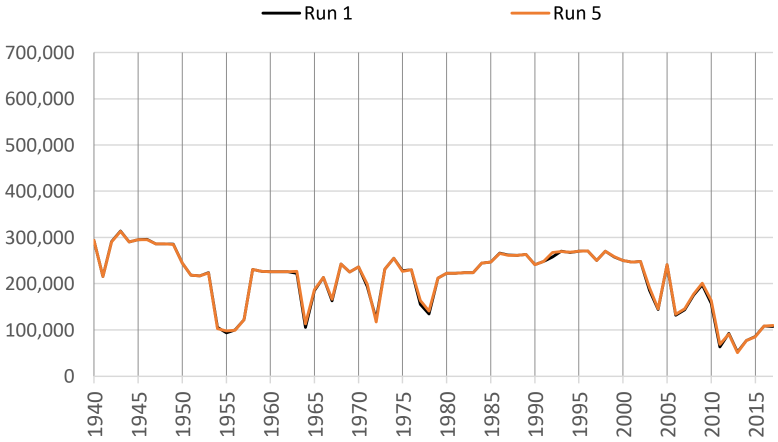
Farm Headgate Deliveries



Pumping



RHG Diversions - FHG Deliveries

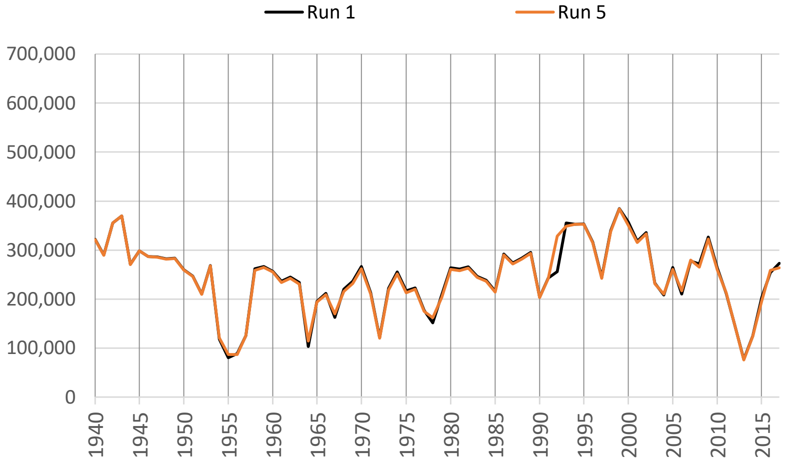


Notes: EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).
Pumping includes Supplemental and Primary groundwater pumping.

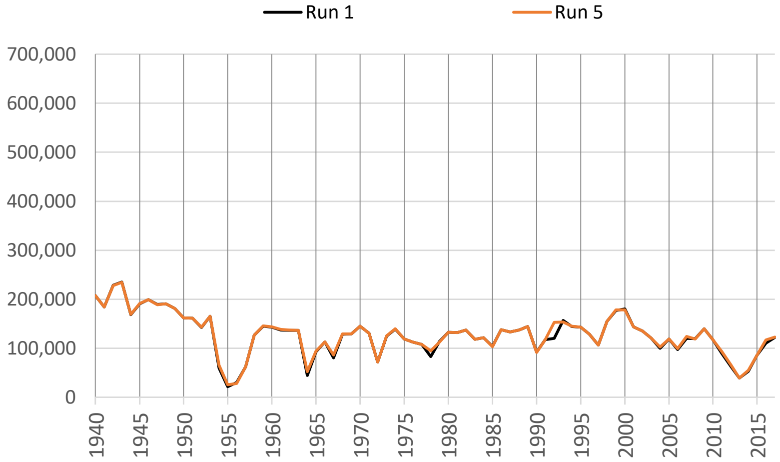
Run 5 - MX Pumping Off
Irrigation Season Summary of Irrigation Operations
Run 5 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

EPCWID Total

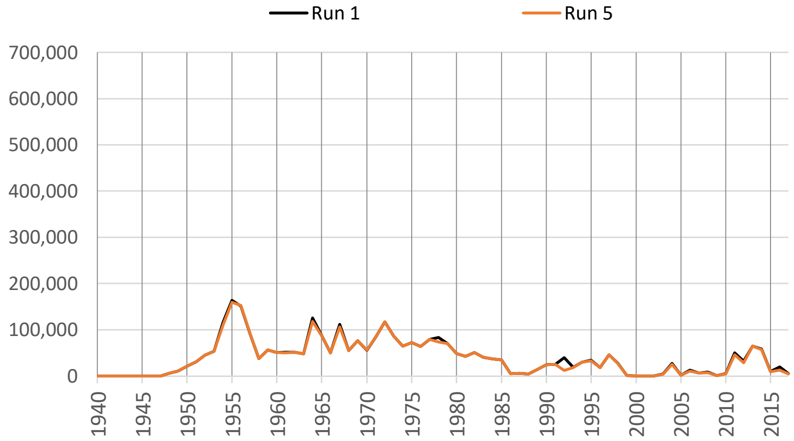
Net River Headgate Diversions



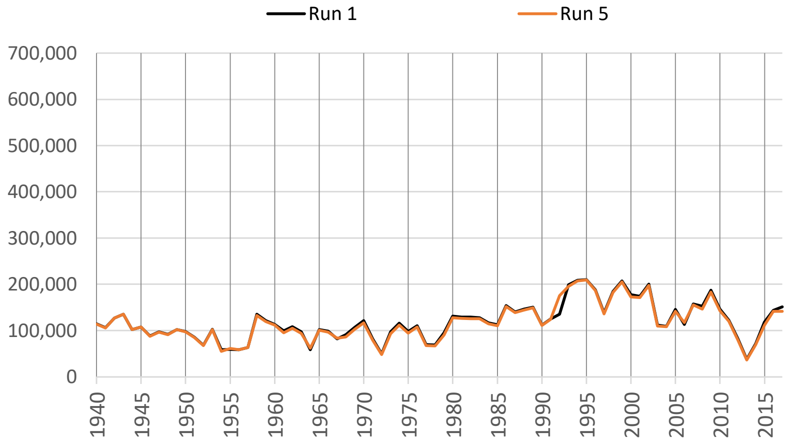
Farm Headgate Deliveries



Pumping



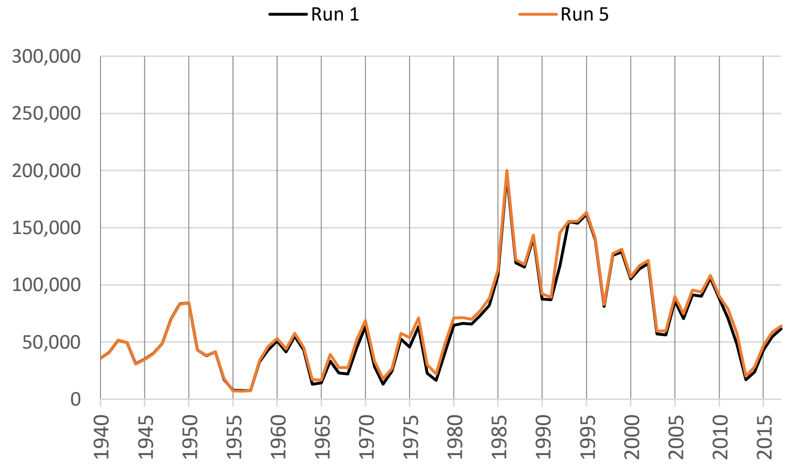
RHG Diversions - FHG Deliveries

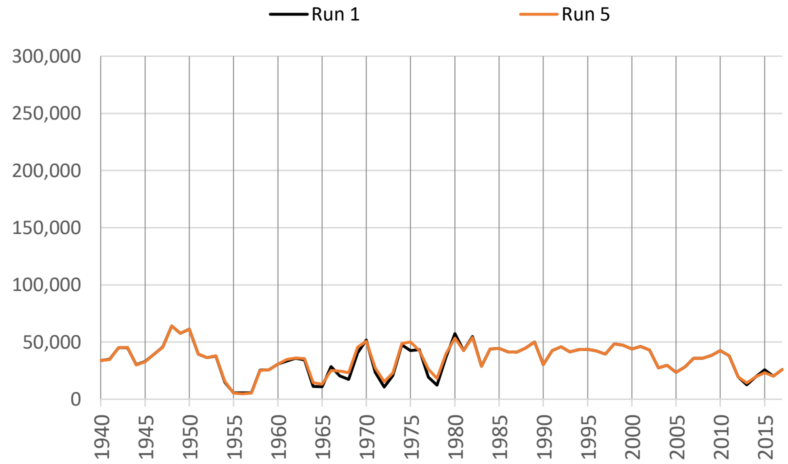


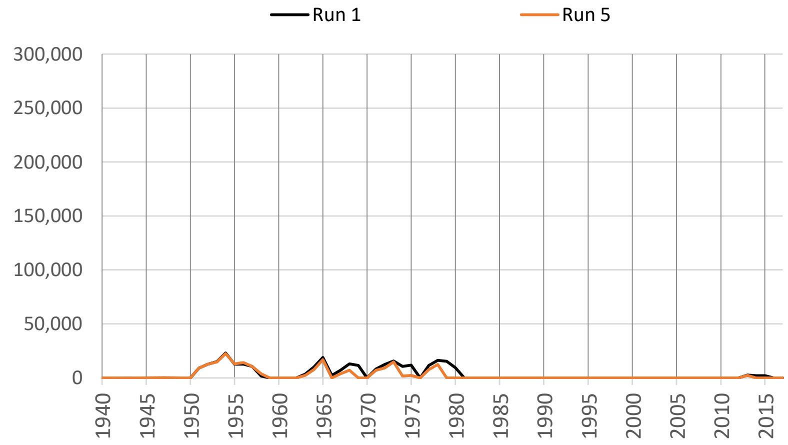
Note: EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

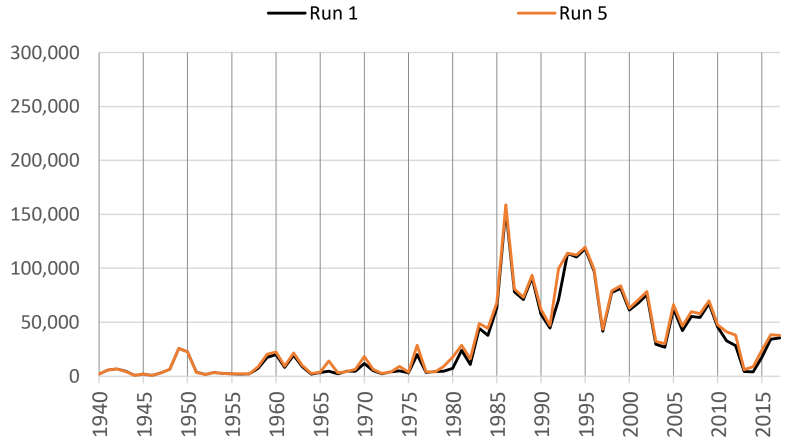
Run 5 - MX Pumping Off
Irrigation Season Summary of Irrigation Operations
Run 5 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

HCCRD Total


Net River Headgate Diversions


Farm Headgate Deliveries

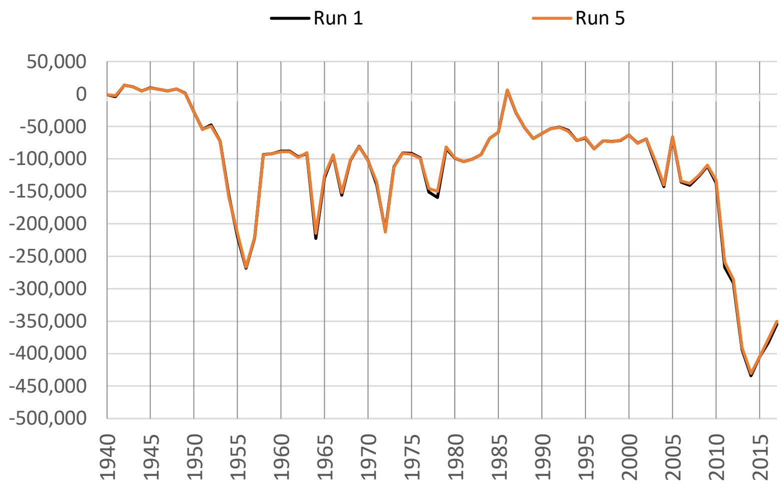

Pumping


RHG Diversions - FHG Deliveries

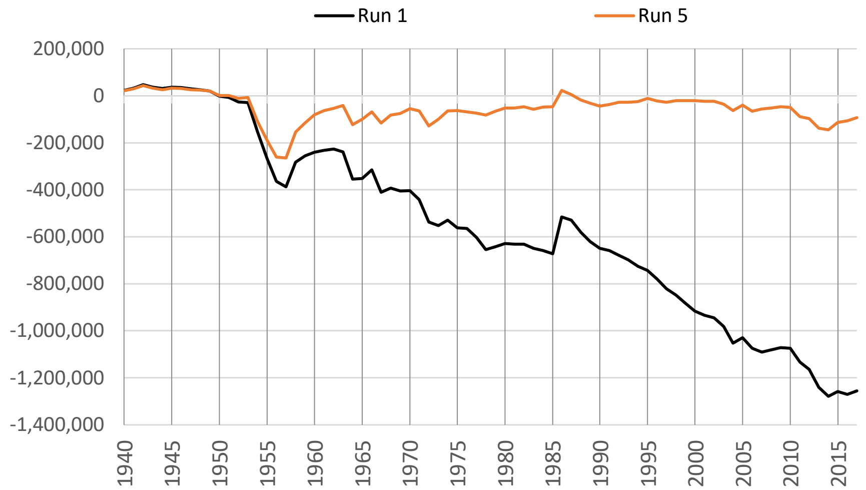
Note: HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

Run 5 - MX Pumping Off
Cumulative Change in Ground Water Storage
Run 5 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

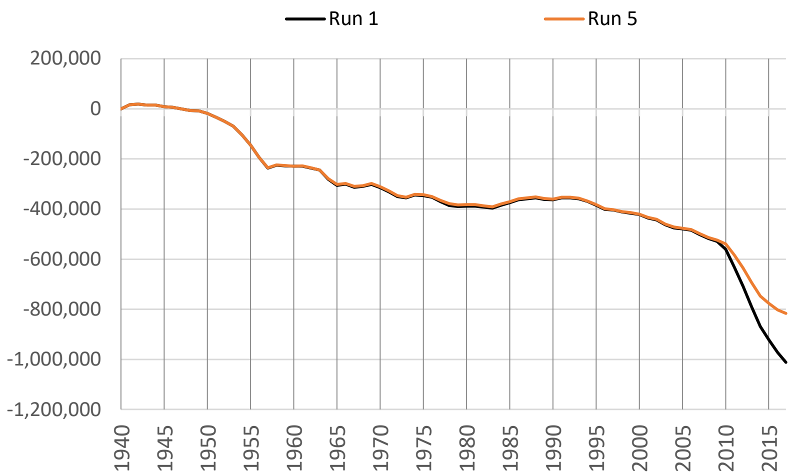
Rincon-Mesilla Alluvial Aquifer



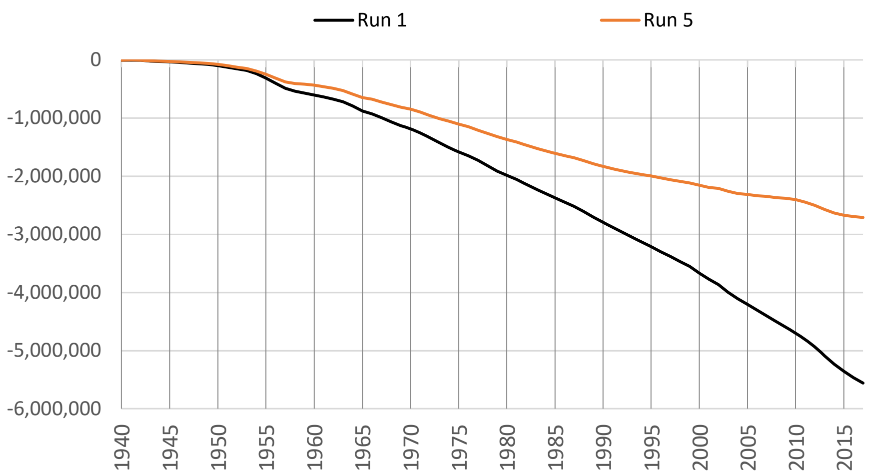
Hueco Alluvial Aquifer



Rincon-Mesilla Non-Alluvial Aquifer

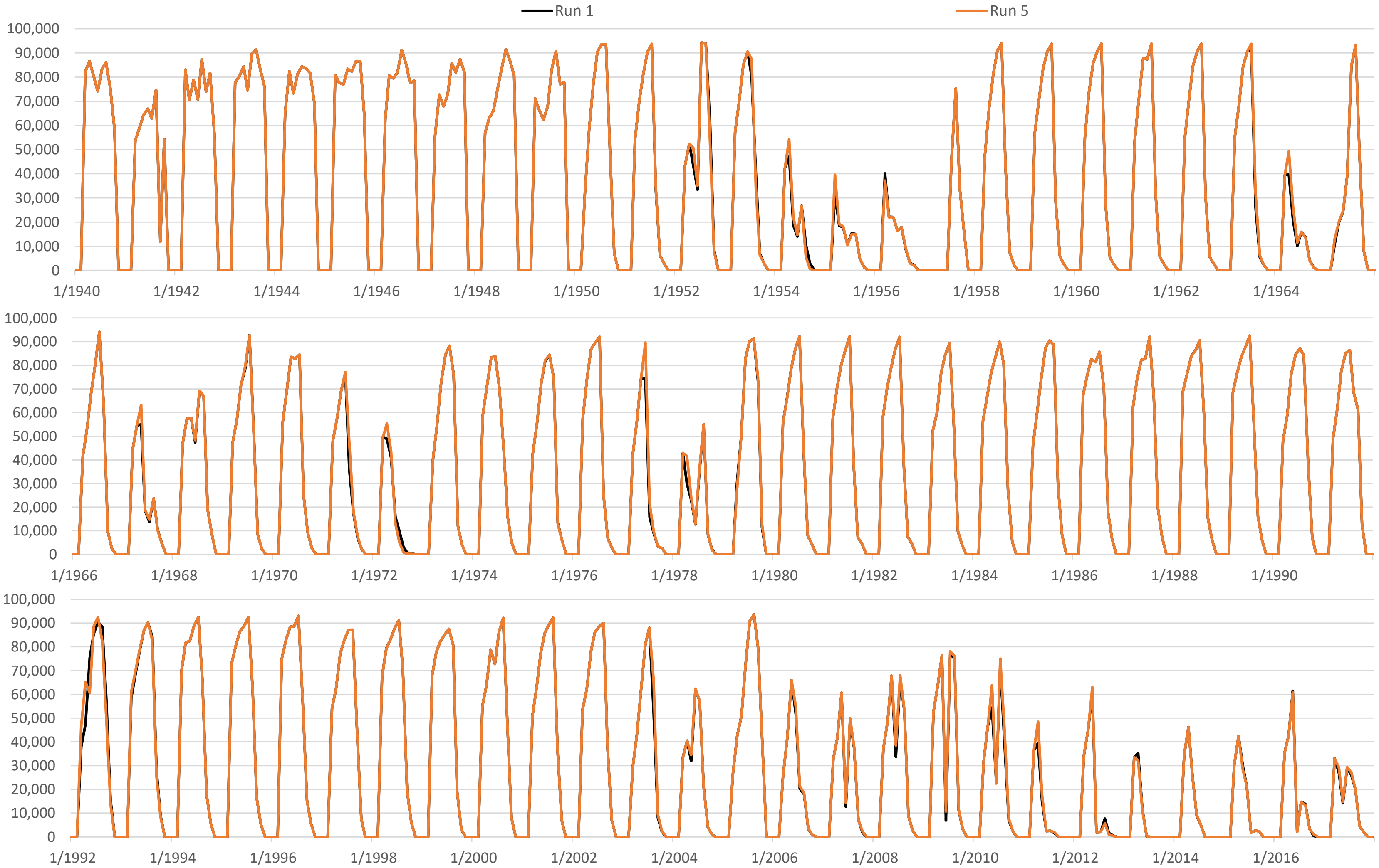


Hueco Non-Alluvial Aquifer



***Note different scales.**

Run 5 - MX Pumping Off
Monthly Net RHG Diversions
Run 5 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)
EBID Total

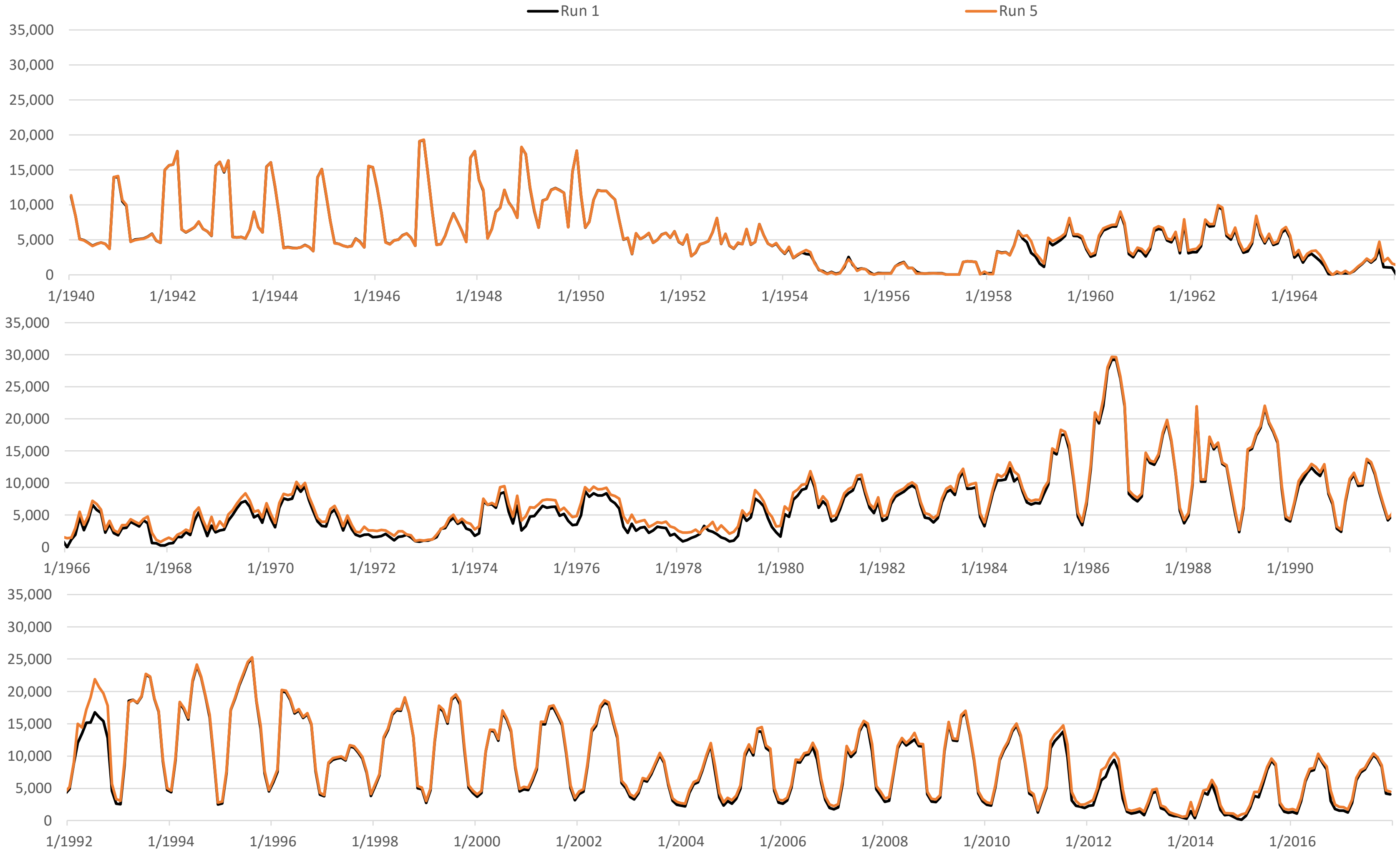


Note: EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).

Run 5 - MX Pumping Off
Monthly Net RHG Diversions
Run 5 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)
EPCWID Total

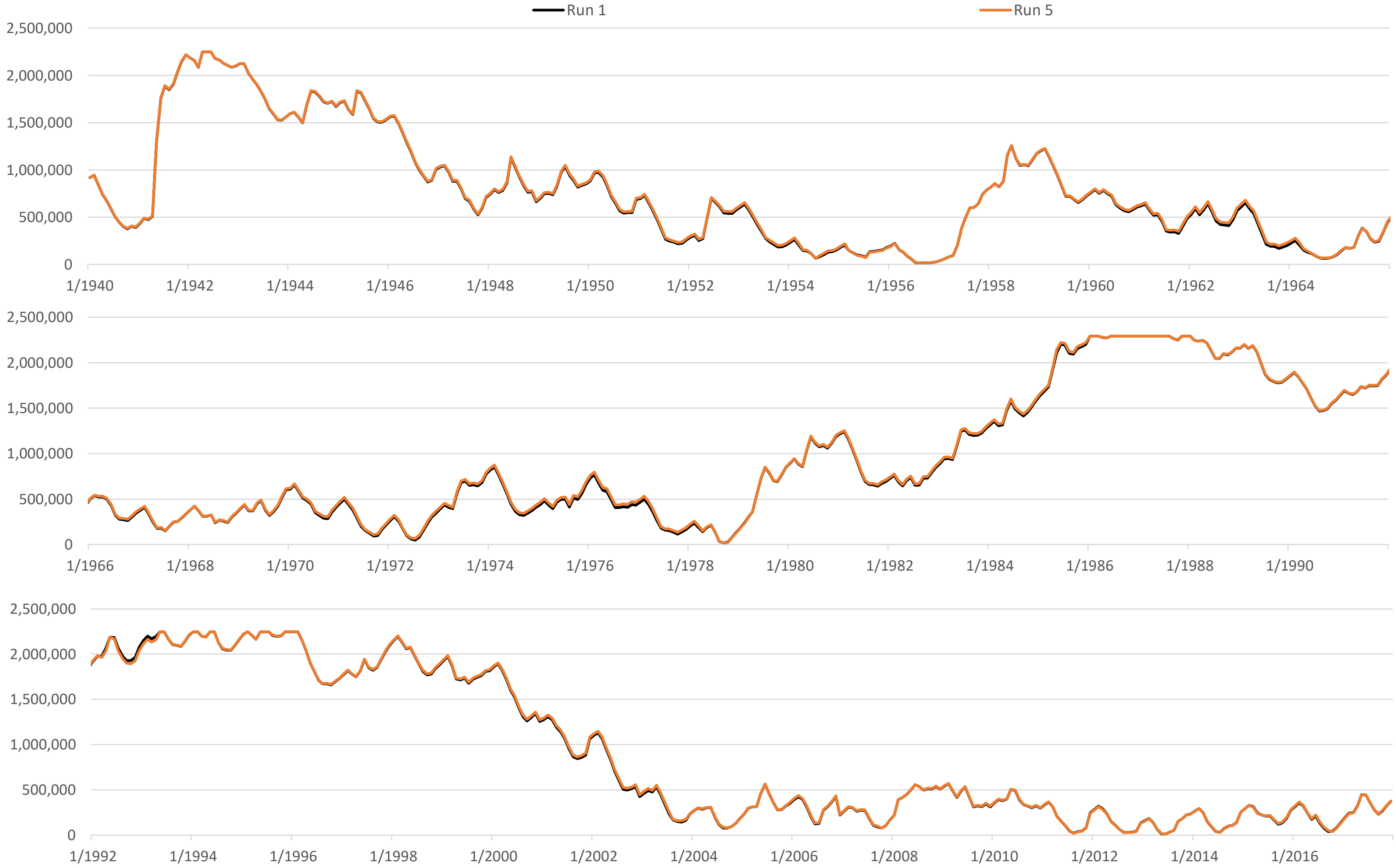
Note: EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

Run 5 - MX Pumping Off
Monthly Net RHG Diversions
Run 5 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)
HCCRD Total



Note: HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

Run 5 - MX Pumping Off
End of Month Reservoir Storage (Elephant Butte + Caballo)
Run 5 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)



Run 5 - MX Pumping Off

Monthly Caballo Releases

Run 5 v. Run 1

ILRG Model

1940 - 2017 (acre-feet)

Run 5 - MX Pumping Off

Monthly Rio Grande at El Paso Flow

Run 5 v. Run 1

ILRG Model

1940 - 2017 (acre-feet)

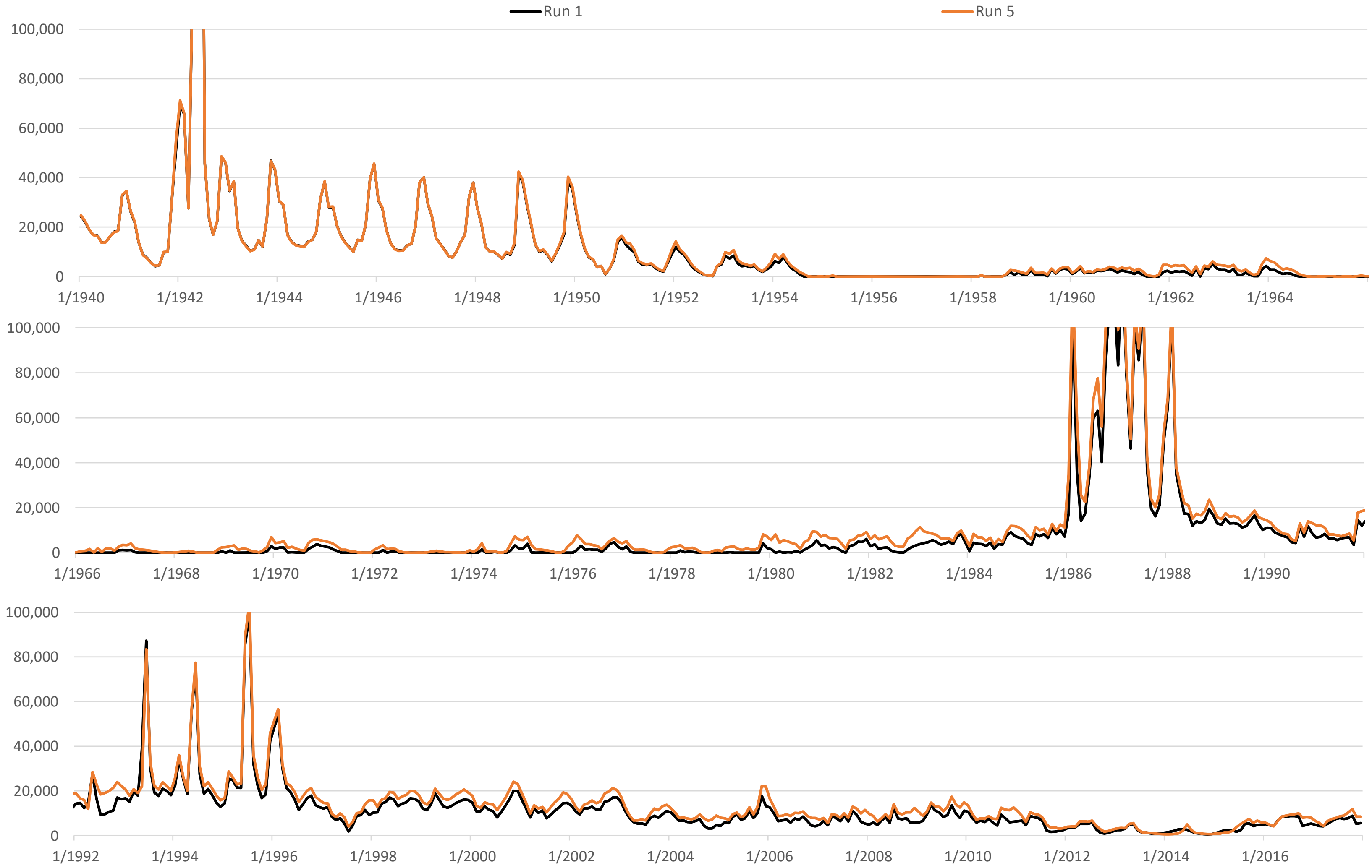
Run 5 - MX Pumping Off

Monthly Rio Grande at Fort Quitman Flow

Run 5 v. Run 1

ILRG Model

1940 - 2017 (acre-feet)



Appendix 30F

Comparison of ILRG Model Runs
Run 6 v. Run 1

Model Run Specifications

Model Version: LRG_v116

Name: **Run 6 - RM Pumping Off**

Run ID: LRG_v116_Operational_Run6
Date: 8/25/2020

Name: **Run 1 - Historical Base Run**

Run ID: LRG_v116_Operational_Run1
Date: 8/23/2020

Selected Model Inputs

Pumping and Returns	**Run 6**	**Run 1**
Irrigation Pumping	RM Off	On
Irrigated Area	Hist	Hist
Non-Irrigation Pumping	RM Off	On
Non-Irrigation Pumping Returns	RM Off	On
Las Cruces Jornada Pumping Returns	Off	On

Project Allocation Rules		
1950-2005	D1/D2	D1/D2
2006-2007	D3	D3
2008-2017	D3 + CO	D3 + CO

EPCWID Operations		
Charge EPCWID for Use of WWTP Returns	Off	Off
ACE and Haskell Credits for EPCWID	On	On
Increased EPCWID Use of Fabens Drain Flows	Off	Off
Charge EPCWID for Fabens Drain Flow Use	Off	Off

Run 6 - RM Pumping Off
Comparison of ILRG Model Runs
Run 6 v. Run 1
1951 - 2017 Annual Average
(1,000 acre-feet)

Run No.	1	6	6 - 1		
Simulated Input or Output	**Run 1**	**Run 6**	**Run 6 minus Run 1**		
Pumping Stress					
Irrigation Pumping	147.8	0.0	-147.8		
Non-Irrigation Pumping	181.0	129.4	-51.5		
WWTP Flows	58.0	45.2	-12.9		
Urban Deep Percolation	13.1	7.9	-5.2		
Total Stress	257.7	76.4	-181.3		
	Stress is Pumping minus WWTP and Urban Deep Perc				
Effects of Pumping Stress				***% Chg***	
FHG Deliveries (Mar - Oct)				***Stress***	***% Diff.***
EBID	167.6	202.3	34.7	*-19%*	*21%*
EPCWID (incl. EPW)	139.9	152.1	12.2	*-7%*	*9%*
HCCRD	32.8	34.7	1.9	*-1%*	*6%*
Total	340.3	389.1	48.8	*-27%*	*14%*
FHG Deliveries (Nov - Feb)					
EBID	0.0	0.1	0.1	*0%*	*994%*
EPCWID (incl. EPW)	0.2	0.2	0.0	*0%*	*-3%*
HCCRD	2.4	2.3	-0.1	*0%*	*-6%*
Total	2.6	2.5	-0.1	*0%*	*-3%*
Irrigation Pumping					
EBID	140.4	0.0			
EPCWID (Mesilla Valley)	7.4	0.0			
EPCWID (El Paso Valley)	40.1	31.6	8.5	*-5%*	*21%*
HCCRD	4.2	1.9	2.3	*-1%*	*55%*
	44.3	33.5	-10.8	*6%*	*-24%*
	Pumping turned off.	*Other values are simulated responses and are totaled.*			
Other Inflows/Outflows					
Net Reservoir Evaporation	125.3	142.8	17.5	*-10%*	*14%*
Riparian ET	70.9	77.5	6.6	*-4%*	*9%*
River Evaporation + Incidental Canal Loss	30.3	32.1	1.8	*-1%*	*6%*
Total	226.6	252.5	25.9	*-14%*	*11%*
Rio Grande at Fort Quitman					
Reservoir Spills	33.3	49.3	16.0	*-9%*	*48%*
Nov-Feb Flows	21.4	44.2	22.8	*-13%*	*106%*
Mar - Oct Flows	41.1	58.9	17.8	*-10%*	*43%*
Underflow (GW Model)	0.2	0.3	0.1	*0%*	*25%*
Total	96.0	152.6	56.7	*-31%*	*59%*

Run 6 - RM Pumping Off

Comparison of ILRG Model Runs

Run 6 v. Run 1
1951 - 2017 Annual Average
(1,000 acre-feet)

Run No.	1	6	6 - 1		
Simulated Input or Output	**Run 1**	**Run 6**	**Run 6 minus Run 1**		
Effects of Pumping Stress (continued)				*% Chg*	
Change in Storage				***Stress***	***% Diff.***
Reservoir Storage	-4.7	-3.6	1.1	*-1%*	*-24%*
Alluvial GW Storage (RW Model)	-23.6	-17.6	6.0	*-3%*	*-26%*
Non-alluvial GW Storage (GW Models)	-96.4	-79.2	17.1	*-9%*	*-18%*
Soil Moisture Storage	0.6	0.8	0.2	*0%*	*42%*
Total	-124.0	-99.5	24.5	*-14%*	*-20%*
Summary of Effects					
FHG Deliveries (Mar-Oct)	340.3	389.1	48.8	*-27%*	*14%*
FHG Deliveries (Nov-Feb)	2.6	2.5	-0.1	*0%*	*-3%*
Irrigation Pumping	44.3	33.5	-10.8	*6%*	*-24%*
Riparian ET + Evaporation	226.6	252.5	25.9	*-14%*	*11%*
Fort Quitman Flow	96.0	152.6	56.7	*-31%*	*59%*
Change in Storage	-124.0	-99.5	24.5	*-14%*	*-20%*
Total	585.8	730.7	145.0	*-80%*	*25%*
Other Effects of Pumping Stress				*% Chg*	
Rio Grande at El Paso				***Stress***	***% Diff.***
Reservoir Spills	49.4	67.8	18.4	*-10%*	*37%*
Nov-Feb Flows	22.8	51.3	28.5	*-16%*	*125%*
Mar - Oct Flows	263.8	296.6	32.8	*-18%*	*12%*
Total	336.0	415.7	79.7	*-44%*	*24%*
Rio Grande below Caballo					
Reservoir Spills	65.9	85.0	19.2	*-11%*	*29%*
Nov-Feb Flows	0.5	0.4	-0.1	*0%*	*-22%*
Mar - Oct Flows	541.3	504.1	-37.2	*21%*	*-7%*
Total	607.6	589.5	-18.1	*10%*	*-3%*
Surface Water Diversions (Mar - Oct)					
EBID	366.5	416.1	49.7	*-27%*	*14%*
EPCWID (incl. EPW)	236.8	256.8	20.0	*-11%*	*8%*
HCCRD	67.5	75.1	7.6	*-4%*	*11%*
Total	670.8	748.1	77.3	*-43%*	*12%*
Surface Water Diversions (Nov - Feb)					
EBID	0.0	0.0	0.0	*0%*	*0%*
EPCWID (incl. EPW)	14.3	17.2	2.8	*-2%*	*20%*
HCCRD	14.2	16.8	2.6	*-1%*	*18%*
Total	28.5	34.0	5.4	*-3%*	*19%*

Run 6 - RM Pumping Off

Annual Differences in ILRG Model Outputs

Run 6 minus Run 1

1940 - 2017 (acre-feet)

	Net River Headgate Diversions						Farm Headgate Deliveries						Annual Flows		
	EBID		EPCWID (incl. EPW)		HCCRD		EBID		EPCWID (incl. EPW)		HCCRD				
Year	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Caballo Releases	Rio Grande at El Paso	Rio Grande at Fort Quitman
1940	-98	-98	3	2	0	1	17	49	4	3	1	1	-137	-28	-61
1941	-304	-304	-6	-9	-2	-2	-47	-10	-1	0	-2	-4	114	291	185
1942	-195	-195	2	-3	2	4	14	53	3	8	1	0	-267	164	172
1943	-236	-236	1	0	3	6	26	65	-8	-8	3	0	-273	119	68
1944	-272	-272	-151	-138	-107	-85	5	45	11	-8	-97	-98	-412	-71	13
1945	-276	-276	-6	40	3	35	24	62	-7	-35	5	4	-428	110	128
1946	-217	-217	17	59	3	24	49	91	17	19	3	3	-393	212	179
1947	-264	-264	-12	77	-2	51	27	71	-5	-15	-6	-6	-478	180	205
1948	-1,052	-1,052	80	126	1	28	484	533	86	78	2	2	-985	68	55
1949	-2,171	-2,171	-90	-65	-18	7	164	218	-48	-53	0	0	-2,971	-66	-55
1950	-267	-267	34	119	-6	104	2,299	2,354	-3	21	0	-1	-1,901	10,379	7,022
1951	439	439	109	144	115	227	3,393	3,450	58	88	85	134	-26,540	13,018	11,025
1952	-337	-337	293	349	180	287	7,337	7,395	112	161	187	278	-41,774	25,550	17,508
1953	-662	-662	-428	-375	372	463	7,413	7,468	-698	-645	122	-134	-47,760	31,274	22,610
1954	34,734	34,734	27,530	34,484	1,179	3,055	26,834	26,871	22,858	22,925	1,946	3,563	225	99,170	30,646
1955	50,428	50,428	39,706	53,127	8,299	11,349	31,349	31,375	27,974	27,828	7,710	10,392	-1,512	116,772	24,785
1956	22,152	22,152	23,380	38,060	5,151	5,753	21,705	21,727	19,277	18,553	5,415	5,498	-49,293	102,633	14,435
1957	66,732	66,732	38,256	50,742	5,029	7,674	24,154	24,192	9,211	8,868	3,345	4,550	-43,129	97,385	9,140
1958	-1,225	-1,225	-14,889	-6,455	6,176	11,995	11,259	11,302	-1,706	-1,717	-1,278	857	-161,801	24,438	35,442
1959	-1,332	-1,332	-3,674	-837	3,027	6,158	7,344	7,393	-392	-315	403	682	-86,238	28,664	36,074
1960	-1,400	-1,400	-1,866	606	1,595	3,136	7,518	7,567	-528	-445	0	0	-83,679	31,404	34,824
1961	-1,309	-1,309	-1,239	946	2,028	3,561	6,935	6,984	916	996	1,249	-815	-72,770	31,581	40,053
1962	-1,328	-1,328	-491	1,588	1,369	2,581	7,063	7,112	-138	-57	313	279	-77,931	34,712	35,598
1963	7,454	7,454	-833	1,771	1,433	2,957	12,598	12,647	-655	-570	651	669	-65,980	43,996	35,168
1964	268,555	268,555	149,321	156,802	14,438	18,938	148,305	148,354	95,955	95,700	12,439	14,921	254,237	232,865	64,719
1965	83,927	83,927	21,142	28,592	8,914	15,277	63,999	64,053	25,553	25,251	9,370	13,144	-96,845	96,942	66,810
1966	-130	-130	30,363	34,348	14,215	18,394	-1,920	-1,872	16,538	16,636	-3,275	-5,164	-72,298	79,587	69,868
1967	186,195	186,195	109,938	116,939	16,505	24,458	106,562	106,611	71,449	71,041	10,241	11,948	134,547	178,759	59,554
1968	37,014	37,014	-5,854	790	10,419	18,764	41,686	41,744	1,589	1,298	9,297	8,014	-98,812	61,998	52,567
1969	705	705	36,273	39,023	19,248	23,692	-2,308	-2,254	20,323	20,400	2,982	-1,561	-66,045	74,431	61,161
1970	-1,492	-1,492	-3,017	-1,558	3,651	6,056	8,549	8,601	-780	-712	-1,274	-2,725	-99,498	32,788	37,710
1971	117,689	117,689	42,737	46,715	12,059	15,637	67,864	67,917	20,910	21,014	9,224	11,184	8,282	119,087	44,665
1972	165,025	165,025	119,306	129,942	18,363	25,619	81,712	81,757	71,075	70,922	11,975	12,028	125,138	202,200	69,019
1973	-2,358	-2,358	-8,330	-723	14,628	20,813	12,937	12,989	76	-66	15,903	16,460	-152,956	41,194	43,000
1974	-1,810	-1,810	-447	2,492	9,209	14,455	13,305	13,360	1,313	1,397	-1,163	-2,482	-87,018	46,816	45,959
1975	-11	-11	35,130	36,785	19,928	24,870	-2,310	-2,263	18,351	18,427	8,132	3,546	-61,526	78,780	48,847
1976	-1,905	-1,905	-412	1,424	6,476	12,016	9,180	9,211	315	362	-1,658	-5,752	-89,122	35,485	38,070
1977	153,121	153,121	40,481	45,887	13,478	19,108	90,216	90,266	18,794	18,894	11,839	12,198	41,815	115,406	35,644
1978	222,159	222,159	58,501	66,235	11,545	19,554	135,079	135,132	37,129	37,252	12,018	11,631	74,681	153,173	66,171

Run 6 - RM Pumping Off
Annual Differences in ILRG Model Outputs
Run 6 minus Run 1
1940 - 2017 (acre-feet)

	Net River Headgate Diversions						Farm Headgate Deliveries						Annual Flows		
	EBID		EPCWID (incl. EPW)		HCCRD		EBID		EPCWID (incl. EPW)		HCCRD				
Year	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Caballo Releases	Rio Grande at El Paso	Rio Grande at Fort Quitman
1979	1,210	1,210	22,030	26,504	8,765	14,904	11,018	11,073	17,609	17,711	2,413	-213	-113,027	54,647	52,615
1980	-1,414	-1,414	-99	434	3,514	6,186	9,070	9,129	918	997	-3,193	-6,819	-73,339	35,604	55,185
1981	-1,287	-1,287	51	2,329	2,036	4,093	8,997	9,043	824	906	-56	-243	-76,351	39,350	42,823
1982	-1,378	-1,378	230	2,583	1,556	3,344	8,585	8,641	851	934	-369	-1,131	-83,596	38,989	50,617
1983	-1,063	-1,063	355	2,308	1,974	3,522	7,797	7,852	781	857	0	0	-71,021	35,188	39,521
1984	-1,223	-1,223	430	1,959	6,909	8,242	7,841	7,887	713	779	0	0	-42,640	36,343	34,601
1985	1,537	1,537	64,707	64,622	35,413	37,019	-5,051	-4,993	28,709	28,663	0	0	382,997	435,750	387,717
1986	-658	-658	-7,516	-7,493	1,987	3,622	7,240	7,314	-4,041	-3,985	0	0	87,161	151,992	275,056
1987	-1,562	-1,562	460	495	1,179	1,896	4,604	4,673	558	607	0	0	0	55,923	72,818
1988	-1,157	-1,157	450	485	1,028	1,626	5,539	5,605	410	455	0	0	-24,018	35,613	35,409
1989	-939	-939	1,363	1,157	1,034	1,582	6,865	6,920	820	553	0	0	-39,404	30,369	24,238
1990	-676	-676	614	507	3,090	3,504	6,703	6,762	428	244	0	0	-27,120	33,455	24,921
1991	-2,288	-2,288	378	166	804	1,312	3,672	3,739	424	81	0	0	-28,960	23,069	27,436
1992	1,312	1,312	76,069	75,811	35,622	37,102	-5,845	-5,783	34,386	34,089	0	0	94,446	154,612	135,861
1993	-578	-578	-4,821	-4,830	-223	743	7,056	7,127	-2,415	-2,368	0	0	-15,991	43,676	48,947
1994	-1,136	-1,136	1,149	1,169	954	1,538	9,222	9,307	999	1,057	0	0	-16,711	73,803	64,950
1995	-1,364	-1,364	3,779	3,790	3,215	4,010	11,326	11,404	647	670	0	0	34,237	144,612	127,717
1996	-1,504	-1,504	1,003	1,066	909	1,632	11,806	11,891	789	872	0	0	-71,096	55,915	46,149
1997	-843	-843	41	-237	1,095	1,677	8,234	8,295	-359	-970	0	0	-41,169	42,602	29,762
1998	-1,116	-1,116	1,482	1,493	1,477	1,522	8,975	9,055	1,085	1,145	0	0	-18,411	69,356	59,781
1999	-1,876	-1,876	-11,440	-10,929	28,693	28,861	-2,432	-2,372	-14,074	-14,034	0	0	3,446	90,277	89,441
2000	-415	-415	24,104	24,799	3,355	3,403	-1,257	-1,206	2,417	2,450	0	0	-23,155	65,159	49,791
2001	-402	-402	7,627	7,637	2,151	2,503	7,623	7,668	4,859	4,910	0	0	-33,363	42,153	26,688
2002	-769	-769	979	1,574	1,032	1,837	8,576	8,618	333	391	0	0	-47,150	36,645	27,790
2003	115,285	115,285	48,236	48,078	13,821	14,501	70,062	70,125	20,792	20,868	0	0	80,316	118,311	65,139
2004	41,804	41,804	25,747	27,410	5,727	8,163	34,460	34,512	16,803	16,879	0	0	-36,928	78,458	46,282
2005	1,119	1,119	8,274	8,982	4,026	5,517	14,032	14,094	7,585	7,664	0	0	-79,649	39,907	36,848
2006	111,277	111,277	79,160	78,896	19,444	21,433	68,985	69,034	39,341	39,401	0	0	92,843	134,681	67,051
2007	119,778	119,778	10,218	11,470	3,442	5,214	84,639	84,689	9,334	9,418	0	0	-27,098	60,165	38,995
2008	184,130	184,130	3,545	4,666	2,952	4,314	127,162	127,278	3,387	3,585	0	0	23,651	68,345	58,387
2009	171,431	171,431	989	2,764	1,524	3,128	117,388	117,550	380	587	0	0	27,835	81,049	72,070
2010	182,591	182,591	4,295	7,044	2,503	3,802	127,428	127,532	2,613	2,775	0	0	8,631	69,516	56,092
2011	106,343	106,343	63,577	67,243	20,995	27,209	51,441	51,484	43,778	43,887	0	0	7,915	126,802	70,368
2012	105,114	105,114	47,536	49,770	19,581	26,007	56,112	56,144	32,588	32,691	0	0	-43,142	95,684	60,138
2013	70,797	70,797	57,606	60,561	15,744	18,813	37,859	37,890	34,779	34,869	5,926	6,229	32,873	119,482	55,359
2014	77,996	77,996	26,506	28,616	10,409	14,070	37,929	37,951	18,165	18,252	-285	-601	-33,706	84,964	47,985
2015	173,012	173,012	19,108	21,778	5,216	7,677	97,124	97,156	11,788	11,892	-4,348	-3,757	-42,641	62,028	47,821
2016	168,525	168,525	21,562	24,857	4,129	6,342	103,635	103,665	16,014	16,129	0	0	-59,725	74,941	41,903
2017	316,166	316,166	9,667	13,396	2,554	4,233	202,340	202,435	8,509	8,677	0	0	23,278	73,102	50,594
Averages															
1951-2017	49,654	49,654	20,007	22,847	7,592	10,193	34,694	34,750	12,215	12,210	1,885	1,743	-18,110	79,741	56,656
1951-1978	50,037	50,037	26,107	31,352	8,180	12,030	33,848	33,896	16,960	16,910	4,507	4,405	-33,700	79,647	41,110
1979-2005	5,134	5,134	9,840	10,440	6,339	7,550	9,804	9,866	4,550	4,534	-45	-311	-10,389	76,362	73,263
2006-2017	148,930	148,930	28,647	30,922	9,041	11,853	92,670	92,734	18,390	18,514	108	156	893	87,563	55,564
1985-2017	58,513	58,513	17,771	18,691	7,724	9,267	40,105	40,169	9,752	9,770	39	57	5,763	87,043	71,803
1985-2005	6,846	6,846	11,556	11,702	6,971	7,789	10,067	10,131	4,817	4,773	0	0	8,547	86,746	81,083

Notes:

EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).

EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

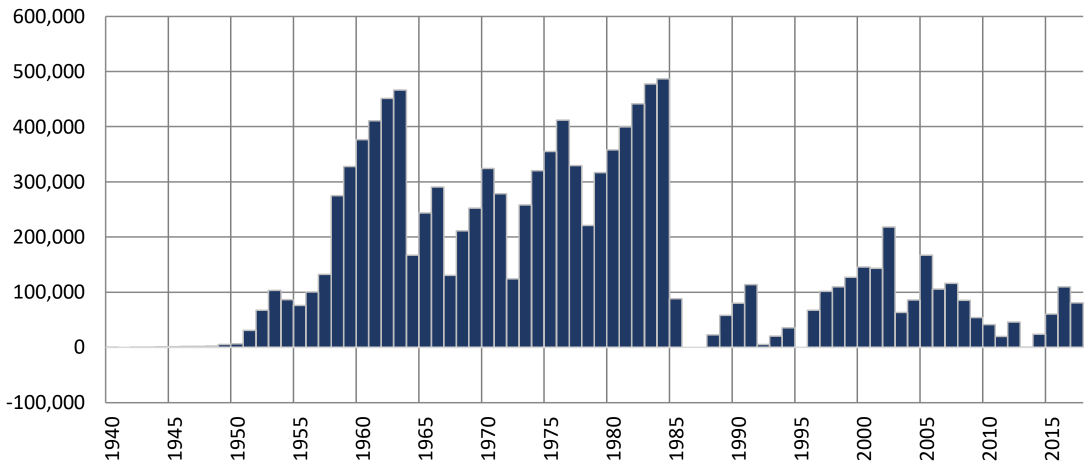
Run 6 - RM Pumping Off

Simulated Differences in ILRG Model Outputs

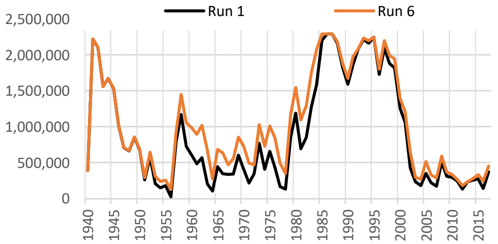
Run 6 minus Run 1

1940 - 2017 (acre-feet)

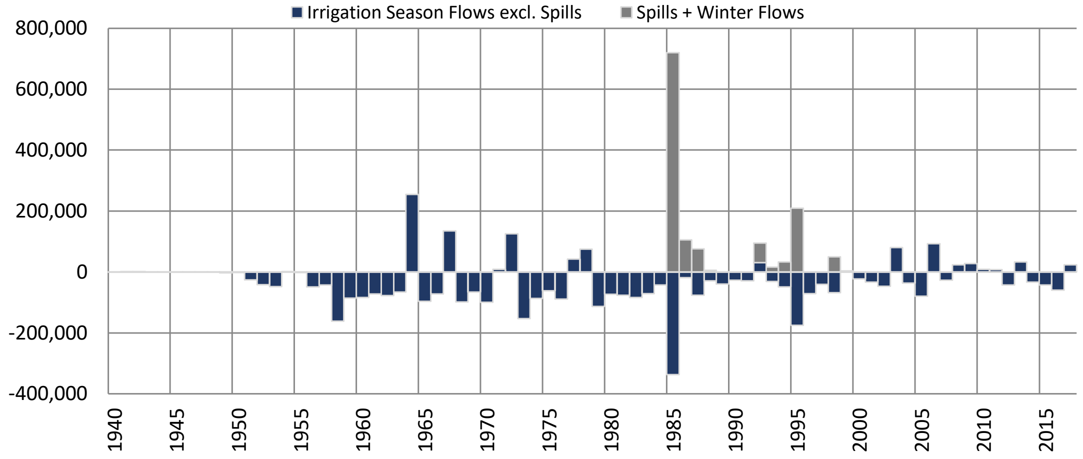
Total Project Storage (Year End)



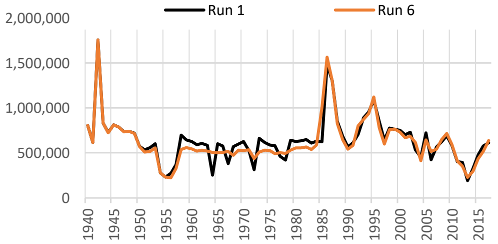
Period	Average Difference
1951-2017	1,108
1951-1978	7,666
1979-2005	-1,995
2006-2017	-7,211
1985-2017	-12,298
1985-2005	-15,205



Caballo Reservoir Outflows (Annual)



	Average Difference		
Period	Irr Season (excl. Spills)	Nov-Feb and Spills	Annual
1951-2017	-37,184	19,074	-18,110
1951-1978	-33,700	0	-33,700
1979-2005	-57,721	47,332	-10,389
2006-2017	893	0	893
1985-2017	-32,963	38,726	5,763
1985-2005	-52,309	60,855	8,547



Notes:

Reservoir storage does not include storage attributed to SJC, CO, or NM credit waters.

Average differences calculated as (Final Storage - Initial Storage)/(no. years).

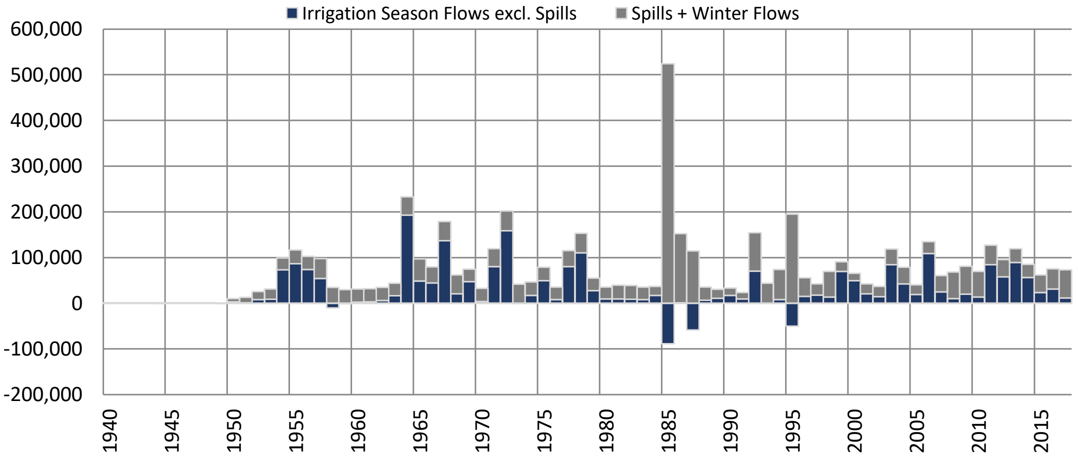
Run 6 - RM Pumping Off

Simulated Differences in ILRG Model Outputs

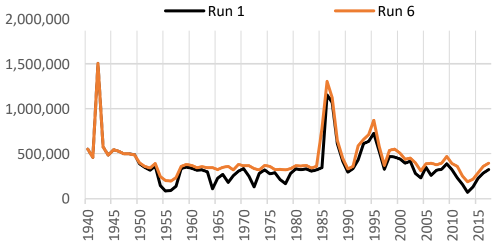
Run 6 minus Run 1

1940 - 2017 (acre-feet)

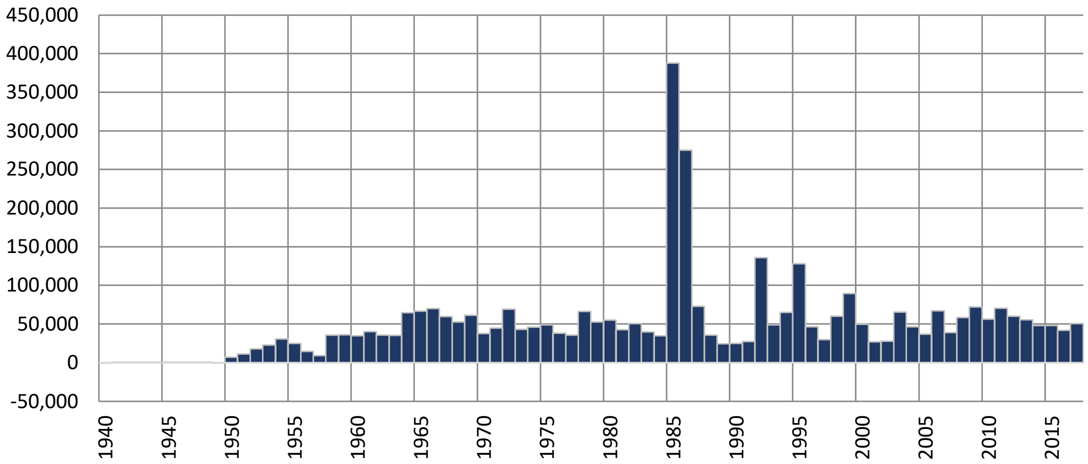
Rio Grande at El Paso (Annual)



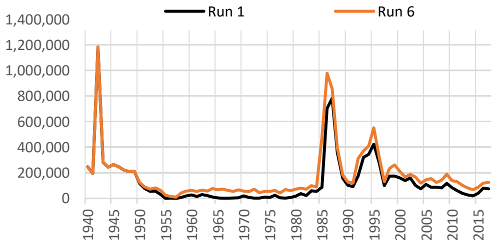
	Average Difference		
Period	Irr Season (excl. Spills)	Nov-Feb and Spills	Annual
1951-2017	32,832	46,909	79,741
1951-1978	47,021	32,626	79,647
1979-2005	13,031	63,332	76,362
2006-2017	44,278	43,285	87,563
1985-2017	24,325	62,718	87,043
1985-2005	12,923	73,823	86,746



Rio Grande at Fort Quitman (Annual)



Period	Average Difference
1951-2017	56,602
1951-1978	41,032
1979-2005	73,217
2006-2017	55,549
1985-2017	71,778
1985-2005	81,051



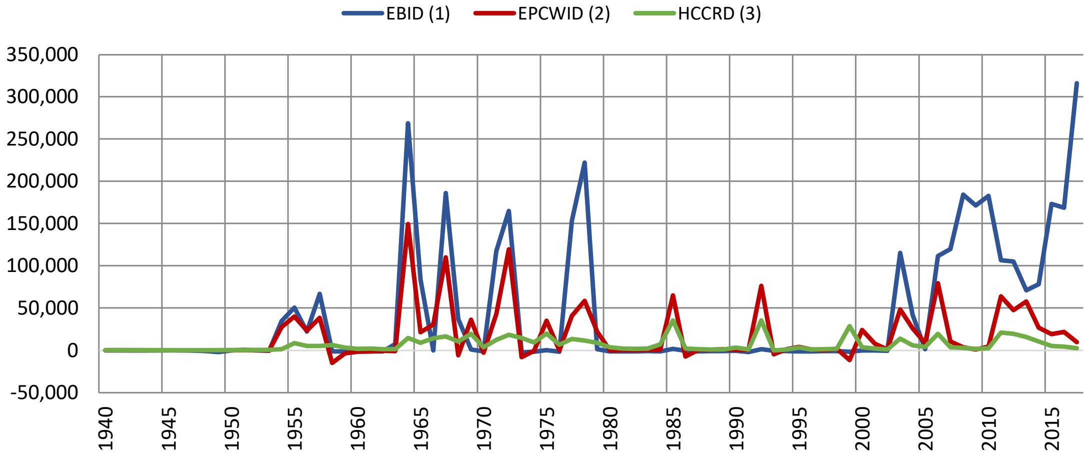
Run 6 - RM Pumping Off

Simulated Differences in ILRG Model Outputs

Run 6 minus Run 1

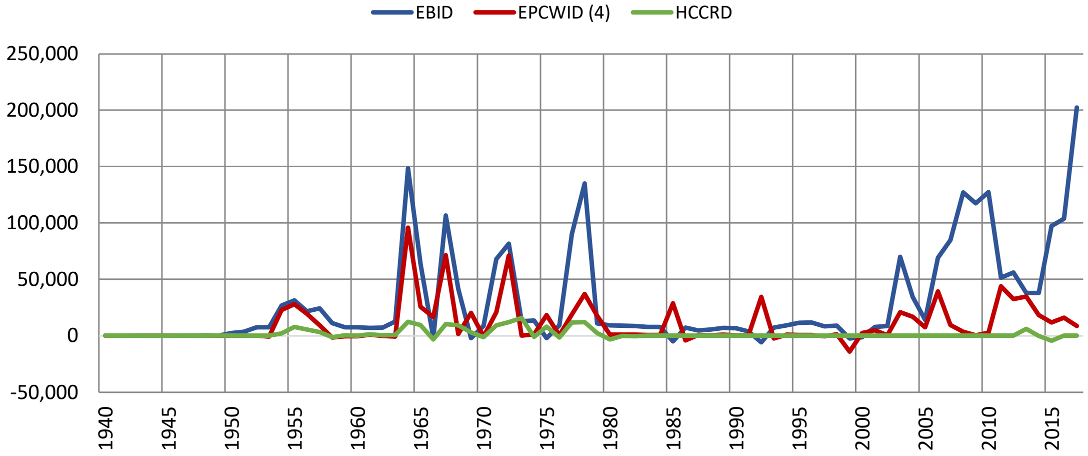
1940 - 2017 (acre-feet)

River Headgate (RHG) Diversions (Irrigation Season)



	Average Difference		
Period	EBID	EPCWID	HCCRD
1951-2017	49,654	20,007	7,592
1951-1978	50,037	26,107	8,180
1979-2005	5,134	9,840	6,339
2006-2017	148,930	28,647	9,041
1985-2017	58,513	17,771	7,724
1985-2005	6,846	11,556	6,971

Farm Headgate (FHG) Deliveries (Irrigation Season)



	Average Difference		
Period	EBID	EPCWID	HCCRD
1951-2017	34,694	12,215	1,885
1951-1978	33,848	16,960	4,507
1979-2005	9,804	4,550	-45
2006-2017	92,670	18,390	108
1985-2017	40,105	9,752	39
1985-2005	10,067	4,817	0

Notes:

(1) EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).

(2) EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

(3) HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

(4) EPCWID FHG values include deliveries to Rogers WTP and R/U WTP.

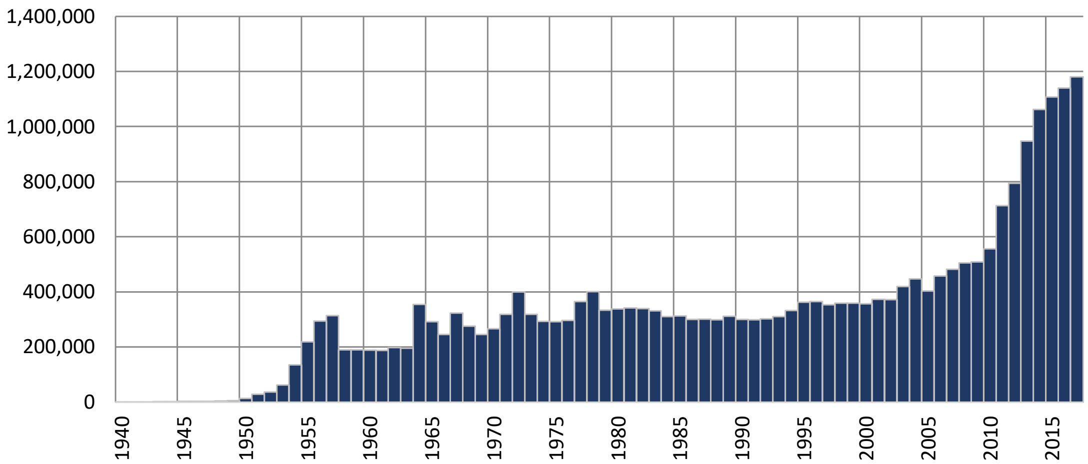
Run 6 - RM Pumping Off

Simulated Differences in ILRG Model Outputs

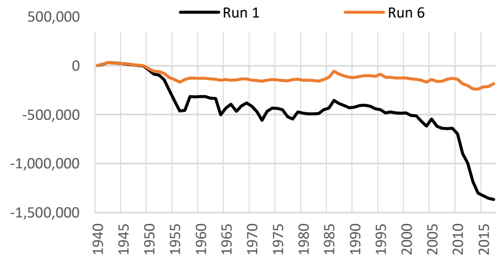
Run 6 minus Run 1

1940 - 2017 (acre-feet)

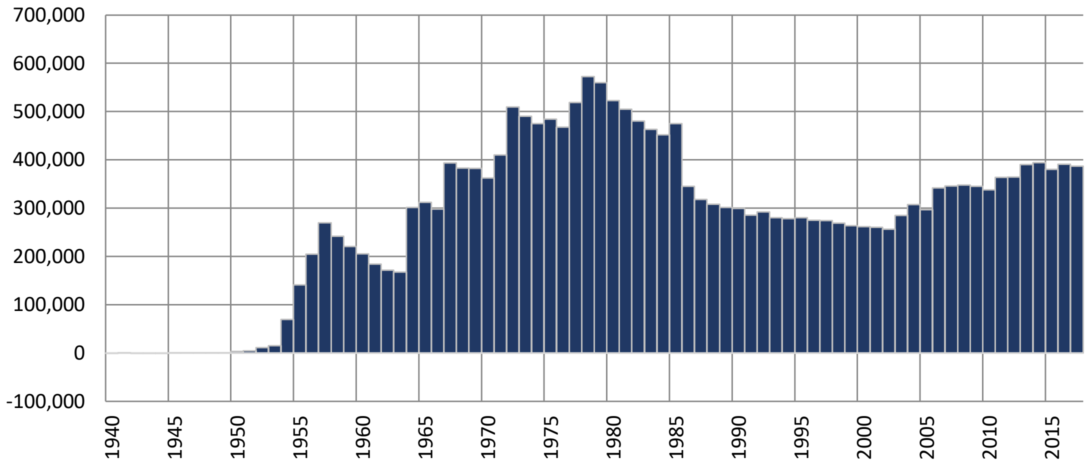
Cumulative Annual Rincon-Mesilla Groundwater Storage



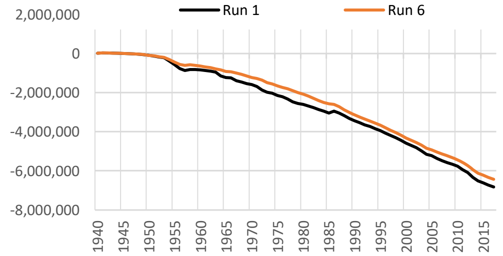
Period	Average Difference
1951-2017	17,414
1951-1978	13,805
1979-2005	102
2006-2017	64,787
1985-2017	26,353
1985-2005	4,391



Cumulative Annual Hueco Groundwater Storage



Period	Average Difference
1951-2017	5,727
1951-1978	20,323
1979-2005	-10,195
2006-2017	7,493
1985-2017	-1,973
1985-2005	-7,382



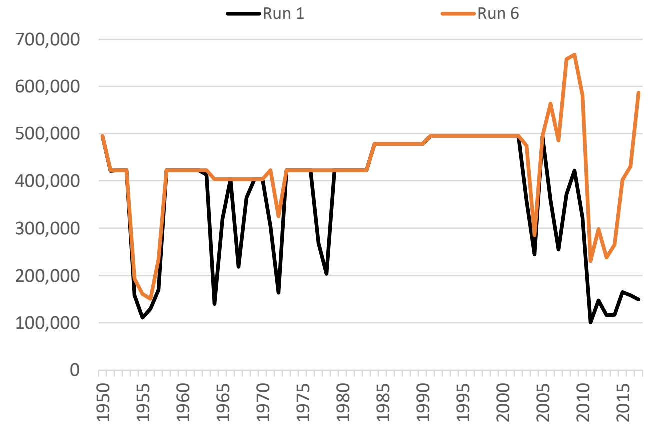
Notes:

Cumulative storage change in alluvial and non-alluvial aquifers.

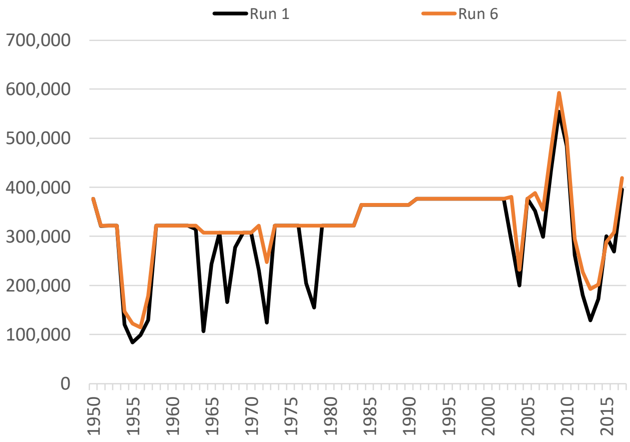
Average differences calculated as (Final Storage - Initial Storage)/(no. years).

Run 6 - RM Pumping Off
Annual Allocation and Charges
Run 6 v. Run 1
ILRG Model
1950 - 2017 (acre-feet)

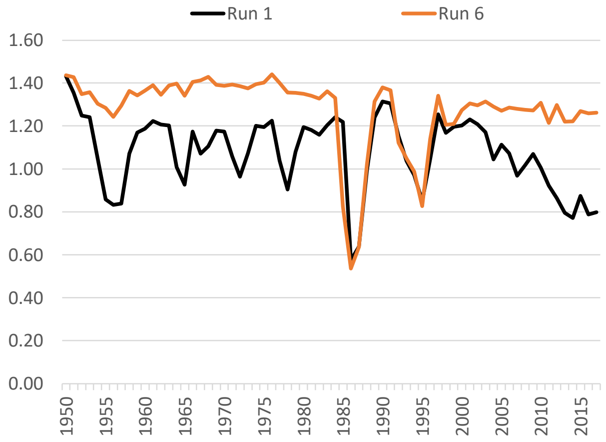
Total Allocation - EBID



Total Allocation - EPCWID



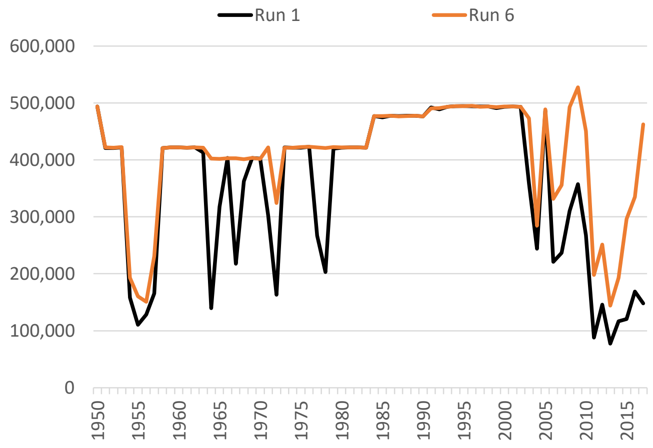
Diversion Ratio



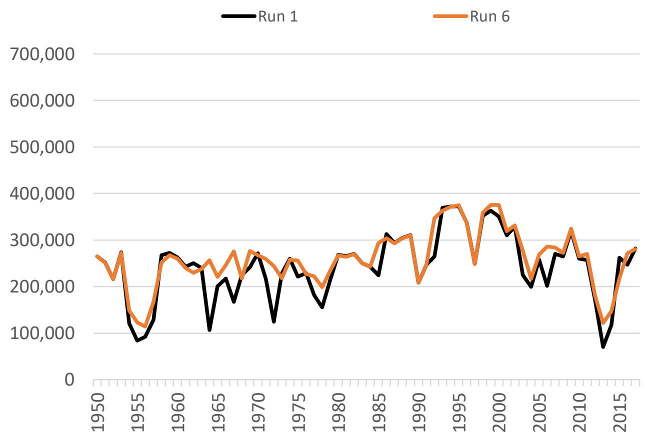
Note:

Computed as Total Charges/Caballo Release.

Annual Delivery Charges - EBID

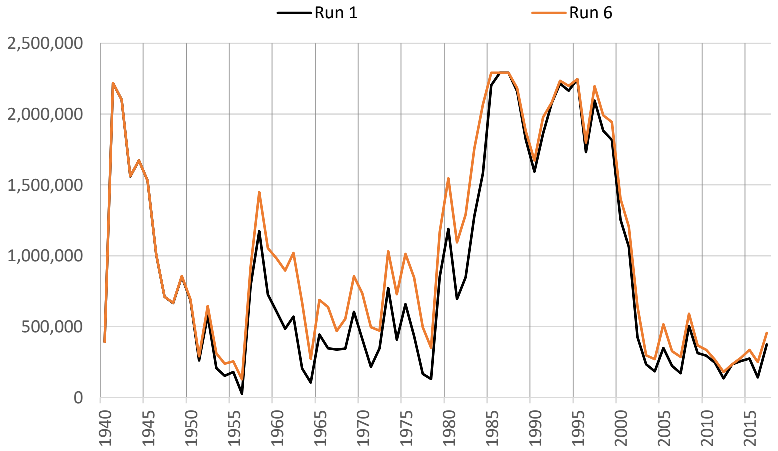


Annual Delivery Charges - EPCWID

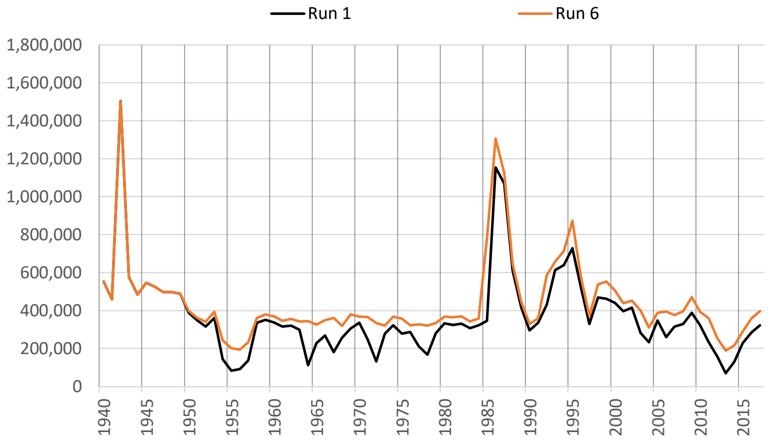


Run 6 - RM Pumping Off
Annual Summary of Project Storage and Rio Grande Flows
Run 6 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

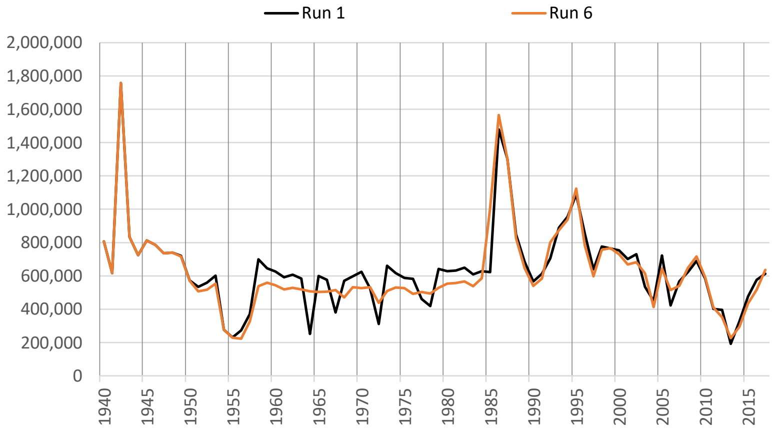
Total Year-End Project Reservoir Storage



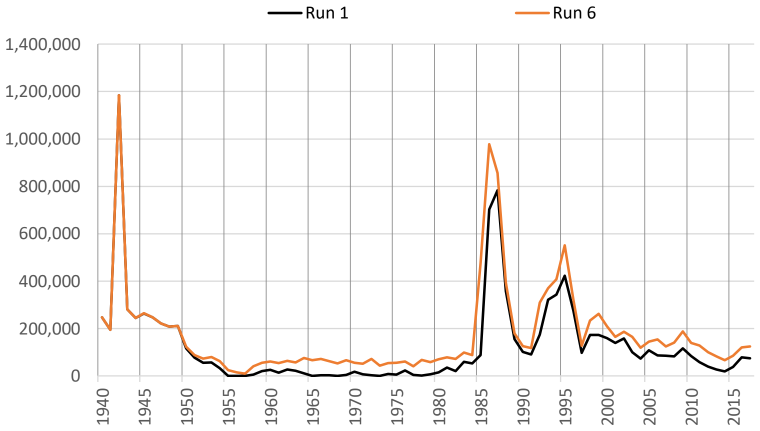
Rio Grande at El Paso



Rio Grande Below Caballo



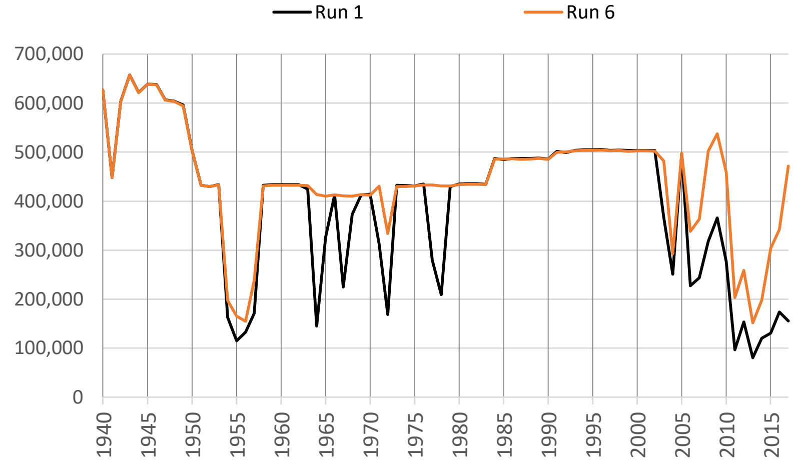
Rio Grande at Fort Quitman

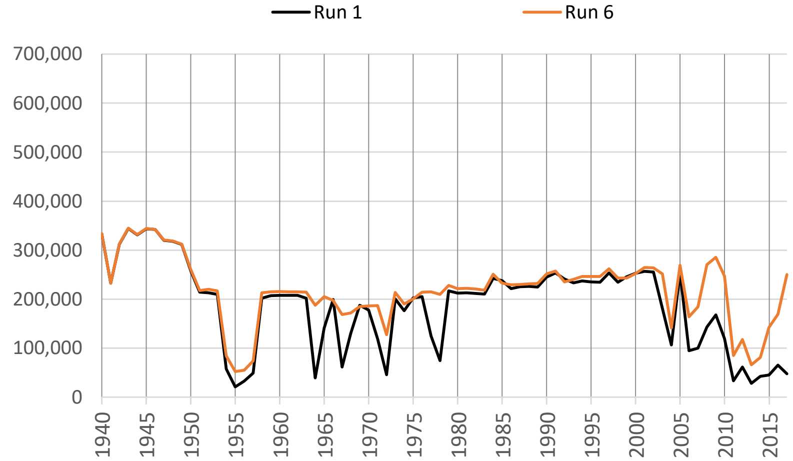


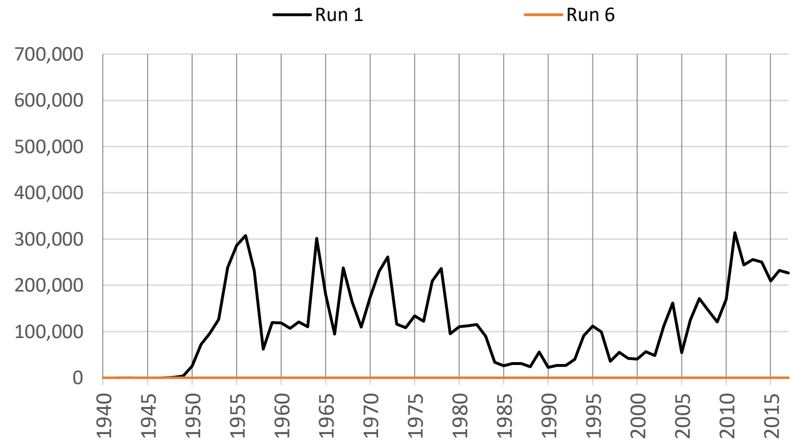
***Note different scales.**

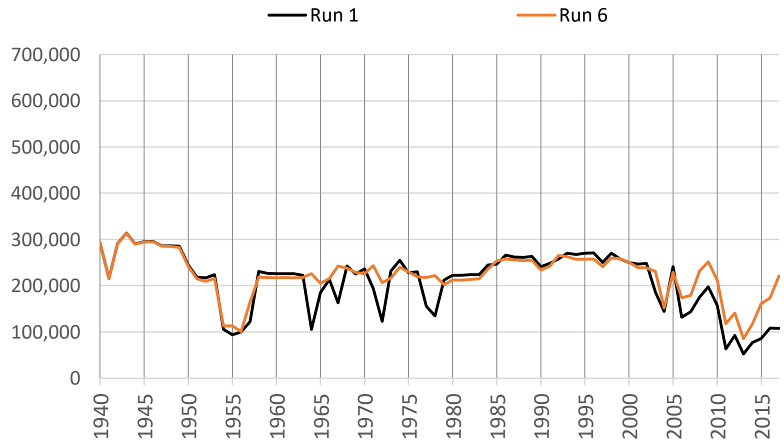
Run 6 - RM Pumping Off
Irrigation Season Summary of Irrigation Operations
Run 6 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

EBID Total


Net River Headgate Diversions


Farm Headgate Deliveries


Pumping


RHG Diversions - FHG Deliveries

Notes: EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).
Pumping includes Supplemental and Primary groundwater pumping.

Run 6 - RM Pumping Off

Irrigation Season Summary of Irrigation Operations

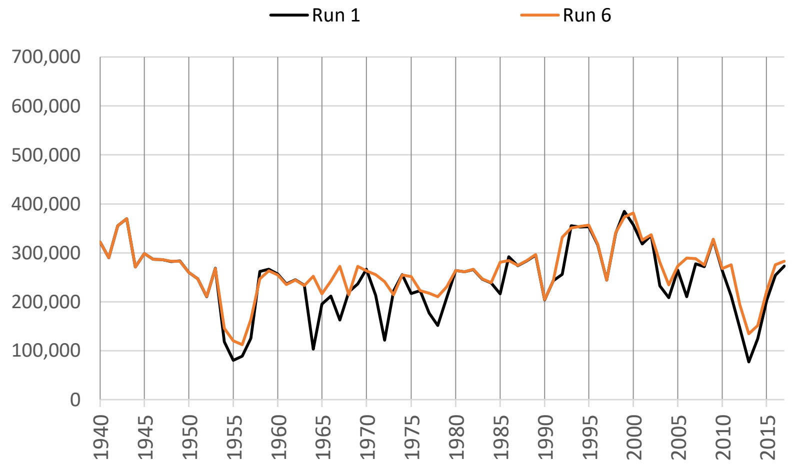
Run 6 v. Run 1

ILRG Model

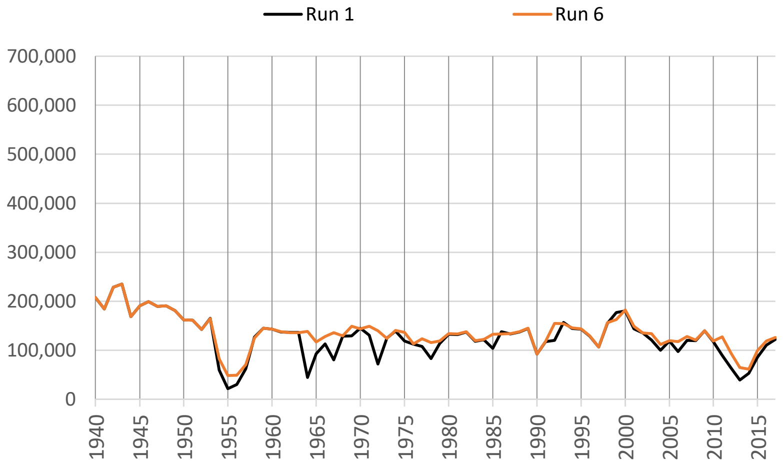
1940 - 2017 (acre-feet)

EPCWID Total

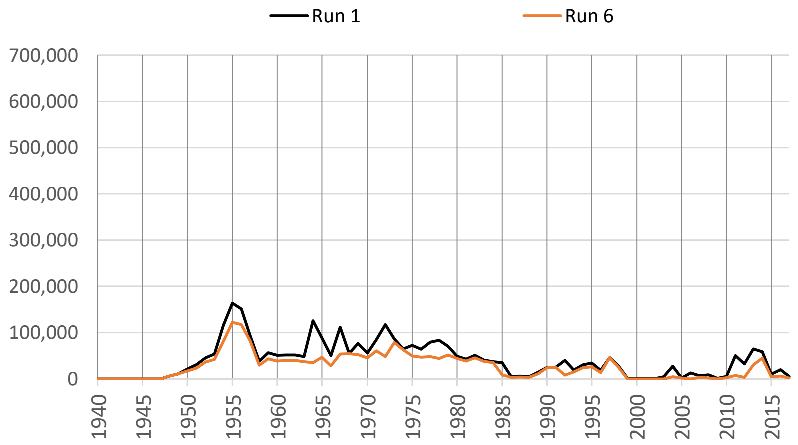
Net River Headgate Diversions



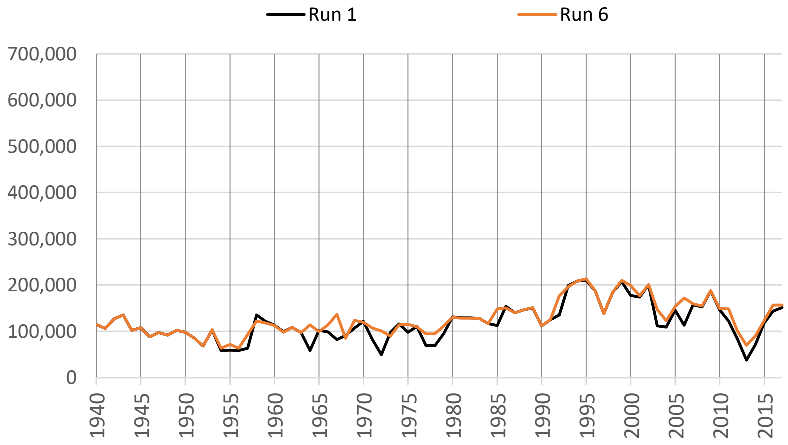
Farm Headgate Deliveries



Pumping



RHG Diversions - FHG Deliveries

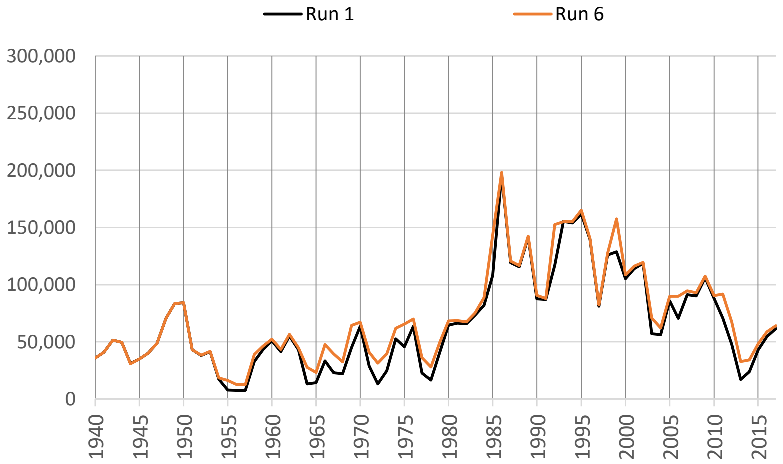


Note: EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

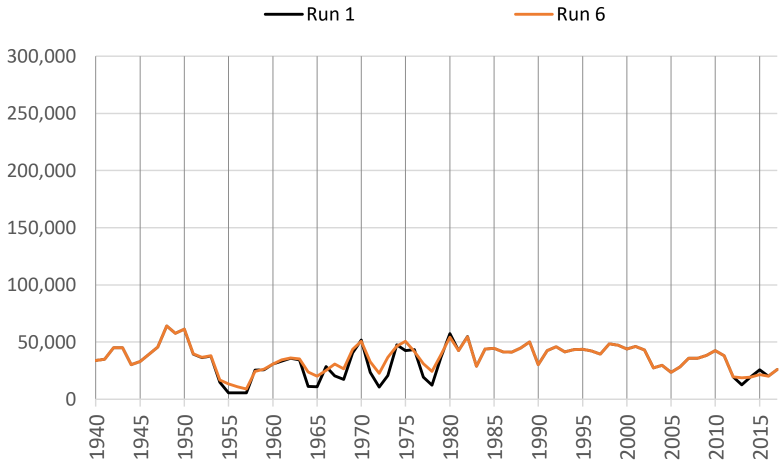
Run 6 - RM Pumping Off
Irrigation Season Summary of Irrigation Operations
Run 6 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

HCCRD Total

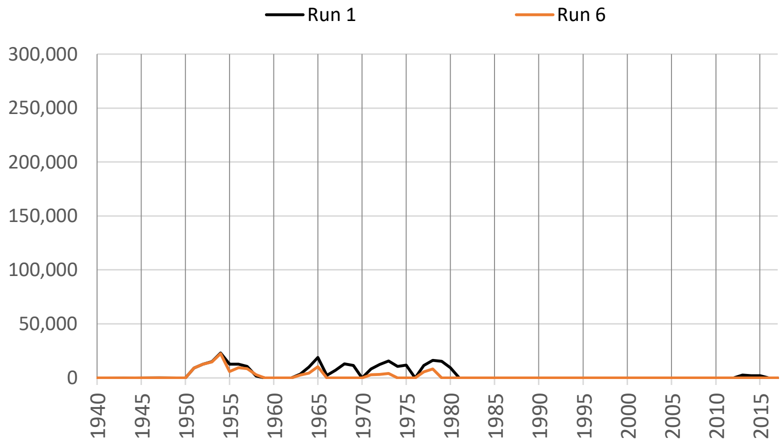
Net River Headgate Diversions



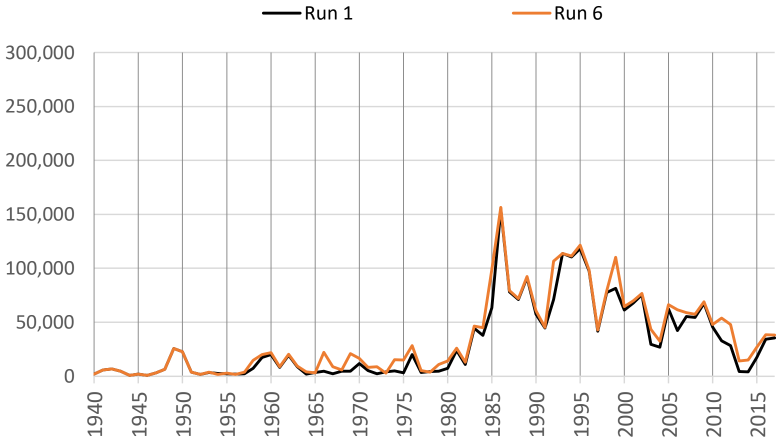
Farm Headgate Deliveries



Pumping



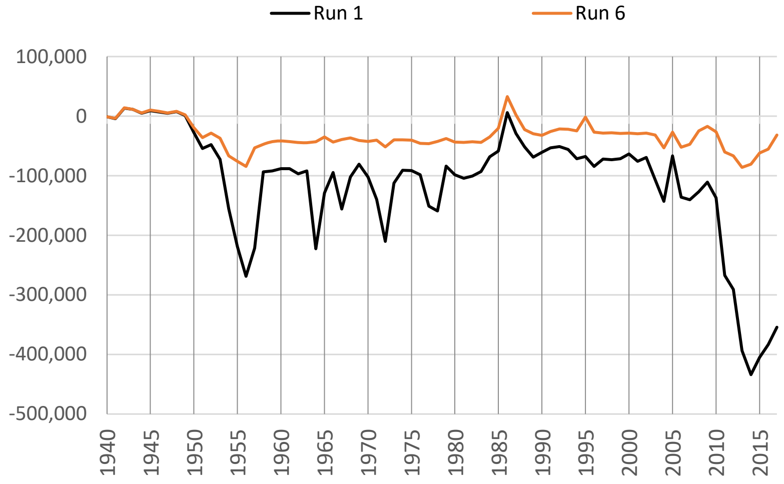
RHG Diversions - FHG Deliveries



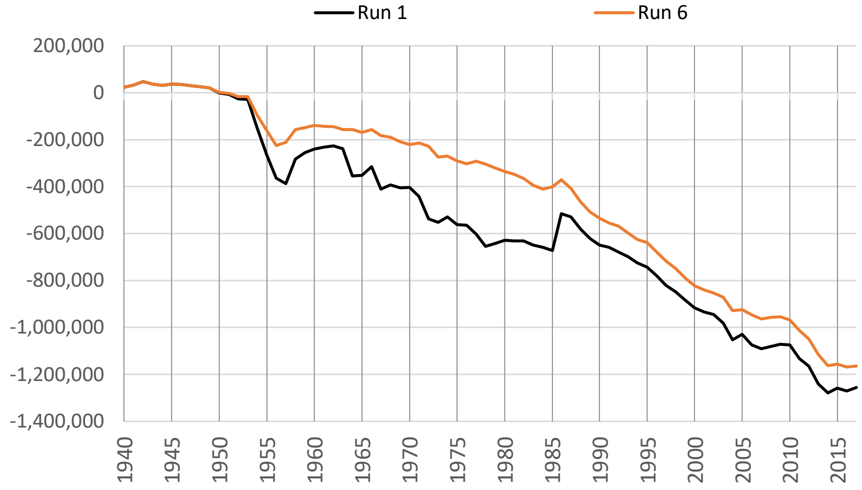
Note: HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

Run 6 - RM Pumping Off
Cumulative Change in Ground Water Storage
Run 6 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

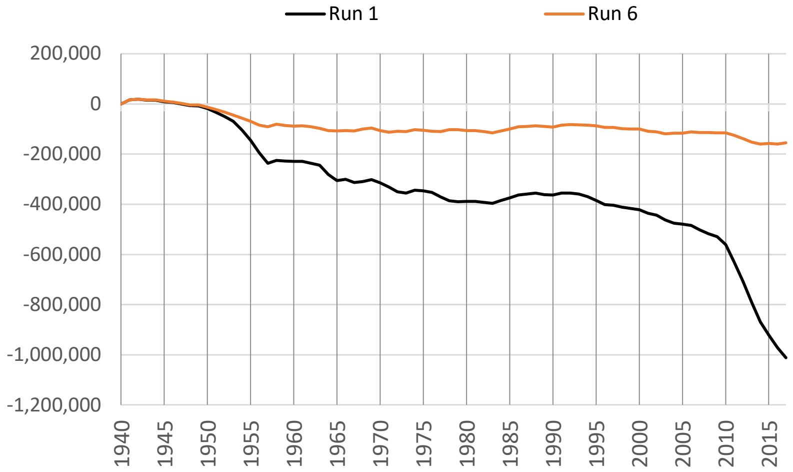
Rincon-Mesilla Alluvial Aquifer



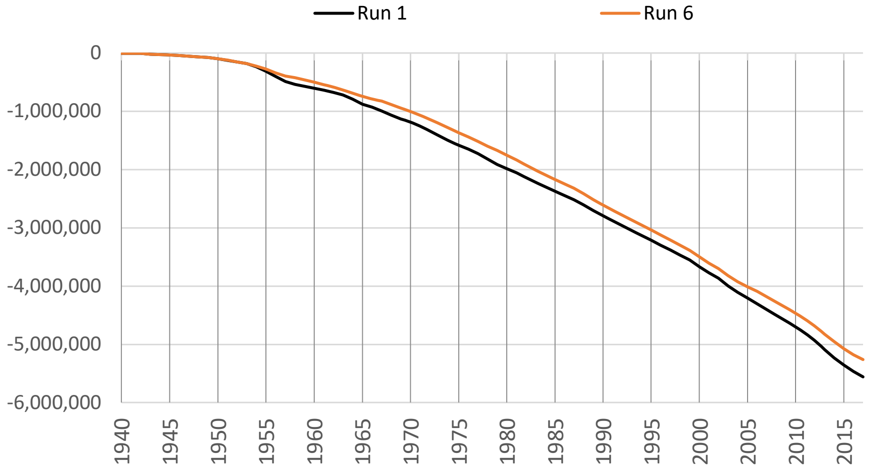
Hueco Alluvial Aquifer



Rincon-Mesilla Non-Alluvial Aquifer

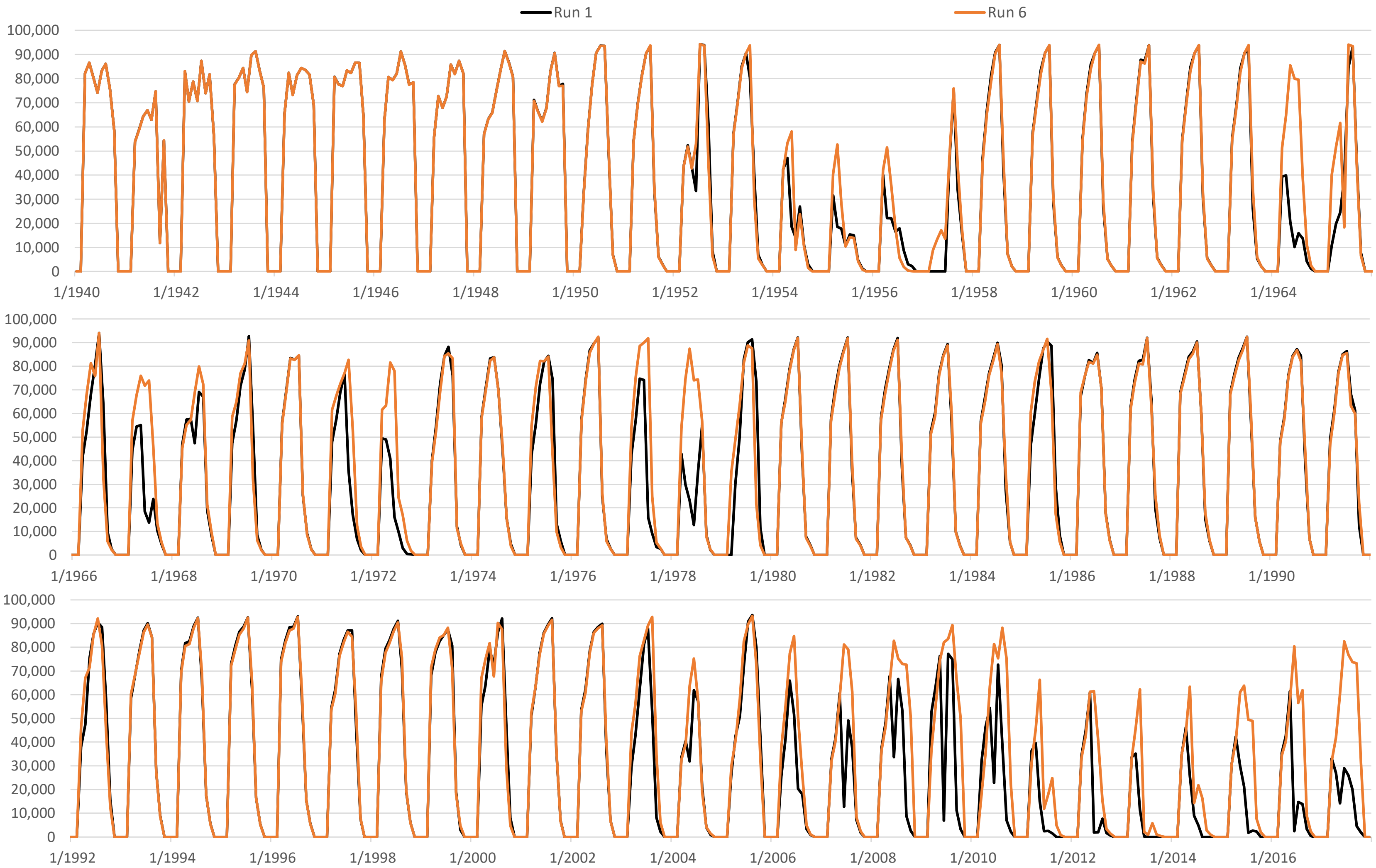


Hueco Non-Alluvial Aquifer



***Note different scales.**

Run 6 - RM Pumping Off
Monthly Net RHG Diversions
Run 6 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)
EBID Total

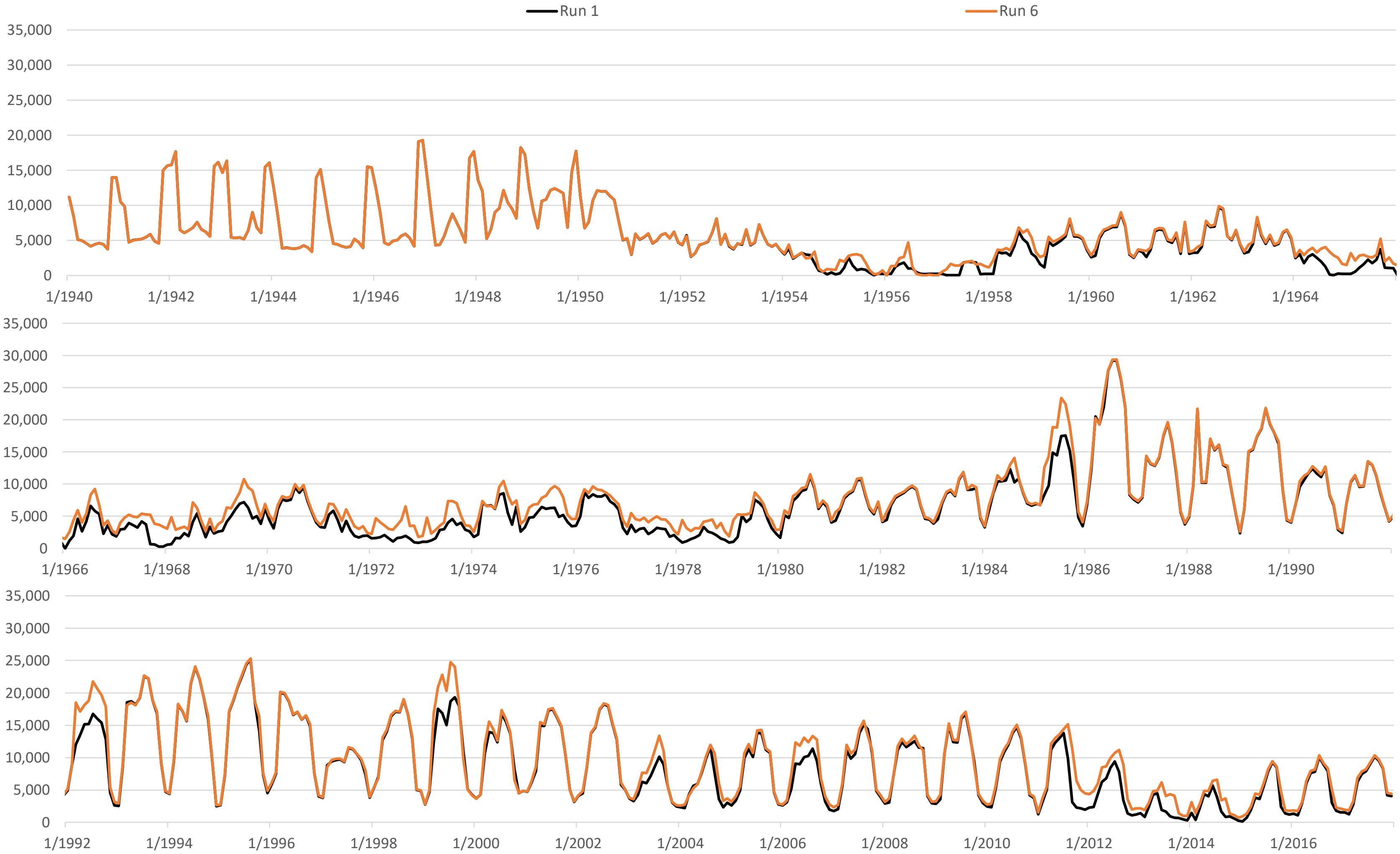


Note: EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).

Run 6 - RM Pumping Off
Monthly Net RHG Diversions
Run 6 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)
EPCWID Total

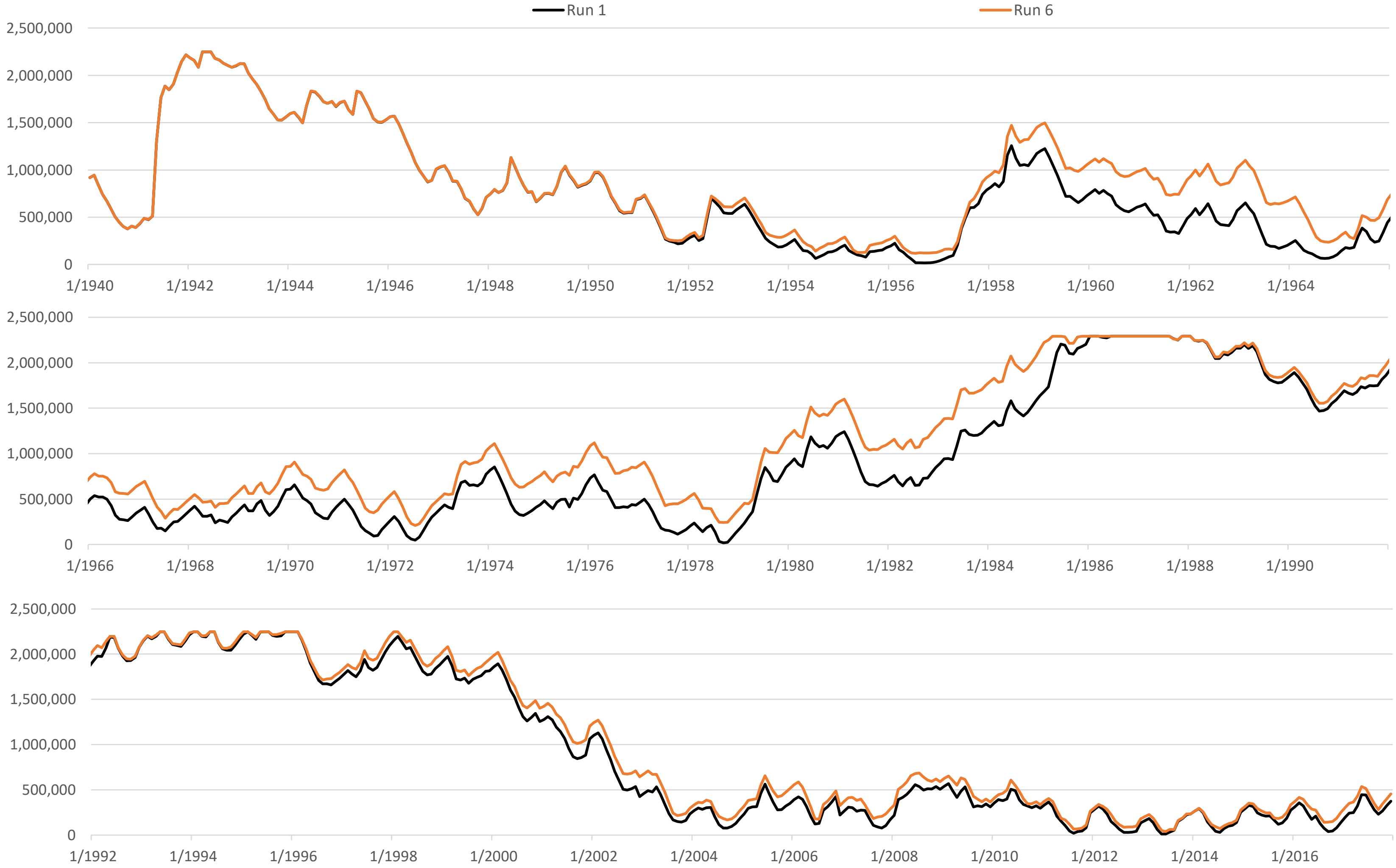
Note: EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

Run 6 - RM Pumping Off
Monthly Net RHG Diversions
Run 6 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)
HCCRD Total

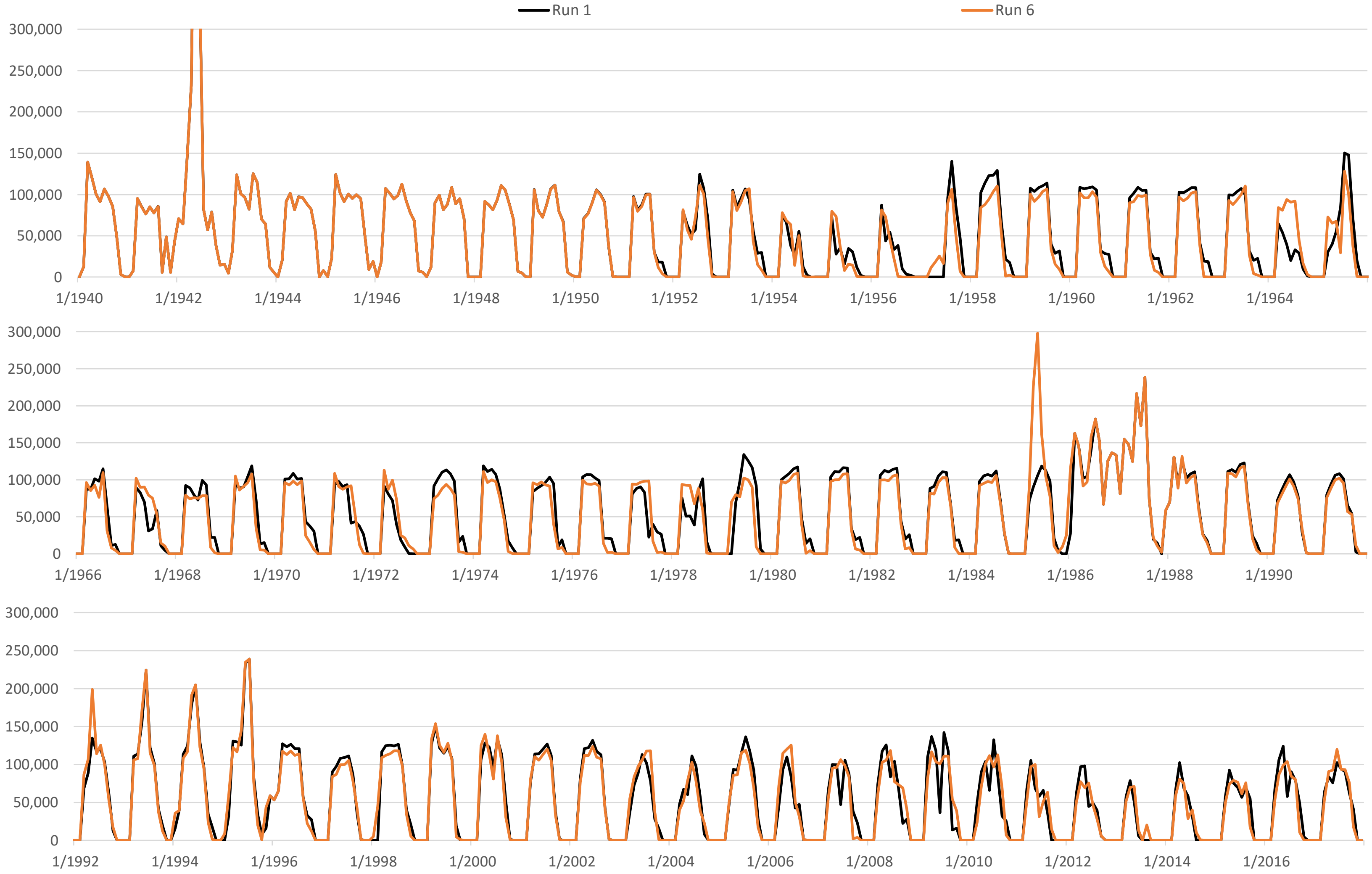


Note: HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

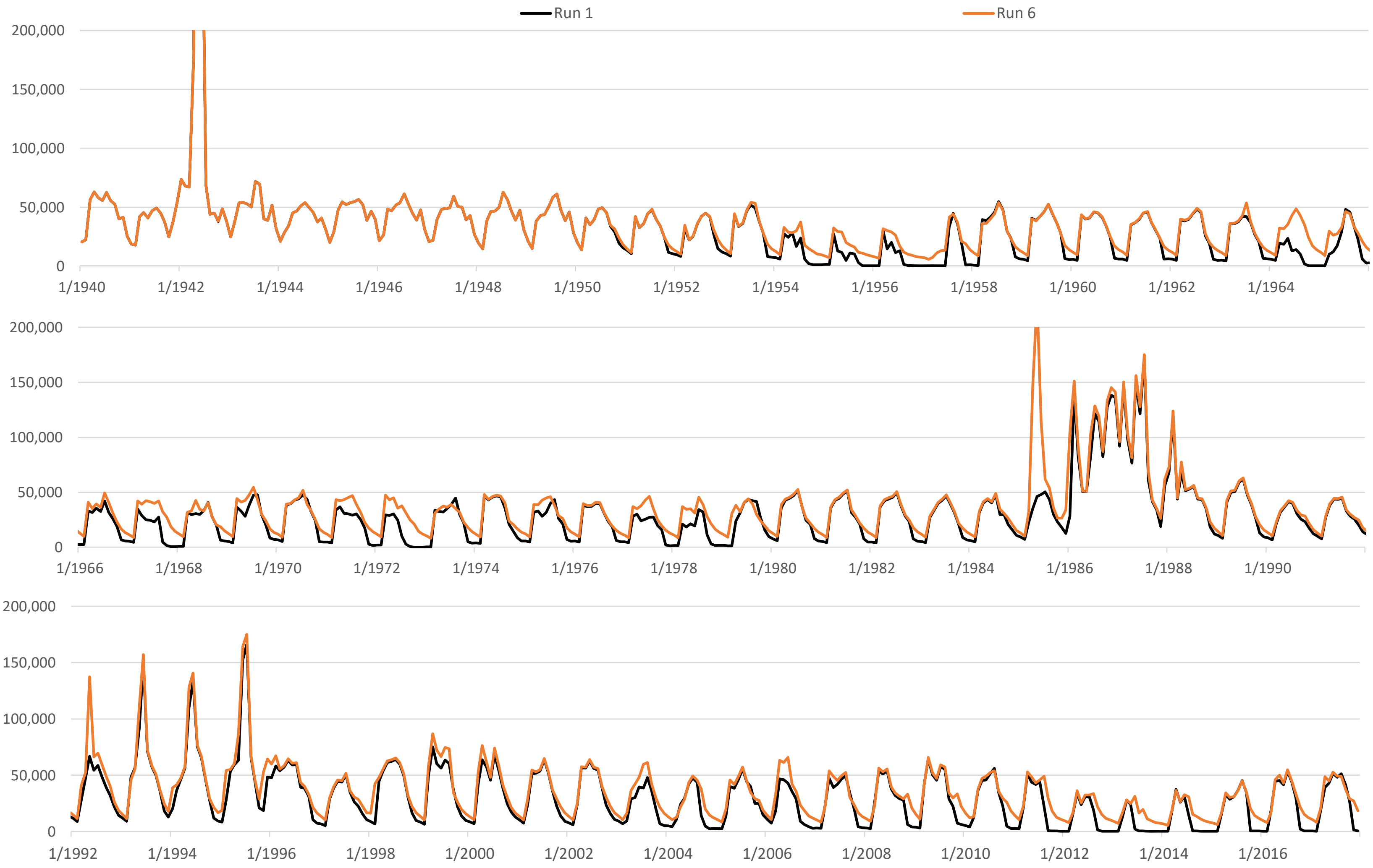
Run 6 - RM Pumping Off
End of Month Reservoir Storage (Elephant Butte + Caballo)
Run 6 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)



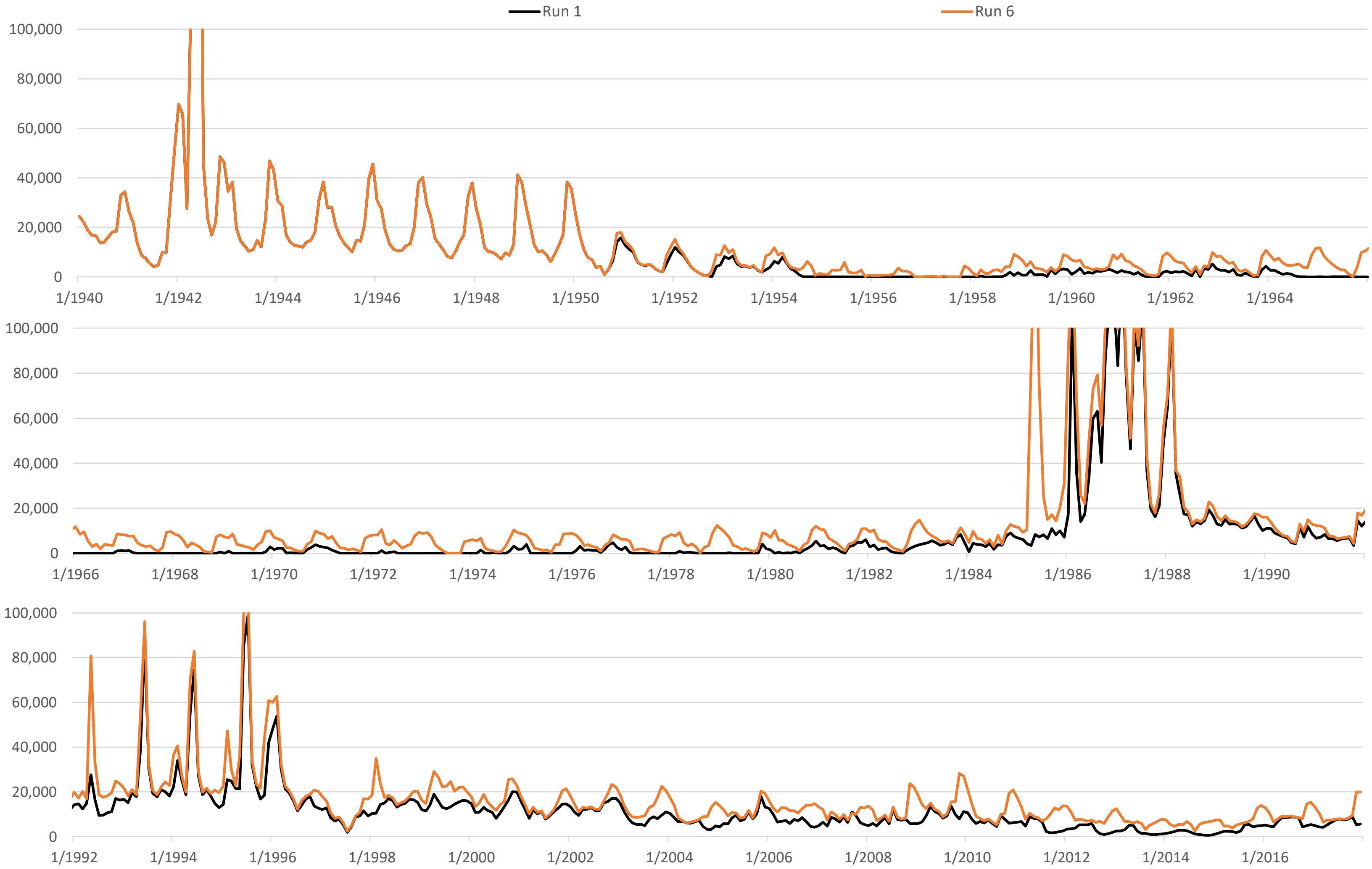
Run 6 - RM Pumping Off
Monthly Caballo Releases
Run 6 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)



Run 6 - RM Pumping Off
Monthly Rio Grande at El Paso Flow
Run 6 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)



Run 6 - RM Pumping Off
Monthly Rio Grande at Fort Quitman Flow
Run 6 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)



Appendix 30G

Comparison of ILRG Model Runs
Run 7 v. Run 1

Model Run Specifications

Model Version: LRG_v116

Name: **Run 7 - TX Mesilla Pumping Off**

Run ID: LRG_v116_Operational_Run7
Date: 8/25/2020

Name: **Run 1 - Historical Base Run**

Run ID: LRG_v116_Operational_Run1
Date: 8/23/2020

Selected Model Inputs

Pumping and Returns	**Run 7**	**Run 1**
Irrigation Pumping	TX Mesilla Off	On
Irrigated Area	Hist	Hist
Non-Irrigation Pumping	TX Mesilla Off	On
Non-Irrigation Pumping Returns	TX Mesilla Off	On
Las Cruces Jornada Pumping Returns	On	On

Project Allocation Rules		
1950-2005	D1/D2	D1/D2
2006-2007	D3	D3
2008-2017	D3 + CO	D3 + CO

EPCWID Operations		
Charge EPCWID for Use of WWTP Returns	Off	Off
ACE and Haskell Credits for EPCWID	On	On
Increased EPCWID Use of Fabens Drain Flows	Off	Off
Charge EPCWID for Fabens Drain Flow Use	Off	Off

Run 7 - TX Mesilla Pumping Off
Comparison of ILRG Model Runs
Run 7 v. Run 1
1951 - 2017 Annual Average
(1,000 acre-feet)

Run No.	1	7	7 - 1		
Simulated Input or Output	**Run 1**	**Run 7**	**Run 7 minus Run 1**		
Pumping Stress					
Irrigation Pumping	7.4	0.0	-7.4		
Non-Irrigation Pumping	181.0	159.3	-21.6		
WWTP Flows	58.0	52.0	-6.1		
Urban Deep Percolation	13.1	10.9	-2.1		
Total Stress	117.2	96.4	-20.8		
	Stress is Pumping minus WWTP and Urban Deep Perc				
Effects of Pumping Stress				***% Chg***	
FHG Deliveries (Mar - Oct)				***Stress***	***% Diff.***
EBID	167.6	173.2	5.6	*-27%*	*3%*
EPCWID (incl. EPW)	139.9	141.7	1.8	*-9%*	*1%*
HCCRD	32.8	33.3	0.4	*-2%*	*1%*
Total	340.3	348.1	7.8	*-38%*	*2%*
FHG Deliveries (Nov - Feb)					
EBID	0.0	0.0	0.0	*0%*	*-2%*
EPCWID (incl. EPW)	0.2	0.1	-0.1	*0%*	*-33%*
HCCRD	2.4	2.5	0.1	*0%*	*2%*
Total	2.6	2.6	0.0	*0%*	*0%*
Irrigation Pumping					
EBID	140.4	135.1	-5.4	*26%*	*-4%*
EPCWID (Mesilla Valley)	7.4	0.0			
EPCWID (El Paso Valley)	40.1	38.8	-1.3	*6%*	*-3%*
HCCRD	4.2	3.6	-0.6	*3%*	*-13%*
	184.8	177.5	-7.2	*35%*	*-4%*
	Pumping turned off.	*Other values are simulated responses and are totaled.*			
Other Inflows/Outflows					
Net Reservoir Evaporation	125.3	127.9	2.6	*-12%*	*2%*
Riparian ET	70.9	72.4	1.5	*-7%*	*2%*
River Evaporation + Incidental Canal Loss	30.3	30.4	0.1	*0%*	*0%*
Total	226.6	230.7	4.1	*-20%*	*2%*
Rio Grande at Fort Quitman					
Reservoir Spills	33.3	36.1	2.8	*-13%*	*8%*
Nov-Feb Flows	21.4	23.0	1.6	*-8%*	*8%*
Mar - Oct Flows	41.1	44.2	3.1	*-15%*	*8%*
Underflow (GW Model)	0.2	0.2	0.0	*0%*	*6%*
Total	96.0	103.5	7.6	*-36%*	*8%*

Run 7 - TX Mesilla Pumping Off
Comparison of ILRG Model Runs
Run 7 v. Run 1
1951 - 2017 Annual Average
(1,000 acre-feet)

Run No.	1	7	7 - 1		
Simulated Input or Output	**Run 1**	**Run 7**	**Run 7 minus Run 1**		
Effects of Pumping Stress (continued)				***% Chg***	
Change in Storage				***Stress***	***% Diff.***
Reservoir Storage	-4.7	-4.7	-0.1	*0%*	*2%*
Alluvial GW Storage (RW Model)	-23.6	-21.8	1.8	*-8%*	*-7%*
Non-alluvial GW Storage (GW Models)	-96.4	-93.6	2.8	*-13%*	*-3%*
Soil Moisture Storage	0.6	0.6	0.0	*0%*	*0%*
Total	-124.0	-119.6	4.4	*-21%*	*-4%*
Summary of Effects					
FHG Deliveries (Mar-Oct)	340.3	348.1	7.8	*-38%*	*2%*
FHG Deliveries (Nov-Feb)	2.6	2.6	0.0	*0%*	*0%*
Irrigation Pumping	184.8	177.5	-7.2	*35%*	*-4%*
Riparian ET + Evaporation	226.6	230.7	4.1	*-20%*	*2%*
Fort Quitman Flow	96.0	103.5	7.6	*-36%*	*8%*
Change in Storage	-124.0	-119.6	4.4	*-21%*	*-4%*
Total	726.2	742.9	16.7	*-80%*	*2%*
Other Effects of Pumping Stress				***% Chg***	
Rio Grande at El Paso				***Stress***	***% Diff.***
Reservoir Spills	49.4	50.6	1.2	*-6%*	*2%*
Nov-Feb Flows	22.8	27.6	4.8	*-23%*	*21%*
Mar - Oct Flows	263.8	276.4	12.6	*-61%*	*5%*
Total	336.0	354.5	18.6	*-89%*	*6%*
Rio Grande below Caballo					
Reservoir Spills	65.9	65.2	-0.6	*3%*	*-1%*
Nov-Feb Flows	0.5	0.3	-0.2	*1%*	*-35%*
Mar - Oct Flows	541.3	539.6	-1.7	*8%*	*0%*
Total	607.6	605.1	-2.5	*12%*	*0%*
Surface Water Diversions (Mar - Oct)					
EBID	366.5	373.7	7.2	*-35%*	*2%*
EPCWID (incl. EPW)	236.8	240.2	3.4	*-17%*	*1%*
HCCRD	67.5	69.1	1.6	*-8%*	*2%*
Total	670.8	683.1	12.2	*-59%*	*2%*
Surface Water Diversions (Nov - Feb)					
EBID	0.0	0.0	0.0	*0%*	*0%*
EPCWID (incl. EPW)	14.3	14.6	0.3	*-1%*	*2%*
HCCRD	14.2	14.5	0.3	*-1%*	*2%*
Total	28.5	29.1	0.5	*-3%*	*2%*

Run 7 - TX Mesilla Pumping Off
Annual Differences in ILRG Model Outputs
Run 7 minus Run 1
1940 - 2017 (acre-feet)

	Net River Headgate Diversions						Farm Headgate Deliveries						Annual Flows		
	EBID		EPCWID (incl. EPW)		HCCRD		EBID		EPCWID (incl. EPW)		HCCRD				
Year	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Caballo Releases	Rio Grande at El Paso	Rio Grande at Fort Quitman
1940	-55	-55	5	-2	0	-3	-2	-2	3	3	0	0	-58	-23	-58
1941	-163	-163	-2	-5	-2	-2	-3	-3	-1	0	-2	-4	49	86	27
1942	-34	-34	0	-4	-1	0	0	0	3	8	0	-1	27	18	-11
1943	-65	-65	-4	-6	3	3	-14	-14	-12	-12	2	-1	-23	-10	-76
1944	-81	-81	-143	-137	-110	-92	-6	-6	17	-2	-99	-100	-159	-154	-47
1945	-78	-78	-4	24	2	23	1	1	-5	-32	4	4	-91	-1	23
1946	-38	-38	18	32	3	10	5	5	15	15	3	3	-52	67	45
1947	-72	-72	-5	28	-3	16	1	0	-3	-14	-7	-6	-94	36	58
1948	-74	-74	1	19	-1	8	0	0	12	3	1	1	-98	45	45
1949	-102	-102	-9	9	0	12	2	2	0	-2	0	0	-115	26	38
1950	-311	-311	-75	-59	-6	16	380	380	-75	-69	0	-1	-901	1,471	883
1951	280	280	-66	-60	27	41	702	702	-91	-87	21	25	-3,099	1,348	975
1952	-763	-763	-43	-32	45	57	705	705	-210	-201	49	49	-6,155	2,644	659
1953	-750	-750	-267	-255	84	59	1,365	1,365	-560	-551	59	10	-6,341	5,535	1,555
1954	938	938	946	1,945	63	-70	4,735	4,735	4,144	4,161	214	147	-4,262	14,142	2,083
1955	10,196	10,196	7,814	9,558	85	-70	5,747	5,747	5,039	4,833	-155	-293	10,325	16,190	484
1956	4,244	4,244	5,593	6,741	440	418	-454	-454	870	87	345	306	4,155	11,783	46
1957	-434	-434	18	1,712	-26	-28	359	359	-2	-423	-73	-97	-6,093	6,803	1
1958	-855	-855	-2,559	-1,467	635	1,444	1,265	1,264	-306	-384	-80	38	-23,670	5,983	1,305
1959	-1,062	-1,062	-853	-451	303	418	1,234	1,234	-646	-626	2	8	-18,162	7,853	1,330
1960	-1,138	-1,138	-425	-271	124	49	1,331	1,331	-822	-799	0	0	-14,055	9,370	1,127
1961	-1,035	-1,035	-185	-59	361	356	1,359	1,359	-274	-250	298	-300	-14,145	9,129	1,529
1962	-1,108	-1,108	-89	35	153	89	1,358	1,358	-527	-501	-63	-249	-14,889	9,668	4,139
1963	7,675	7,675	-47	177	315	366	6,409	6,409	-790	-759	204	209	-5,532	17,904	4,101
1964	12,132	12,132	8,389	9,495	249	347	18,679	18,679	9,751	9,410	946	878	-4,351	28,238	6,234
1965	41,474	41,474	24,418	25,042	2,832	3,047	23,265	23,265	17,724	17,326	2,941	3,128	41,079	44,649	2,597
1966	-1,133	-1,133	-1,594	-155	2,349	3,337	1,891	1,891	-325	-288	974	-46	-26,853	16,262	4,134
1967	26,715	26,715	21,164	24,315	3,345	5,248	16,171	16,171	16,851	16,365	2,736	3,546	28,728	39,123	2,765
1968	4,327	4,327	-1,993	414	2,963	4,790	5,097	5,097	289	-83	2,887	3,510	-18,416	15,208	1,853
1969	-664	-664	-813	-165	3,247	4,831	1,656	1,656	-226	-205	3,502	2,986	-20,626	9,129	2,430
1970	-953	-953	-170	41	1,076	1,513	1,381	1,381	-41	-22	-745	-1,180	-13,337	11,876	3,492
1971	31,121	31,121	1,212	2,568	474	1,156	20,790	20,790	476	504	438	1,020	9,153	21,127	721
1972	229	229	1,343	2,843	80	832	-2,444	-2,444	-5,528	-5,769	-388	304	-7,947	16,688	-49
1973	-1,460	-1,460	449	986	2,022	2,196	2,691	2,691	666	442	1,986	1,968	-24,113	13,492	135
1974	-1,227	-1,227	197	903	1,343	1,722	1,880	1,880	-231	-209	711	733	-19,723	12,622	1,473
1975	-1,038	-1,038	472	441	2,348	2,320	2,579	2,579	309	327	2,562	2,603	-12,406	13,328	263
1976	-1,343	-1,343	337	336	2,187	2,239	2,459	2,459	-101	-87	-26	-85	-16,802	13,404	2,903
1977	58,722	58,722	36,918	39,473	10,373	11,072	28,037	28,037	15,536	15,565	9,420	10,339	50,270	64,954	6,840
1978	19,351	19,351	13,454	16,799	-1,112	1,424	11,351	11,351	12,149	12,184	-869	1,432	15,835	36,993	2,461

Run 7 - TX Mesilla Pumping Off
Annual Differences in ILRG Model Outputs
Run 7 minus Run 1
1940 - 2017 (acre-feet)

	Net River Headgate Diversions						Farm Headgate Deliveries						Annual Flows		
	EBID		EPCWID (incl. EPW)		HCCRD		EBID		EPCWID (incl. EPW)		HCCRD				
Year	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Caballo Releases	Rio Grande at El Paso	Rio Grande at Fort Quitman
1979	-850	-850	171	1,249	761	2,834	3,166	3,167	3,288	3,327	790	2,948	-25,529	23,544	3,715
1980	-949	-949	-383	138	1,614	3,331	1,812	1,812	187	213	353	-399	-17,388	16,087	5,456
1981	-911	-911	-117	108	346	660	1,966	1,966	186	206	0	0	-13,693	12,883	2,331
1982	-964	-964	-64	-60	29	164	1,574	1,574	158	176	-29	-85	-12,358	13,052	2,507
1983	-682	-682	41	30	371	466	1,387	1,387	169	186	0	0	-9,967	12,679	1,382
1984	-743	-743	46	283	2,590	2,836	1,493	1,494	134	153	0	0	-6,770	15,793	4,282
1985	-675	-675	24	-41	1,277	1,462	1,768	1,769	14	-58	0	0	-6,864	13,332	4,708
1986	-727	-727	-94	-70	1,127	1,553	1,453	1,463	89	115	0	0	70,618	89,226	160,994
1987	-890	-890	382	398	270	443	953	955	148	165	0	0	8	20,027	30,322
1988	-675	-675	306	320	249	399	1,715	1,716	82	96	0	0	-5,194	16,235	10,396
1989	-802	-802	975	784	343	541	1,673	1,674	388	139	0	0	-5,952	15,959	6,891
1990	-525	-525	302	122	1,515	1,667	1,559	1,559	167	-79	0	0	-4,356	15,268	6,619
1991	-881	-881	229	1	117	367	349	350	175	-198	0	0	-4,441	12,749	8,697
1992	2,068	2,068	74,909	74,752	34,176	35,239	-9,051	-9,062	33,574	33,399	0	0	33,461	56,924	40,586
1993	-38	-38	-5,159	-5,184	-1,070	-422	2,094	2,090	-2,789	-2,787	0	0	-20,236	-5,877	-1,808
1994	-917	-917	774	765	276	457	1,443	1,443	493	499	0	0	470	21,369	12,214
1995	-1,023	-1,023	809	769	339	580	1,633	1,634	461	415	0	0	3,974	29,446	17,882
1996	-1,185	-1,185	391	406	180	362	2,196	2,196	207	224	0	0	-10,192	19,277	7,454
1997	-603	-603	110	-56	336	636	1,468	1,468	-468	-825	0	0	-6,463	17,709	4,267
1998	-781	-781	543	529	241	214	1,672	1,672	289	299	0	0	-9,099	18,151	8,114
1999	-612	-612	-767	-784	259	-20	1,580	1,580	2,033	2,041	0	0	-103	23,524	12,599
2000	-586	-586	-2,190	-2,300	-296	-349	1,753	1,753	-1,881	-1,870	0	0	-11,699	13,008	3,774
2001	-598	-598	608	47	496	484	1,427	1,427	-87	-79	0	0	-7,204	16,044	5,040
2002	-558	-558	1,050	643	525	774	1,670	1,670	89	97	0	0	-8,378	16,084	5,604
2003	29,840	29,840	3,927	2,936	1,038	600	19,729	19,729	2,165	2,180	0	0	13,464	24,112	5,031
2004	12,100	12,100	5,103	4,337	1,502	1,617	8,871	8,871	2,406	2,425	0	0	-1,299	23,151	6,846
2005	1,271	1,271	3,024	2,064	929	988	3,914	3,906	1,536	1,555	0	0	-16,226	16,890	6,009
2006	44,276	44,276	20,324	18,871	8,750	8,837	21,406	21,406	2,088	2,101	0	0	37,556	45,515	24,184
2007	16,218	16,218	562	-192	525	367	9,903	9,903	-306	-287	0	0	-9,419	13,106	3,290
2008	30,040	30,040	1,570	714	820	593	20,700	20,700	168	188	0	0	-2,050	15,960	4,179
2009	44,238	44,238	1,156	511	602	659	25,859	25,859	-283	-261	0	0	-648	16,626	7,742
2010	51,094	51,094	2,159	2,575	929	1,155	33,051	33,051	829	850	0	0	1,782	17,909	6,685
2011	31,586	31,586	6,995	6,924	2,546	2,124	17,664	17,664	4,775	4,794	0	0	19,317	23,326	6,546
2012	-4,968	-4,968	1,997	640	3,840	2,713	-671	-671	863	876	0	0	-12,649	15,103	6,143
2013	1,621	1,621	-2,369	-2,978	249	16	798	798	-1,424	-1,413	316	155	-5,198	10,438	3,092
2014	4,497	4,497	-609	-1,670	38	-362	2,816	2,816	-163	-153	246	-83	2,163	10,794	410
2015	3,926	3,926	282	-249	244	226	2,317	2,317	-251	-241	101	159	134	11,733	2,028
2016	7,709	7,709	-3,364	-3,581	-430	-688	2,478	2,478	-2,878	-2,867	0	0	-9,288	7,132	491
2017	24,900	24,900	2,669	3,015	545	586	13,142	13,142	1,318	1,330	0	0	13,039	15,990	2,282
Averages															
1951-2017	7,249	7,249	3,432	3,697	1,561	1,840	5,557	5,557	1,807	1,745	443	503	-2,509	18,593	7,561
1951-1978	7,230	7,230	4,058	5,032	1,299	1,757	5,771	5,771	2,612	2,499	996	1,107	-4,337	16,980	2,057
1979-2005	1,041	1,041	3,146	3,044	1,835	2,144	2,269	2,269	1,601	1,556	41	91	-3,015	20,987	14,145
2006-2017	21,261	21,261	2,614	2,048	1,555	1,352	12,455	12,455	395	410	55	19	2,895	16,969	5,589
1985-2017	8,738	8,738	3,534	3,182	1,893	1,934	6,040	6,040	1,328	1,293	20	7	1,183	20,492	13,009
1985-2005	1,581	1,581	4,060	3,830	2,087	2,266	2,375	2,374	1,861	1,798	0	0	204	22,505	17,250

Notes:

EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).

EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

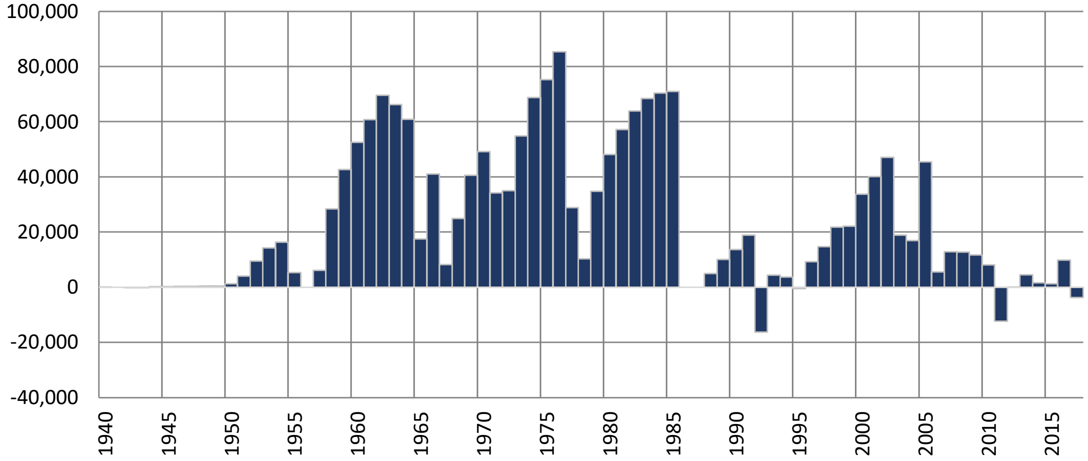
Run 7 - TX Mesilla Pumping Off

Simulated Differences in ILRG Model Outputs

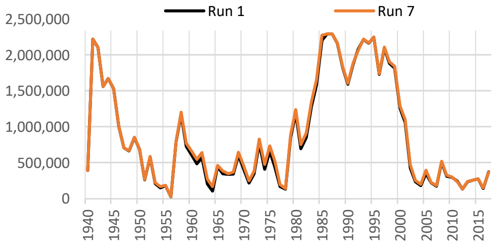
Run 7 minus Run 1

1940 - 2017 (acre-feet)

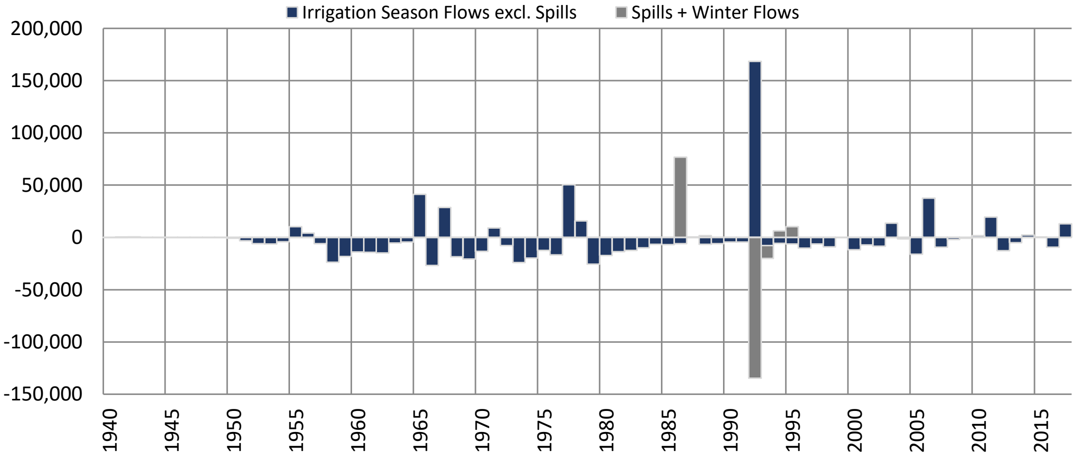
Total Project Storage (Year End)



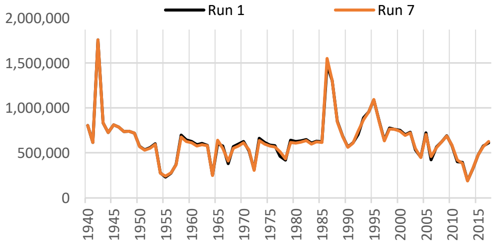
Period	Average Difference
1951-2017	-74
1951-1978	324
1979-2005	1,301
2006-2017	-4,096
1985-2017	-2,245
1985-2005	-1,187



Caballo Reservoir Outflows (Annual)



	Average Difference		
Period	Irr Season (excl. Spills)	Nov-Feb and Spills	Annual
1951-2017	-1,722	-787	-2,509
1951-1978	-4,337	0	-4,337
1979-2005	-1,061	-1,954	-3,015
2006-2017	2,895	0	2,895
1985-2017	2,781	-1,599	1,183
1985-2005	2,716	-2,512	204



Notes:

Reservoir storage does not include storage attributed to SJC, CO, or NM credit waters.

Average differences calculated as (Final Storage - Initial Storage)/(no. years).

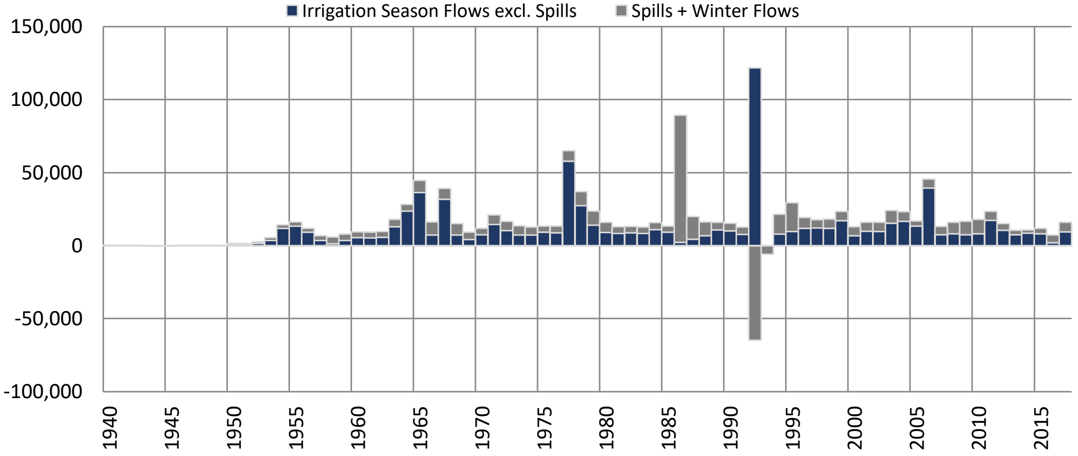
Run 7 - TX Mesilla Pumping Off

Simulated Differences in ILRG Model Outputs

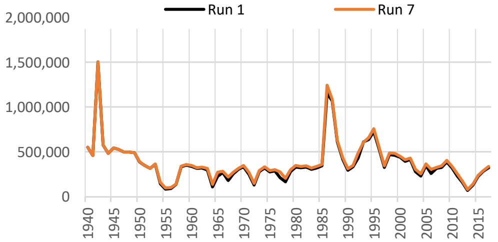
Run 7 minus Run 1

1940 - 2017 (acre-feet)

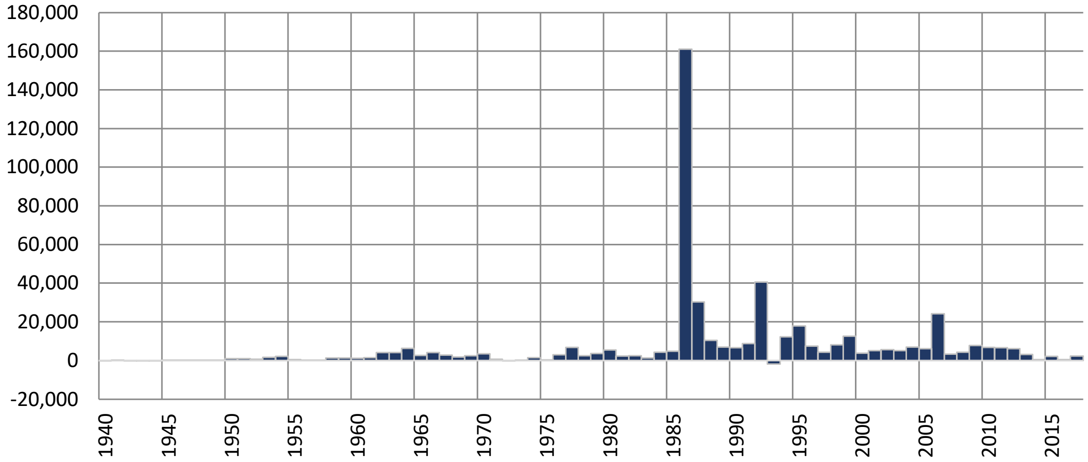
Rio Grande at El Paso (Annual)



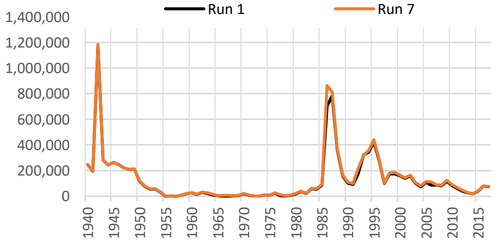
	Average Difference		
Period	Irr Season (excl. Spills)	Nov-Feb and Spills	Annual
1951-2017	12,613	5,980	18,593
1951-1978	12,051	4,929	16,980
1979-2005	13,849	7,138	20,987
2006-2017	11,144	5,825	16,969
1985-2017	13,586	6,907	20,492
1985-2005	14,981	7,524	22,505



Rio Grande at Fort Quitman (Annual)



Period	Average Difference
1951-2017	7,547
1951-1978	2,042
1979-2005	14,128
2006-2017	5,586
1985-2017	13,001
1985-2005	17,239



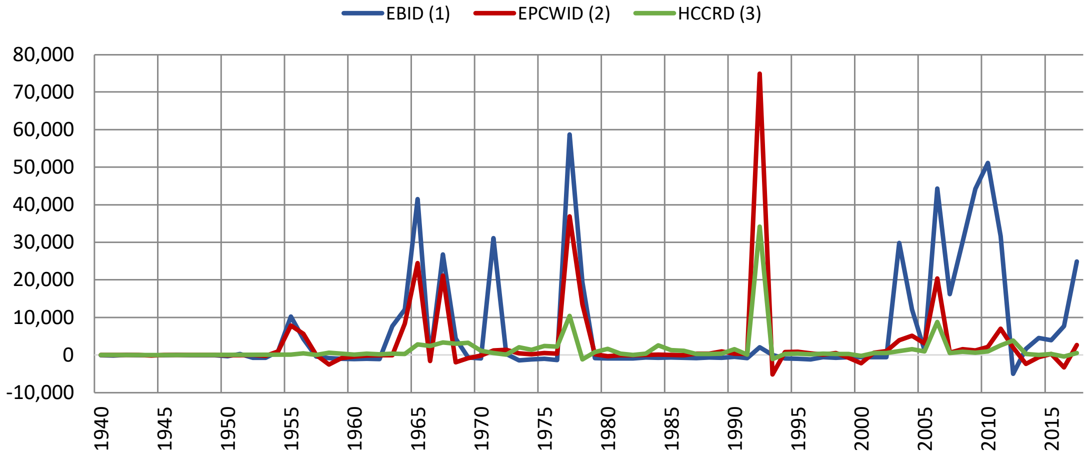
Run 7 - TX Mesilla Pumping Off

Simulated Differences in ILRG Model Outputs

Run 7 minus Run 1

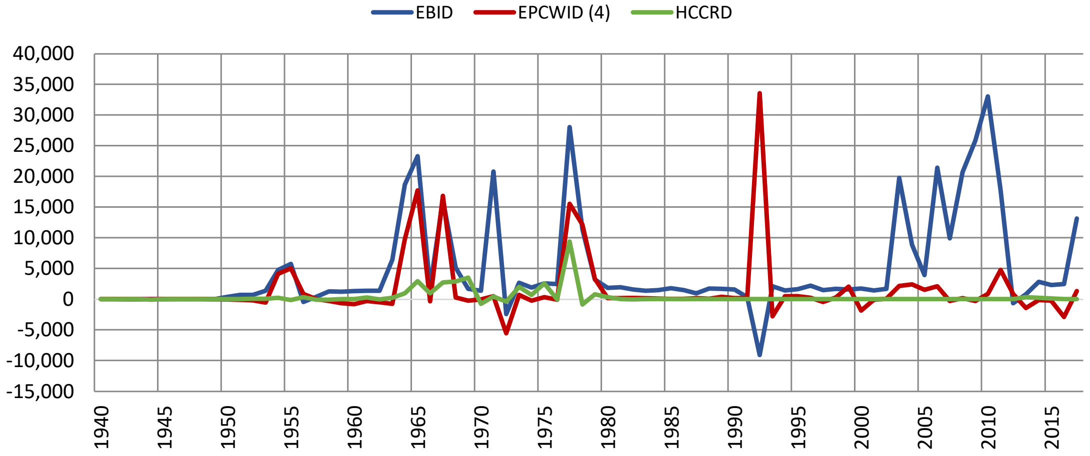
1940 - 2017 (acre-feet)

River Headgate (RHG) Diversions (Irrigation Season)



	Average Difference		
Period	EBID	EPCWID	HCCRD
1951-2017	7,249	3,432	1,561
1951-1978	7,230	4,058	1,299
1979-2005	1,041	3,146	1,835
2006-2017	21,261	2,614	1,555
1985-2017	8,738	3,534	1,893
1985-2005	1,581	4,060	2,087

Farm Headgate (FHG) Deliveries (Irrigation Season)



	Average Difference		
Period	EBID	EPCWID	HCCRD
1951-2017	5,557	1,807	443
1951-1978	5,771	2,612	996
1979-2005	2,269	1,601	41
2006-2017	12,455	395	55
1985-2017	6,040	1,328	20
1985-2005	2,375	1,861	0

Notes:

(1) EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).

(2) EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

(3) HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

(4) EPCWID FHG values include deliveries to Rogers WTP and R/U WTP.

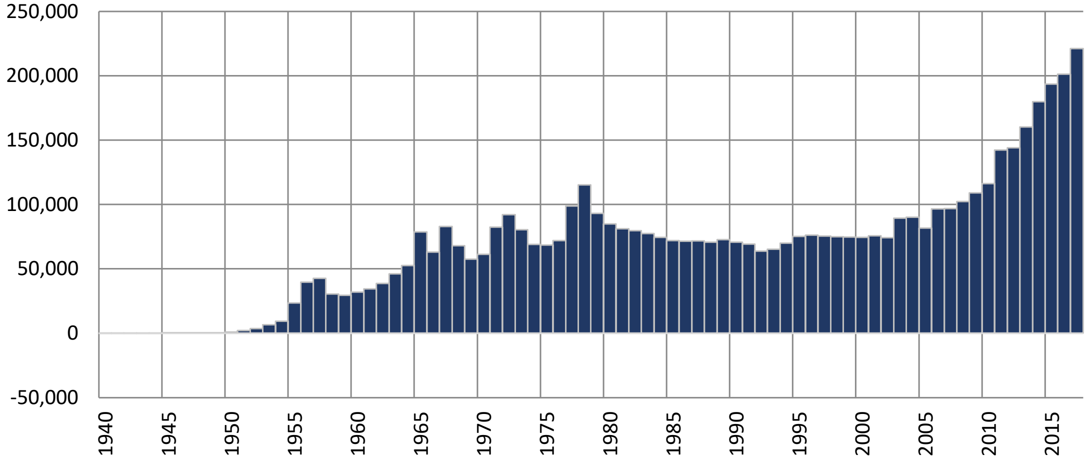
Run 7 - TX Mesilla Pumping Off

Simulated Differences in ILRG Model Outputs

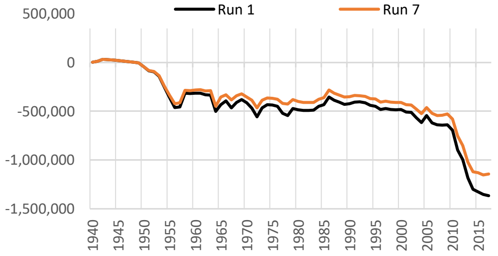
Run 7 minus Run 1

1940 - 2017 (acre-feet)

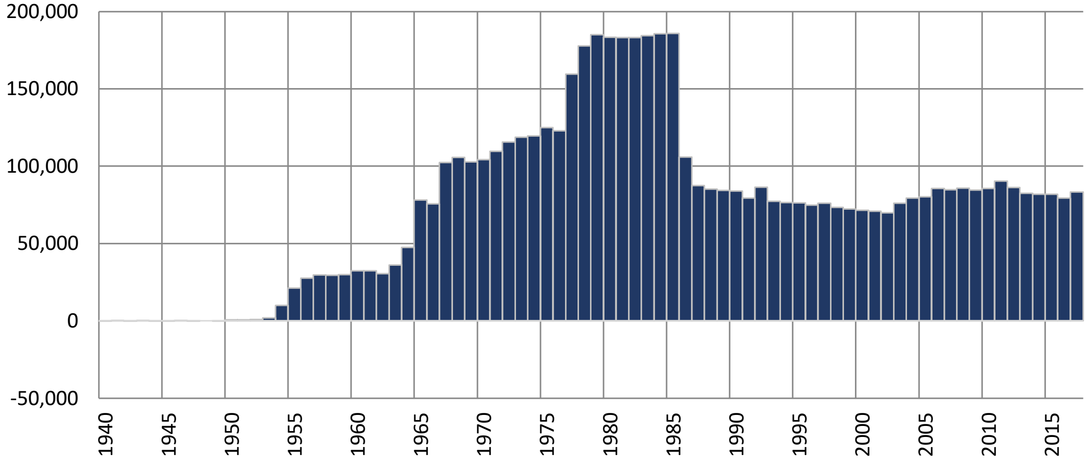
Cumulative Annual Rincon-Mesilla Groundwater Storage



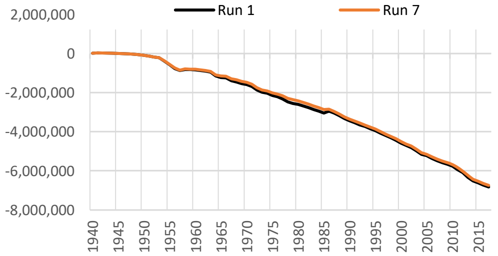
Period	Average Difference
1951-2017	3,285
1951-1978	4,085
1979-2005	-1,246
2006-2017	11,615
1985-2017	4,444
1985-2005	346



Cumulative Annual Hueco Groundwater Storage



Period	Average Difference
1951-2017	1,235
1951-1978	6,331
1979-2005	-3,619
2006-2017	262
1985-2017	-3,102
1985-2005	-5,025

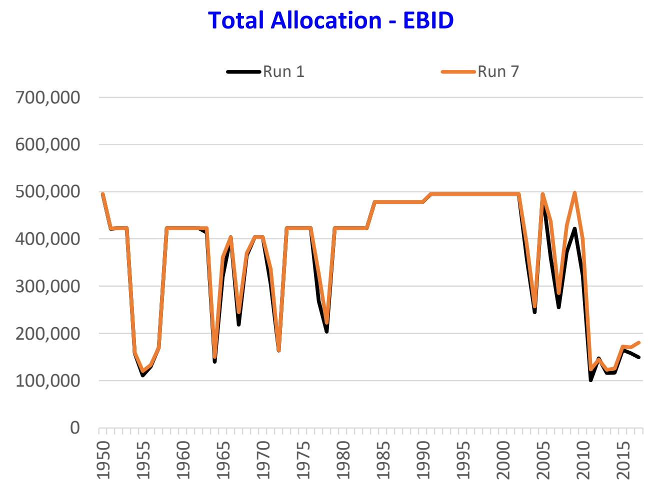


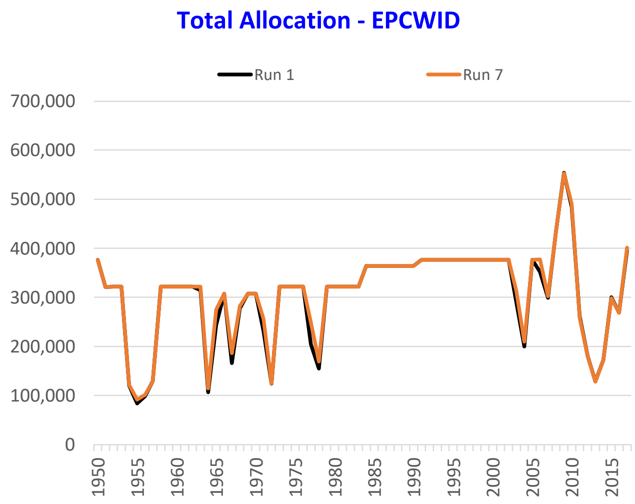
Notes:

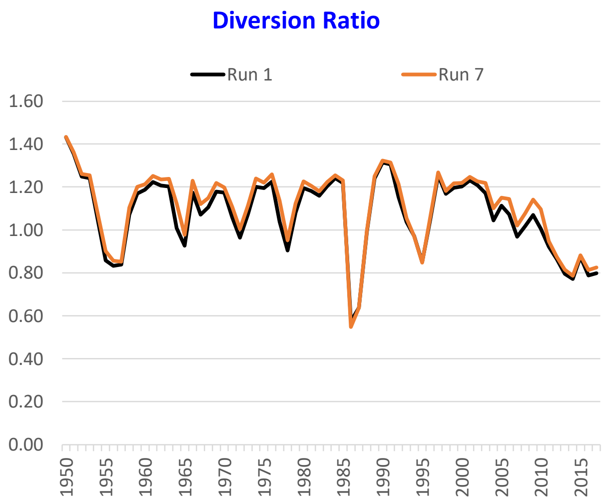
Cumulative storage change in alluvial and non-alluvial aquifers.

Average differences calculated as (Final Storage - Initial Storage)/(no. years).

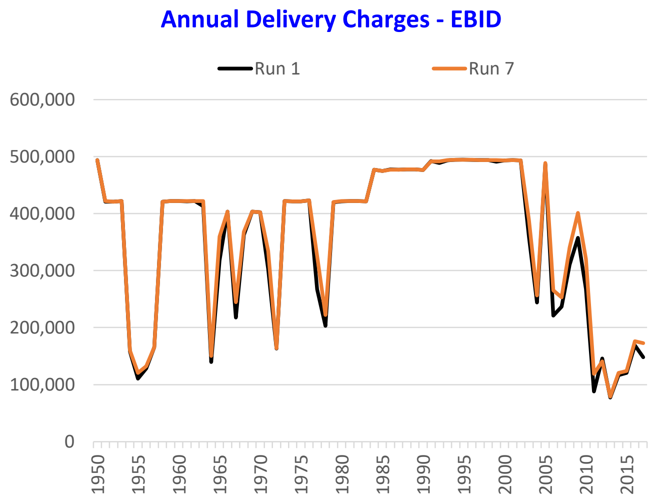
Run 7 - TX Mesilla Pumping Off
Annual Allocation and Charges
Run 7 v. Run 1
ILRG Model
1950 - 2017 (acre-feet)

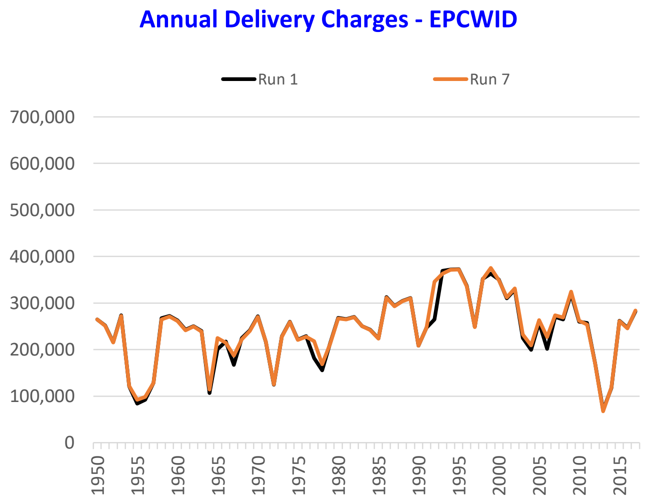

Total Allocation - EBID


Total Allocation - EPCWID


Diversion Ratio

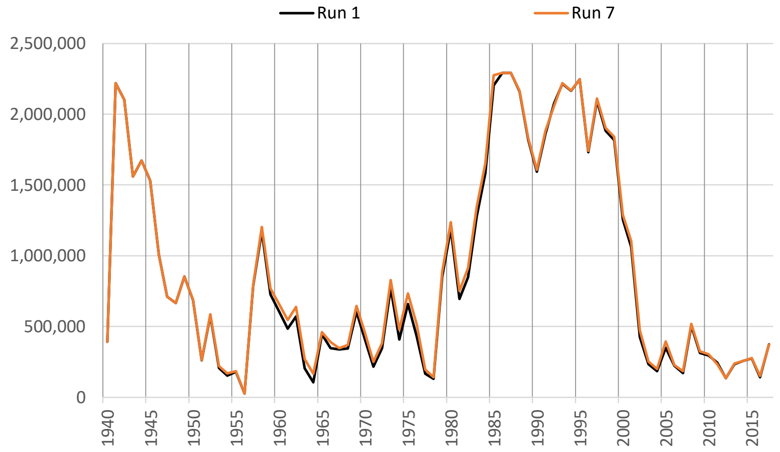
Note:
Computed as Total Charges/Caballo Release.


Annual Delivery Charges - EBID

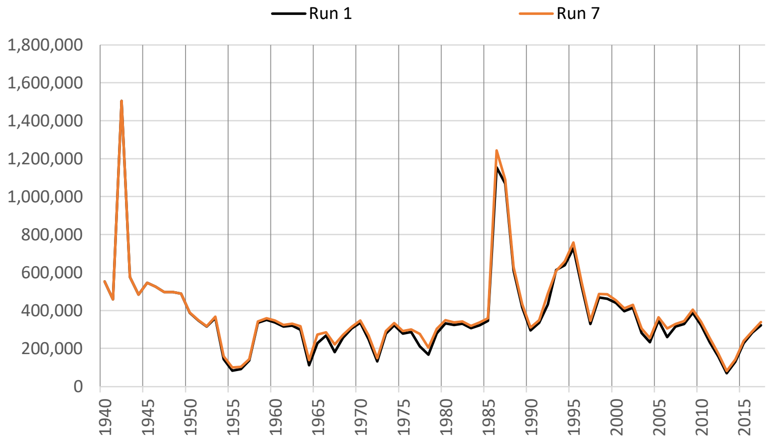

Annual Delivery Charges - EPCWID

Run 7 - TX Mesilla Pumping Off
Annual Summary of Project Storage and Rio Grande Flows
Run 7 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

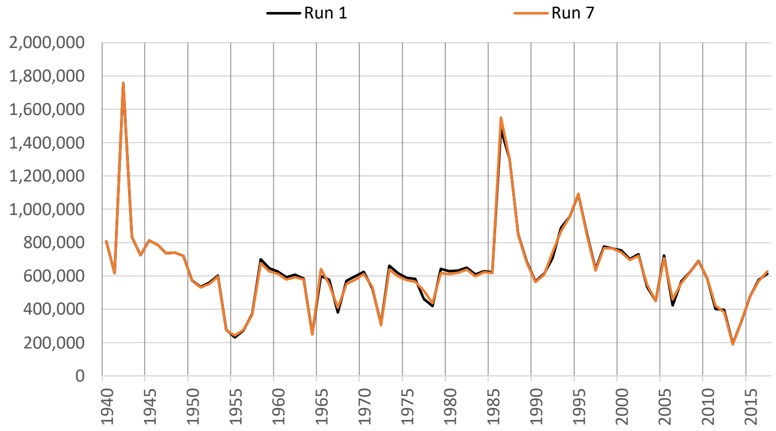
Total Year-End Project Reservoir Storage



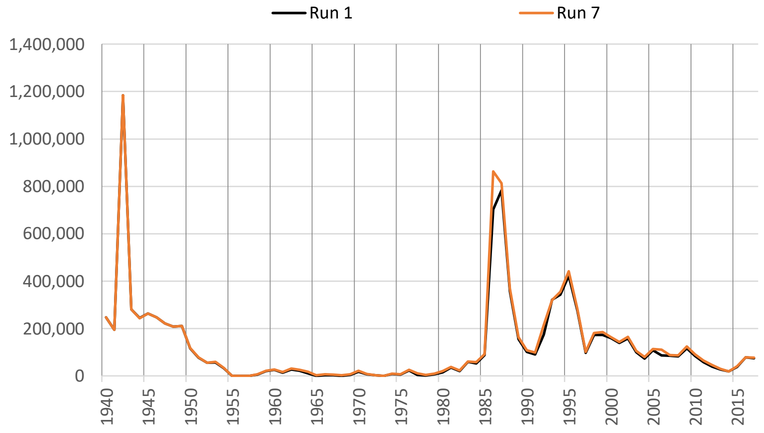
Rio Grande at El Paso



Rio Grande Below Caballo



Rio Grande at Fort Quitman

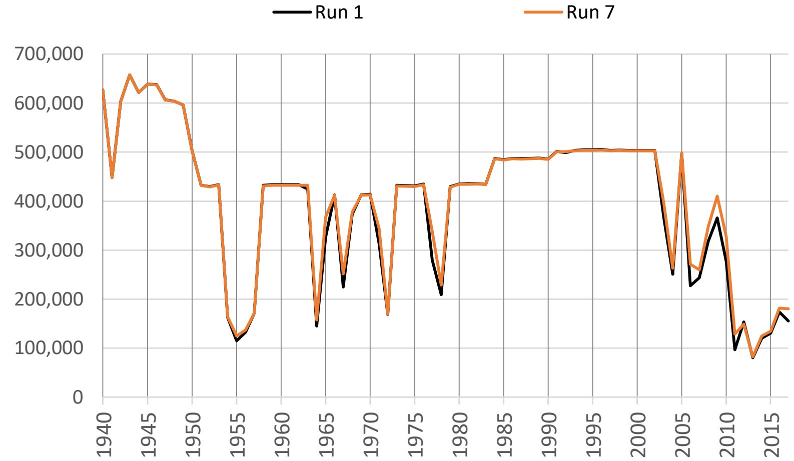


***Note different scales.**

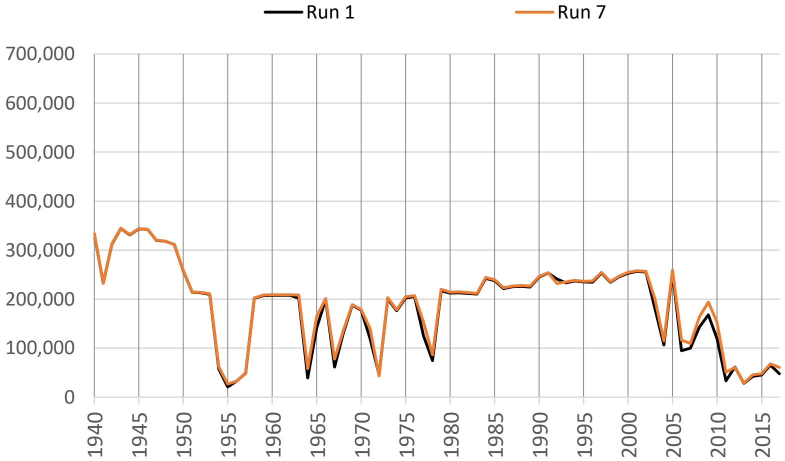
Run 7 - TX Mesilla Pumping Off
Irrigation Season Summary of Irrigation Operations
Run 7 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

EBID Total

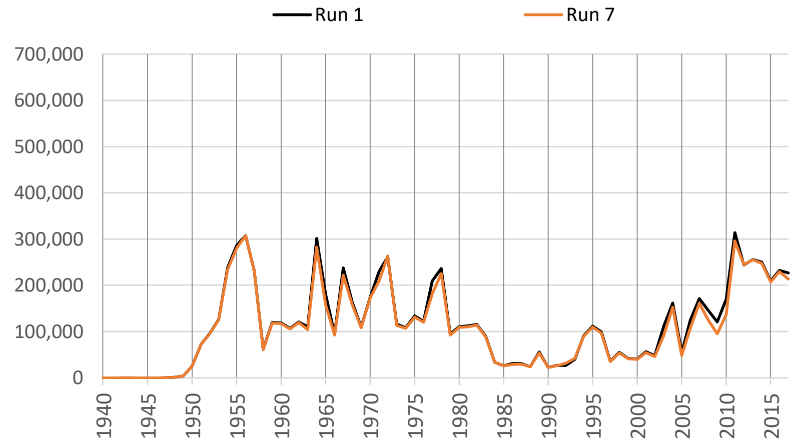
Net River Headgate Diversions



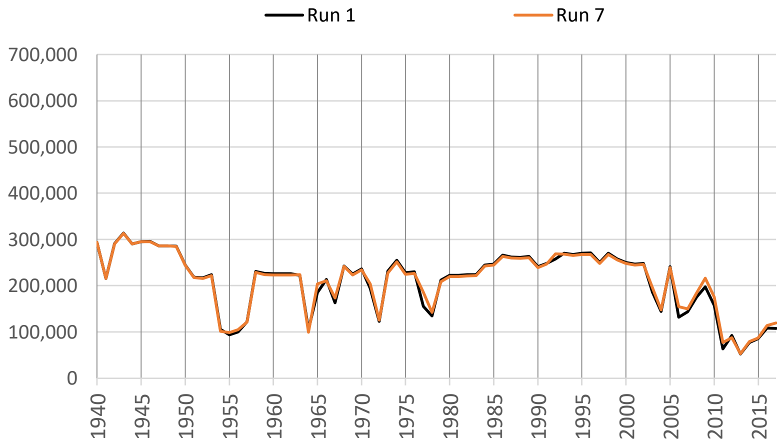
Farm Headgate Deliveries



Pumping



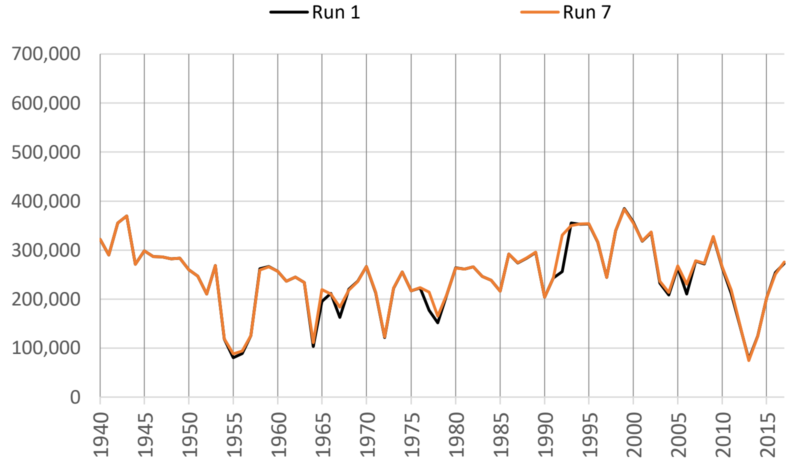
RHG Diversions - FHG Deliveries

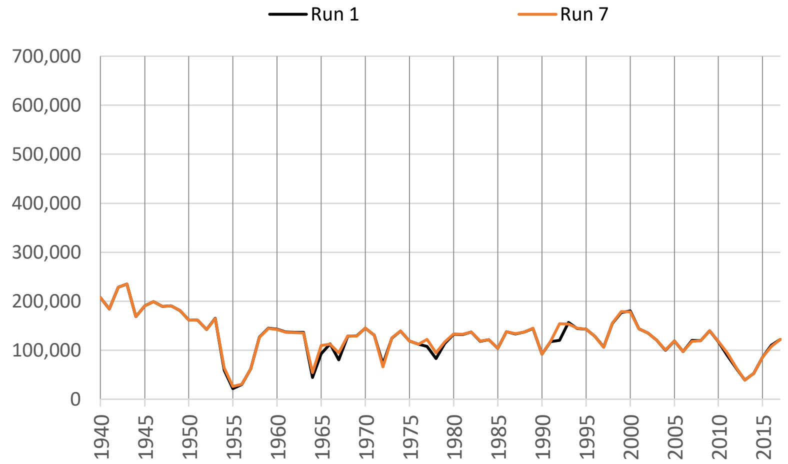


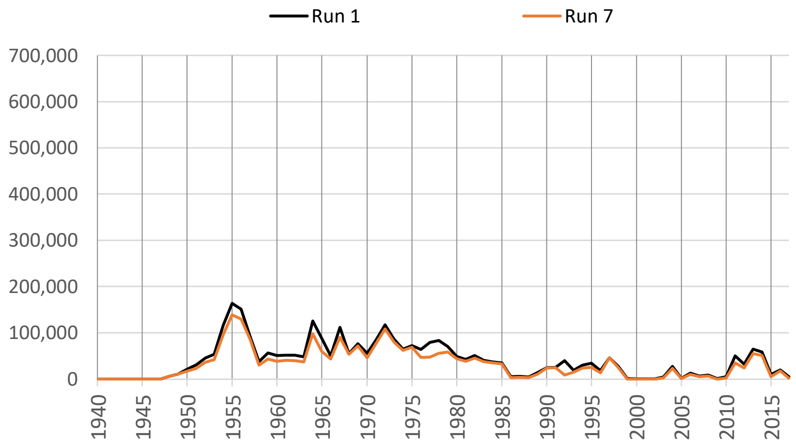
Notes: EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).
Pumping includes Supplemental and Primary groundwater pumping.

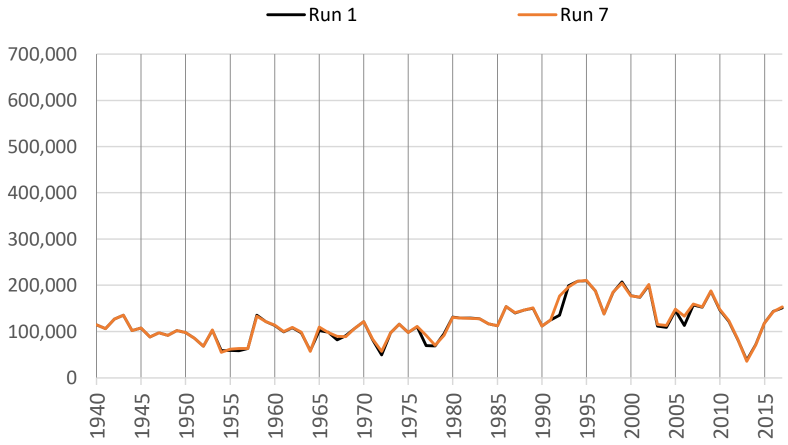
Run 7 - TX Mesilla Pumping Off
Irrigation Season Summary of Irrigation Operations
Run 7 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

EPCWID Total


Net River Headgate Diversions


Farm Headgate Deliveries


Pumping

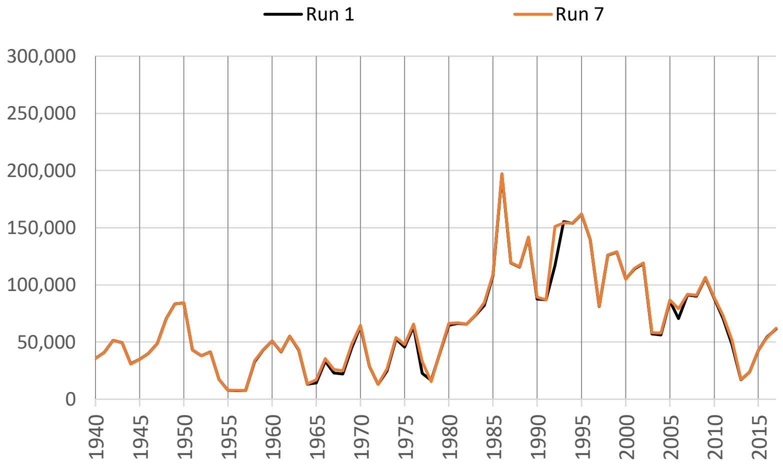

RHG Diversions - FHG Deliveries

Note: EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

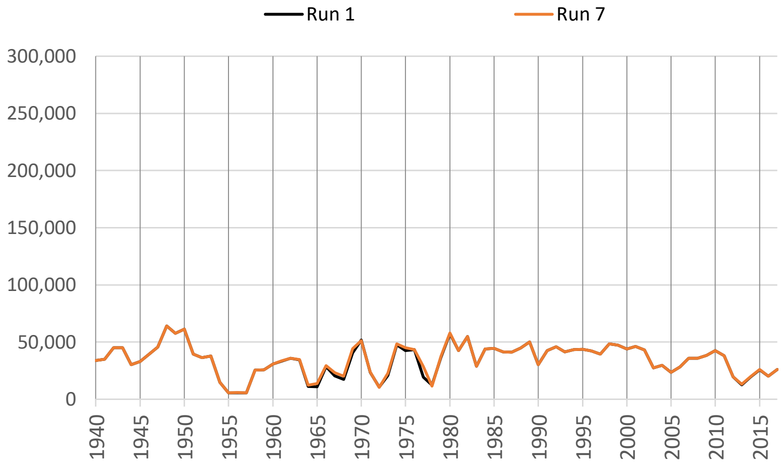
Run 7 - TX Mesilla Pumping Off
Irrigation Season Summary of Irrigation Operations
Run 7 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

HCCRD Total

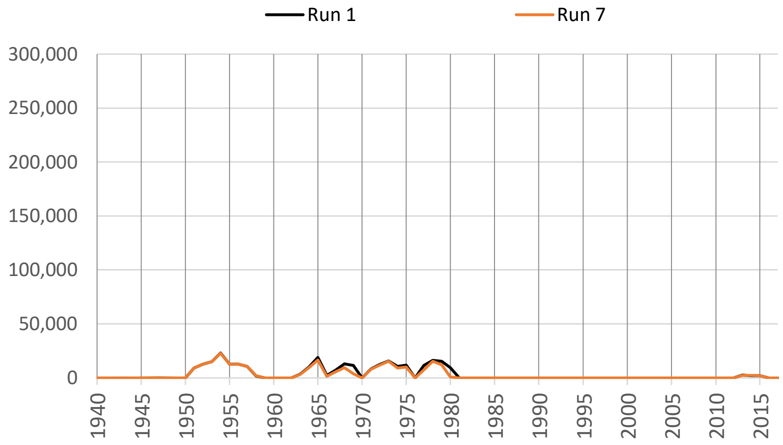
Net River Headgate Diversions



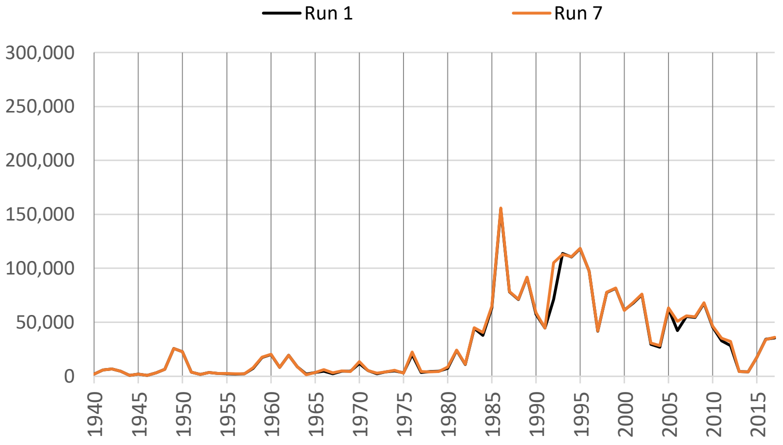
Farm Headgate Deliveries



Pumping

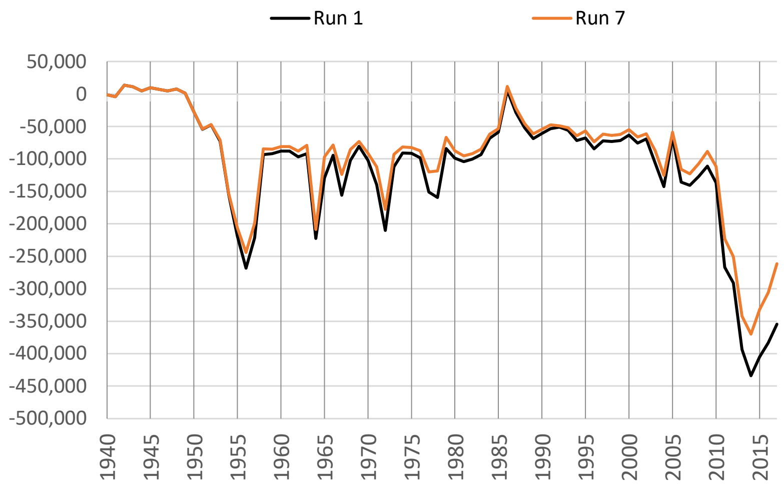


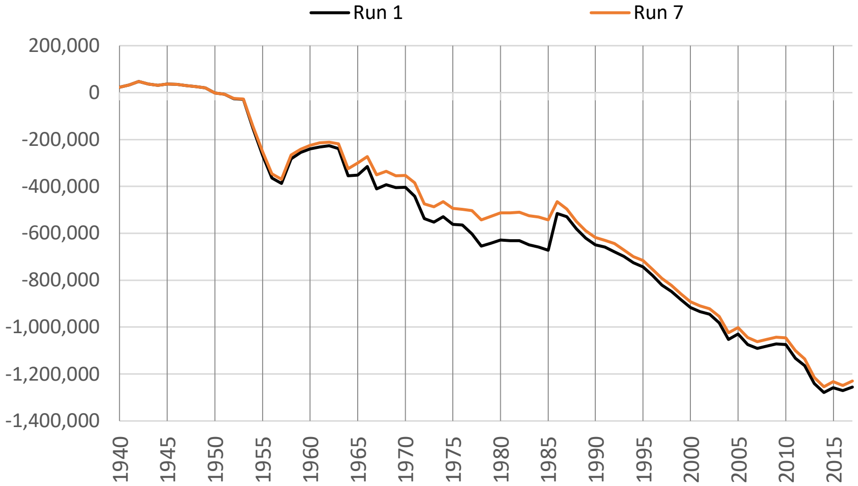
RHG Diversions - FHG Deliveries

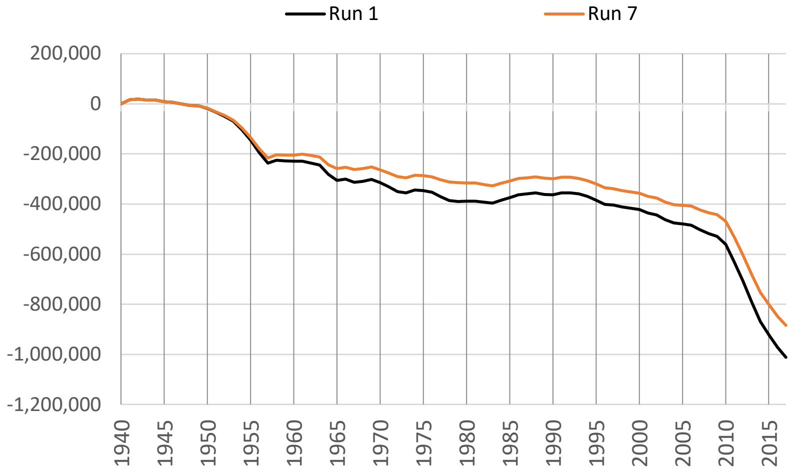


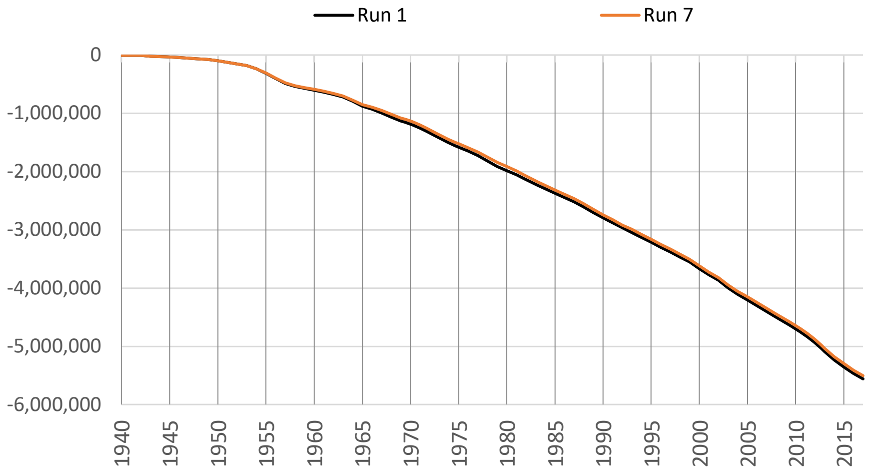
Note: HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

Run 7 - TX Mesilla Pumping Off
Cumulative Change in Ground Water Storage
Run 7 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)


Rincon-Mesilla Alluvial Aquifer

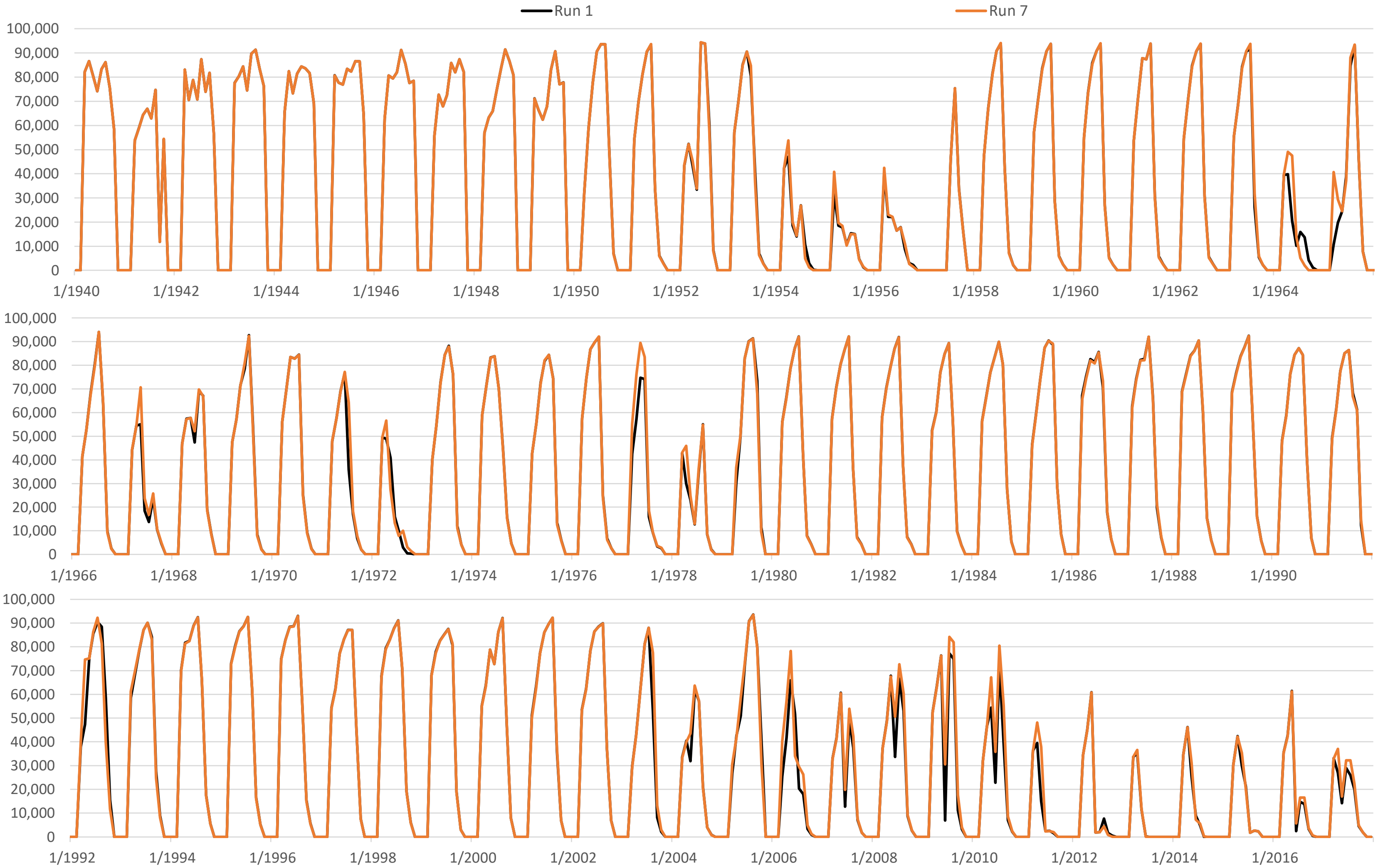

Hueco Alluvial Aquifer


Rincon-Mesilla Non-Alluvial Aquifer


Hueco Non-Alluvial Aquifer

***Note different scales.**

Run 7 - TX Mesilla Pumping Off
Monthly Net RHG Diversions
Run 7 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)
EBID Total



Note: EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).

Run 7 - TX Mesilla Pumping Off

Monthly Net RHG Diversions

Run 7 v. Run 1

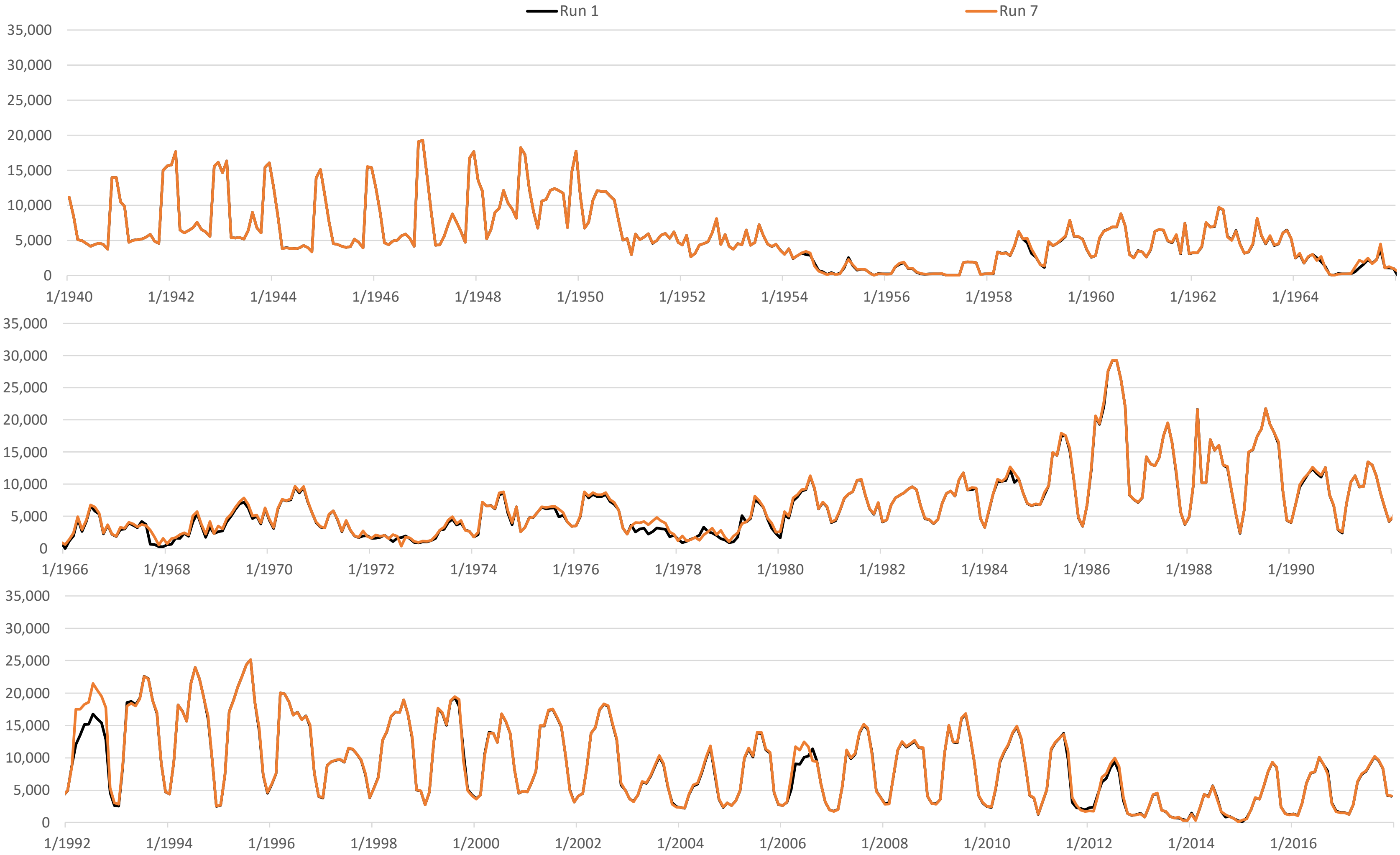
ILRG Model

1940 - 2017 (acre-feet)

EPCWID Total

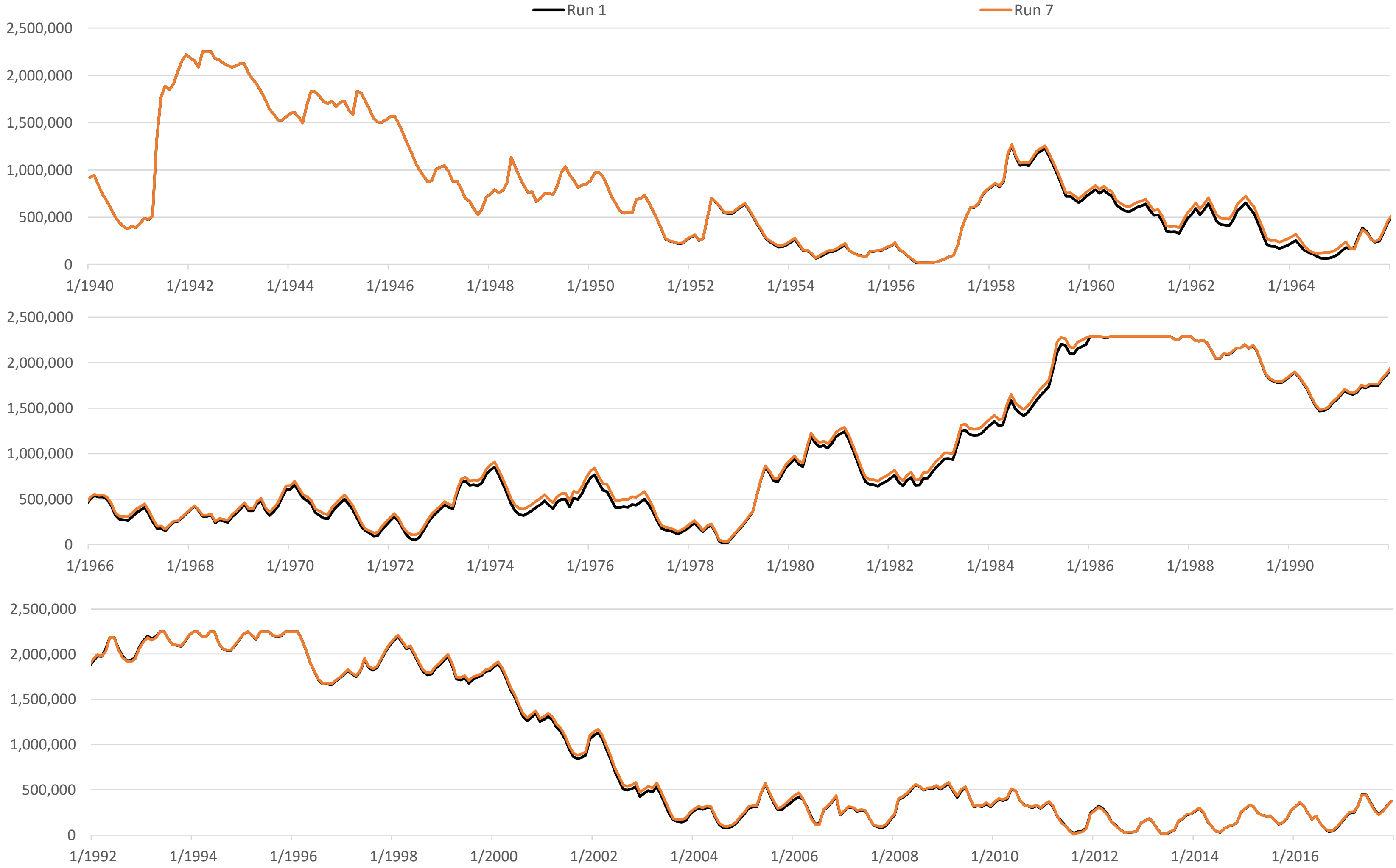
Note: EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

Run 7 - TX Mesilla Pumping Off
Monthly Net RHG Diversions
Run 7 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)
HCCRD Total

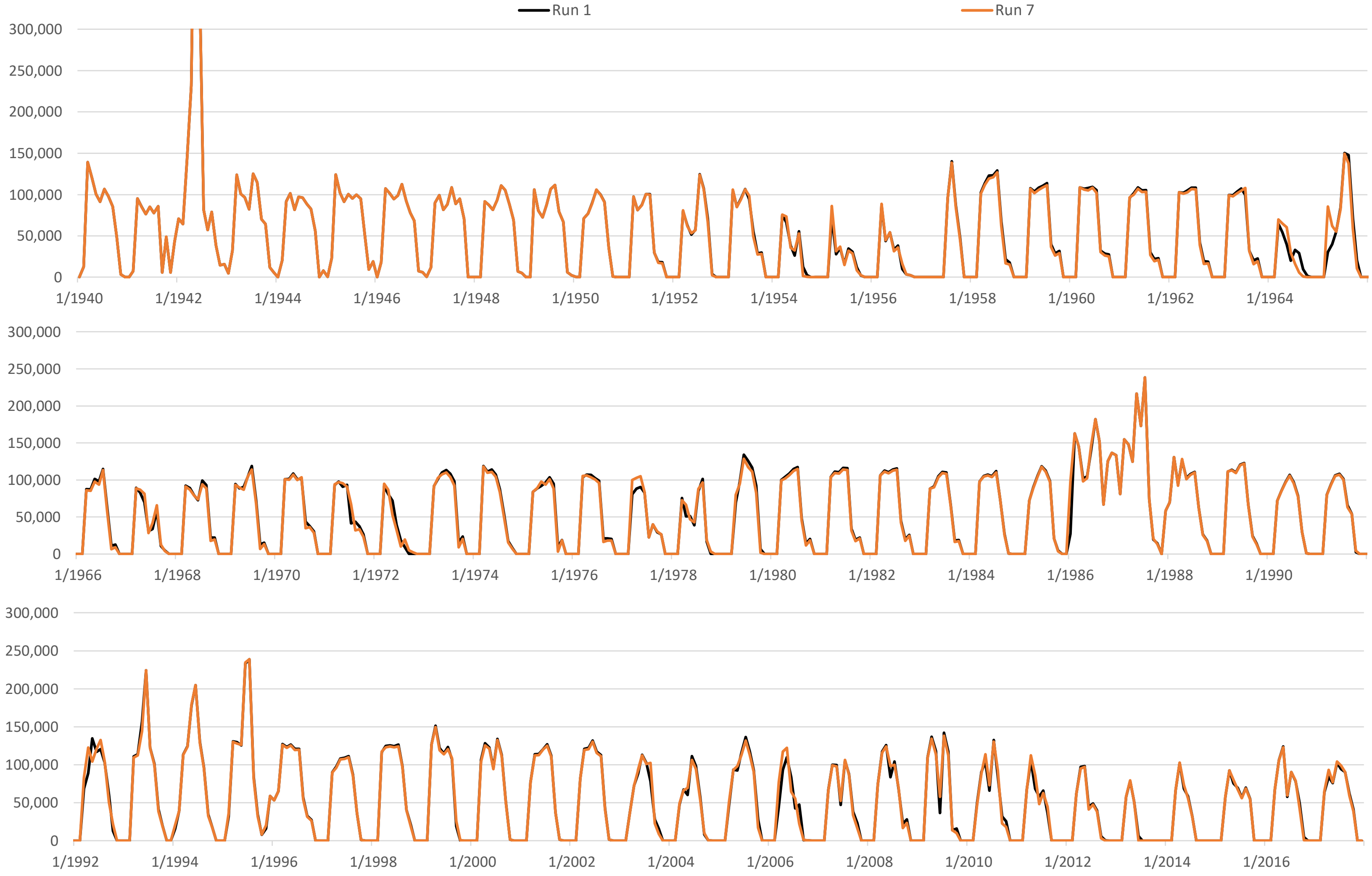


Note: HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

Run 7 - TX Mesilla Pumping Off
End of Month Reservoir Storage (Elephant Butte + Caballo)
Run 7 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

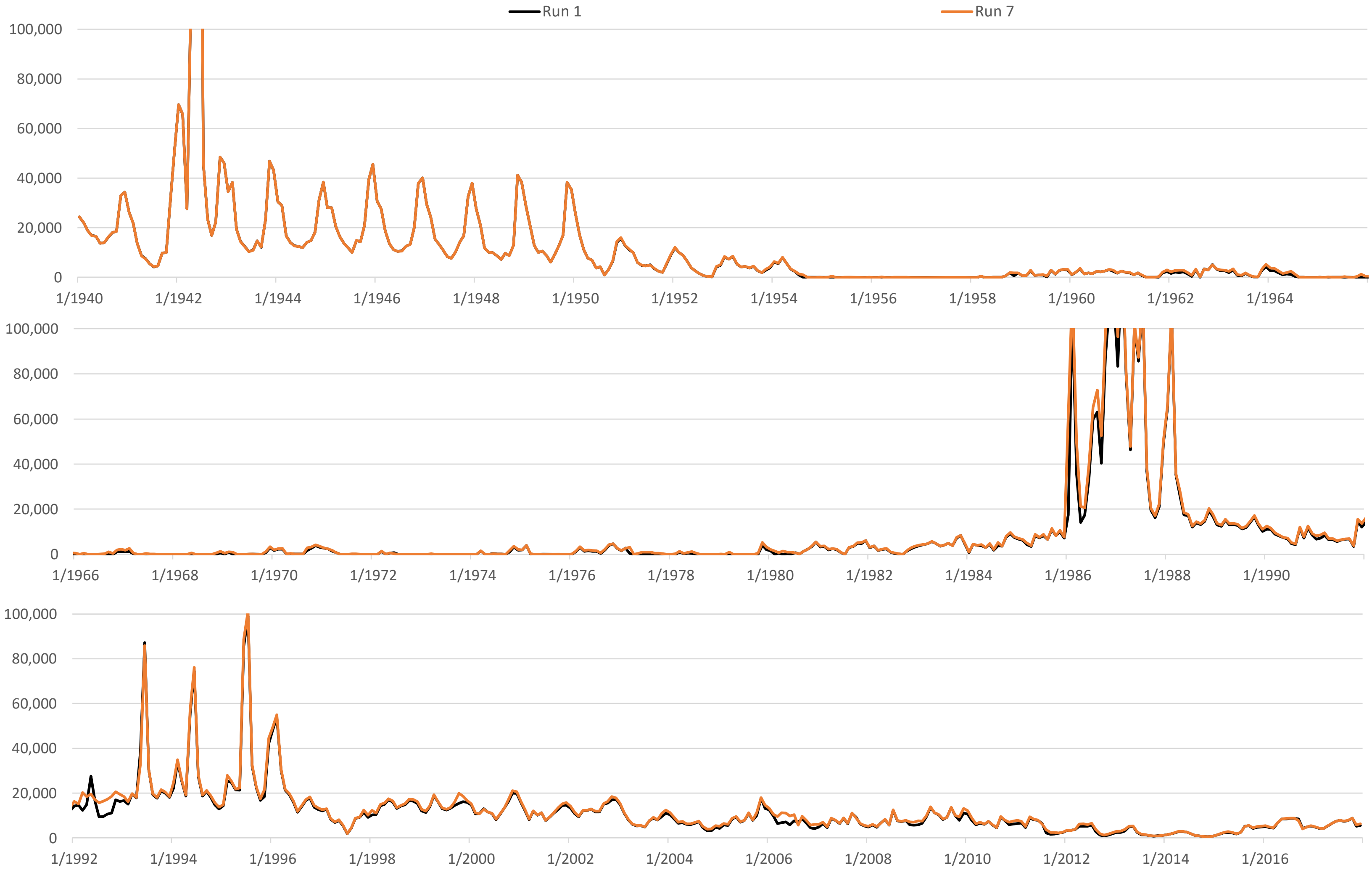


Run 7 - TX Mesilla Pumping Off
Monthly Caballo Releases
Run 7 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)



Run 7 - TX Mesilla Pumping Off
Monthly Rio Grande at El Paso Flow
Run 7 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

Run 7 - TX Mesilla Pumping Off
Monthly Rio Grande at Fort Quitman Flow
Run 7 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)



Appendix 30H

Comparison of ILRG Model Runs
Run 8 v. Run 1

Model Run Specifications

Model Version: LRG_v116

Name: **Run 8 - TX Non-Irrigation Pumping Off**

Run ID: LRG_v116_Operational_Run8
Date: 8/27/2020

Name: **Run 1 - Historical Base Run**

Run ID: LRG_v116_Operational_Run1
Date: 8/23/2020

Selected Model Inputs

Pumping and Returns	**Run 8**	**Run 1**
Irrigation Pumping	On	On
Irrigated Area	Hist	Hist
Non-Irrigation Pumping	TX Off	On
Non-Irrigation Pumping Returns	TX Off	On
Las Cruces Jornada Pumping Returns	On	On

Project Allocation Rules		
1950-2005	D1/D2	D1/D2
2006-2007	D3	D3
2008-2017	D3 + CO	D3 + CO

EPCWID Operations		
Charge EPCWID for Use of WWTP Returns	Off	Off
ACE and Haskell Credits for EPCWID	On	On
Increased EPCWID Use of Fabens Drain Flows	Off	Off
Charge EPCWID for Fabens Drain Flow Use	Off	Off

Run 8 - TX Non-Irrigation Pumping Off

Comparison of ILRG Model Runs

Run 8 v. Run 1

1951 - 2017 Annual Average

(1,000 acre-feet)

Run No.	1	8	8 - 1		
Simulated Input or Output	**Run 1**	**Run 8**	**Run 8 minus Run 1**		
Pumping Stress					
Non-Irrigation Pumping	181.0	96.9	-84.1		
WWTP Flows	58.0	40.6	-17.4		
Urban Deep Percolation	13.1	5.7	-7.3		
Total Stress	109.9	50.5	-59.3		
	Stress is Pumping minus WWTP and Urban Deep Perc				
Effects of Pumping Stress				***% Chg***	
FHG Deliveries (Mar - Oct)				***Stress***	***% Diff.***
EBID	167.6	169.1	1.5	*-3%*	*1%*
EPCWID (incl. EPW)	139.9	137.6	-2.2	*4%*	*-2%*
HCCRD	32.8	32.9	0.0	*0%*	*0%*
Total	340.3	339.6	-0.7	*1%*	*0%*
FHG Deliveries (Nov - Feb)					
EBID	0.0	0.0	0.0	*0%*	*2%*
EPCWID (incl. EPW)	0.2	0.1	-0.1	*0%*	*-49%*
HCCRD	2.4	2.1	-0.3	*1%*	*-14%*
Total	2.6	2.2	-0.4	*1%*	*-16%*
Irrigation Pumping					
EBID	140.4	139.0	-1.5	*3%*	*-1%*
EPCWID (Mesilla Valley)	7.4	7.3	0.0	*0%*	*0%*
EPCWID (El Paso Valley)	40.1	42.2	2.1	*-4%*	*5%*
HCCRD	4.2	4.2	0.0	*0%*	*0%*
	192.1	192.8	0.7	*-1%*	*0%*
	Pumping turned off.	*Other values are simulated responses and are totaled.*			
Other Inflows/Outflows					
Net Reservoir Evaporation	125.3	123.7	-1.6	*3%*	*-1%*
Riparian ET	70.9	71.4	0.5	*-1%*	*1%*
River Evaporation + Incidental Canal Loss	30.3	30.0	-0.3	*1%*	*-1%*
Total	226.6	225.2	-1.4	*2%*	*-1%*
Rio Grande at Fort Quitman					
Reservoir Spills	33.3	29.3	-4.0	*7%*	*-12%*
Nov-Feb Flows	21.4	19.0	-2.4	*4%*	*-11%*
Mar - Oct Flows	41.1	42.1	1.0	*-2%*	*3%*
Underflow (GW Model)	0.2	0.2	0.0	*0%*	*2%*
Total	96.0	90.6	-5.4	*9%*	*-6%*

Run 8 - TX Non-Irrigation Pumping Off

Comparison of ILRG Model Runs

Run 8 v. Run 1

1951 - 2017 Annual Average

(1,000 acre-feet)

Run No.	1	8	8 - 1		
Simulated Input or Output	**Run 1**	**Run 8**	**Run 8 minus Run 1**		
Effects of Pumping Stress (continued)				***% Chg***	
Change in Storage				***Stress***	***% Diff.***
Reservoir Storage	-4.7	-4.7	0.0	*0%*	*0%*
Alluvial GW Storage (RW Model)	-23.6	-16.3	7.3	*-12%*	*-31%*
Non-alluvial GW Storage (GW Models)	-96.4	-51.3	45.1	*-76%*	*-47%*
Soil Moisture Storage	0.6	0.6	0.0	*0%*	*-1%*
Total	-124.0	-71.6	52.4	*-88%*	*-42%*
Summary of Effects					
FHG Deliveries (Mar-Oct)	340.3	339.6	-0.7	*1%*	*0%*
FHG Deliveries (Nov-Feb)	2.6	2.2	-0.4	*1%*	*-16%*
Irrigation Pumping	192.1	192.8	0.7	*-1%*	*0%*
Riparian ET + Evaporation	226.6	225.2	-1.4	*2%*	*-1%*
Fort Quitman Flow	96.0	90.6	-5.4	*9%*	*-6%*
Change in Storage	-124.0	-71.6	52.4	*-88%*	*-42%*
Total	733.6	778.7	45.1	*-76%*	*6%*
Other Effects of Pumping Stress				***% Chg***	
Rio Grande at El Paso				***Stress***	***% Diff.***
Reservoir Spills	49.4	44.5	-4.9	*8%*	*-10%*
Nov-Feb Flows	22.8	26.9	4.1	*-7%*	*18%*
Mar - Oct Flows	263.8	282.7	18.9	*-32%*	*7%*
Total	336.0	354.1	18.2	*-31%*	*5%*
Rio Grande below Caballo					
Reservoir Spills	65.9	57.5	-8.4	*14%*	*-13%*
Nov-Feb Flows	0.5	0.4	0.0	*0%*	*-5%*
Mar - Oct Flows	541.3	551.2	9.9	*-17%*	*2%*
Total	607.6	609.1	1.5	*-3%*	*0%*
Surface Water Diversions (Mar - Oct)					
EBID	366.5	366.9	0.4	*-1%*	*0%*
EPCWID (incl. EPW)	236.8	243.9	7.1	*-12%*	*3%*
HCCRD	67.5	68.2	0.7	*-1%*	*1%*
Total	670.8	679.0	8.2	*-14%*	*1%*
Surface Water Diversions (Nov - Feb)					
EBID	0.0	0.0	0.0	*0%*	*0%*
EPCWID (incl. EPW)	14.3	12.3	-2.1	*4%*	*-15%*
HCCRD	14.2	12.6	-1.6	*3%*	*-11%*
Total	28.5	24.8	-3.7	*6%*	*-13%*

Run 8 - TX Non-Irrigation Pumping Off
Annual Differences in ILRG Model Outputs
Run 8 minus Run 1
1940 - 2017 (acre-feet)

	Net River Headgate Diversions						Farm Headgate Deliveries						Annual Flows		
	EBID		EPCWID (incl. EPW)		HCCRD		EBID		EPCWID (incl. EPW)		HCCRD				
Year	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Caballo Releases	Rio Grande at El Paso	Rio Grande at Fort Quitman
1940	5	5	-620	68	-150	554	-12	-12	377	377	-95	-95	-3,500	-3,375	6,842
1941	1	1	-112	-1,250	219	51	4	4	-2	-199	200	110	3,200	2,929	3,462
1942	-32	-32	-48	-2,055	-175	-176	10	11	464	-154	-197	-219	1,886	1,889	-255
1943	-38	-38	-160	-1,662	-157	-295	23	23	433	189	-100	-403	4,295	4,211	2,315
1944	-41	-41	-487	-1,868	129	-171	0	0	-234	-447	78	-155	1,809	1,798	2,068
1945	-47	-47	-258	-2,171	216	-415	12	12	-298	-698	191	215	2,970	2,926	2,496
1946	-24	-24	52	-2,521	319	-529	25	26	-48	-860	257	180	2,980	3,079	2,616
1947	-43	-43	471	-1,544	209	-441	9	9	643	57	155	186	1,913	2,067	2,790
1948	-35	-35	-98	-1,475	215	-288	-2	-1	352	45	168	-55	95	290	2,463
1949	-44	-44	-619	-2,368	146	-484	4	4	-269	-293	-13	-61	986	1,094	2,067
1950	0	0	-643	-1,519	541	144	4	4	-216	-216	-8	-13	946	1,056	828
1951	-6,969	-6,969	-787	-1,190	71	-16	-3,977	-3,978	-350	-351	31	-26	-768	2,229	1,912
1952	-174	-174	-891	-1,399	-82	-219	-90	-89	-484	-483	-85	-65	5,317	5,594	1,485
1953	-4,058	-4,058	-771	-1,112	187	97	-2,646	-2,646	-778	-774	148	154	-1,976	4,635	3,862
1954	-5,679	-5,679	-4,452	-6,553	-1,333	-1,670	-3,413	-3,413	-3,480	-3,475	-1,484	-1,663	-4,546	1,165	742
1955	-2,787	-2,787	-2,271	-5,623	573	228	-1,937	-1,937	-4,183	-4,404	-41	-203	4,458	2,935	1
1956	-4,961	-4,961	-7,896	-11,988	-272	-1,128	-2,927	-2,927	-4,961	-5,761	-372	-1,174	-8,011	-428	-80
1957	-104	-104	-926	-4,069	97	-421	13	13	-1,371	-1,806	146	-354	2,344	4,863	0
1958	-272	-272	3,820	2,799	1,003	1,035	488	488	621	534	-1,251	-1,734	42	15,216	2,965
1959	-257	-257	486	204	-1,023	-1,792	564	564	-649	-638	18	-79	-4,914	10,157	-1,860
1960	-281	-281	332	-476	79	-626	653	653	-1,210	-1,196	0	0	785	13,981	52
1961	-306	-306	-87	-912	843	437	740	740	-304	-289	809	-633	957	15,227	3,119
1962	-339	-339	-42	-973	278	-271	715	715	-1,261	-1,244	1	-338	1,362	16,011	1,074
1963	-615	-615	332	-424	549	68	736	736	-1,582	-1,562	363	369	1,577	19,191	2,595
1964	-1,152	-1,152	-1,395	-5,832	173	-750	-1,003	-1,003	-3,345	-3,700	-116	-184	6,502	12,503	3,077
1965	-5,562	-5,562	-4,433	-7,085	456	-176	-1,456	-1,456	-4,626	-5,043	648	268	-5,189	15,389	-25
1966	-522	-522	86	-229	-491	-1,098	919	919	-273	-248	-540	-752	-7,469	19,659	-121
1967	3,300	3,300	2,324	142	1,725	826	2,567	2,567	-1,922	-2,420	735	676	-2,093	14,587	309
1968	3,999	3,999	9,214	8,199	1,322	290	4,162	4,162	286	-98	1,213	836	6,632	27,132	5
1969	-432	-432	7,359	6,980	2,945	2,666	940	940	-46	-30	2,958	2,841	-110	22,491	88
1970	-397	-397	7,641	6,801	1,542	938	987	987	-208	-195	-769	-1,192	6,606	24,004	2,563
1971	-4,170	-4,170	9,045	6,562	1,566	336	-1,369	-1,369	-1,572	-1,556	1,376	675	8,145	27,265	440
1972	-7,459	-7,459	-4,947	-8,069	-2,253	-4,570	-4,493	-4,493	-10,843	-11,038	-2,814	-4,985	-15,767	6,516	-140
1973	-580	-580	17,223	14,850	1,270	-504	1,292	1,292	-688	-914	1,155	-391	13,783	33,731	185
1974	-570	-570	15,464	14,864	4,884	3,695	1,107	1,107	275	291	2,704	779	7,465	33,321	2,692
1975	-475	-475	15,129	13,954	4,504	3,342	826	826	178	193	4,419	4,320	11,426	30,786	-851
1976	-316	-316	17,447	16,267	6,548	4,362	1,030	1,030	-100	-91	-10	-33	16,240	33,893	4,746
1977	-25,769	-25,769	3,548	342	1,241	-759	-15,466	-15,466	-9,014	-9,003	1,201	364	-10,165	19,325	-740
1978	-15,073	-15,073	-11,237	-16,380	-2,913	-4,881	-6,248	-6,248	-18,733	-18,724	-2,706	-4,620	-16,297	4,151	-1,061

Run 8 - TX Non-Irrigation Pumping Off

Annual Differences in ILRG Model Outputs

Run 8 minus Run 1

1940 - 2017 (acre-feet)

	Net River Headgate Diversions						Farm Headgate Deliveries						Annual Flows		
	EBID		EPCWID (incl. EPW)		HCCRD		EBID		EPCWID (incl. EPW)		HCCRD				
Year	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Caballo Releases	Rio Grande at El Paso	Rio Grande at Fort Quitman
1979	-491	-491	14,336	11,557	121	-1,570	888	887	-4,665	-4,645	227	-1,549	17,897	37,958	527
1980	-605	-605	21,066	20,491	1,216	-2,015	1,142	1,143	216	234	1,408	-343	17,020	42,853	-142
1981	-499	-499	22,178	21,171	1,834	-1,343	991	991	143	157	0	0	20,749	40,627	-332
1982	-501	-501	22,122	20,720	2,553	395	1,181	1,181	161	174	-738	-1,883	24,018	42,708	4,168
1983	-457	-457	22,274	20,751	4,257	2,130	1,197	1,197	157	169	0	0	23,014	41,113	1,715
1984	-452	-452	23,845	22,626	6,208	3,659	1,095	1,096	155	169	0	0	20,372	39,947	2,566
1985	1,113	1,113	30,945	30,494	-14,186	-16,828	9,303	9,303	4,902	4,827	0	0	-9,379	6,576	-18,878
1986	-850	-850	24,916	24,802	6,552	3,425	571	565	-361	-359	0	0	-80,808	-60,027	-78,124
1987	-792	-792	27,392	27,278	7,273	4,219	728	728	151	161	0	0	166	18,148	-29,195
1988	-552	-552	28,464	28,342	7,822	4,498	1,558	1,558	77	87	0	0	21,172	36,465	2,204
1989	-530	-530	31,737	31,324	8,858	5,802	1,573	1,574	501	130	0	0	40,111	56,143	13,902
1990	-397	-397	30,059	29,250	7,680	4,566	1,432	1,433	346	-157	0	0	20,681	39,372	1,277
1991	-889	-889	18,017	17,393	2,610	152	-224	-223	13	-763	0	0	18,050	33,669	-3,141
1992	-621	-621	16,284	15,902	847	-1,144	2,721	2,724	-148	-478	0	0	-10,042	4,467	-24,476
1993	-703	-703	714	566	-194	-2,703	814	815	-3,097	-3,096	0	0	-59,280	-41,355	-62,452
1994	-707	-707	1,688	1,545	316	-2,264	1,205	1,204	-968	-968	0	0	-13,467	5,885	-18,259
1995	-562	-562	862	681	-323	-3,670	1,285	1,286	-780	-833	0	0	7,978	26,310	-7,392
1996	-495	-495	5,504	5,379	1,045	-1,354	1,267	1,267	199	209	0	0	6,887	28,980	-6,945
1997	-331	-331	4,549	1,934	493	-2,871	1,201	1,201	-1,295	-2,305	0	0	8,350	30,230	-5,525
1998	-576	-576	9,727	9,371	2,019	-879	1,515	1,515	678	685	0	0	12,259	35,890	4,491
1999	-1,923	-1,923	-4,781	-7,808	1,300	800	9,827	9,832	4,315	4,332	0	0	0	14,462	-13,665
2000	-690	-690	7,157	3,488	1,708	1,543	2,068	2,069	-3,522	-3,507	0	0	-2,004	27,367	-791
2001	-601	-601	9,494	4,927	1,881	1,443	1,416	1,416	-195	-187	0	0	1,558	24,755	-4,359
2002	-471	-471	3,891	794	-201	-695	1,660	1,660	266	273	0	0	-7,289	17,161	-8,292
2003	-8,042	-8,042	19,922	16,491	3,168	2,024	-3,539	-3,539	-839	-834	0	0	16,125	37,345	1,458
2004	-13,719	-13,719	-16,802	-21,110	-3,629	-5,751	-6,560	-6,560	-16,199	-16,194	0	0	-23,843	3,934	-8,780
2005	-127	-127	9,690	5,190	-1,313	-2,842	1,206	1,206	-39	-24	0	0	2,089	21,439	-13,605
2006	4,846	4,846	-5,284	-9,699	-2,018	-3,190	3,337	3,337	-8,839	-8,830	0	0	-10,278	7,688	-9,097
2007	11,344	11,344	4,456	52	-1,656	-2,985	6,662	6,662	-316	-302	0	0	-3,741	12,853	-10,328
2008	24,083	24,083	5,269	1,141	-895	-2,006	16,240	16,240	41	56	0	0	1,809	17,499	-7,341
2009	38,135	38,135	6,178	1,614	235	-649	21,553	21,553	-361	-342	0	0	4,499	20,560	423
2010	40,191	40,191	6,810	2,450	1,235	1,013	25,647	25,647	663	680	0	0	6,745	21,695	2,658
2011	18,671	18,671	2,647	-1,319	-98	-3,321	10,183	10,183	237	247	0	0	7,972	14,598	-2,491
2012	-8,195	-8,195	951	-3,361	-3,713	-7,687	-1,334	-1,334	-9,013	-9,010	0	0	-11,425	15,009	-8,679
2013	3,938	3,938	-7,958	-11,357	-3,904	-6,044	2,238	2,238	-14,131	-14,131	-1,902	-2,184	1,973	9,368	-11,789
2014	3,541	3,541	-3,804	-7,939	-5,744	-8,454	2,173	2,173	-10,212	-10,212	-4,716	-6,311	2,158	6,853	-7,595
2015	259	259	1,650	-2,055	-4,756	-7,247	595	595	-11,430	-11,429	1,280	961	4,289	13,450	-22,469
2016	-4,165	-4,165	-612	-4,627	-4,384	-7,202	-2,941	-2,941	-6,926	-6,923	0	0	-7,101	10,267	-29,243
2017	12,328	12,328	8,356	4,960	-282	-1,438	6,302	6,302	368	373	0	0	16,511	19,818	-11,927
Averages															
1951-2017	411	411	7,063	4,971	708	-911	1,506	1,506	-2,244	-2,337	49	-275	1,524	18,173	-5,416
1951-1978	-2,928	-2,928	2,475	702	839	-20	-974	-974	-2,522	-2,644	276	-255	583	15,555	965
1979-2005	-1,314	-1,314	14,269	12,724	1,849	-418	1,390	1,390	-734	-842	33	-140	2,681	22,682	-10,076
2006-2017	12,081	12,081	1,555	-2,512	-2,165	-4,101	7,555	7,555	-4,993	-4,985	-445	-628	1,117	14,138	-9,823
1985-2017	3,409	3,409	8,427	5,942	235	-1,871	3,687	3,688	-2,300	-2,389	-162	-228	-1,130	16,269	-12,073
1985-2005	-1,546	-1,546	12,354	10,773	1,606	-597	1,477	1,478	-762	-905	0	0	-2,414	17,486	-13,359

Notes:

EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).

EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

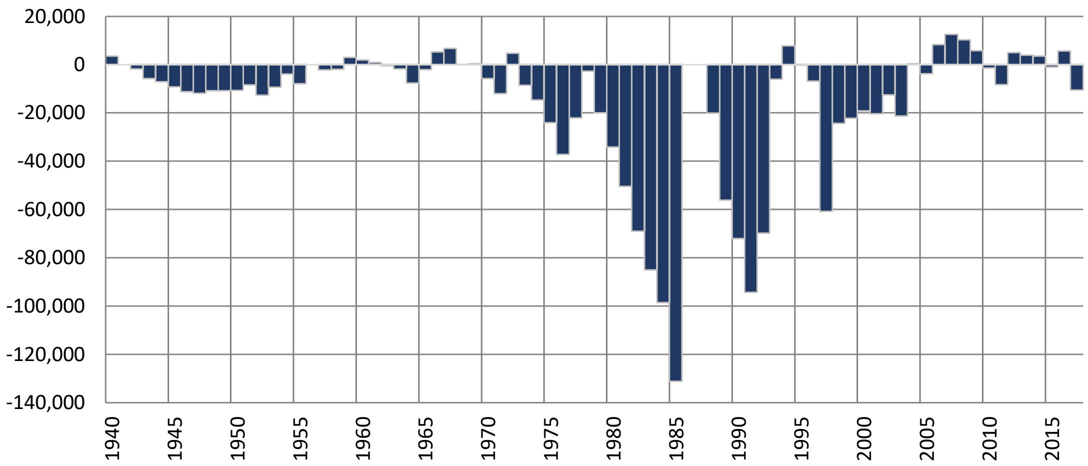
Run 8 - TX Non-Irrigation Pumping Off

Simulated Differences in ILRG Model Outputs

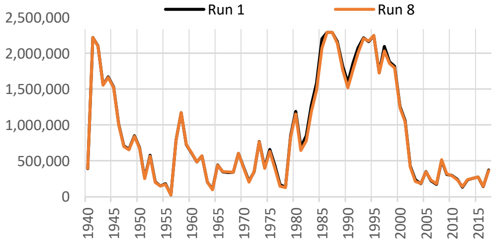
Run 8 minus Run 1

1940 - 2017 (acre-feet)

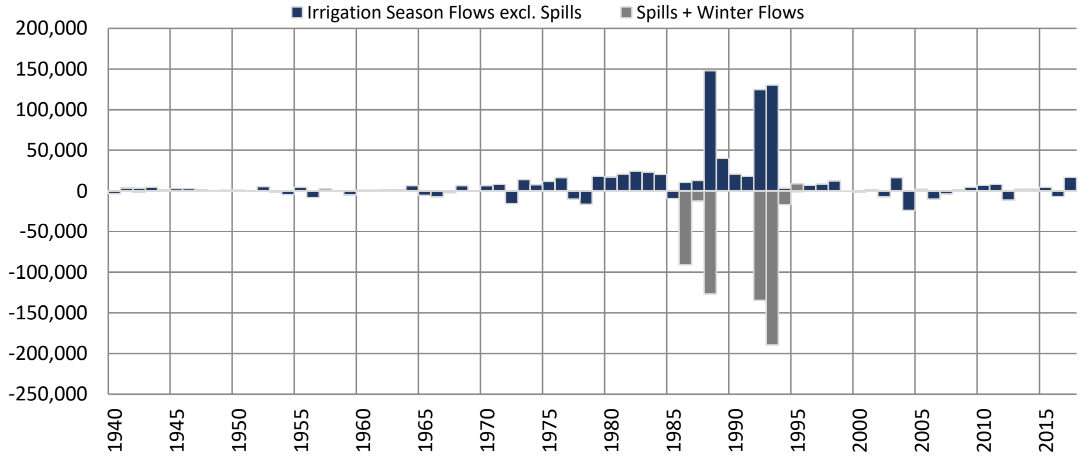
Total Project Storage (Year End)



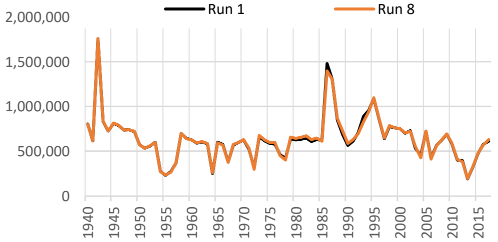
Period	Average Difference
1951-2017	1
1951-1978	284
1979-2005	-44
2006-2017	-558
1985-2017	2,669
1985-2005	4,514



Caballo Reservoir Outflows (Annual)



	Average Difference		
Period	Irr Season (excl. Spills)	Nov-Feb and Spills	Annual
1951-2017	9,918	-8,394	1,524
1951-1978	583	0	583
1979-2005	23,510	-20,829	2,681
2006-2017	1,117	0	1,117
1985-2017	15,912	-17,042	-1,130
1985-2005	24,366	-26,780	-2,414



Notes:

Reservoir storage does not include storage attributed to SJC, CO, or NM credit waters.

Average differences calculated as (Final Storage - Initial Storage)/(no. years).

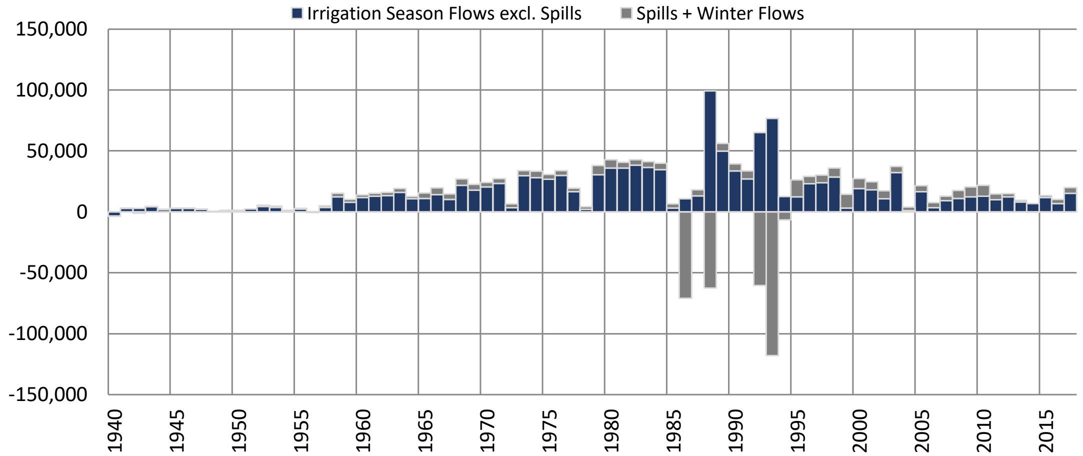
Run 8 - TX Non-Irrigation Pumping Off

Simulated Differences in ILRG Model Outputs

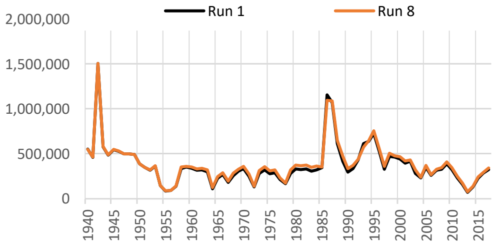
Run 8 minus Run 1

1940 - 2017 (acre-feet)

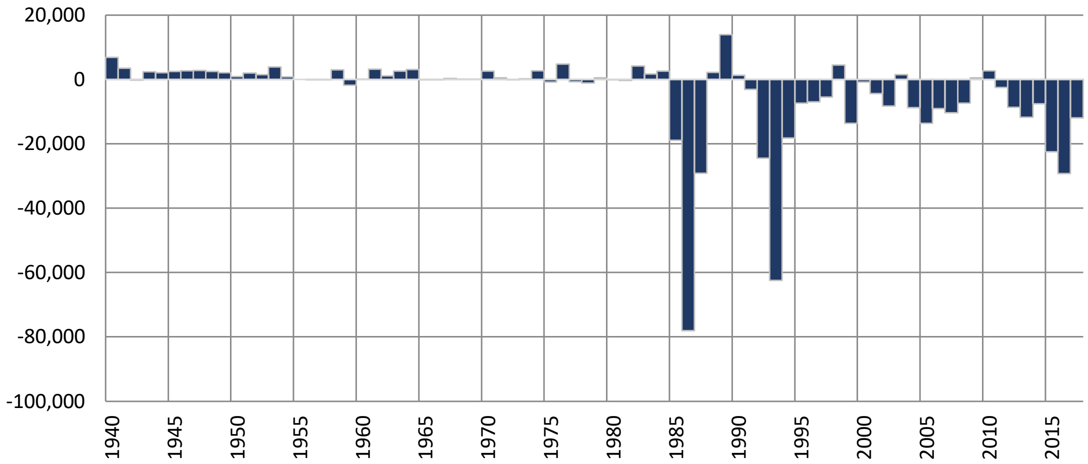
Rio Grande at El Paso (Annual)



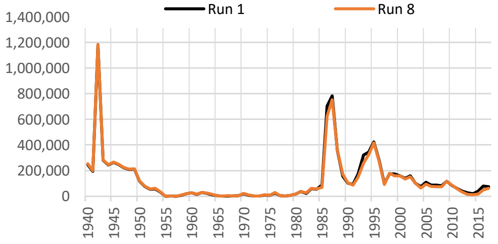
	Average Difference		
Period	Irr Season (excl. Spills)	Nov-Feb and Spills	Annual
1951-2017	18,903	-729	18,173
1951-1978	12,709	2,845	15,555
1979-2005	29,303	-6,621	22,682
2006-2017	9,951	4,187	14,138
1985-2017	21,190	-4,921	16,269
1985-2005	27,612	-10,125	17,486



Rio Grande at Fort Quitman (Annual)



Period	Average Difference
1951-2017	-5,420
1951-1978	960
1979-2005	-10,081
2006-2017	-9,820
1985-2017	-12,075
1985-2005	-13,363



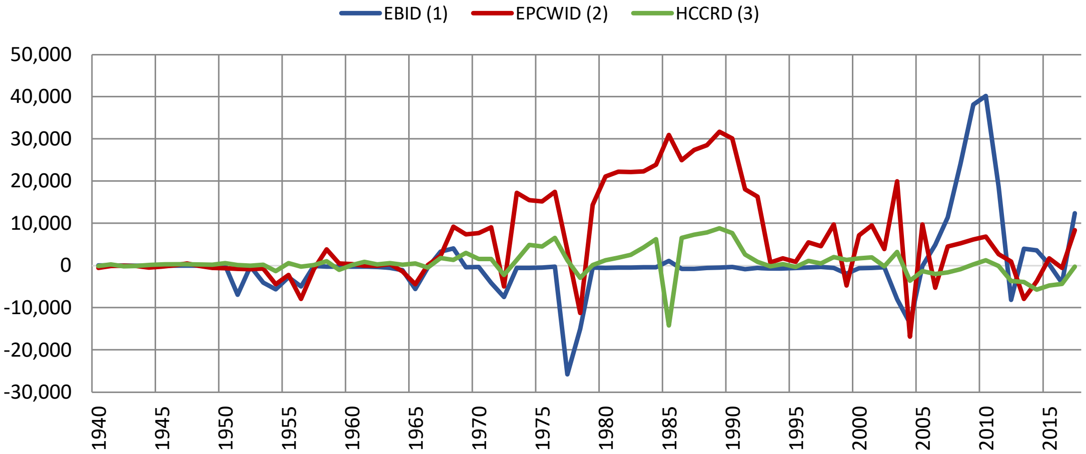
Run 8 - TX Non-Irrigation Pumping Off

Simulated Differences in ILRG Model Outputs

Run 8 minus Run 1

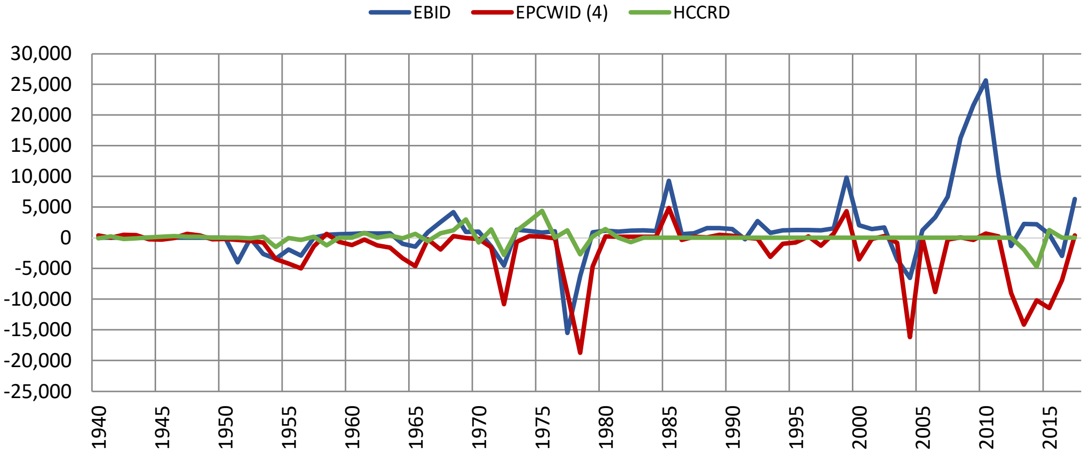
1940 - 2017 (acre-feet)

River Headgate (RHG) Diversions (Irrigation Season)



	Average Difference		
Period	EBID	EPCWID	HCCRD
1951-2017	411	7,063	708
1951-1978	-2,928	2,475	839
1979-2005	-1,314	14,269	1,849
2006-2017	12,081	1,555	-2,165
1985-2017	3,409	8,427	235
1985-2005	-1,546	12,354	1,606

Farm Headgate (FHG) Deliveries (Irrigation Season)



	Average Difference		
Period	EBID	EPCWID	HCCRD
1951-2017	1,506	-2,244	49
1951-1978	-974	-2,522	276
1979-2005	1,390	-734	33
2006-2017	7,555	-4,993	-445
1985-2017	3,687	-2,300	-162
1985-2005	1,477	-762	0

Notes:

(1) EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).

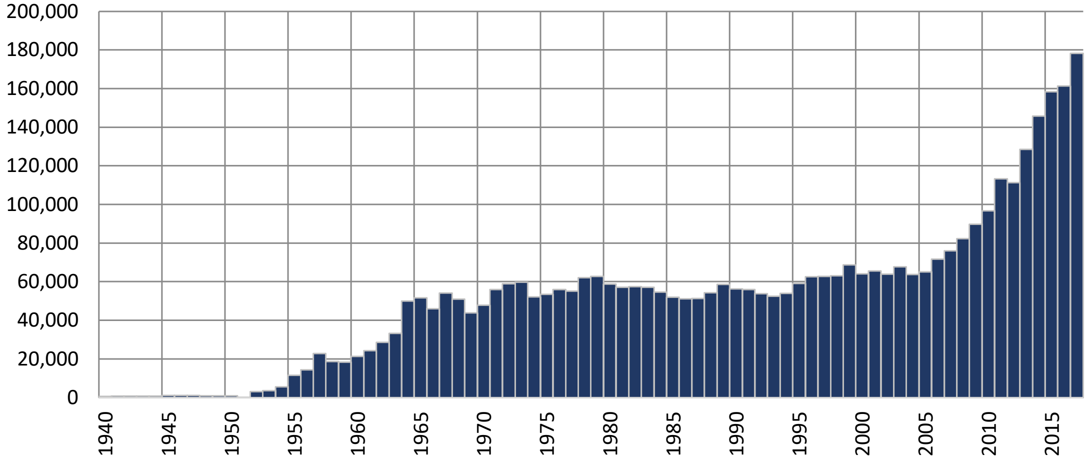
(2) EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

(3) HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

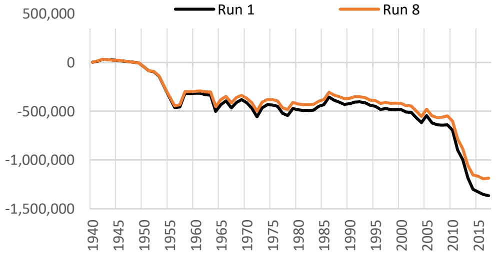
(4) EPCWID FHG values include deliveries to Rogers WTP and R/U WTP.

Run 8 - TX Non-Irrigation Pumping Off
Simulated Differences in ILRG Model Outputs
Run 8 minus Run 1
1940 - 2017 (acre-feet)

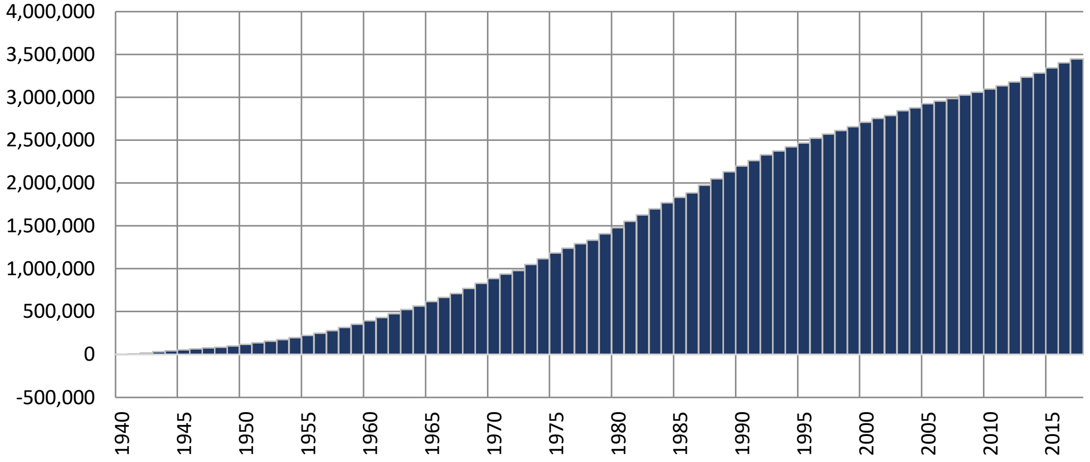
Cumulative Annual Rincon-Mesilla Groundwater Storage



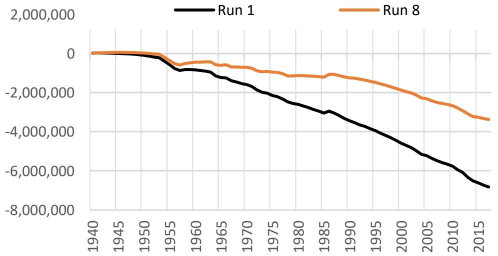
Period	Average Difference
1951-2017	2,646
1951-1978	2,181
1979-2005	109
2006-2017	9,437
1985-2017	3,746
1985-2005	494



Cumulative Annual Hueco Groundwater Storage



Period	Average Difference
1951-2017	49,740
1951-1978	43,453
1979-2005	58,901
2006-2017	43,793
1985-2017	50,923
1985-2005	54,998



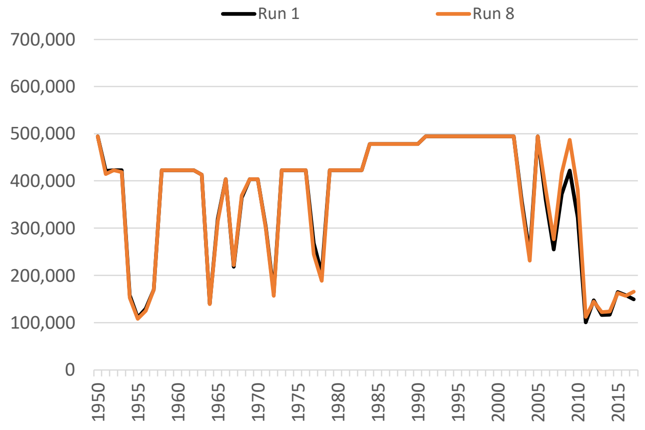
Notes:

Cumulative storage change in alluvial and non-alluvial aquifers.

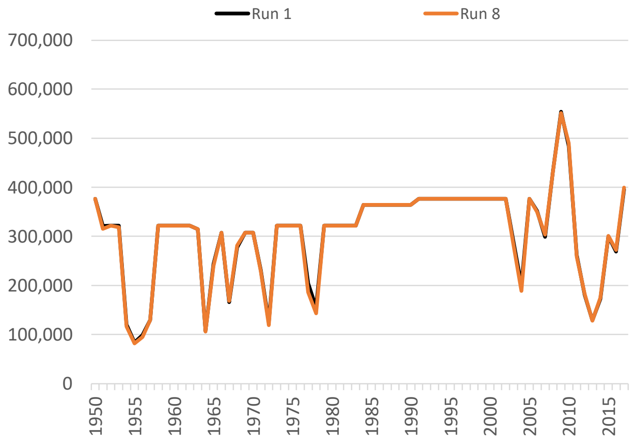
Average differences calculated as (Final Storage - Initial Storage)/(no. years).

Run 8 - TX Non-Irrigation Pumping Off
Annual Allocation and Charges
Run 8 v. Run 1
ILRG Model
1950 - 2017 (acre-feet)

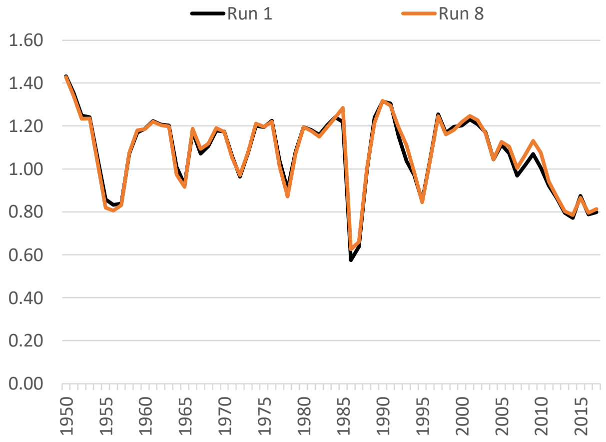
Total Allocation - EBID



Total Allocation - EPCWID



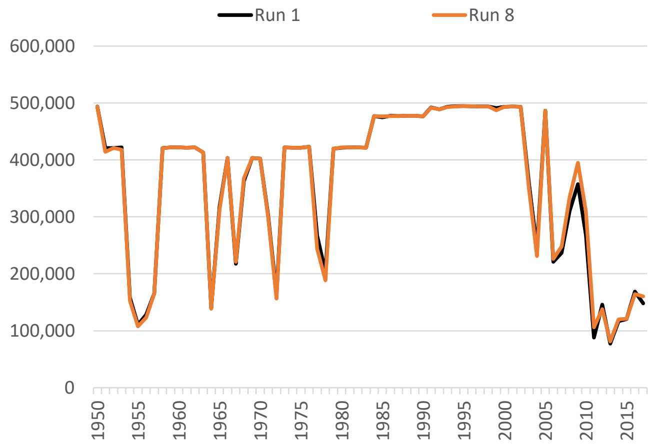
Diversion Ratio



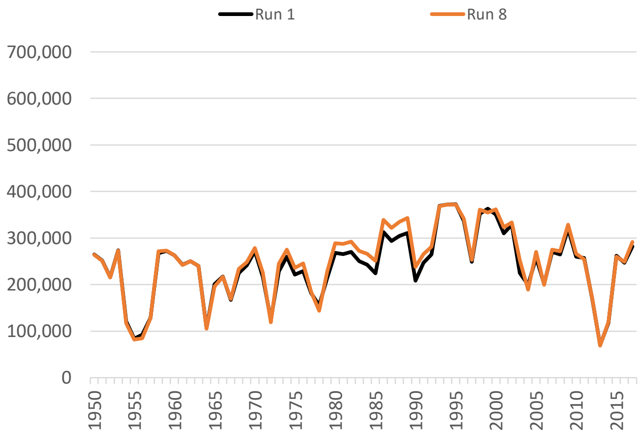
Note:

Computed as Total Charges/Caballo Release.

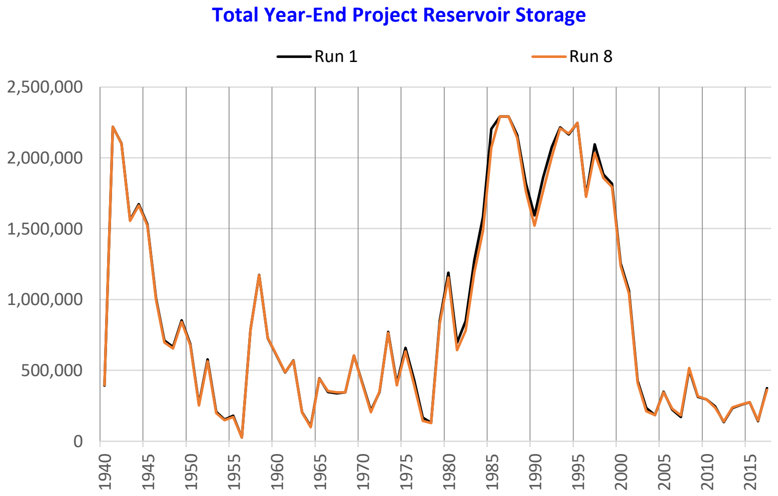
Annual Delivery Charges - EBID

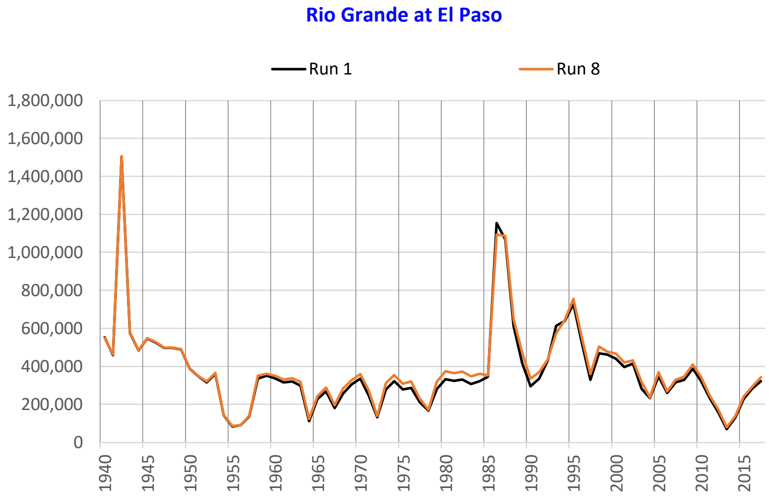


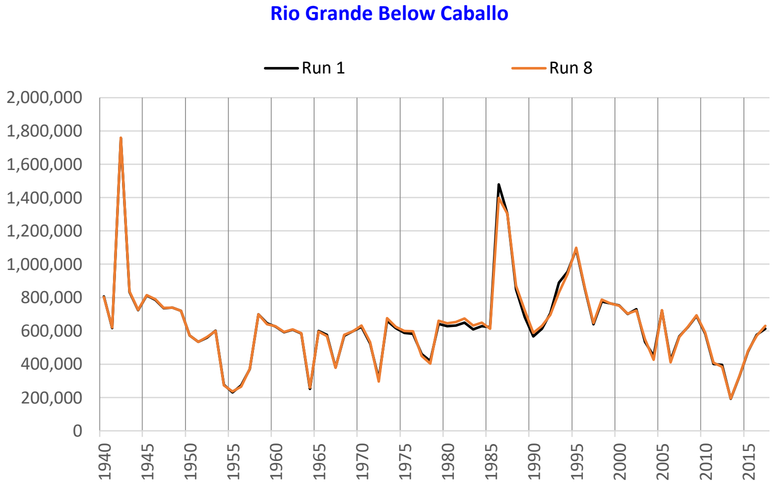
Annual Delivery Charges - EPCWID

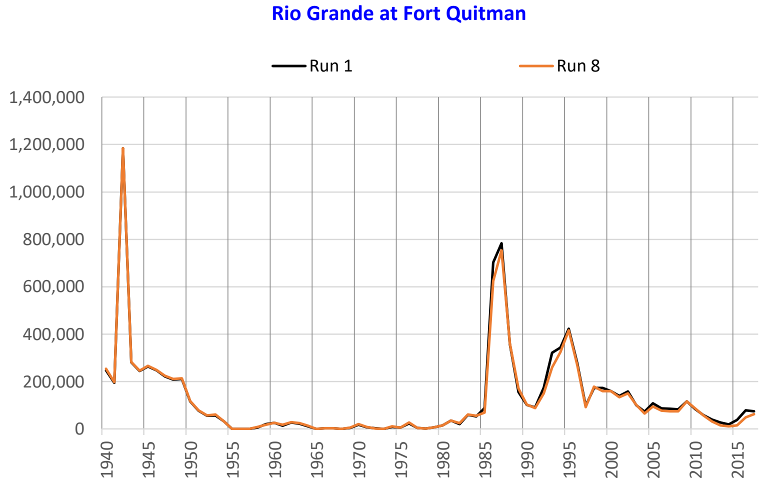


Run 8 - TX Non-Irrigation Pumping Off
Annual Summary of Project Storage and Rio Grande Flows
Run 8 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)





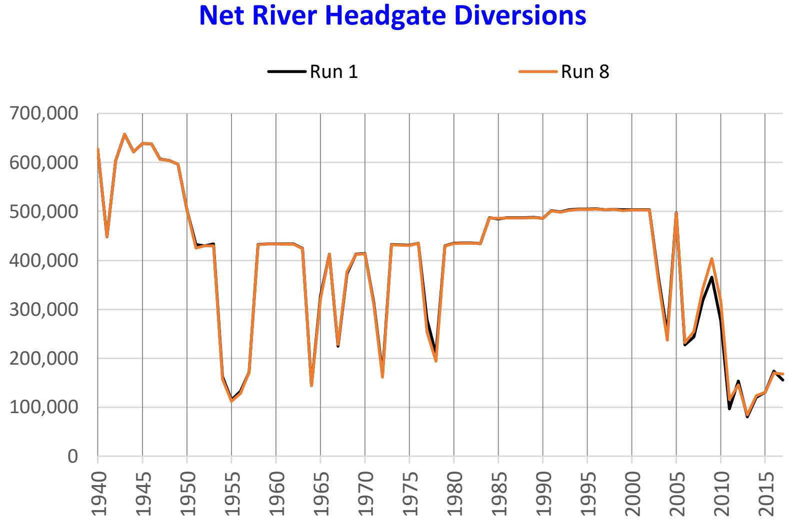


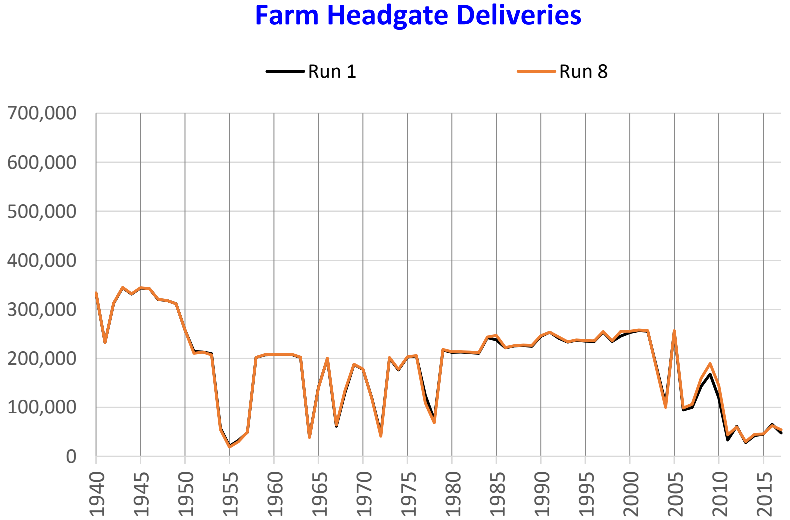


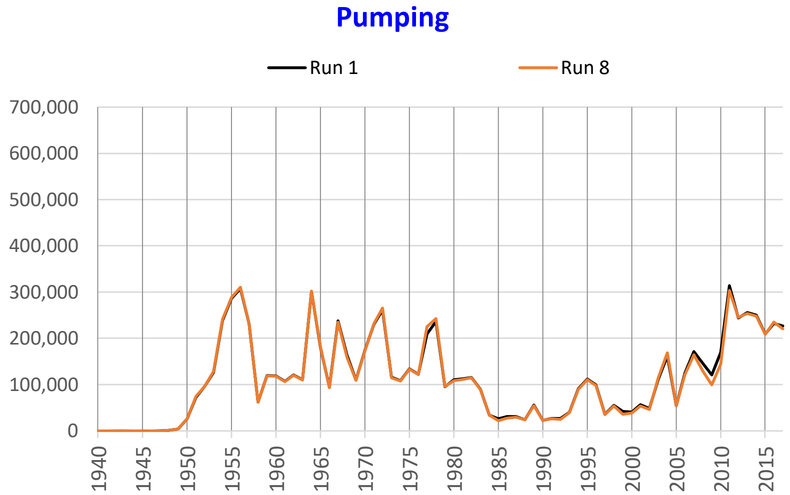
***Note different scales.**

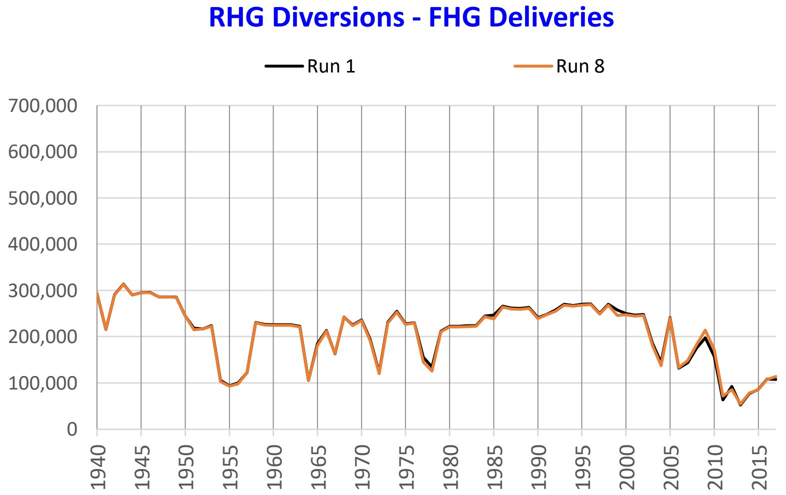
Run 8 - TX Non-Irrigation Pumping Off
Irrigation Season Summary of Irrigation Operations
Run 8 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

EBID Total


Net River Headgate Diversions


Farm Headgate Deliveries


Pumping

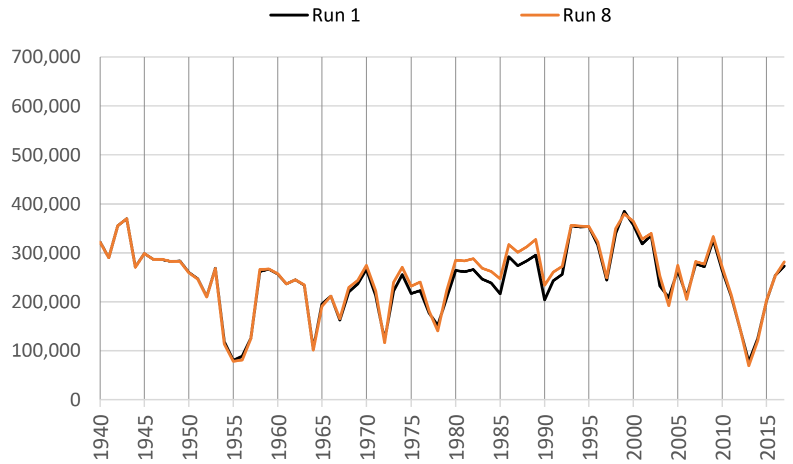

RHG Diversions - FHG Deliveries

Notes: EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).
Pumping includes Supplemental and Primary groundwater pumping.

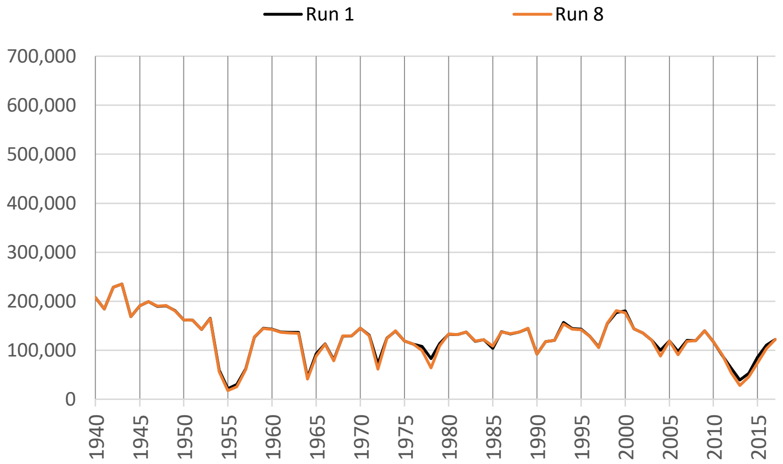
Run 8 - TX Non-Irrigation Pumping Off
Irrigation Season Summary of Irrigation Operations
Run 8 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

EPCWID Total

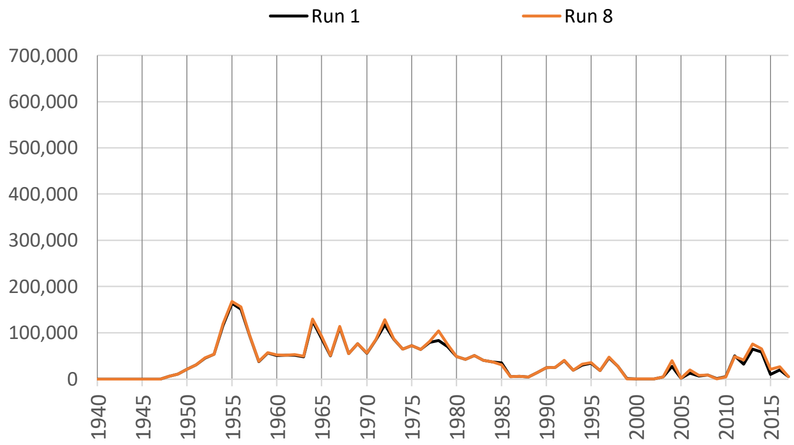
Net River Headgate Diversions



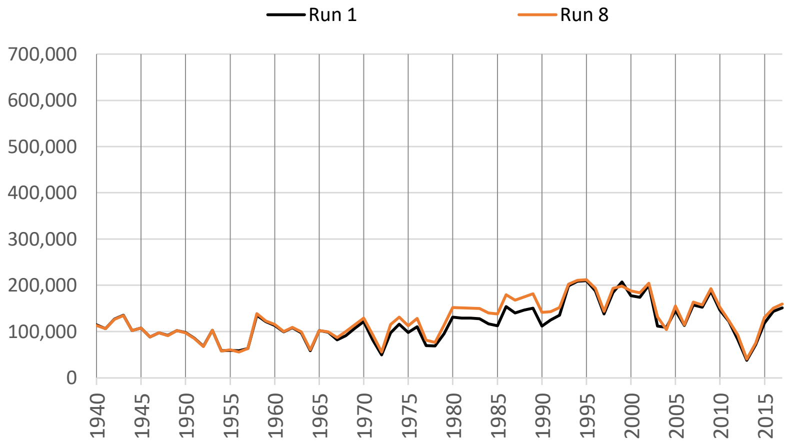
Farm Headgate Deliveries



Pumping



RHG Diversions - FHG Deliveries

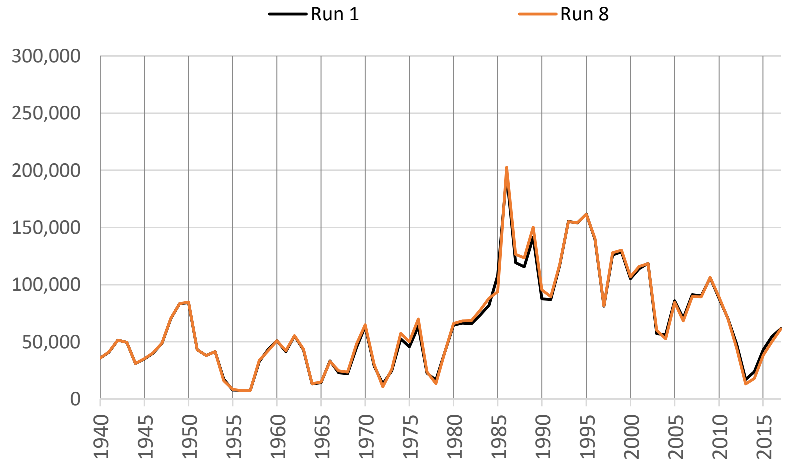


Note: EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

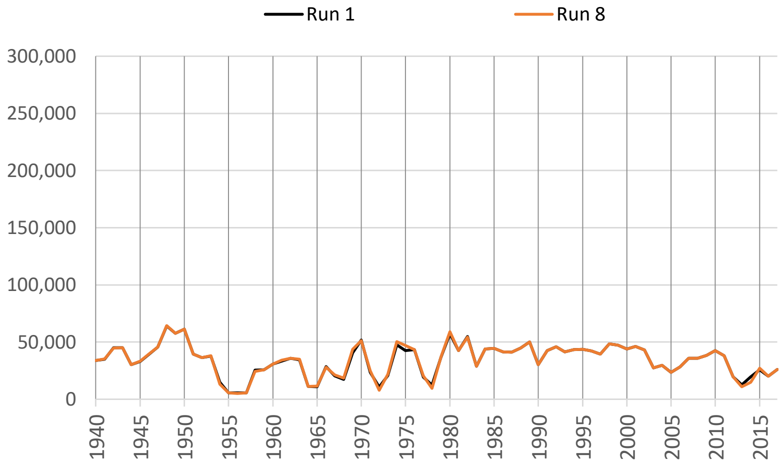
Run 8 - TX Non-Irrigation Pumping Off
Irrigation Season Summary of Irrigation Operations
Run 8 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

HCCRD Total

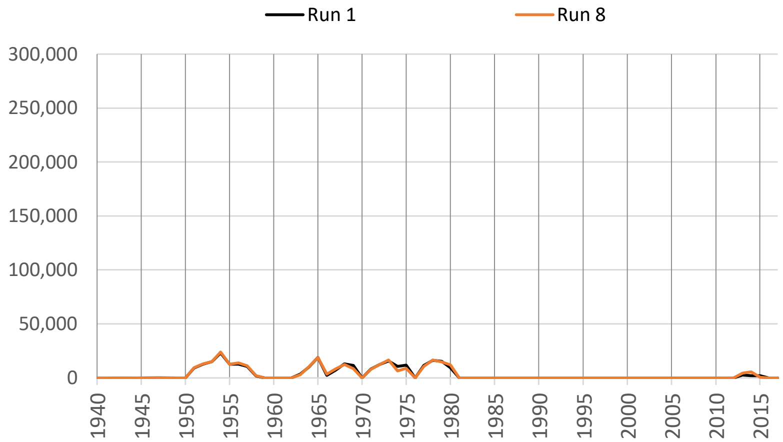
Net River Headgate Diversions



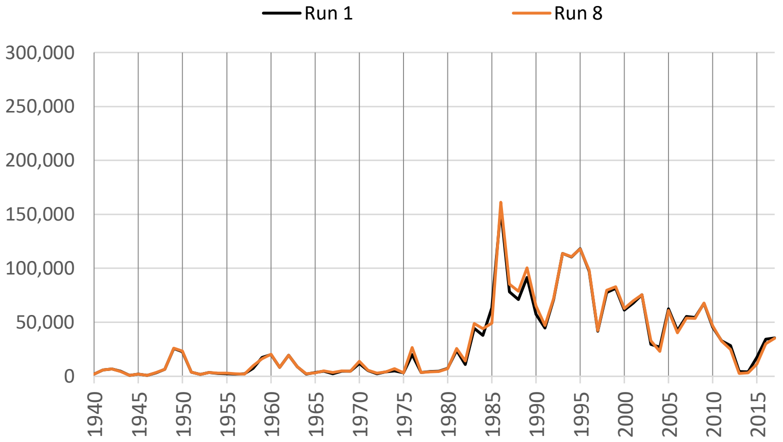
Farm Headgate Deliveries



Pumping



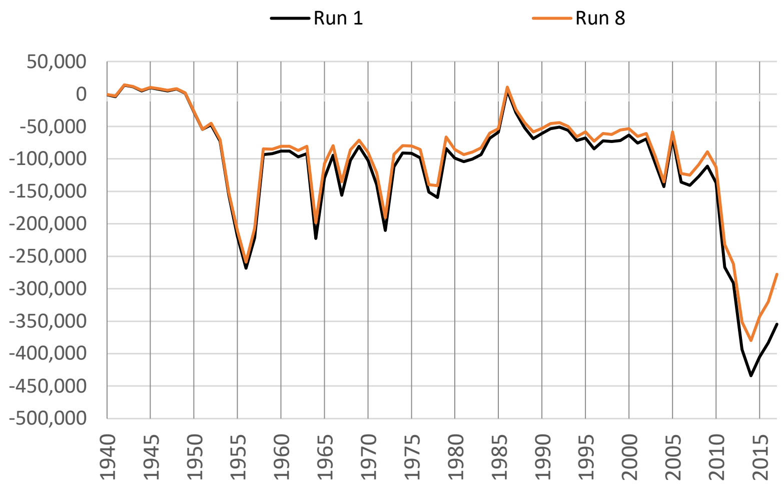
RHG Diversions - FHG Deliveries



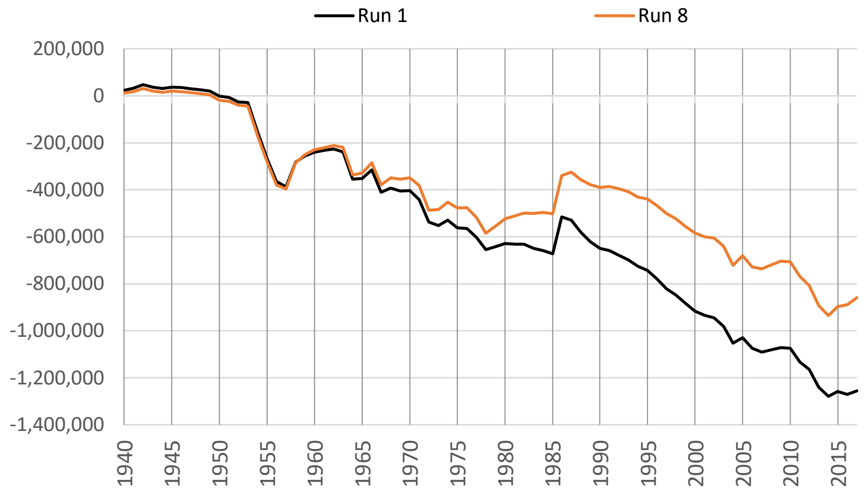
Note: HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

Run 8 - TX Non-Irrigation Pumping Off
Cumulative Change in Ground Water Storage
Run 8 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

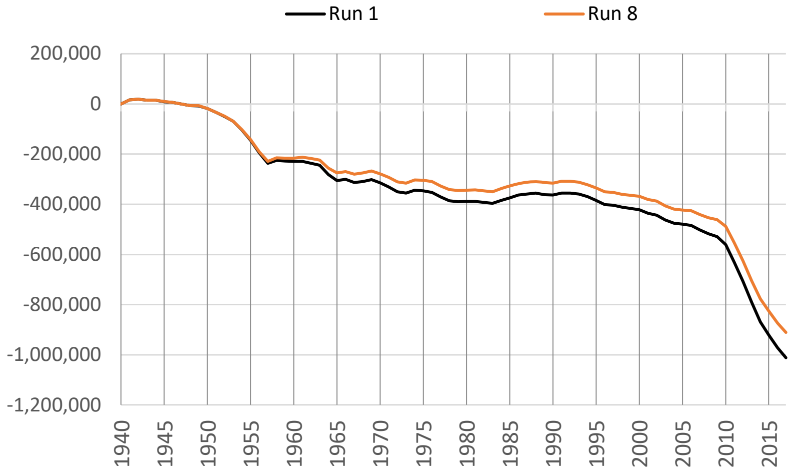
Rincon-Mesilla Alluvial Aquifer



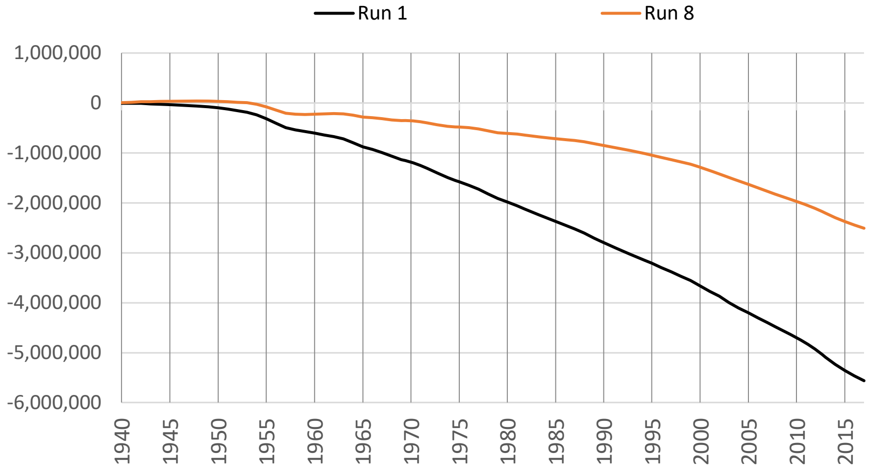
Hueco Alluvial Aquifer



Rincon-Mesilla Non-Alluvial Aquifer



Hueco Non-Alluvial Aquifer



***Note different scales.**

Run 8 - TX Non-Irrigation Pumping Off

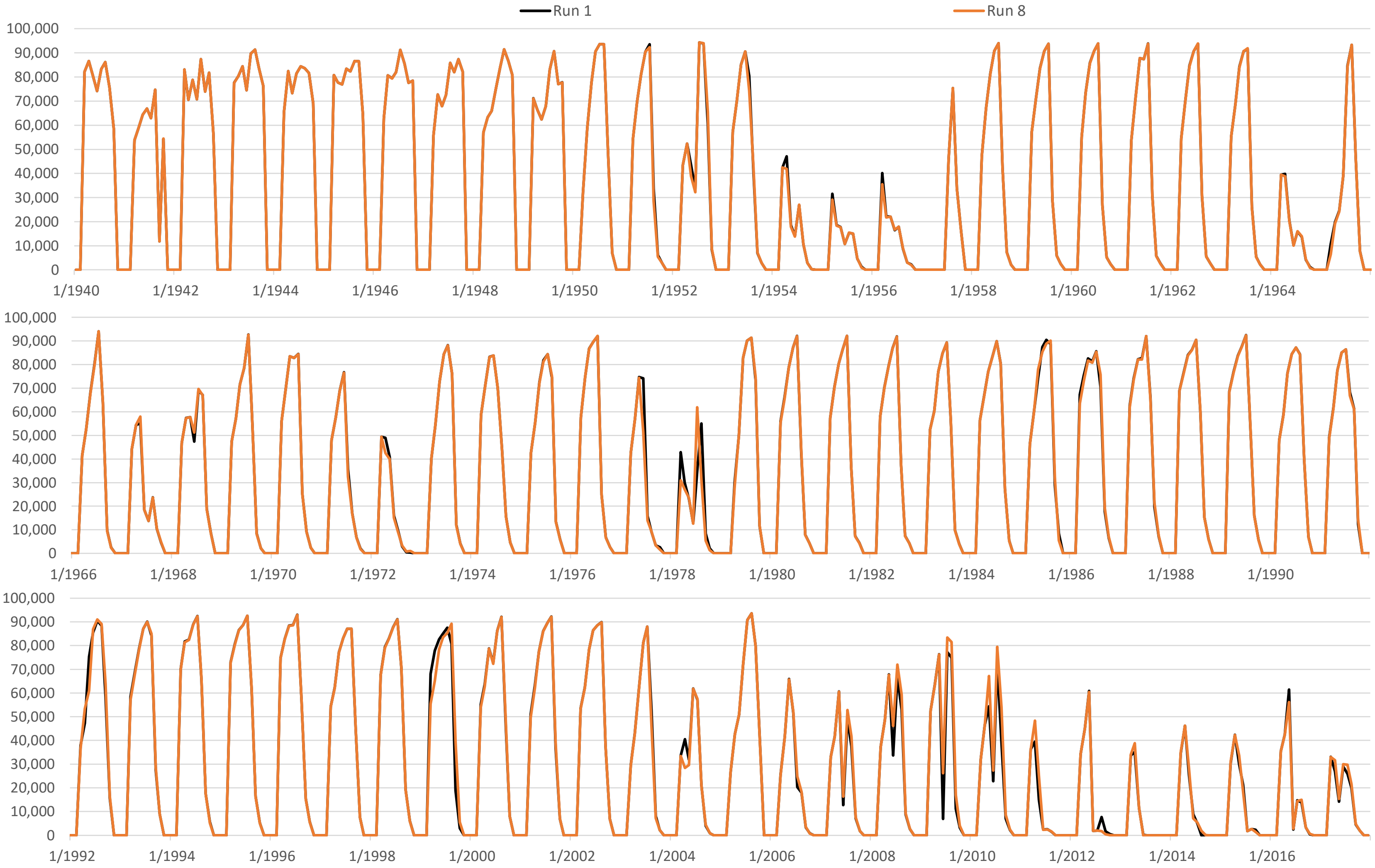
Monthly Net RHG Diversions

Run 8 v. Run 1

ILRG Model

1940 - 2017 (acre-feet)

EBID Total



Note: EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).

Run 8 - TX Non-Irrigation Pumping Off

Monthly Net RHG Diversions

Run 8 v. Run 1

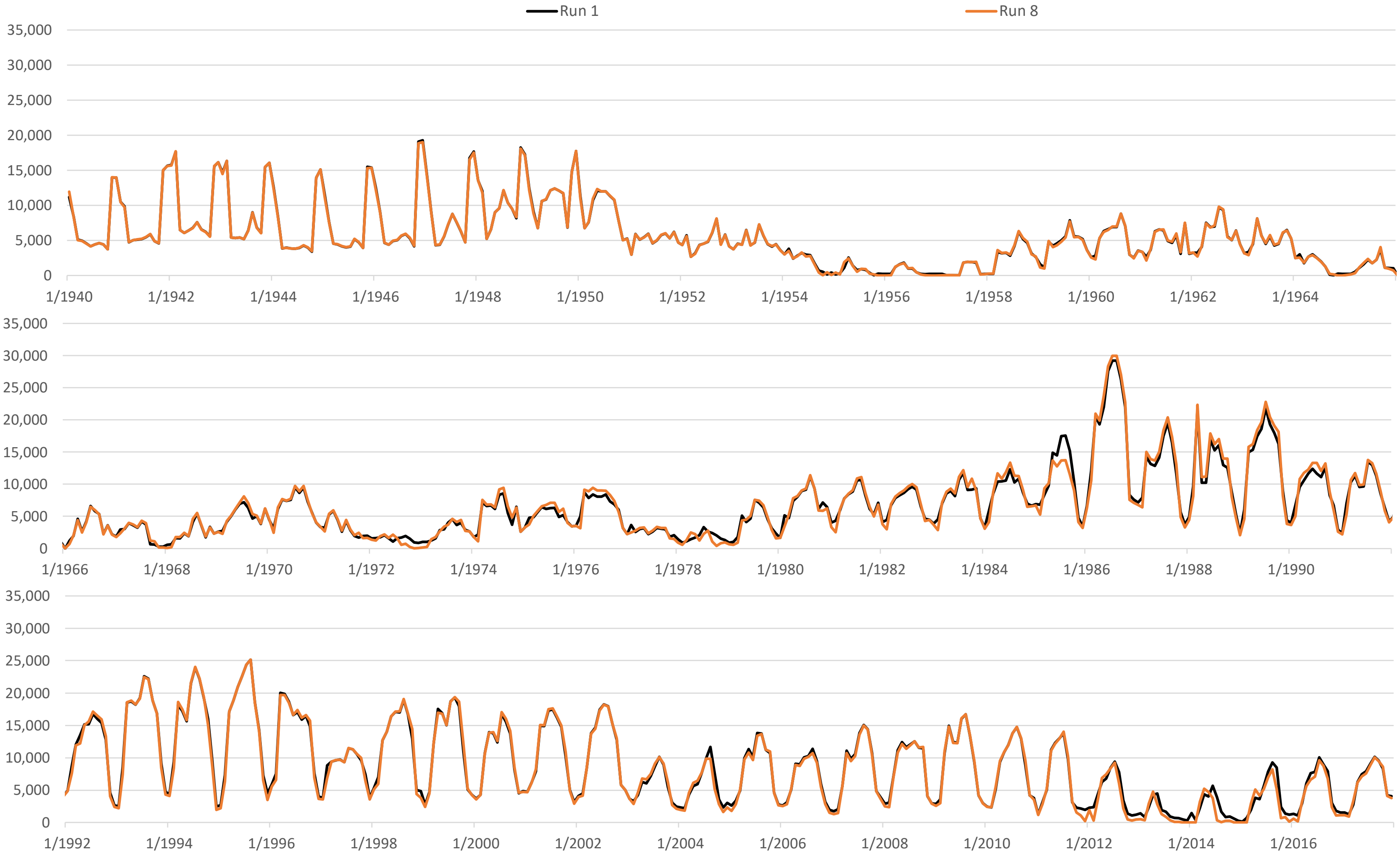
ILRG Model

1940 - 2017 (acre-feet)

EPCWID Total

Note: EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

Run 8 - TX Non-Irrigation Pumping Off
Monthly Net RHG Diversions
Run 8 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)
HCCRD Total



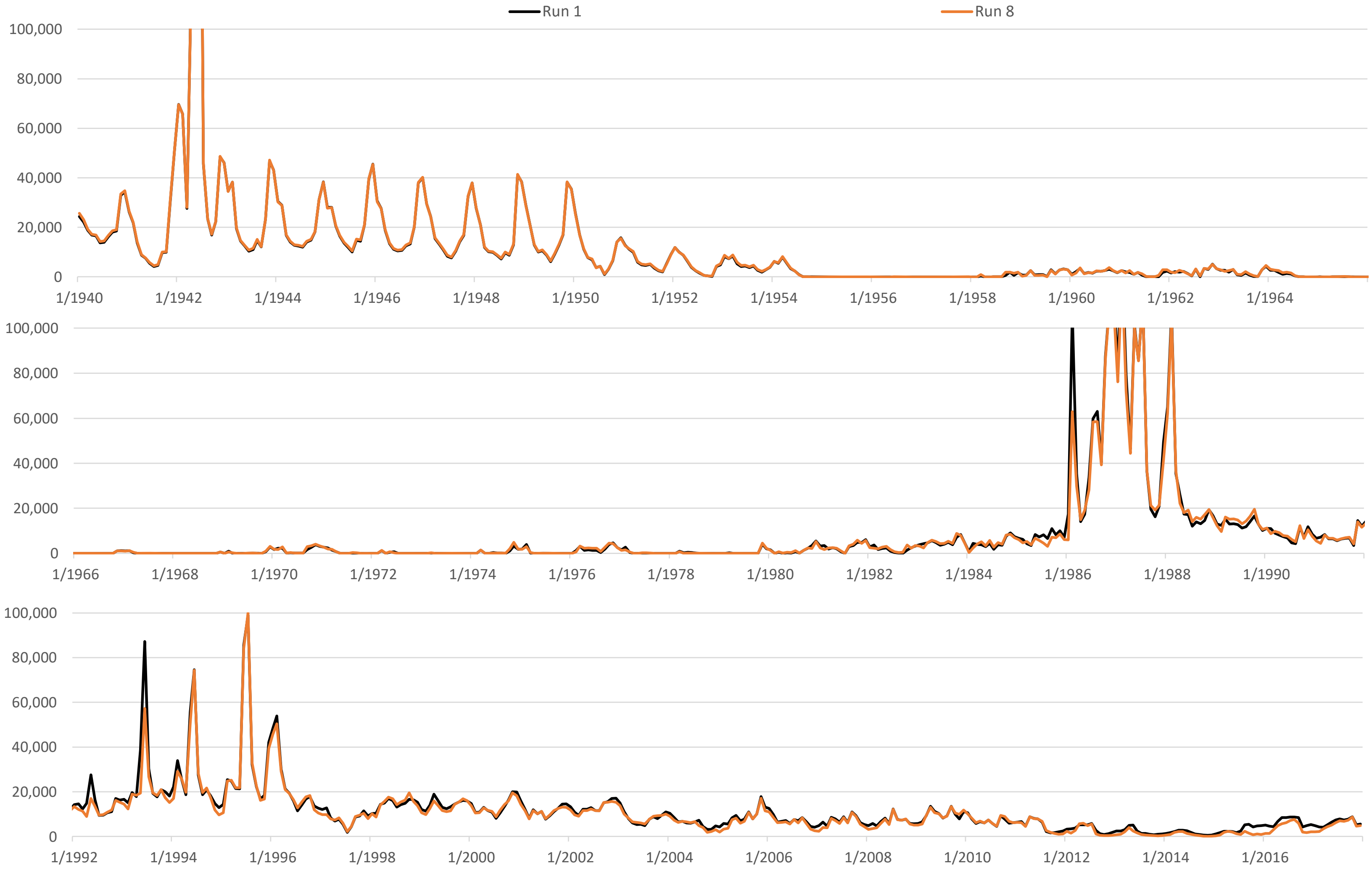
Note: HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

Run 8 - TX Non-Irrigation Pumping Off
End of Month Reservoir Storage (Elephant Butte + Caballo)
Run 8 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

Run 8 - TX Non-Irrigation Pumping Off
Monthly Caballo Releases
Run 8 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

Run 8 - TX Non-Irrigation Pumping Off
Monthly Rio Grande at El Paso Flow
Run 8 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

Run 8 - TX Non-Irrigation Pumping Off
Monthly Rio Grande at Fort Quitman Flow
Run 8 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)



Appendix 30I

Comparison of ILRG Model Runs

Run 9 v. Run 1

Model Run Specifications

Model Version: LRG_v116

Name: **Run 9 - NM Non-Irrigation Pumping Off**

Run ID: LRG_v116_Operational_Run9
Date: 8/26/2020

Name: **Run 1 - Historical Base Run**

Run ID: LRG_v116_Operational_Run1
Date: 8/23/2020

Selected Model Inputs

Pumping and Returns	**Run 9**	**Run 1**
Irrigation Pumping	On	On
Irrigated Area	Hist	Hist
Non-Irrigation Pumping	NM Off	On
Non-Irrigation Pumping Returns	NM Off	On
Las Cruces Jornada Pumping Returns	Off	On

Project Allocation Rules		
1950-2005	D1/D2	D1/D2
2006-2007	D3	D3
2008-2017	D3 + CO	D3 + CO

EPCWID Operations		
Charge EPCWID for Use of WWTP Returns	Off	Off
ACE and Haskell Credits for EPCWID	On	On
Increased EPCWID Use of Fabens Drain Flows	Off	Off
Charge EPCWID for Fabens Drain Flow Use	Off	Off

Run 9 - NM Non-Irrigation Pumping Off

Comparison of ILRG Model Runs

Run 9 v. Run 1

1951 - 2017 Annual Average

(1,000 acre-feet)

Run No.	1	9	9 - 1		
Simulated Input or Output	**Run 1**	**Run 9**	**Run 9 minus Run 1**		
Pumping Stress					
Non-Irrigation Pumping	181.0	155.5	-25.4		
WWTP Flows	58.0	52.3	-5.7		
Urban Deep Percolation	13.1	10.0	-3.0		
Total Stress	109.9	93.2	-16.7		
	Stress is Pumping minus WWTP and Urban Deep Perc				
Effects of Pumping Stress				***% Chg***	
FHG Deliveries (Mar - Oct)				***Stress***	***% Diff.***
EBID	167.6	171.7	4.1	*-24%*	*2%*
EPCWID (incl. EPW)	139.9	141.2	1.3	*-8%*	*1%*
HCCRD	32.8	33.0	0.1	*-1%*	*0%*
Total	340.3	345.8	5.5	*-33%*	*2%*
FHG Deliveries (Nov - Feb)					
EBID	0.0	0.0	0.0	*0%*	*561%*
EPCWID (incl. EPW)	0.2	0.2	0.0	*0%*	*8%*
HCCRD	2.4	2.4	0.0	*0%*	*-1%*
Total	2.6	2.6	0.0	*0%*	*1%*
Irrigation Pumping					
EBID	140.4	136.4	-4.0	*24%*	*-3%*
EPCWID (Mesilla Valley)	7.4	7.2	-0.2	*1%*	*-2%*
EPCWID (El Paso Valley)	40.1	39.1	-1.0	*6%*	*-3%*
HCCRD	4.2	4.0	-0.2	*1%*	*-4%*
	192.1	186.8	-5.4	*32%*	*-3%*
	Pumping turned off.	*Other values are simulated responses and are totaled.*			
Other Inflows/Outflows					
Net Reservoir Evaporation	125.3	126.5	1.2	*-7%*	*1%*
Riparian ET	70.9	71.4	0.5	*-3%*	*1%*
River Evaporation + Incidental Canal Loss	30.3	30.4	0.1	*0%*	*0%*
Total	226.6	228.3	1.8	*-11%*	*1%*
Rio Grande at Fort Quitman					
Reservoir Spills	33.3	34.6	1.3	*-8%*	*4%*
Nov-Feb Flows	21.4	22.8	1.4	*-9%*	*7%*
Mar - Oct Flows	41.1	43.4	2.3	*-14%*	*6%*
Underflow (GW Model)	0.2	0.2	0.0	*0%*	*2%*
Total	96.0	101.0	5.1	*-30%*	*5%*

Run 9 - NM Non-Irrigation Pumping Off

Comparison of ILRG Model Runs

Run 9 v. Run 1

1951 - 2017 Annual Average

(1,000 acre-feet)

Run No.	1	9	9 - 1		
Simulated Input or Output	**Run 1**	**Run 9**	**Run 9 minus Run 1**		
Effects of Pumping Stress (continued)				***% Chg***	
Change in Storage				***Stress***	***% Diff.***
Reservoir Storage	-4.7	-4.7	-0.1	*0%*	*1%*
Alluvial GW Storage (RW Model)	-23.6	-21.2	2.3	*-14%*	*-10%*
Non-alluvial GW Storage (GW Models)	-96.4	-91.7	4.6	*-28%*	*-5%*
Soil Moisture Storage	0.6	0.6	0.0	*0%*	*1%*
Total	-124.0	-117.1	6.9	*-41%*	*-6%*
Summary of Effects					
FHG Deliveries (Mar-Oct)	340.3	345.8	5.5	*-33%*	*2%*
FHG Deliveries (Nov-Feb)	2.6	2.6	0.0	*0%*	*1%*
Irrigation Pumping	192.1	186.8	-5.4	*32%*	*-3%*
Riparian ET + Evaporation	226.6	228.3	1.8	*-11%*	*1%*
Fort Quitman Flow	96.0	101.0	5.1	*-30%*	*5%*
Change in Storage	-124.0	-117.1	6.9	*-41%*	*-6%*
Total	733.6	747.5	13.9	*-84%*	*2%*
Other Effects of Pumping Stress				***% Chg***	
Rio Grande at El Paso				***Stress***	***% Diff.***
Reservoir Spills	49.4	49.8	0.4	*-2%*	*1%*
Nov-Feb Flows	22.8	24.5	1.7	*-10%*	*8%*
Mar - Oct Flows	263.8	267.8	4.0	*-24%*	*2%*
Total	336.0	342.1	6.1	*-37%*	*2%*
Rio Grande below Caballo					
Reservoir Spills	65.9	64.8	-1.1	*6%*	*-2%*
Nov-Feb Flows	0.5	0.4	-0.1	*1%*	*-25%*
Mar - Oct Flows	541.3	541.3	0.1	*0%*	*0%*
Total	607.6	606.5	-1.1	*7%*	*0%*
Surface Water Diversions (Mar - Oct)					
EBID	366.5	372.5	6.0	*-36%*	*2%*
EPCWID (incl. EPW)	236.8	239.3	2.6	*-15%*	*1%*
HCCRD	67.5	68.7	1.1	*-7%*	*2%*
Total	670.8	680.5	9.7	*-58%*	*1%*
Surface Water Diversions (Nov - Feb)					
EBID	0.0	0.0	0.0	*0%*	*0%*
EPCWID (incl. EPW)	14.3	14.6	0.3	*-2%*	*2%*
HCCRD	14.2	14.4	0.2	*-1%*	*1%*
Total	28.5	29.0	0.4	*-3%*	*2%*

Run 9 - NM Non-Irrigation Pumping Off
Annual Differences in ILRG Model Outputs
Run 9 minus Run 1
1940 - 2017 (acre-feet)

	Net River Headgate Diversions						Farm Headgate Deliveries						Annual Flows		
	EBID		EPCWID (incl. EPW)		HCCRD		EBID		EPCWID (incl. EPW)		HCCRD				
Year	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Caballo Releases	Rio Grande at El Paso	Rio Grande at Fort Quitman
1940	-55	-55	4	7	1	4	18	51	2	2	1	1	-85	-6	-31
1941	-193	-193	-1	-1	1	2	-44	-7	0	1	1	0	70	228	134
1942	-162	-162	-4	-2	2	4	15	54	-2	-4	1	1	-282	146	135
1943	-186	-186	7	12	0	4	37	77	7	-7	0	-1	-252	133	59
1944	-207	-207	-144	-131	-102	-81	9	50	4	-8	-93	-93	-398	-59	29
1945	-215	-215	9	37	-103	-41	22	59	8	0	-104	27	-323	124	53
1946	-186	-186	10	39	11	37	44	86	7	9	-7	-68	-326	158	180
1947	-207	-207	-4	56	-33	14	26	70	-1	-23	-33	-33	-378	152	158
1948	-248	-248	13	36	5	23	24	69	16	12	1	1	-334	146	136
1949	-277	-277	0	26	-17	7	20	67	3	2	0	0	-411	156	115
1950	-11	-11	21	54	8	33	222	269	14	15	0	0	-141	436	334
1951	1,010	1,010	37	38	6	10	720	767	25	26	4	6	75	449	327
1952	13	13	47	48	10	12	244	287	31	32	11	9	-1,647	120	88
1953	44	44	10	10	6	3	423	465	9	9	3	-4	-1,085	461	171
1954	2,181	2,181	1,757	2,011	368	350	1,505	1,530	1,081	1,081	547	527	1,910	2,449	186
1955	845	845	613	439	218	61	464	478	262	522	133	-42	1,510	866	0
1956	108	108	-275	-961	-312	-556	-959	-949	-22	364	-324	-568	-658	-1,070	-5
1957	-6	-6	-22	237	-16	-147	32	48	36	223	72	-62	-1,233	-416	0
1958	2	2	-511	-145	-61	243	223	249	49	-49	54	121	-9,208	547	97
1959	1	1	-131	116	50	144	281	312	8	9	3	12	-3,939	816	273
1960	1	1	-54	112	31	105	280	312	6	6	0	0	-3,194	652	366
1961	1	1	8	158	19	89	240	272	-14	-13	-6	5	-3,159	707	212
1962	3	3	18	171	26	87	279	311	28	28	1	5	-3,218	742	437
1963	8,871	8,871	185	354	43	117	5,082	5,114	145	147	14	15	2,234	2,927	476
1964	7,813	7,813	5,740	5,733	692	727	4,593	4,612	3,548	3,789	643	575	8,610	6,837	1,276
1965	2,159	2,159	997	690	113	61	1,208	1,230	1,288	1,458	-10	47	-4,893	2,117	25
1966	-18	-18	-244	318	666	748	495	522	28	31	591	-554	-5,206	2,480	749
1967	8,073	8,073	6,113	7,294	1,523	2,107	5,525	5,545	3,727	3,432	1,259	1,343	7,924	8,114	1,068
1968	1,770	1,770	-18	1,355	769	636	1,790	1,814	249	-151	723	300	-3,477	3,683	420
1969	-3	-3	-196	70	1,112	1,862	759	789	-34	-33	1,382	1,015	-5,251	947	841
1970	-9	-9	-41	192	286	547	480	511	41	42	-256	-410	-3,961	946	1,143
1971	8,102	8,102	81	686	108	413	5,197	5,223	210	211	94	210	1,084	2,220	370
1972	-99	-99	453	513	295	490	6,908	6,925	1,167	1,225	324	517	-5,130	1,541	95
1973	-47	-47	585	70	389	321	150	174	208	284	336	341	-6,750	472	4
1974	-10	-10	132	390	53	199	521	552	56	57	-1	94	-5,043	1,250	278
1975	-227	-227	316	579	111	248	1,390	1,417	261	262	47	35	-5,762	1,053	156
1976	-18	-18	168	421	223	446	770	790	101	101	-1	-3	-4,111	1,153	544
1977	18,024	18,024	431	1,815	26	264	10,787	10,815	373	376	54	144	6,622	4,216	269
1978	11,916	11,916	8,363	10,146	-1,797	-1,221	6,398	6,419	9,333	9,338	-1,620	-1,129	16,948	17,519	1,027

Run 9 - NM Non-Irrigation Pumping Off
Annual Differences in ILRG Model Outputs
Run 9 minus Run 1
1940 - 2017 (acre-feet)

	Net River Headgate Diversions						Farm Headgate Deliveries						Annual Flows		
	EBID		EPCWID (incl. EPW)		HCCRD		EBID		EPCWID (incl. EPW)		HCCRD				
Year	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Caballo Releases	Rio Grande at El Paso	Rio Grande at Fort Quitman
1979	-156	-156	-664	59	1,052	2,023	1,095	1,127	89	96	1,130	2,089	-11,011	2,734	1,133
1980	-102	-102	-152	355	1,104	2,322	638	678	82	88	1,156	1,098	-7,527	1,872	1,395
1981	-66	-66	-57	308	349	633	759	788	58	62	0	0	-6,552	1,545	1,194
1982	-58	-58	-13	372	169	425	577	613	62	66	-39	-121	-6,895	1,590	1,277
1983	-53	-53	8	402	165	411	633	670	60	64	0	0	-6,552	1,724	840
1984	-100	-100	104	576	809	1,116	774	807	122	127	0	0	-5,311	3,613	2,110
1985	-131	-131	42	77	660	708	922	967	39	63	0	0	-6,521	2,938	1,868
1986	-128	-128	-37	-27	554	795	963	1,018	7	18	0	0	36,392	45,540	51,794
1987	-211	-211	77	83	141	215	698	748	83	89	0	0	-6	8,736	24,265
1988	-74	-74	49	54	115	172	988	1,038	56	61	0	0	-5,148	4,834	5,372
1989	-46	-46	70	103	114	123	963	1,001	51	70	0	0	-7,747	2,654	2,744
1990	-99	-99	92	126	589	564	1,191	1,237	80	89	0	0	-6,353	5,552	4,264
1991	-398	-398	111	161	138	127	726	778	101	187	0	0	-8,208	3,935	5,020
1992	2,358	2,358	74,380	74,340	34,132	35,125	-9,209	-9,165	33,305	33,289	0	0	37,324	56,397	43,904
1993	401	401	-5,547	-5,567	-1,093	-491	1,908	1,959	-2,887	-2,885	0	0	-20,136	-10,089	822
1994	-67	-67	55	57	166	314	1,375	1,434	267	274	0	0	2,221	14,892	14,465
1995	-74	-74	81	48	246	359	1,520	1,563	144	102	0	0	4,391	18,003	17,397
1996	-124	-124	90	96	130	234	1,871	1,925	147	154	0	0	-12,599	4,235	4,801
1997	-97	-97	-29	36	250	229	1,410	1,453	81	120	0	0	-8,700	5,741	3,651
1998	-124	-124	-8	-5	178	81	1,552	1,607	103	114	0	0	-14,768	4,010	5,841
1999	85	85	863	1,030	-210	-111	1,297	1,341	2,444	2,454	0	0	-799	13,626	10,914
2000	-105	-105	-3,250	-2,941	-522	-384	1,470	1,514	-2,195	-2,184	0	0	-15,053	2,280	4,502
2001	-169	-169	-37	275	121	276	1,486	1,521	61	73	0	0	-12,379	5,858	5,399
2002	-116	-116	-37	361	127	306	1,602	1,631	92	105	0	0	-12,034	6,326	6,153
2003	44,077	44,077	38,625	39,031	11,517	12,020	21,207	21,243	14,654	14,667	0	0	38,338	48,057	27,060
2004	8,023	8,023	5,803	6,425	1,329	2,257	5,720	5,752	4,085	4,096	0	0	422	11,793	8,882
2005	953	953	8	379	826	1,387	3,123	3,162	842	858	0	0	-21,164	5,905	10,463
2006	44,945	44,945	23,290	23,905	8,757	9,348	21,509	21,542	5,634	5,648	0	0	33,335	36,410	26,116
2007	21,861	21,861	2,575	3,151	901	1,307	13,174	13,200	2,226	2,242	0	0	-7,898	6,622	5,488
2008	35,455	35,455	184	715	307	612	24,350	24,379	251	269	0	0	-6,138	5,005	5,430
2009	48,801	48,801	138	603	179	437	28,864	28,900	188	212	0	0	-3,238	6,885	7,159
2010	59,142	59,142	1,148	2,192	381	737	38,756	38,787	922	946	0	0	-1,056	8,237	7,264
2011	42,865	42,865	12,729	13,289	4,212	4,217	24,235	24,250	9,286	9,306	0	0	28,272	17,607	9,293
2012	-2,421	-2,421	3,532	3,529	4,016	3,703	1,306	1,316	2,590	2,602	0	0	-8,053	2,622	5,448
2013	-5,133	-5,133	-818	-873	67	-15	-2,691	-2,682	-629	-621	253	0	-7,472	-2,788	1,720
2014	-1,870	-1,870	510	349	456	8	-674	-670	317	324	385	-92	-331	-1,340	589
2015	-1,612	-1,612	-126	-211	80	-86	-548	-540	16	24	18	-170	-1,489	-704	-232
2016	20,288	20,288	-9,189	-9,142	-1,780	-2,161	10,461	10,470	-6,065	-6,055	0	0	-3,636	-9,976	-4,675
2017	18,257	18,257	1,767	1,865	-177	-359	10,090	10,103	919	930	0	-22	8,356	2,545	-1,991
Averages															
1951-2017	6,037	6,037	2,551	2,813	1,127	1,304	4,058	4,090	1,342	1,357	104	80	-1,130	6,108	5,075
1951-1978	2,518	2,518	877	1,174	177	299	1,992	2,019	793	814	146	91	-1,072	2,279	389
1979-2005	1,978	1,978	4,097	4,304	1,969	2,268	1,750	1,793	1,927	1,938	83	114	-2,829	10,159	9,908
2006-2017	23,381	23,381	2,978	3,281	1,450	1,479	14,069	14,088	1,305	1,319	55	-24	2,554	5,927	5,134
1985-2017	10,137	10,137	4,459	4,652	2,027	2,183	6,413	6,448	2,037	2,050	20	-9	-57	10,071	9,733
1985-2005	2,568	2,568	5,305	5,435	2,358	2,586	2,037	2,082	2,455	2,467	0	0	-1,549	12,439	12,361

Notes:

EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).

EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

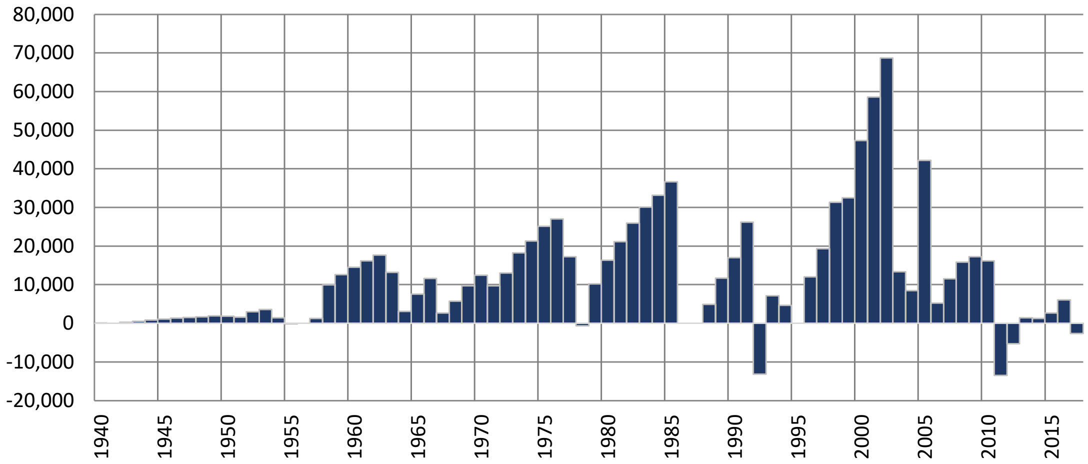
Run 9 - NM Non-Irrigation Pumping Off

Simulated Differences in ILRG Model Outputs

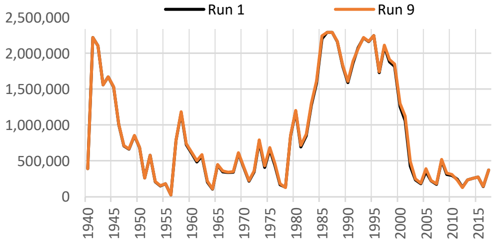
Run 9 minus Run 1

1940 - 2017 (acre-feet)

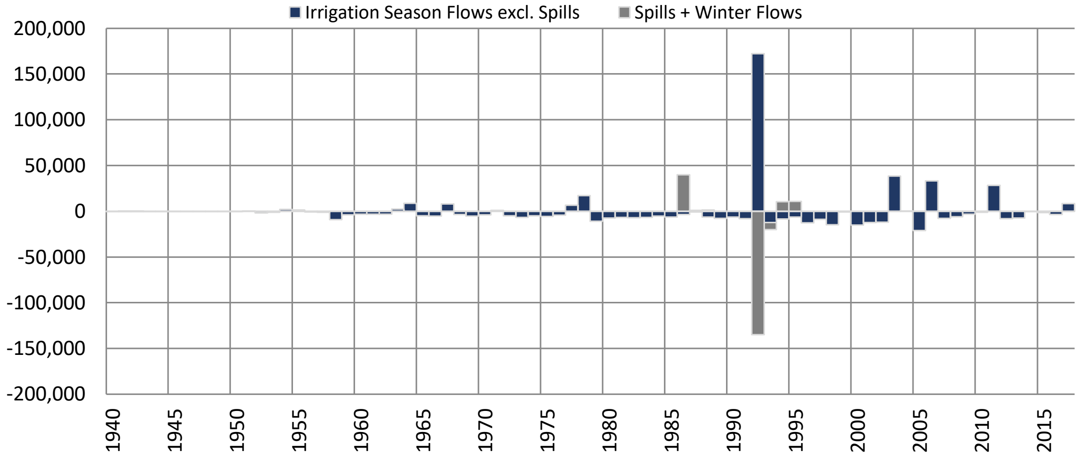
Total Project Storage (Year End)



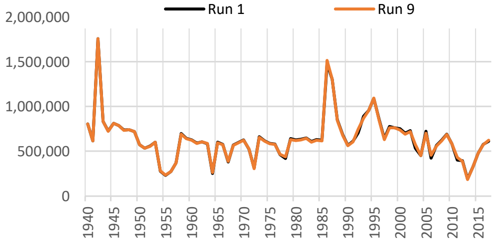
Period	Average Difference
1951-2017	-67
1951-1978	-89
1979-2005	1,587
2006-2017	-3,736
1985-2017	-1,085
1985-2005	430



Caballo Reservoir Outflows (Annual)



	Average Difference		
Period	Irr Season (excl. Spills)	Nov-Feb and Spills	Annual
1951-2017	54	-1,185	-1,130
1951-1978	-1,072	0	-1,072
1979-2005	111	-2,940	-2,829
2006-2017	2,554	0	2,554
1985-2017	2,349	-2,405	-57
1985-2005	2,231	-3,780	-1,549



Notes:

Reservoir storage does not include storage attributed to SJC, CO, or NM credit waters.

Average differences calculated as (Final Storage - Initial Storage)/(no. years).

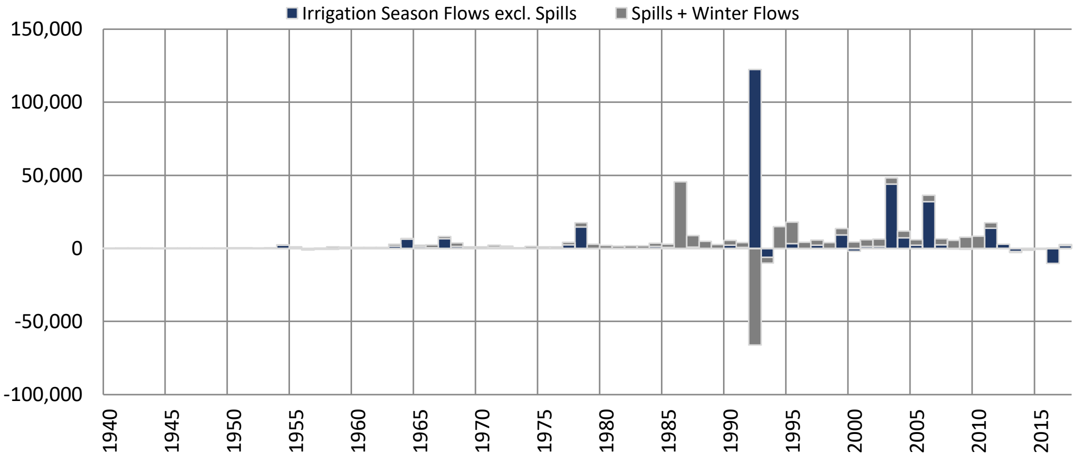
Run 9 - NM Non-Irrigation Pumping Off

Simulated Differences in ILRG Model Outputs

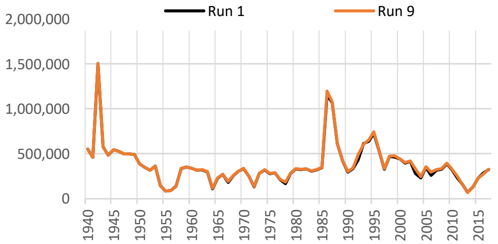
Run 9 minus Run 1

1940 - 2017 (acre-feet)

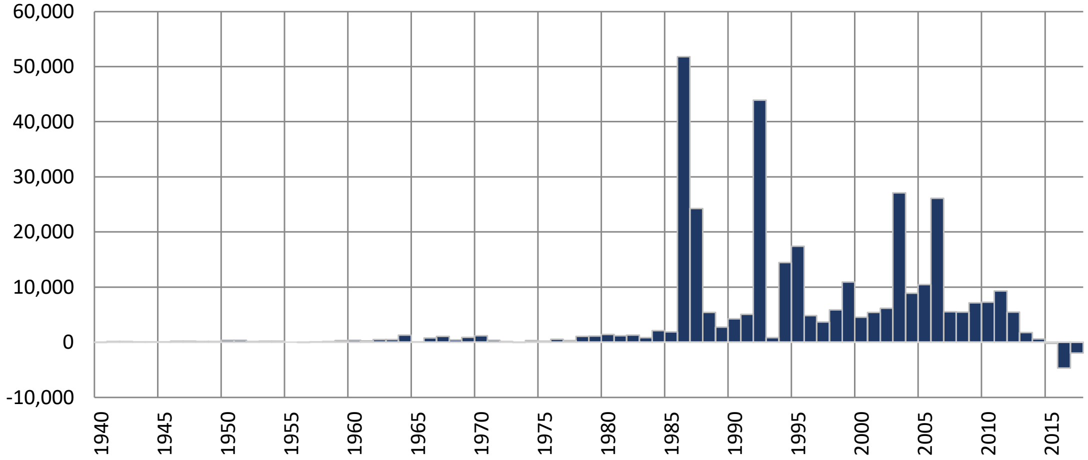
Rio Grande at El Paso (Annual)



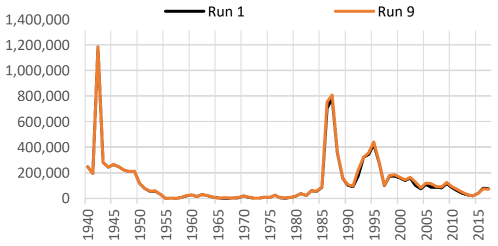
	Average Difference		
Period	Irr Season (excl. Spills)	Nov-Feb and Spills	Annual
1951-2017	4,003	2,105	6,108
1951-1978	1,364	914	2,279
1979-2005	7,067	3,092	10,159
2006-2017	3,267	2,661	5,927
1985-2017	6,942	3,129	10,071
1985-2005	9,043	3,396	12,439



Rio Grande at Fort Quitman (Annual)



Period	Average Difference
1951-2017	5,072
1951-1978	386
1979-2005	9,904
2006-2017	5,132
1985-2017	9,730
1985-2005	12,358



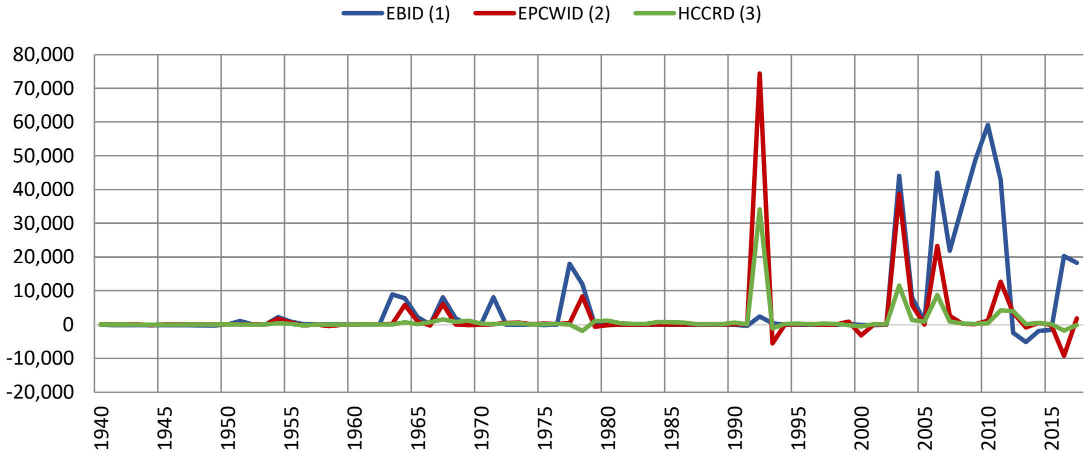
Run 9 - NM Non-Irrigation Pumping Off

Simulated Differences in ILRG Model Outputs

Run 9 minus Run 1

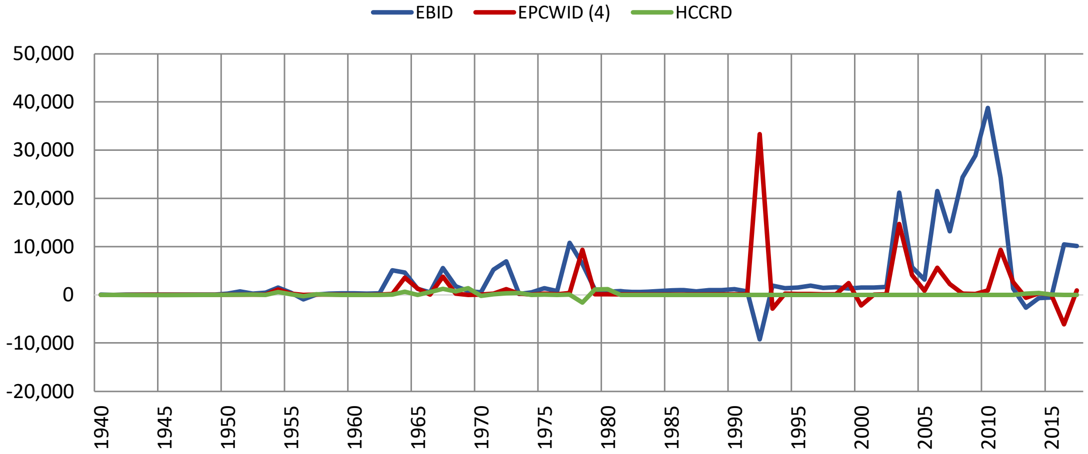
1940 - 2017 (acre-feet)

River Headgate (RHG) Diversions (Irrigation Season)



	Average Difference		
Period	EBID	EPCWID	HCCRD
1951-2017	6,037	2,551	1,127
1951-1978	2,518	877	177
1979-2005	1,978	4,097	1,969
2006-2017	23,381	2,978	1,450
1985-2017	10,137	4,459	2,027
1985-2005	2,568	5,305	2,358

Farm Headgate (FHG) Deliveries (Irrigation Season)



	Average Difference		
Period	EBID	EPCWID	HCCRD
1951-2017	4,058	1,342	104
1951-1978	1,992	793	146
1979-2005	1,750	1,927	83
2006-2017	14,069	1,305	55
1985-2017	6,413	2,037	20
1985-2005	2,037	2,455	0

Notes:

(1) EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).

(2) EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

(3) HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

(4) EPCWID FHG values include deliveries to Rogers WTP and R/U WTP.

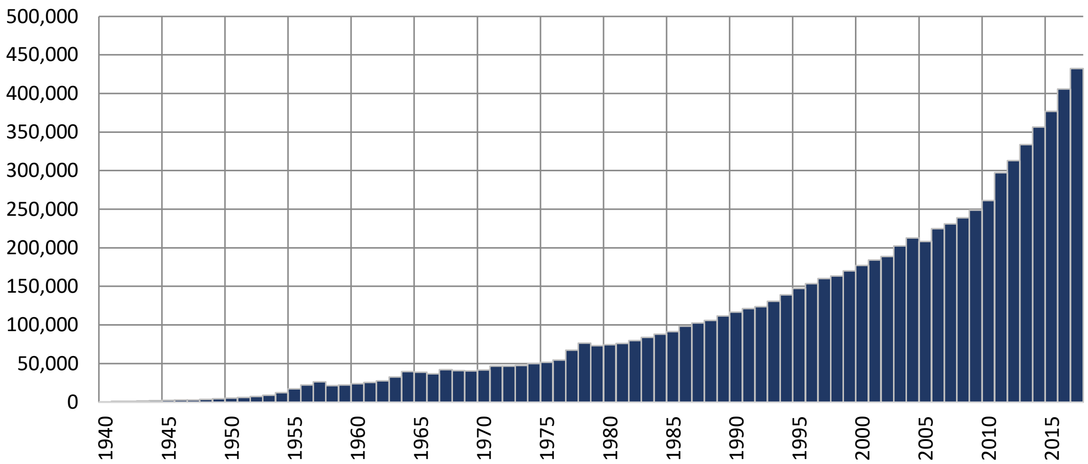
Run 9 - NM Non-Irrigation Pumping Off

Simulated Differences in ILRG Model Outputs

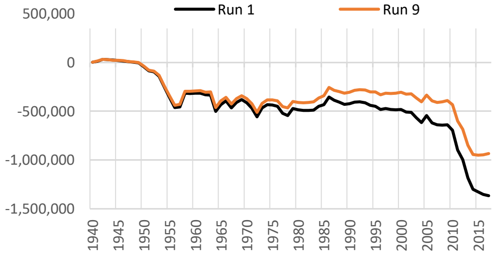
Run 9 minus Run 1

1940 - 2017 (acre-feet)

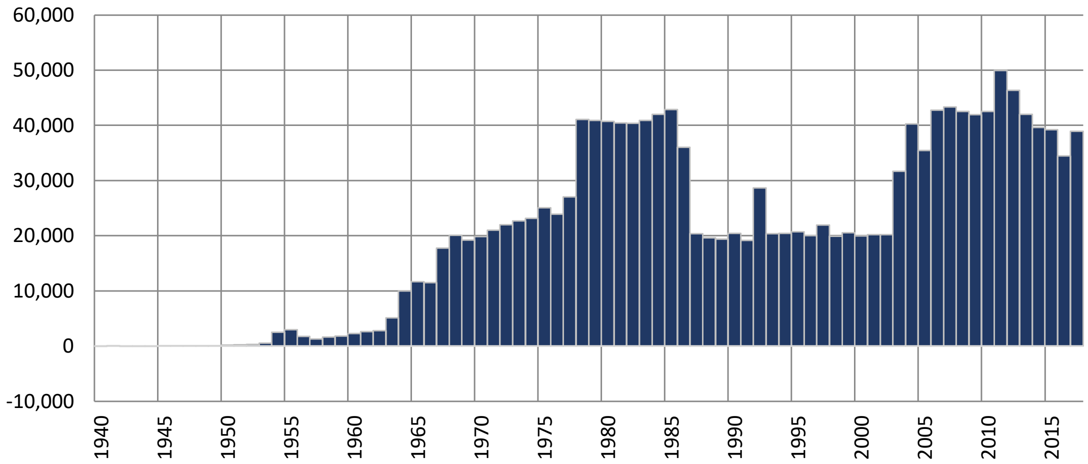
Cumulative Annual Rincon-Mesilla Groundwater Storage



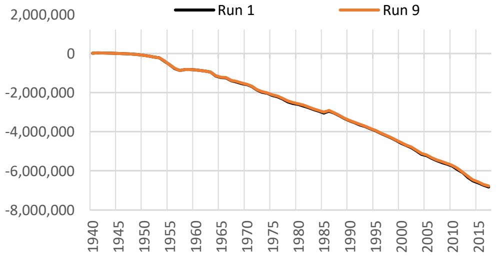
Period	Average Difference
1951-2017	6,373
1951-1978	2,547
1979-2005	4,875
2006-2017	18,673
1985-2017	10,432
1985-2005	5,723



Cumulative Annual Hueco Groundwater Storage



Period	Average Difference
1951-2017	579
1951-1978	1,461
1979-2005	-209
2006-2017	293
1985-2017	-93
1985-2005	-313



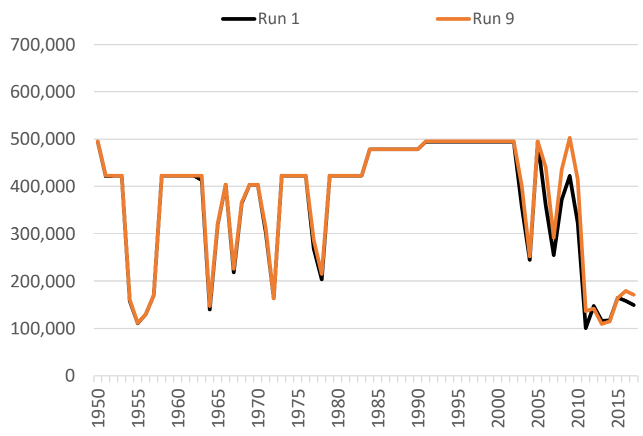
Notes:

Cumulative storage change in alluvial and non-alluvial aquifers.

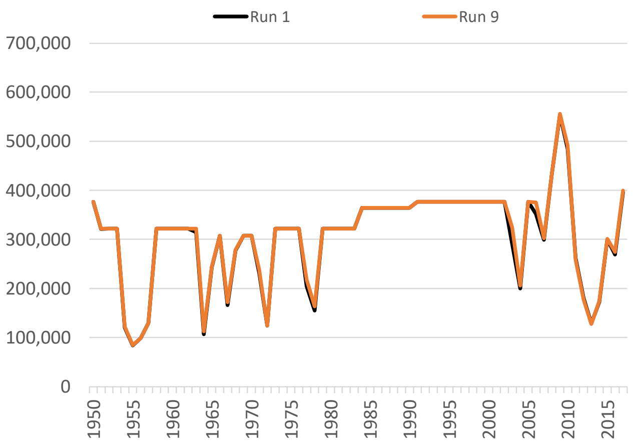
Average differences calculated as (Final Storage - Initial Storage)/(no. years).

Run 9 - NM Non-Irrigation Pumping Off
Annual Allocation and Charges
Run 9 v. Run 1
ILRG Model
1950 - 2017 (acre-feet)

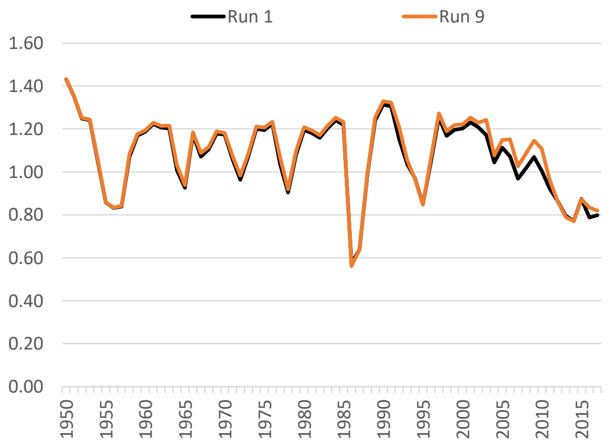
Total Allocation - EBID



Total Allocation - EPCWID

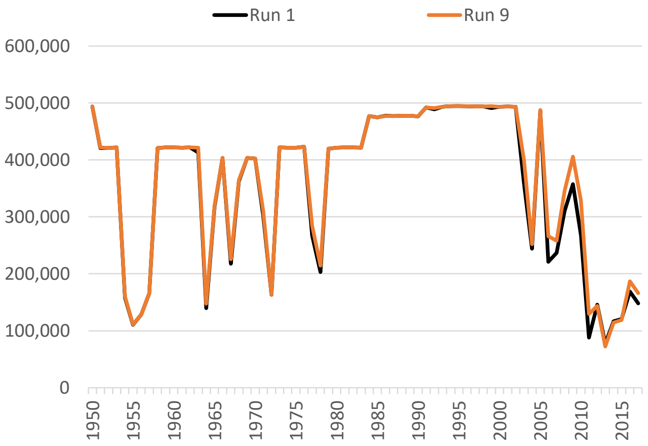


Diversion Ratio

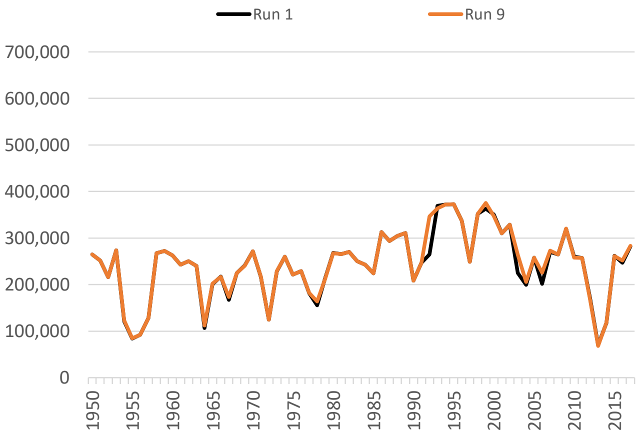


Note:
Computed as Total Charges/Caballo Release.

Annual Delivery Charges - EBID

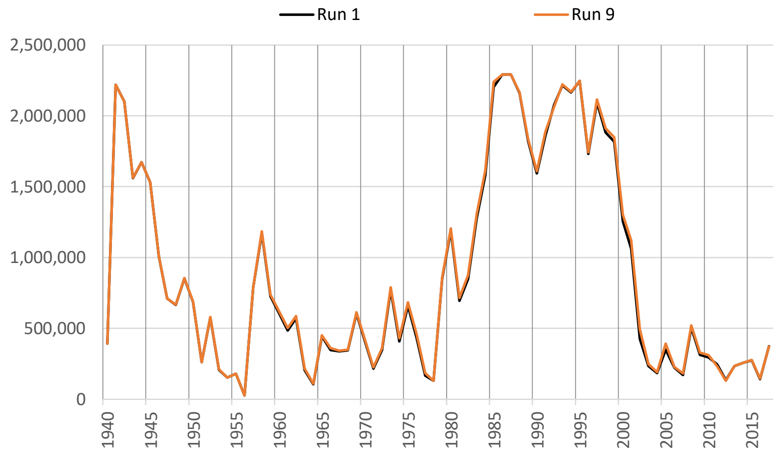


Annual Delivery Charges - EPCWID

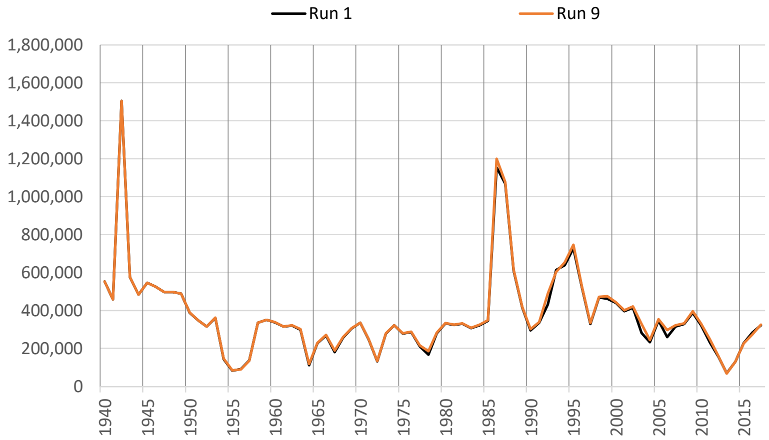


Run 9 - NM Non-Irrigation Pumping Off
Annual Summary of Project Storage and Rio Grande Flows
Run 9 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

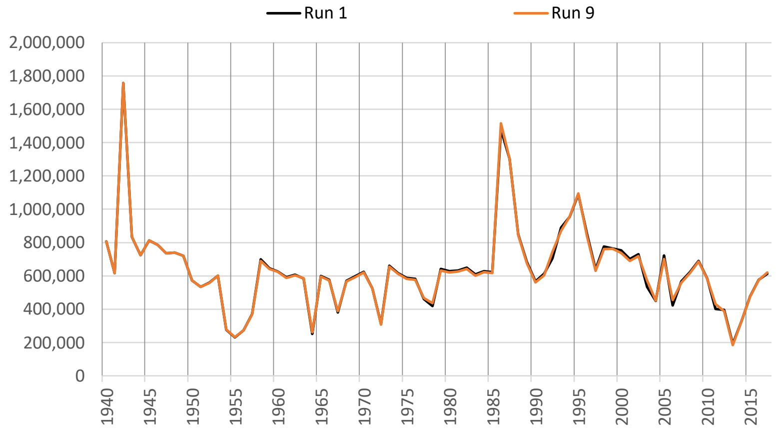
Total Year-End Project Reservoir Storage



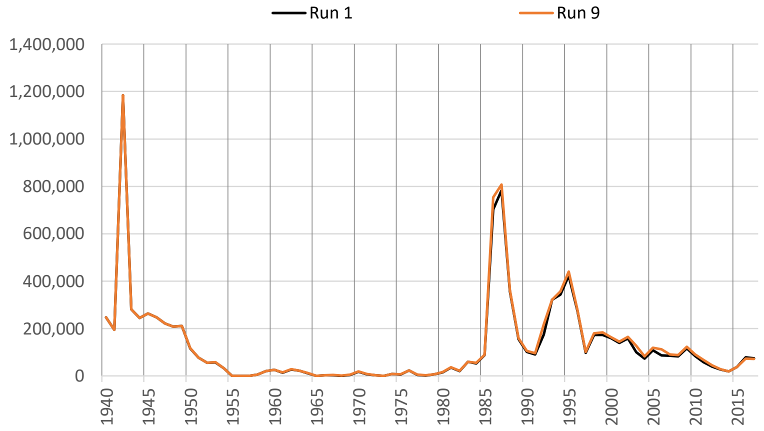
Rio Grande at El Paso



Rio Grande Below Caballo



Rio Grande at Fort Quitman

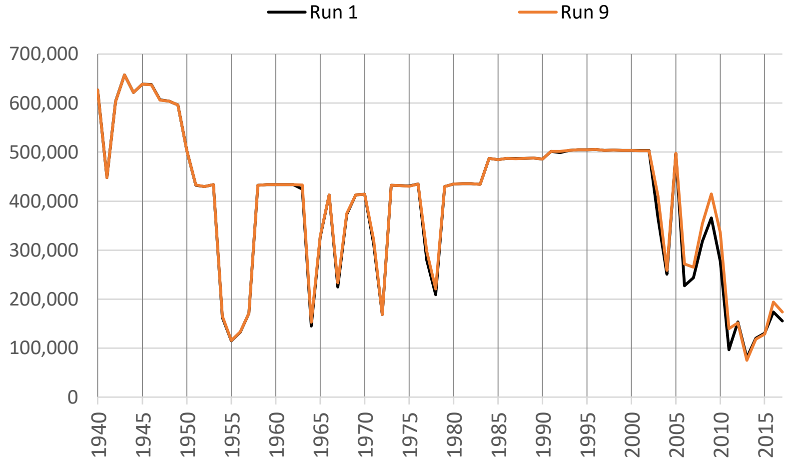


***Note different scales.**

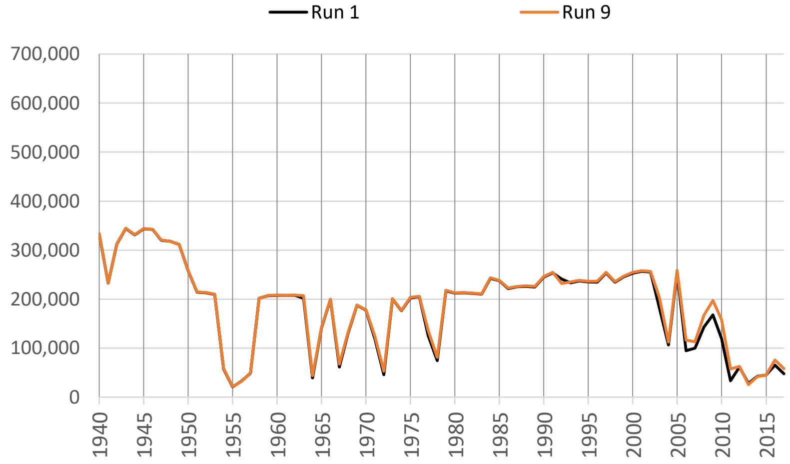
Run 9 - NM Non-Irrigation Pumping Off
Irrigation Season Summary of Irrigation Operations
Run 9 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

EBID Total

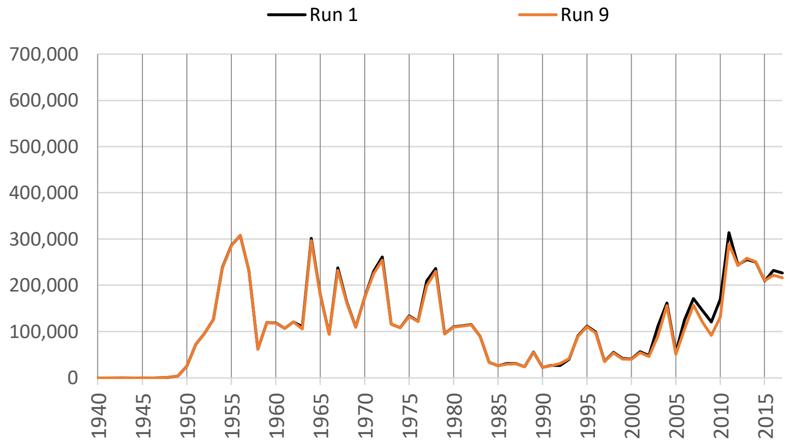
Net River Headgate Diversions



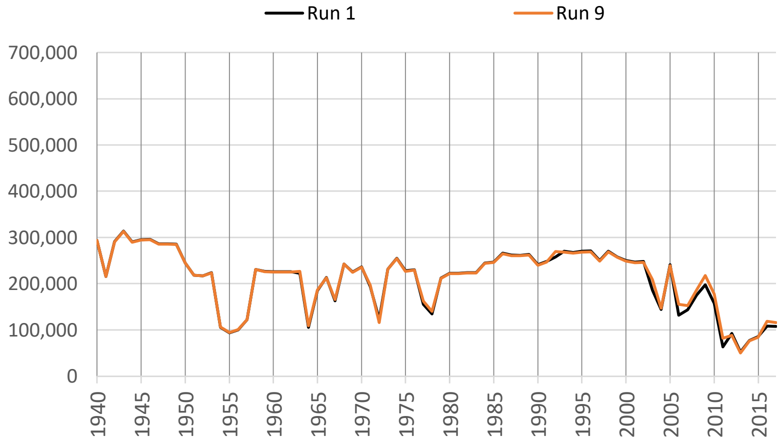
Farm Headgate Deliveries



Pumping



RHG Diversions - FHG Deliveries

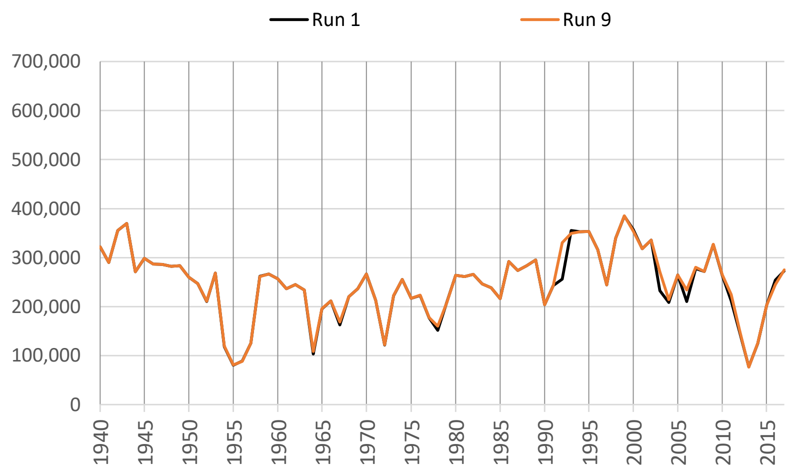


Notes: EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).
Pumping includes Supplemental and Primary groundwater pumping.

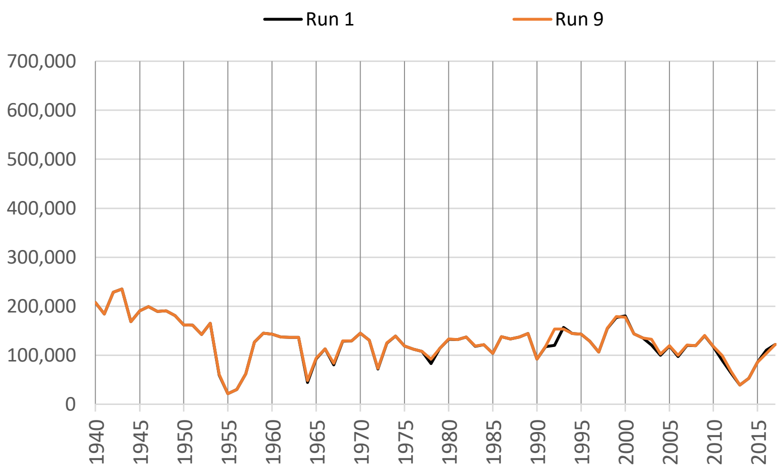
Run 9 - NM Non-Irrigation Pumping Off
Irrigation Season Summary of Irrigation Operations
Run 9 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

EPCWID Total

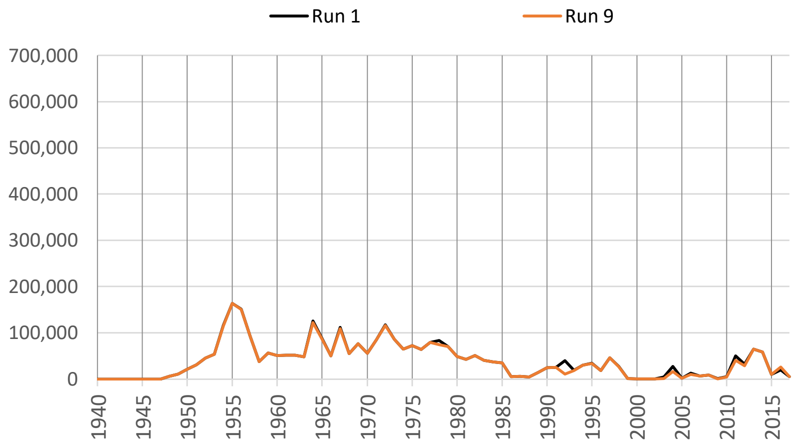
Net River Headgate Diversions



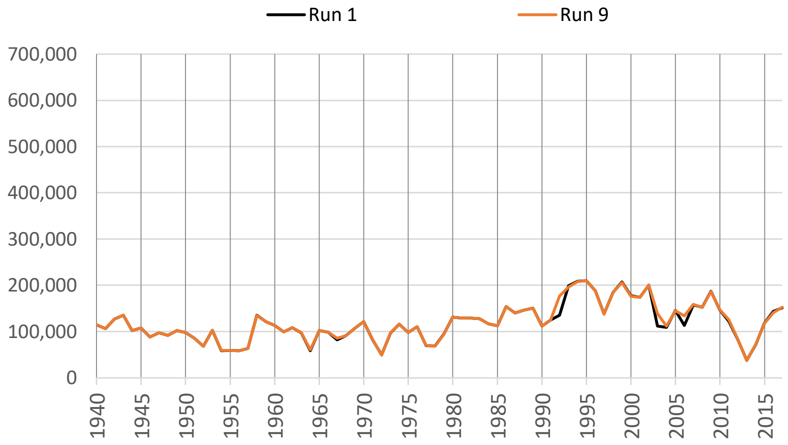
Farm Headgate Deliveries



Pumping



RHG Diversions - FHG Deliveries

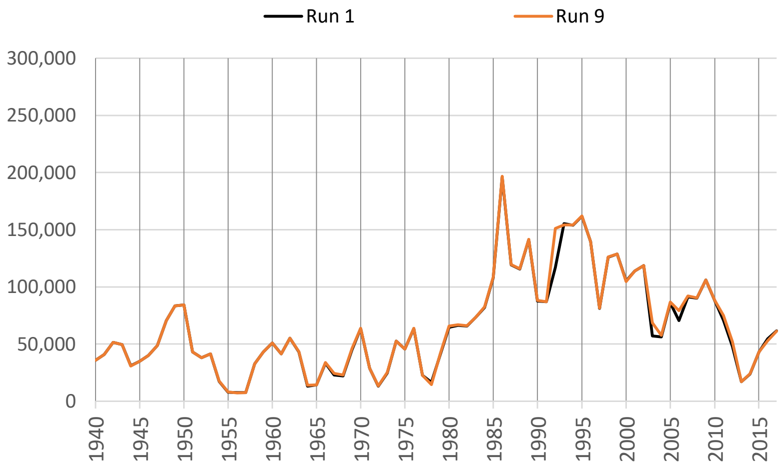


Note: EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

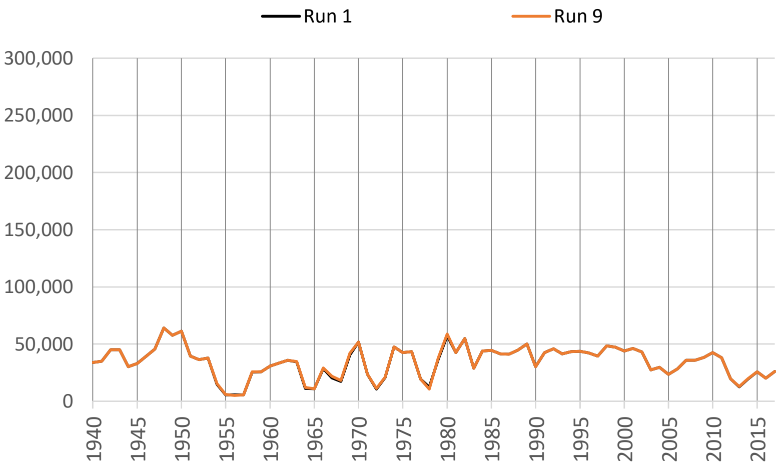
Run 9 - NM Non-Irrigation Pumping Off
Irrigation Season Summary of Irrigation Operations
Run 9 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

HCCRD Total

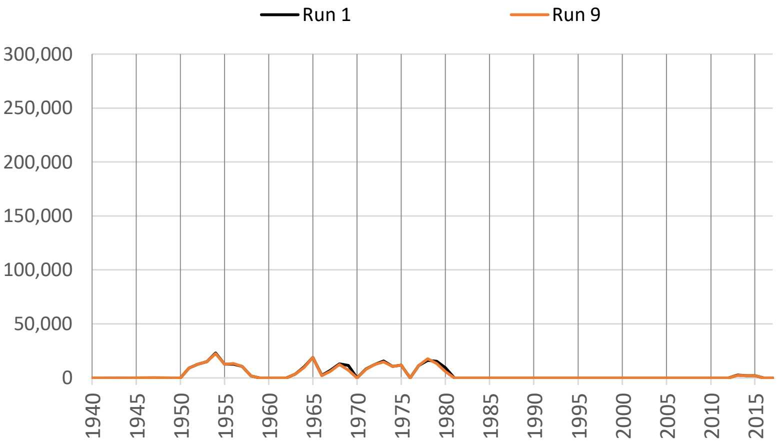
Net River Headgate Diversions



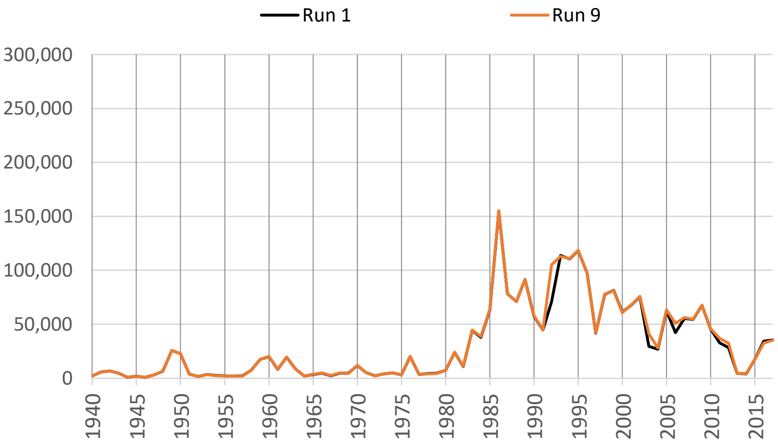
Farm Headgate Deliveries



Pumping



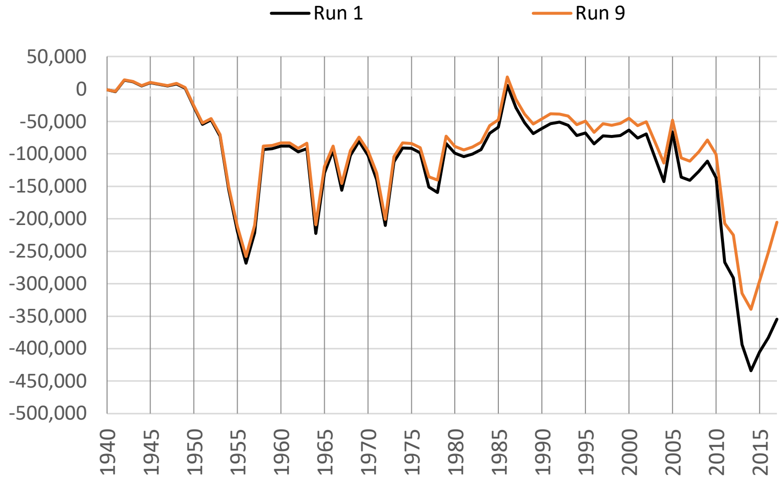
RHG Diversions - FHG Deliveries



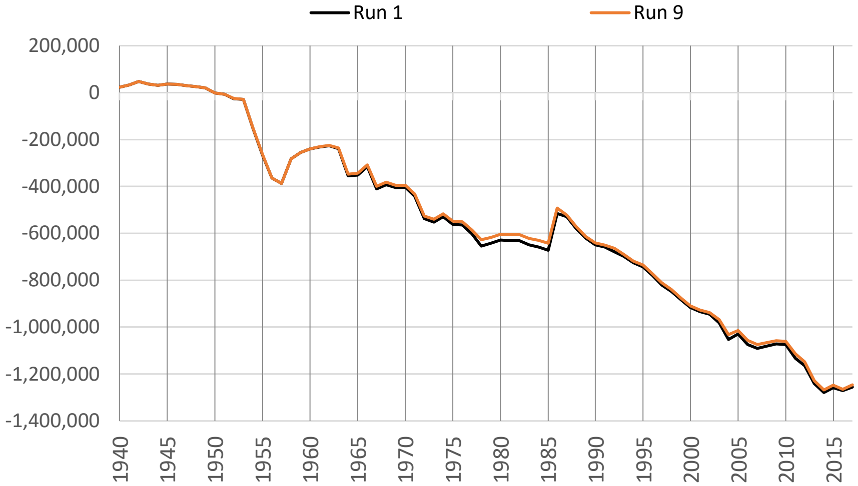
Note: HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

Run 9 - NM Non-Irrigation Pumping Off
Cumulative Change in Ground Water Storage
Run 9 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

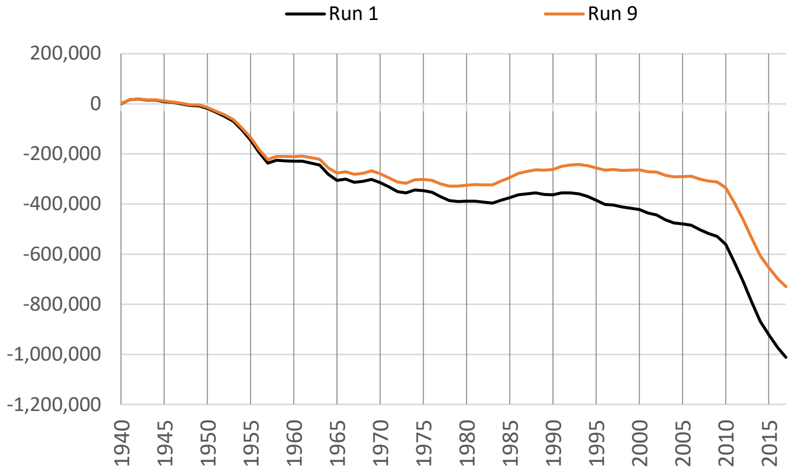
Rincon-Mesilla Alluvial Aquifer



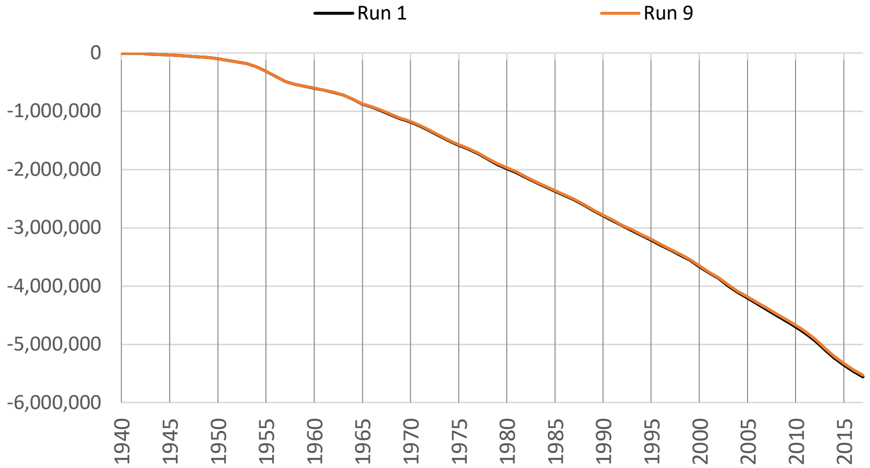
Hueco Alluvial Aquifer



Rincon-Mesilla Non-Alluvial Aquifer

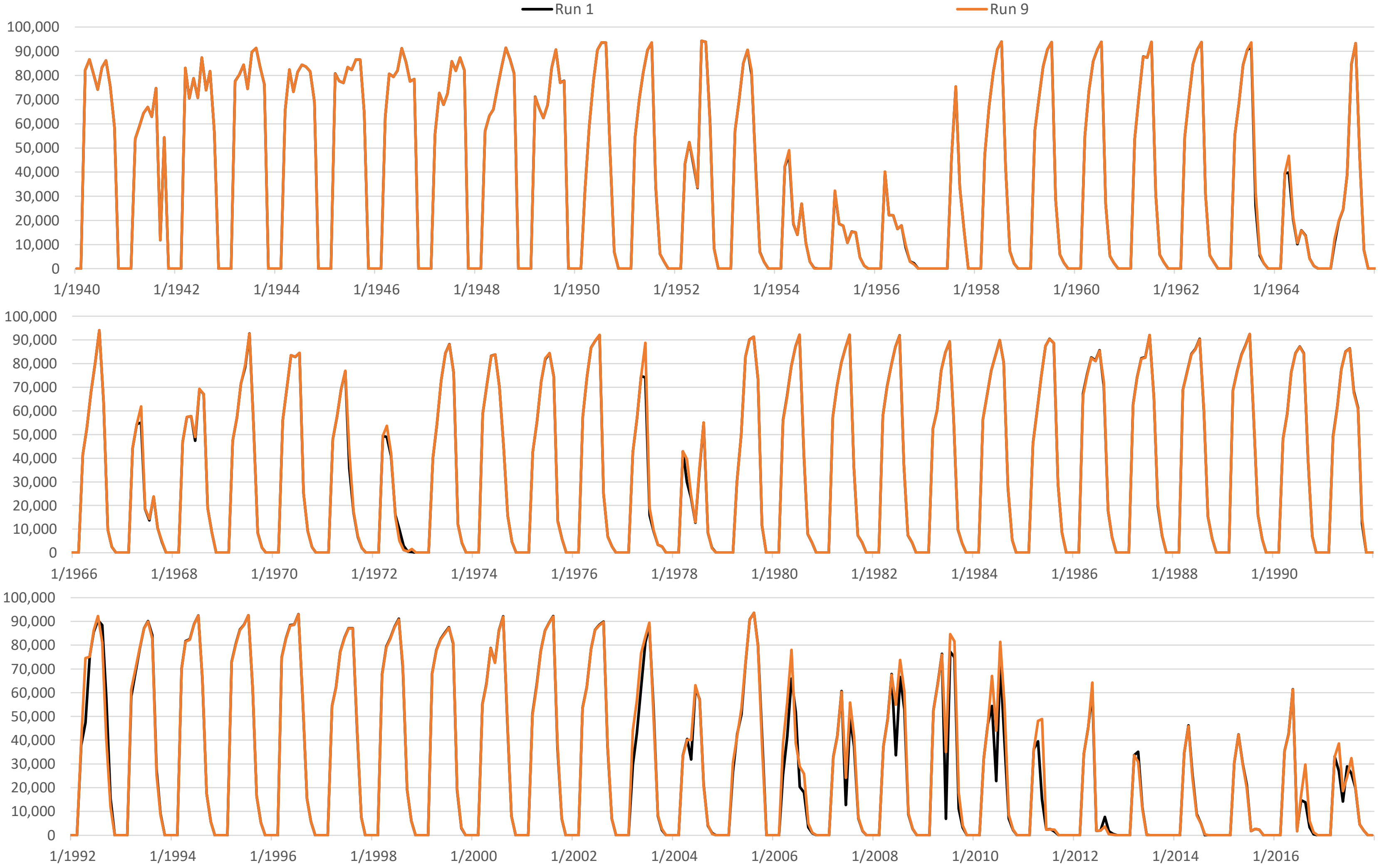


Hueco Non-Alluvial Aquifer



***Note different scales.**

Run 9 - NM Non-Irrigation Pumping Off
Monthly Net RHG Diversions
Run 9 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)
EBID Total

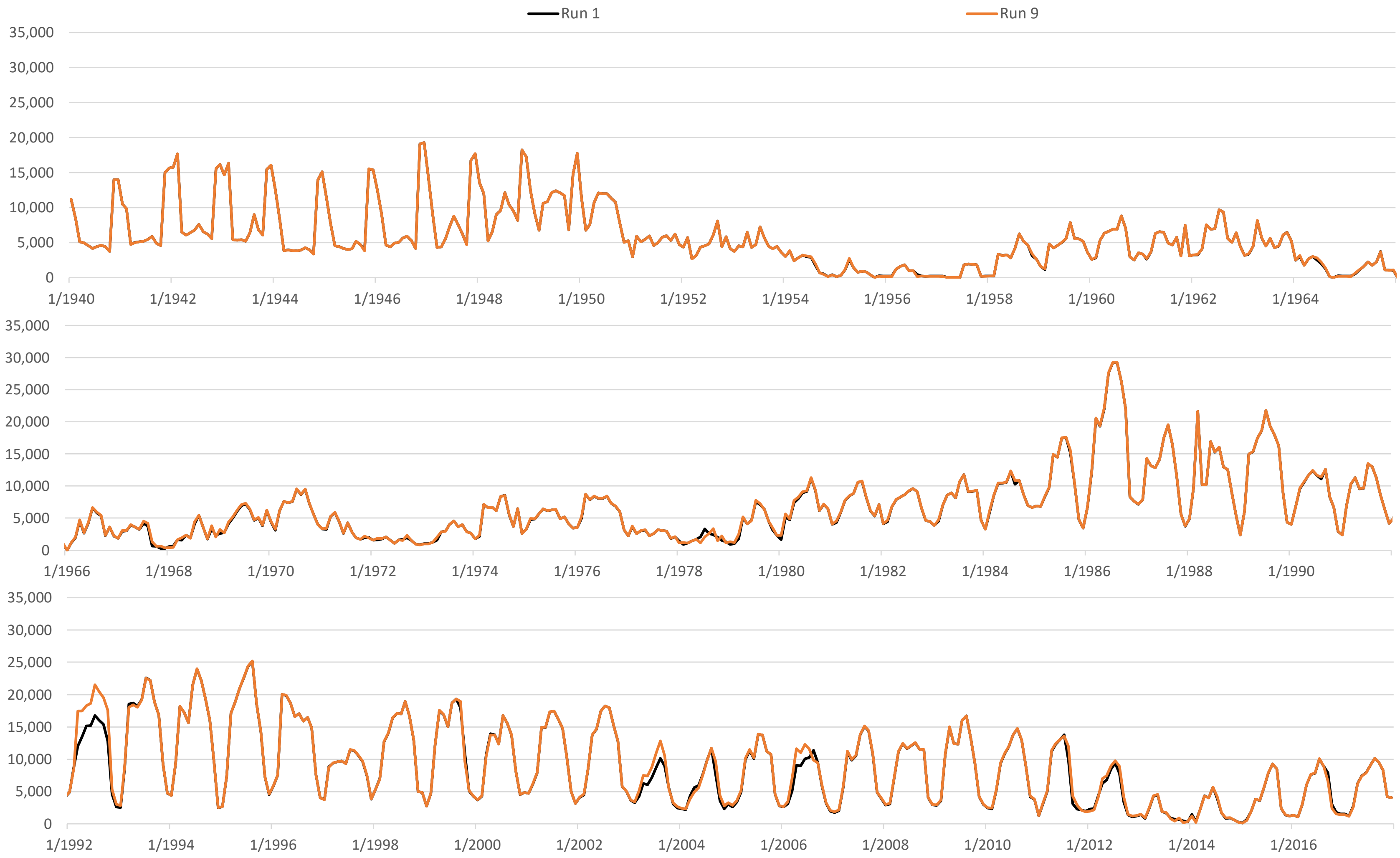


Note: EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).

Run 9 - NM Non-Irrigation Pumping Off
Monthly Net RHG Diversions
Run 9 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)
EPCWID Total

Note: EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

Run 9 - NM Non-Irrigation Pumping Off
Monthly Net RHG Diversions
Run 9 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)
HCCRD Total



Note: HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

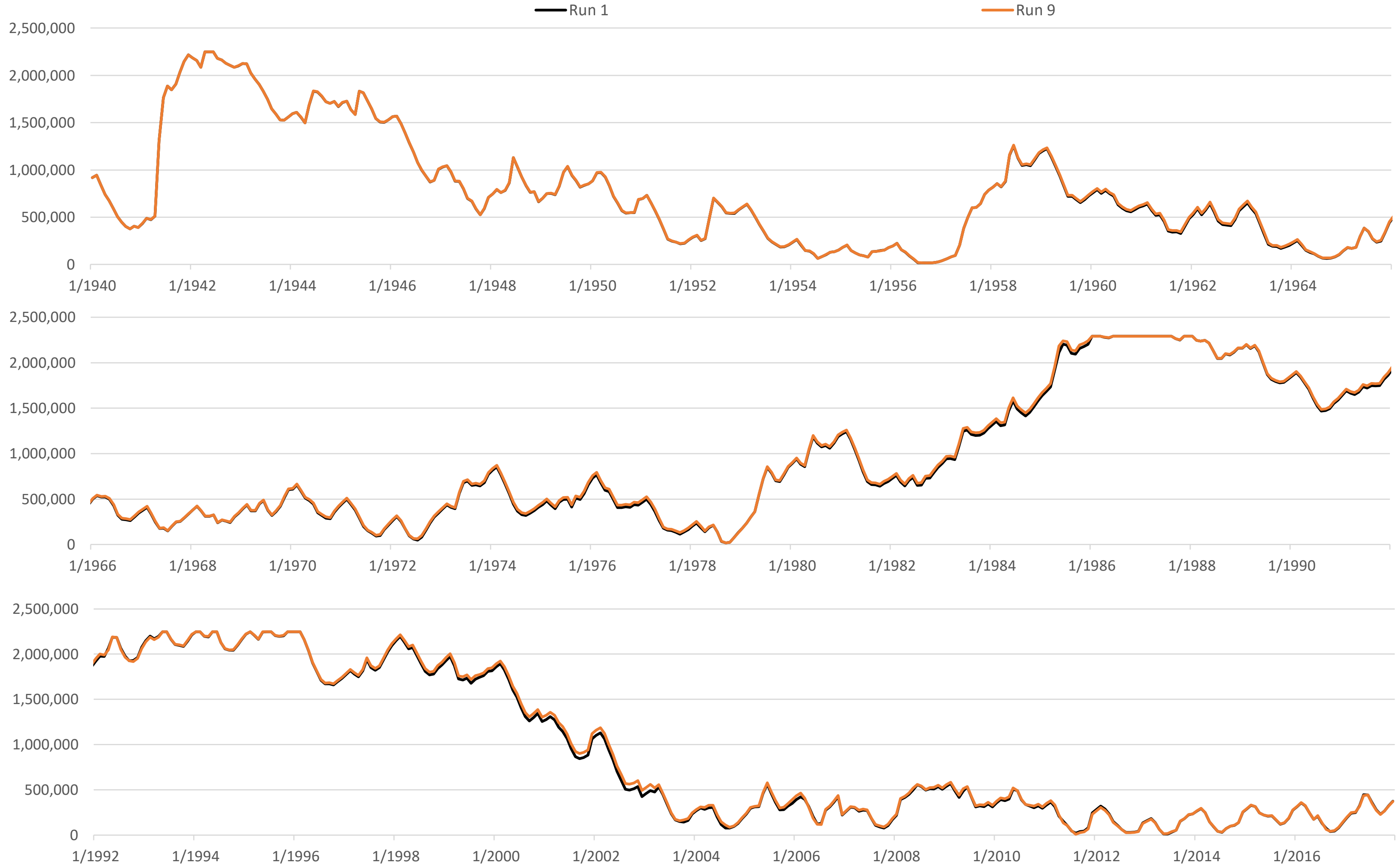
Run 9 - NM Non-Irrigation Pumping Off

End of Month Reservoir Storage (Elephant Butte + Caballo)

Run 9 v. Run 1

ILRG Model

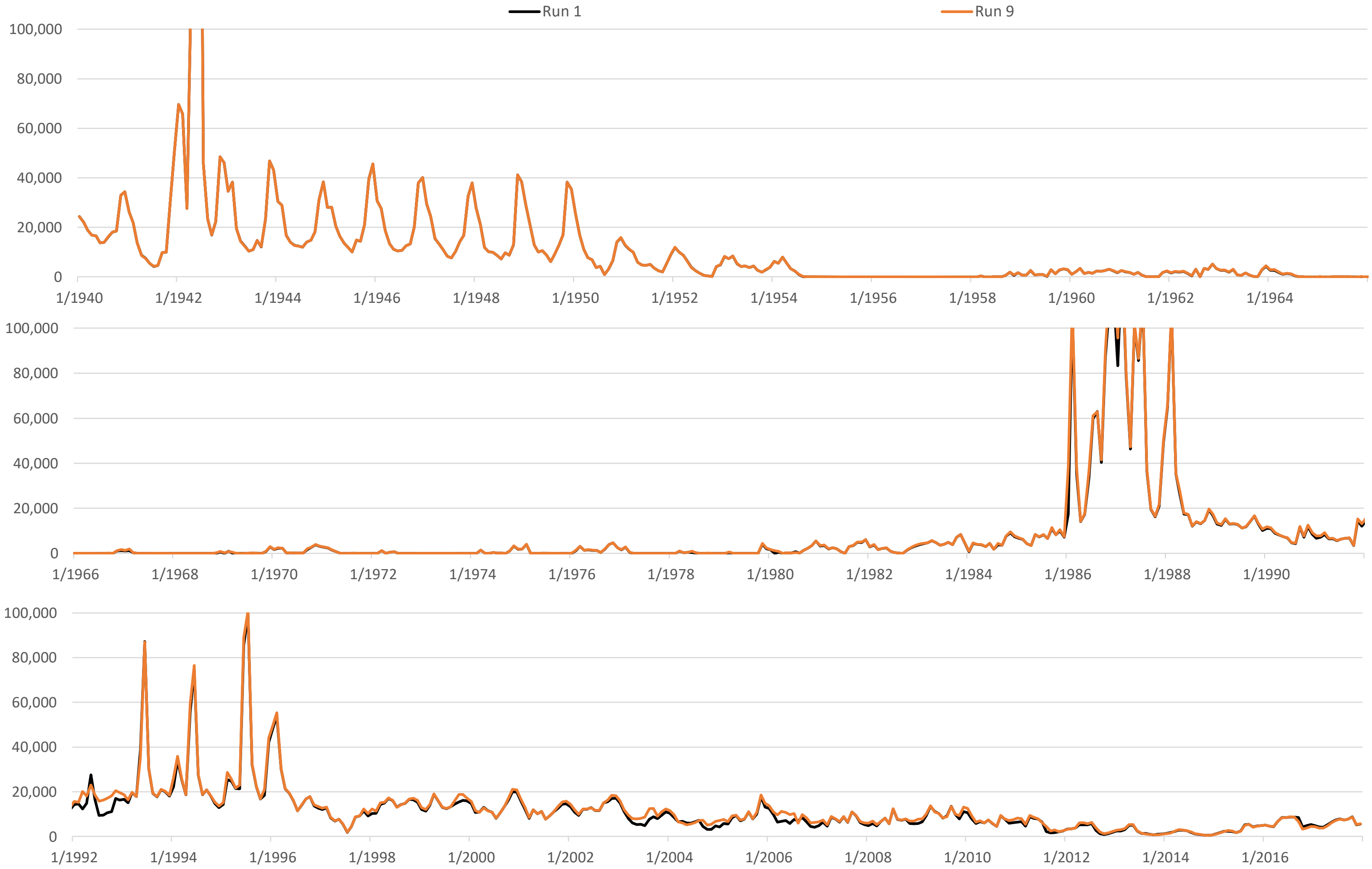
1940 - 2017 (acre-feet)



Run 9 - NM Non-Irrigation Pumping Off
Monthly Caballo Releases
Run 9 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

Run 9 - NM Non-Irrigation Pumping Off
Monthly Rio Grande at El Paso Flow
Run 9 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

Run 9 - NM Non-Irrigation Pumping Off
Monthly Rio Grande at Fort Quitman Flow
Run 9 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)



Appendix 30J

Comparison of ILRG Model Runs
Run 10 v. Run 1

Model Run Specifications

Model Version: LRG_v116

Name: **Run 10 - MX Non-Irrigation Pumping Off**

Run ID: LRG_v116_Operational_Run10
Date: 8/27/2020

Name: **Run 1 - Historical Base Run**

Run ID: LRG_v116_Operational_Run1
Date: 8/23/2020

Selected Model Inputs

Pumping and Returns	**Run 10**	**Run 1**
Irrigation Pumping	On	On
Irrigated Area	Hist	Hist
Non-Irrigation Pumping	MX Off	On
Non-Irrigation Pumping Returns	MX Off	On
Las Cruces Jornada Pumping Returns	On	On

Project Allocation Rules		
1950-2005	D1/D2	D1/D2
2006-2007	D3	D3
2008-2017	D3 + CO	D3 + CO

EPCWID Operations		
Charge EPCWID for Use of WWTP Returns	Off	Off
ACE and Haskell Credits for EPCWID	On	On
Increased EPCWID Use of Fabens Drain Flows	Off	Off
Charge EPCWID for Fabens Drain Flow Use	Off	Off

Run 10 - MX Non-Irrigation Pumping Off
Comparison of ILRG Model Runs
Run 10 v. Run 1
1951 - 2017 Annual Average
(1,000 acre-feet)

Run No.	1	10	10 - 1		
Simulated Input or Output	**Run 1**	**Run 10**	**Run 10 minus Run 1**		
Pumping Stress					
Non-Irrigation Pumping	181.0	109.4	-71.6		
WWTP Flows	58.0	34.3	-23.8		
Urban Deep Percolation	13.1	13.1	0.0		
Total Stress	109.9	62.0	-47.8		
	Stress is Pumping minus WWTP and Urban Deep Perc				
Effects of Pumping Stress				***% Chg***	
FHG Deliveries (Mar - Oct)				***Stress***	***% Diff.***
EBID	167.6	168.0	0.3	*-1%*	*0%*
EPCWID (incl. EPW)	139.9	140.1	0.2	*0%*	*0%*
HCCRD	32.8	32.7	-0.2	*0%*	*0%*
Total	340.3	340.7	0.4	*-1%*	*0%*
FHG Deliveries (Nov - Feb)					
EBID	0.0	0.0	0.0	*0%*	*0%*
EPCWID (incl. EPW)	0.2	0.2	0.0	*0%*	*-4%*
HCCRD	2.4	2.4	0.0	*0%*	*-1%*
Total	2.6	2.6	0.0	*0%*	*-1%*
Irrigation Pumping					
EBID	140.4	140.1	-0.3	*1%*	*0%*
EPCWID (Mesilla Valley)	7.4	7.3	0.0	*0%*	*0%*
EPCWID (El Paso Valley)	40.1	39.9	-0.2	*0%*	*0%*
HCCRD	4.2	4.4	0.2	*0%*	*5%*
	192.1	191.8	-0.3	*1%*	*0%*
	Pumping turned off.	*Other values are simulated responses and are totaled.*			
Other Inflows/Outflows					
Net Reservoir Evaporation	125.3	125.4	0.0	*0%*	*0%*
Riparian ET	70.9	69.8	-1.1	*2%*	*-2%*
River Evaporation + Incidental Canal Loss	30.3	30.2	-0.1	*0%*	*0%*
Total	226.6	225.4	-1.2	*3%*	*-1%*
Rio Grande at Fort Quitman					
Reservoir Spills	33.3	32.0	-1.2	*3%*	*-4%*
Nov-Feb Flows	21.4	19.3	-2.1	*4%*	*-10%*
Mar - Oct Flows	41.1	36.9	-4.1	*9%*	*-10%*
Underflow (GW Model)	0.2	0.2	0.0	*0%*	*-1%*
Total	96.0	88.5	-7.5	*16%*	*-8%*

Run 10 - MX Non-Irrigation Pumping Off

Comparison of ILRG Model Runs

Run 10 v. Run 1
1951 - 2017 Annual Average
(1,000 acre-feet)

Run No.	1	10	10 - 1		
Simulated Input or Output	**Run 1**	**Run 10**	**Run 10 minus Run 1**		
Effects of Pumping Stress (continued)				***% Chg***	
Change in Storage				***Stress***	***% Diff.***
Reservoir Storage	-4.7	-4.8	-0.2	*0%*	*3%*
Alluvial GW Storage (RW Model)	-23.6	-15.4	8.2	*-17%*	*-35%*
Non-alluvial GW Storage (GW Models)	-96.4	-59.7	36.7	*-77%*	*-38%*
Soil Moisture Storage	0.6	0.4	-0.2	*0%*	*-29%*
Total	-124.0	-79.5	44.5	*-93%*	*-36%*
Summary of Effects					
FHG Deliveries (Mar-Oct)	340.3	340.7	0.4	*-1%*	*0%*
FHG Deliveries (Nov-Feb)	2.6	2.6	0.0	*0%*	*-1%*
Irrigation Pumping	192.1	191.8	-0.3	*1%*	*0%*
Riparian ET + Evaporation	226.6	225.4	-1.2	*3%*	*-1%*
Fort Quitman Flow	96.0	88.5	-7.5	*16%*	*-8%*
Change in Storage	-124.0	-79.5	44.5	*-93%*	*-36%*
Total	733.6	769.5	35.9	*-75%*	*5%*
Other Effects of Pumping Stress				***% Chg***	
Rio Grande at El Paso				***Stress***	***% Diff.***
Reservoir Spills	49.4	49.6	0.2	*0%*	*0%*
Nov-Feb Flows	22.8	22.5	-0.3	*1%*	*-1%*
Mar - Oct Flows	263.8	263.9	0.1	*0%*	*0%*
Total	336.0	336.0	0.1	*0%*	*0%*
Rio Grande below Caballo					
Reservoir Spills	65.9	65.7	-0.1	*0%*	*0%*
Nov-Feb Flows	0.5	0.3	-0.2	*0%*	*-43%*
Mar - Oct Flows	541.3	541.7	0.4	*-1%*	*0%*
Total	607.6	607.7	0.1	*0%*	*0%*
Surface Water Diversions (Mar - Oct)					
EBID	366.5	366.7	0.3	*-1%*	*0%*
EPCWID (incl. EPW)	236.8	237.5	0.7	*-2%*	*0%*
HCCRD	67.5	66.1	-1.5	*3%*	*-2%*
Total	670.8	670.3	-0.5	*1%*	*0%*
Surface Water Diversions (Nov - Feb)					
EBID	0.0	0.0	0.0	*0%*	*0%*
EPCWID (incl. EPW)	14.3	14.3	0.0	*0%*	*0%*
HCCRD	14.2	13.3	-0.9	*2%*	*-6%*
Total	28.5	27.7	-0.9	*2%*	*-3%*

Run 10 - MX Non-Irrigation Pumping Off
Annual Differences in ILRG Model Outputs
Run 10 minus Run 1
1940 - 2017 (acre-feet)

	Net River Headgate Diversions						Farm Headgate Deliveries						Annual Flows		
	EBID		EPCWID (incl. EPW)		HCCRD		EBID		EPCWID (incl. EPW)		HCCRD				
Year	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Caballo Releases	Rio Grande at El Paso	Rio Grande at Fort Quitman
1940	3	3	-154	465	-246	79	-13	-13	464	514	-223	-223	-4,020	-3,820	144
1941	-110	-110	-662	84	-255	34	0	1	-34	97	-223	-157	3,492	2,242	4,426
1942	-4	-4	-302	480	108	100	3	4	-273	116	70	87	-682	492	3,928
1943	6	6	-310	268	45	159	-10	-10	-257	-158	78	236	-1,902	-1,842	210
1944	14	14	-294	87	-215	-113	-7	-7	154	240	-178	-70	-2,066	-2,001	23
1945	11	11	-224	208	-258	-53	-8	-8	148	258	-239	-85	-2,041	-2,004	-74
1946	5	5	-299	319	-157	29	-11	-11	101	389	-156	-203	-2,077	-2,041	-57
1947	8	8	-552	-6	-189	-166	-10	-10	-89	261	-159	-170	-2,331	-2,289	-249
1948	13	13	-398	130	-181	-63	-8	-8	61	295	-76	-45	-2,302	-2,263	-630
1949	13	13	-192	383	-193	19	-5	-5	239	367	13	28	-2,220	-2,190	-503
1950	1	1	-286	-97	-116	17	-6	-6	97	97	12	21	-2,051	-2,013	586
1951	1,018	1,018	-123	-139	-97	-98	554	555	224	224	-73	-68	-1,130	-1,431	-453
1952	172	172	146	137	9	9	315	314	237	235	7	42	-4,893	-3,444	-65
1953	157	157	-84	-85	-99	-74	960	959	256	255	-60	-41	-1,209	-2,102	-837
1954	1,308	1,308	1,060	840	316	99	4,685	4,685	4,299	4,298	265	136	-412	4,551	961
1955	8,538	8,538	6,125	5,932	-793	-1,045	4,405	4,405	4,220	4,166	-746	-880	18,980	9,096	306
1956	-3,239	-3,239	-1,878	-1,878	-494	-515	-2,376	-2,376	-1,642	-1,753	-683	-703	-5,511	-2,335	2
1957	-6	-6	102	101	61	-36	-13	-13	-119	-174	-21	-116	79	14	0
1958	-3	-3	807	785	91	-30	5	5	123	68	-19	-13	5	839	-197
1959	-1	-1	433	444	-1,165	-2,028	6	6	16	16	4	14	297	462	-2,015
1960	1	1	364	438	-461	-681	-2	-2	163	163	0	0	-1,890	-1,625	-965
1961	1	1	177	304	-374	-477	-4	-4	807	807	-116	223	-2,950	-2,641	-452
1962	0	0	344	462	-339	-469	-8	-8	264	264	40	157	-3,412	-3,184	-585
1963	4,694	4,694	340	520	-559	-699	2,615	2,615	450	451	-318	-320	-740	-2,562	76
1964	4,098	4,098	2,985	3,194	-69	-118	2,402	2,402	1,862	1,689	25	15	4,244	2,564	-973
1965	1,340	1,340	838	840	103	-351	626	626	-15	-148	-50	-473	614	1,284	36
1966	-7	-7	564	850	-819	-1,633	47	47	5	5	-969	-98	-969	76	-1,004
1967	1,308	1,308	1,282	1,425	-183	-309	784	784	533	430	-775	-536	554	269	-406
1968	831	831	283	305	220	-87	615	615	80	-27	198	312	418	528	-222
1969	0	0	566	619	-455	-1,127	44	44	2	2	-497	-364	-597	-123	-901
1970	-1	-1	681	730	-629	-1,358	10	10	3	3	308	491	-907	-688	-1,767
1971	1,289	1,289	375	582	-665	-797	827	827	182	182	-419	-285	-108	-544	-400
1972	-4,722	-4,722	-3,322	-3,305	-474	-737	594	594	-1,532	-1,571	-441	-687	-9,520	-3,062	163
1973	-2	-2	1,267	1,265	-555	-572	-302	-302	-171	-218	-655	-547	4,867	1,081	9
1974	7	7	927	905	16	-66	-74	-74	66	66	-53	-188	604	86	-465
1975	-10	-10	832	856	627	579	71	71	3	3	584	560	120	3	-141
1976	-2	-2	952	986	997	985	143	143	59	59	-4	-15	-116	-173	582
1977	2,364	2,364	688	966	11	-156	1,493	1,493	158	158	-54	-185	1,254	198	42
1978	1,319	1,319	940	1,129	189	-1,010	728	728	516	516	131	-1,130	1,701	1,358	206

Run 10 - MX Non-Irrigation Pumping Off
Annual Differences in ILRG Model Outputs
Run 10 minus Run 1
1940 - 2017 (acre-feet)

	Net River Headgate Diversions						Farm Headgate Deliveries						Annual Flows		
	EBID		EPCWID (incl. EPW)		HCCRD		EBID		EPCWID (incl. EPW)		HCCRD				
Year	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Caballo Releases	Rio Grande at El Paso	Rio Grande at Fort Quitman
1979	9	9	584	790	221	-1,222	25	25	-42	-42	49	-1,442	978	1,292	65
1980	-4	-4	1,162	1,197	-1,776	-4,534	14	14	0	0	-1,055	-1,613	531	787	-4,135
1981	-1	-1	1,122	1,137	-3,504	-6,660	-12	-12	-2	-2	287	287	1,029	994	-7,234
1982	-3	-3	1,094	1,110	-2,613	-4,142	9	9	0	0	-43	1,617	1,178	1,153	-5,834
1983	-4	-4	1,185	1,203	-1,573	-2,636	11	11	0	0	0	0	1,184	1,263	-3,619
1984	-7	-7	1,790	1,810	-749	-1,912	10	10	0	0	0	0	2,456	2,305	-2,039
1985	22	22	2,268	2,272	-4,681	-5,751	1,550	1,549	296	255	0	0	-5,152	-4,601	-5,735
1986	14	14	1,835	1,853	-1,201	-2,186	90	90	-13	-13	0	0	-399	-593	-9,577
1987	8	8	1,767	1,778	-1,387	-2,360	3	3	-4	-4	0	0	-4	-130	-67,805
1988	-2	-2	2,437	2,449	-1,184	-2,154	12	12	1	1	0	0	1,607	1,531	-7,888
1989	-5	-5	3,099	3,074	-1,016	-1,980	22	22	71	-6	0	0	4,285	4,021	-5,392
1990	-40	-40	3,135	3,062	440	-623	156	156	72	-76	0	0	2,986	3,407	-2,116
1991	-47	-47	2,997	2,935	-1,530	-2,531	-144	-144	5	-48	0	0	2,782	2,808	-7,353
1992	-367	-367	2,573	2,551	-3,455	-4,556	1,725	1,726	-246	-246	0	0	2,406	1,009	-14,524
1993	-183	-183	923	881	-2,052	-3,218	115	115	-1,524	-1,526	0	0	-12,942	-11,251	-25,494
1994	-203	-203	947	896	-2,094	-3,438	-23	-23	-970	-972	0	0	-4,963	-3,882	-20,135
1995	-287	-287	1,076	1,064	-2,264	-3,756	101	101	-900	-838	0	0	7,215	5,918	-11,530
1996	-33	-33	3,381	3,316	-1,636	-2,788	344	344	32	32	0	0	766	1,649	-9,785
1997	-4	-4	2,537	2,789	-2,053	-3,492	3	3	162	702	0	0	1,481	1,505	-9,453
1998	-5	-5	2,349	2,242	-1,981	-3,231	17	17	-357	-272	0	0	1,251	1,253	-8,242
1999	-69	-69	90	20	-2,701	-3,980	5	5	-1,339	-1,294	0	0	0	179	-8,171
2000	-3	-3	3,621	3,543	-2,356	-3,643	14	14	1,118	1,118	0	0	4,173	3,877	-8,345
2001	-10	-10	1,330	1,255	-2,768	-4,029	5	5	1	1	0	0	1,554	1,546	-8,225
2002	-7	-7	1,127	1,050	-2,732	-4,027	7	7	3	2	0	0	1,397	1,375	-10,153
2003	-6,085	-6,085	-327	-463	-2,925	-4,179	-3,695	-3,695	-417	-419	0	0	-3,391	-1,207	-15,266
2004	-1,819	-1,819	-1,429	-1,560	-3,181	-4,585	-1,160	-1,160	-513	-514	0	0	-1,782	-1,905	-16,014
2005	-58	-58	38	-56	-3,324	-4,799	-99	-99	-68	-69	0	0	1,110	183	-10,936
2006	-1,098	-1,098	-2,202	-2,325	-3,411	-4,759	-585	-585	-1,363	-1,364	0	0	-4,167	-3,135	-9,904
2007	-880	-880	156	42	-3,421	-4,825	-497	-497	714	713	0	0	1,266	482	-14,871
2008	1,097	1,097	-1,520	-1,644	-2,289	-3,446	737	737	-377	-377	0	0	-1,241	-1,360	-9,883
2009	1,732	1,732	-922	-1,050	-3,179	-4,435	666	666	-195	-195	0	0	-125	-631	-7,422
2010	2,796	2,796	-868	-990	-3,040	-4,194	1,846	1,846	-5	-5	0	0	357	-486	-7,871
2011	1,737	1,737	296	182	1,617	-347	929	929	1,018	1,018	0	0	1,968	821	-7,858
2012	-5	-5	192	76	468	-1,081	108	108	1,615	1,615	0	0	614	399	-14,424
2013	-1,147	-1,147	-268	-380	-4,022	-4,980	-625	-625	1,172	1,172	-2,418	-2,710	-397	-27	-19,363
2014	773	773	-1,407	-1,520	-3,409	-2,989	741	741	216	216	-4,122	-3,947	-241	-1,012	-16,029
2015	-603	-603	-3,312	-3,433	-6,397	-8,128	-794	-794	-7	-7	753	645	-4,661	-3,120	-30,741
2016	-555	-555	2,429	2,298	-5,537	-7,591	-115	-115	4,186	4,187	0	0	6,748	3,557	-27,554
2017	3,353	3,353	-4,895	-5,038	-5,003	-6,610	2,018	2,018	-274	-274	0	0	-4,347	-4,956	-21,492
Averages															
1951-2017	275	275	717	711	-1,482	-2,367	339	339	196	189	-163	-177	103	52	-7,490
1951-1978	730	730	631	686	-200	-457	684	684	395	363	-157	-168	-22	-54	-338
1979-2005	-340	-340	1,582	1,563	-2,077	-3,423	-33	-33	-172	-157	-28	-43	435	536	-11,294
2006-2017	600	600	-1,027	-1,149	-3,135	-4,449	369	369	558	558	-482	-501	-352	-789	-15,618
1985-2017	-60	-60	711	641	-2,536	-3,779	105	105	64	76	-175	-182	5	-84	-14,229
1985-2005	-437	-437	1,704	1,664	-2,194	-3,396	-45	-45	-219	-199	0	0	209	319	-13,435

Notes:

EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).

EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

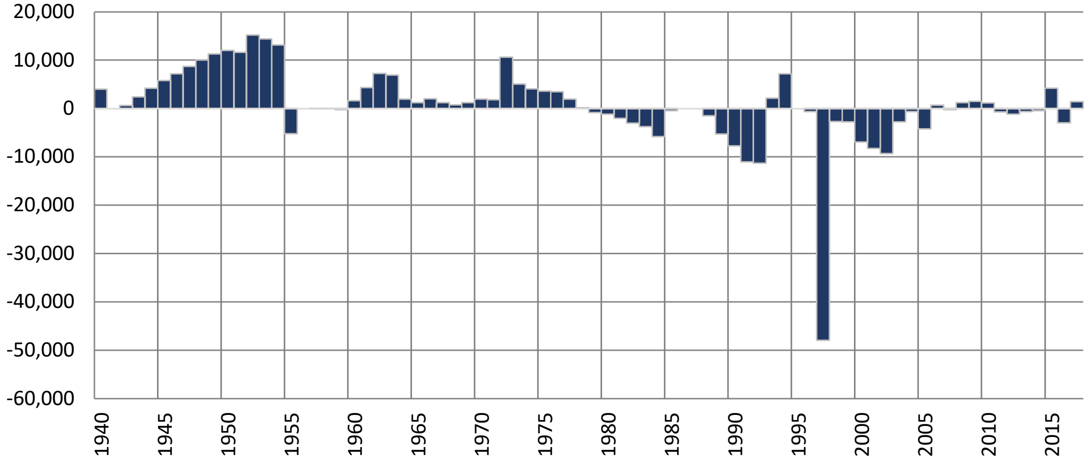
Run 10 - MX Non-Irrigation Pumping Off

Simulated Differences in ILRG Model Outputs

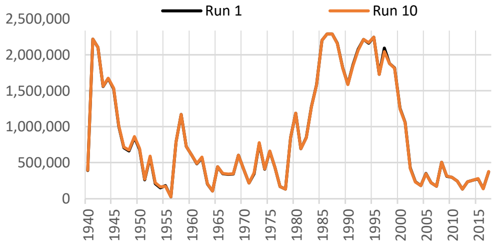
Run 10 minus Run 1

1940 - 2017 (acre-feet)

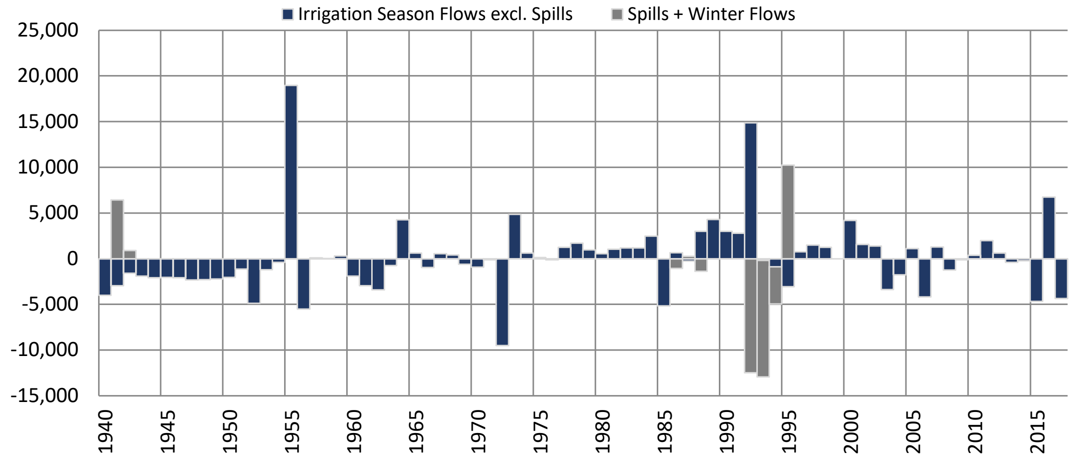
Total Project Storage (Year End)



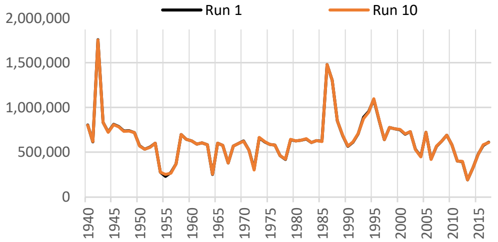
Period	Average Difference
1951-2017	-158
1951-1978	-425
1979-2005	-160
2006-2017	469
1985-2017	220
1985-2005	78



Caballo Reservoir Outflows (Annual)



Period	Average Difference Irr Season (excl. Spills)	Nov-Feb and Spills	Annual
1951-2017	419	-317	103
1951-1978	-22	0	-22
1979-2005	1,220	-785	435
2006-2017	-352	0	-352
1985-2017	647	-643	5
1985-2005	1,218	-1,010	209



Notes:

Reservoir storage does not include storage attributed to SJC, CO, or NM credit waters.

Average differences calculated as (Final Storage - Initial Storage)/(no. years).

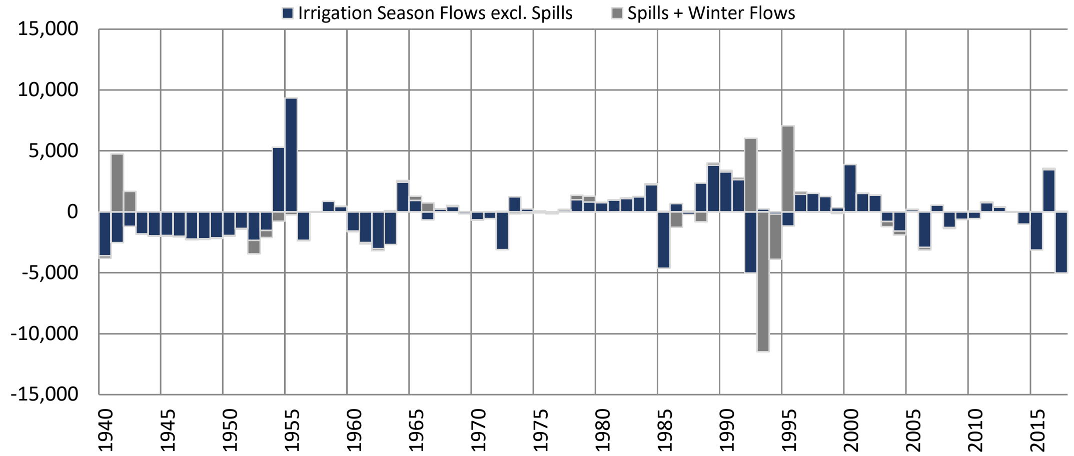
Run 10 - MX Non-Irrigation Pumping Off

Simulated Differences in ILRG Model Outputs

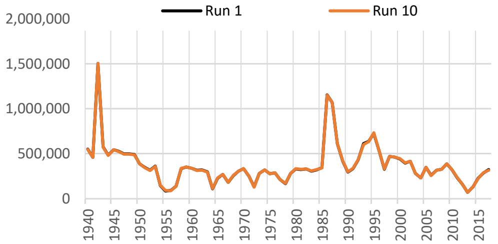
Run 10 minus Run 1

1940 - 2017 (acre-feet)

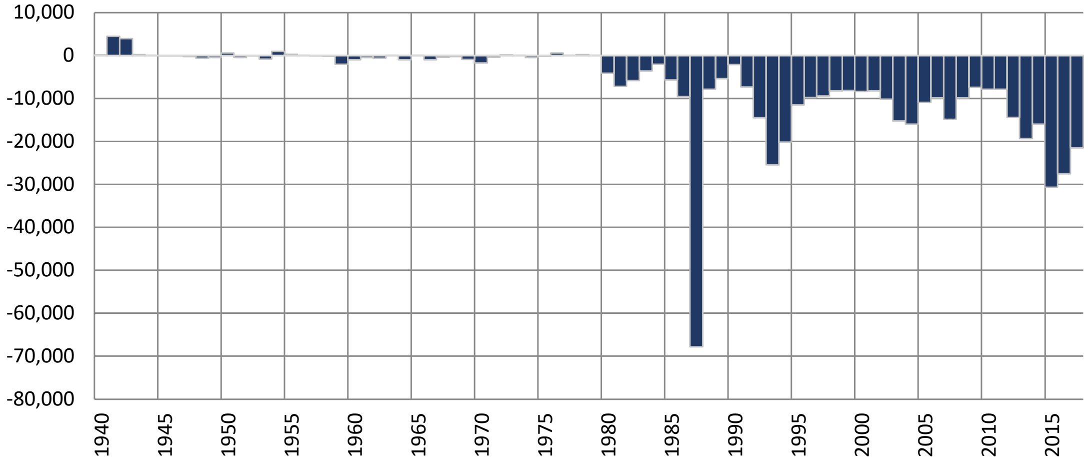
Rio Grande at El Paso (Annual)



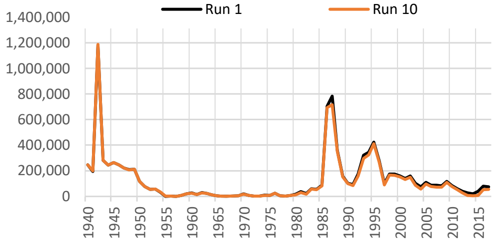
	Average Difference		
Period	Irr Season (excl. Spills)	Nov-Feb and Spills	Annual
1951-2017	130	-78	52
1951-1978	3	-57	-54
1979-2005	667	-131	536
2006-2017	-781	-8	-789
1985-2017	47	-131	-84
1985-2005	520	-201	319



Rio Grande at Fort Quitman (Annual)



Period	Average Difference
1951-2017	-7,487
1951-1978	-340
1979-2005	-11,290
2006-2017	-15,609
1985-2017	-14,224
1985-2005	-13,433



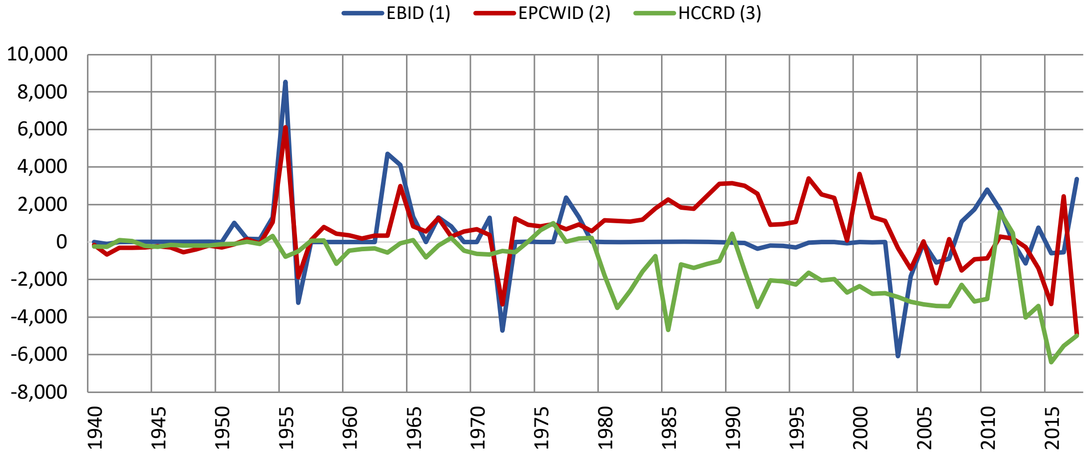
Run 10 - MX Non-Irrigation Pumping Off

Simulated Differences in ILRG Model Outputs

Run 10 minus Run 1

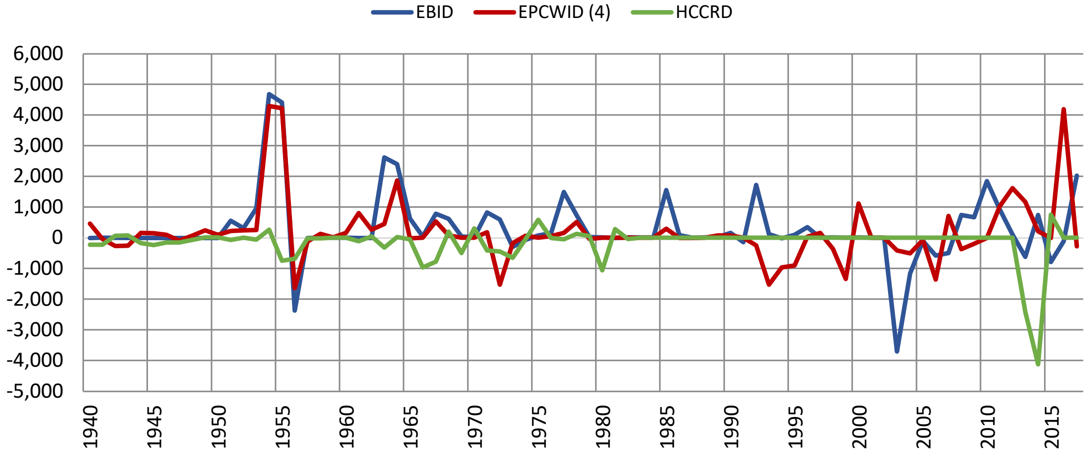
1940 - 2017 (acre-feet)

River Headgate (RHG) Diversions (Irrigation Season)



	Average Difference		
Period	EBID	EPCWID	HCCRD
1951-2017	275	717	-1,482
1951-1978	730	631	-200
1979-2005	-340	1,582	-2,077
2006-2017	600	-1,027	-3,135
1985-2017	-60	711	-2,536
1985-2005	-437	1,704	-2,194

Farm Headgate (FHG) Deliveries (Irrigation Season)



	Average Difference		
Period	EBID	EPCWID	HCCRD
1951-2017	339	196	-163
1951-1978	684	395	-157
1979-2005	-33	-172	-28
2006-2017	369	558	-482
1985-2017	105	64	-175
1985-2005	-45	-219	0

Notes:

(1) EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).

(2) EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

(3) HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

(4) EPCWID FHG values include deliveries to Rogers WTP and R/U WTP.

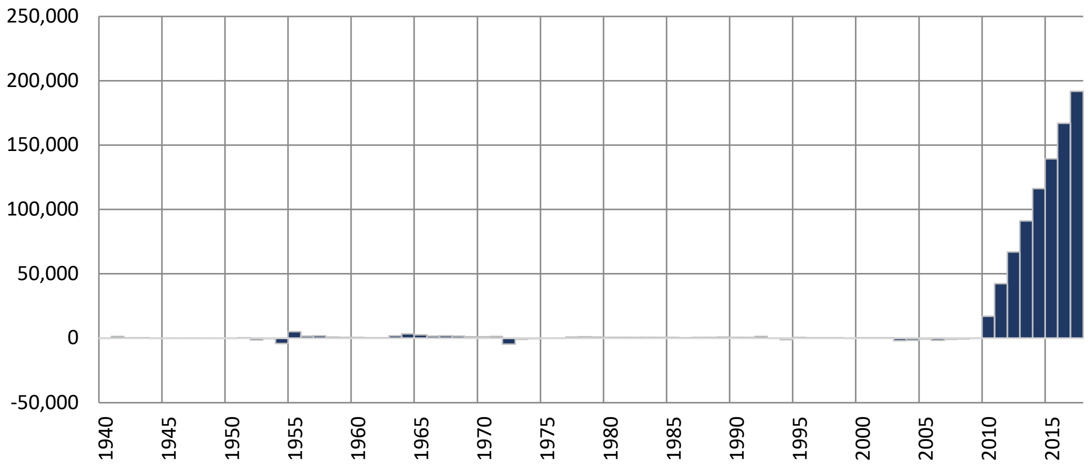
Run 10 - MX Non-Irrigation Pumping Off

Simulated Differences in ILRG Model Outputs

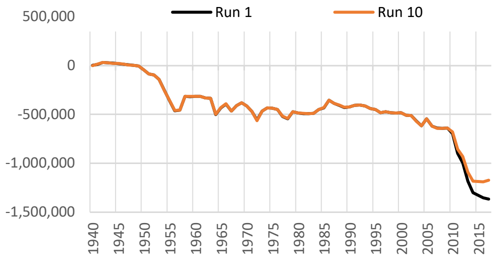
Run 10 minus Run 1

1940 - 2017 (acre-feet)

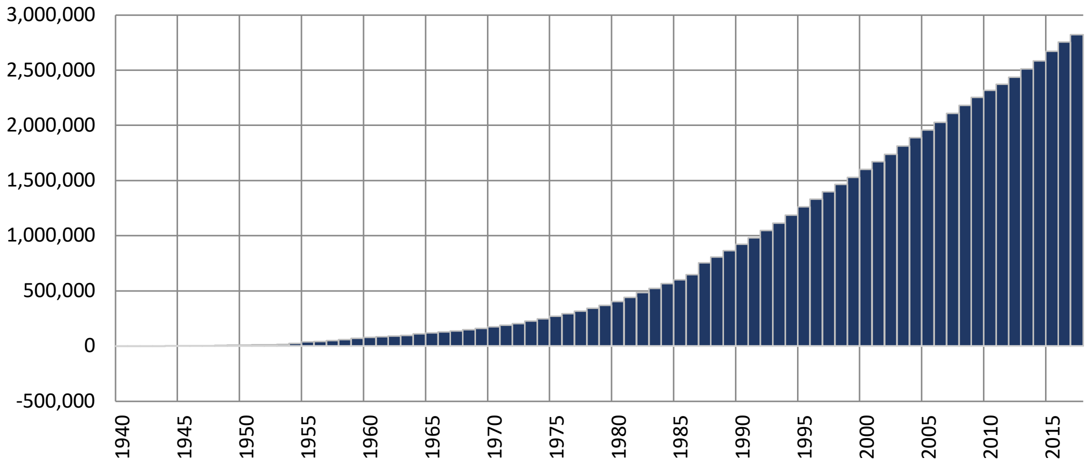
Cumulative Annual Rincon-Mesilla Groundwater Storage



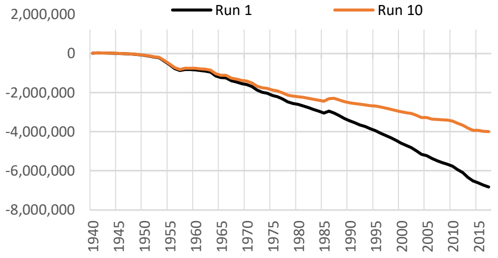
Period	Average Difference
1951-2017	2,863
1951-1978	41
1979-2005	-69
2006-2017	16,044
1985-2017	5,794
1985-2005	-63



Cumulative Annual Hueco Groundwater Storage



Period	Average Difference
1951-2017	42,005
1951-1978	11,923
1979-2005	59,878
2006-2017	71,980
1985-2017	68,434
1985-2005	66,408



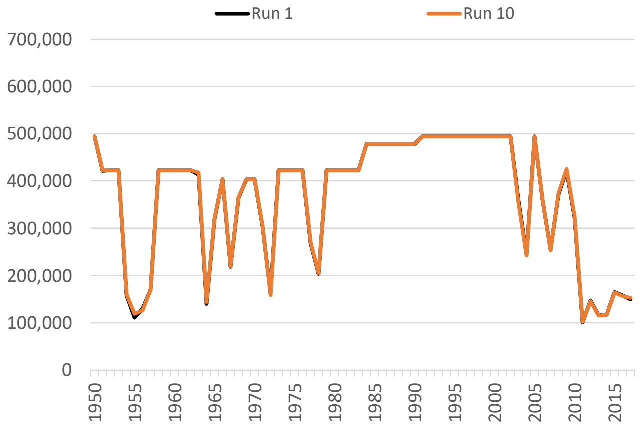
Notes:

Cumulative storage change in alluvial and non-alluvial aquifers.

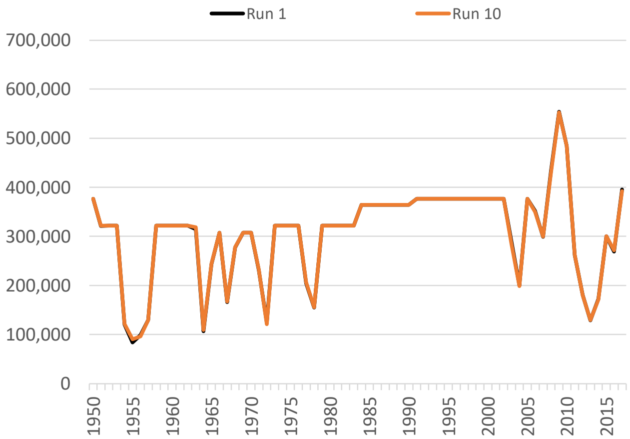
Average differences calculated as (Final Storage - Initial Storage)/(no. years).

Run 10 - MX Non-Irrigation Pumping Off
Annual Allocation and Charges
Run 10 v. Run 1
ILRG Model
1950 - 2017 (acre-feet)

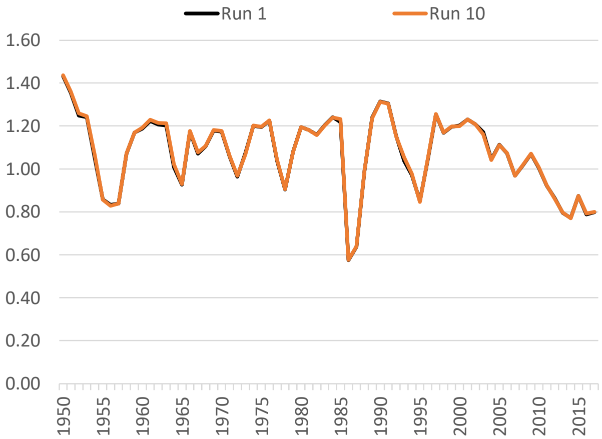
Total Allocation - EBID



Total Allocation - EPCWID



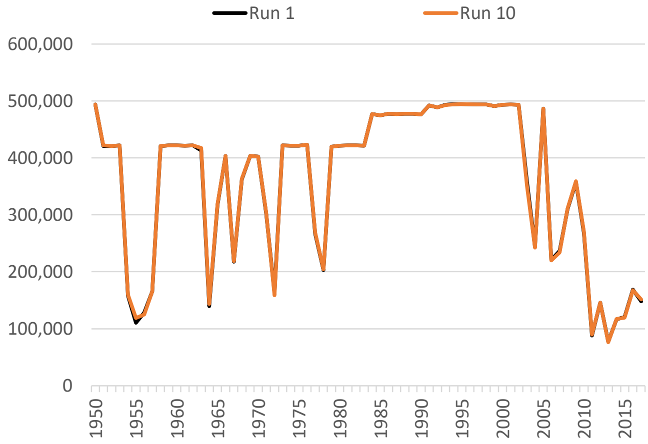
Diversion Ratio



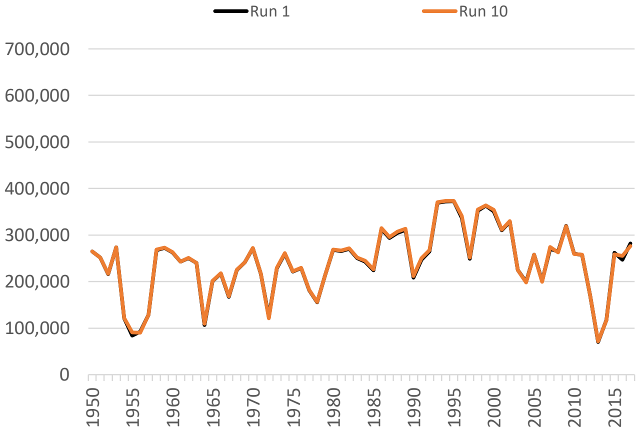
Note:

Computed as Total Charges/Caballo Release.

Annual Delivery Charges - EBID



Annual Delivery Charges - EPCWID



Run 10 - MX Non-Irrigation Pumping Off

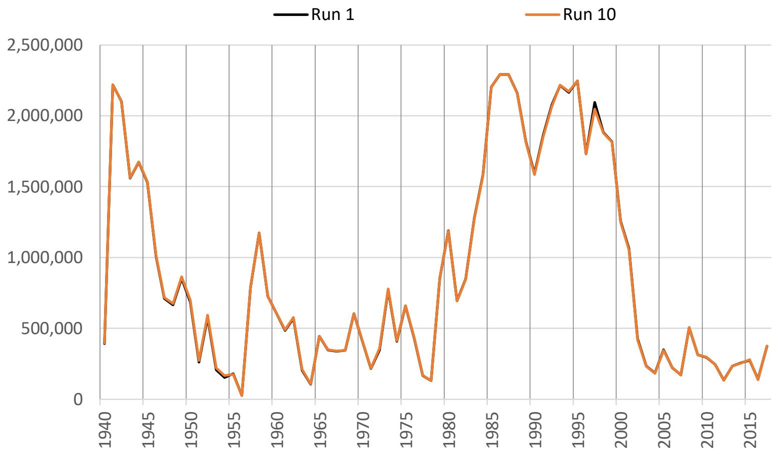
Annual Summary of Project Storage and Rio Grande Flows

Run 10 v. Run 1

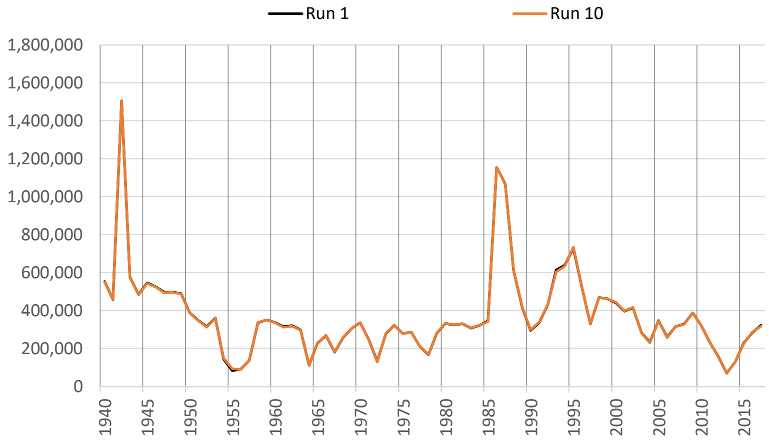
ILRG Model

1940 - 2017 (acre-feet)

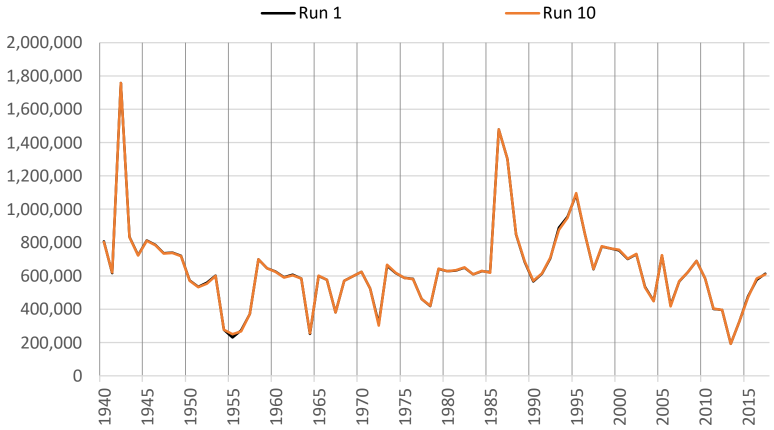
Total Year-End Project Reservoir Storage



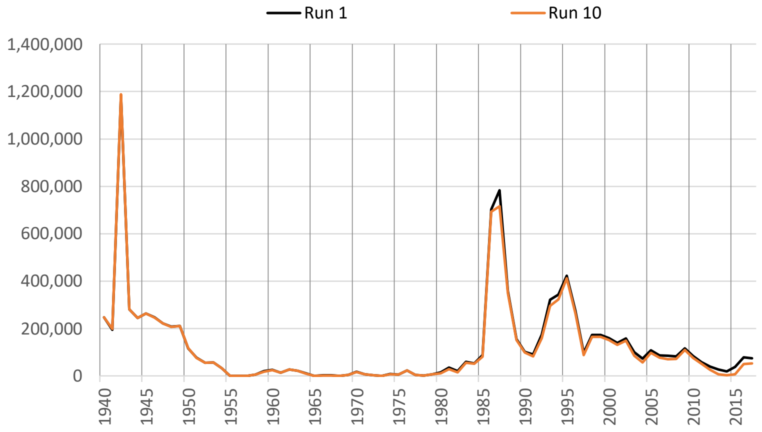
Rio Grande at El Paso



Rio Grande Below Caballo



Rio Grande at Fort Quitman



***Note different scales.**

Run 10 - MX Non-Irrigation Pumping Off

Irrigation Season Summary of Irrigation Operations

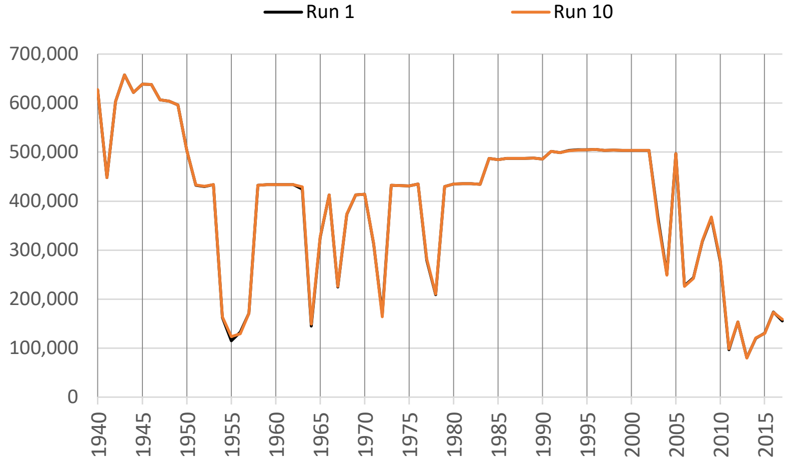
Run 10 v. Run 1

ILRG Model

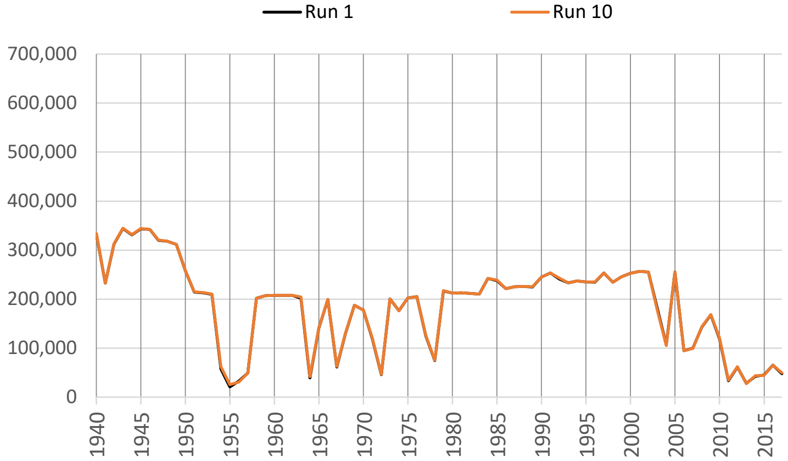
1940 - 2017 (acre-feet)

EBID Total

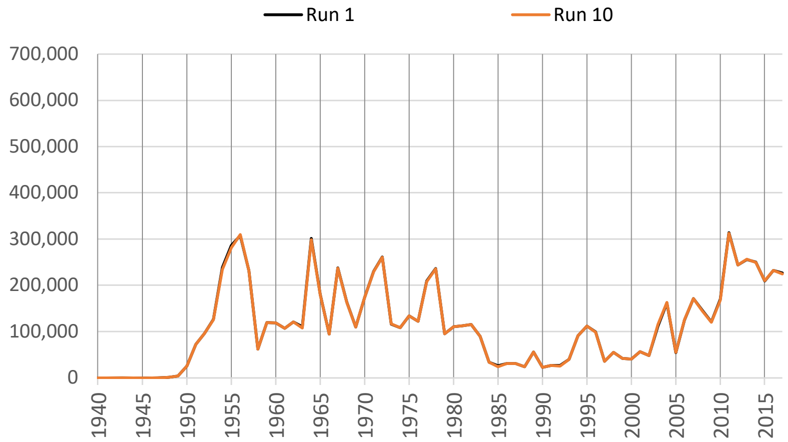
Net River Headgate Diversions



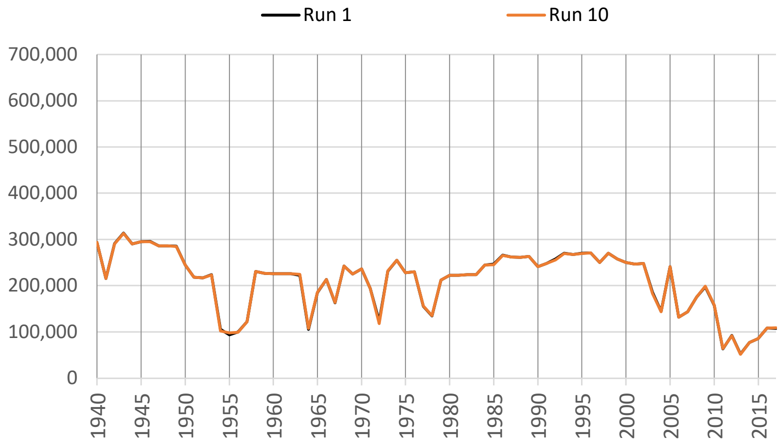
Farm Headgate Deliveries



Pumping



RHG Diversions - FHG Deliveries

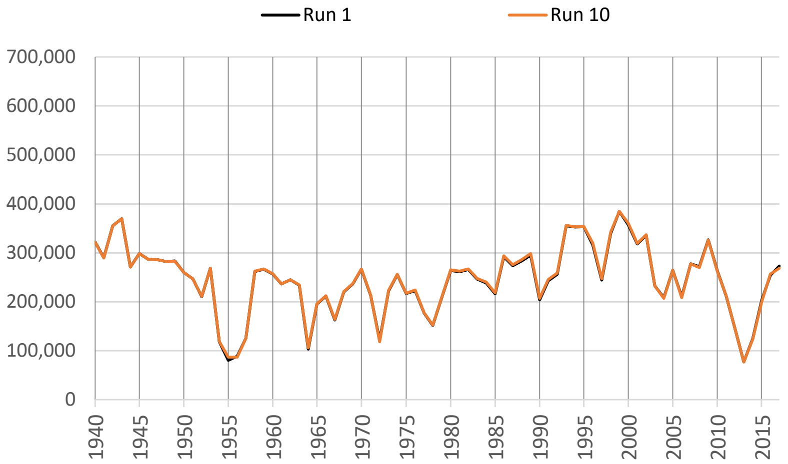


Notes: EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).
Pumping includes Supplemental and Primary groundwater pumping.

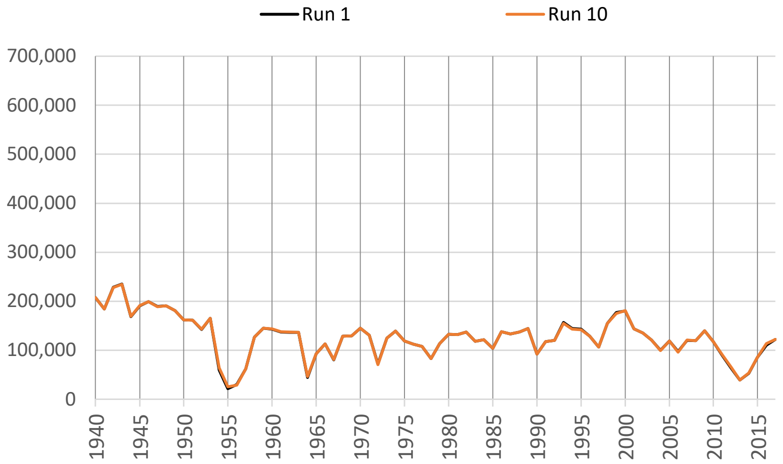
Run 10 - MX Non-Irrigation Pumping Off
Irrigation Season Summary of Irrigation Operations
Run 10 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

EPCWID Total

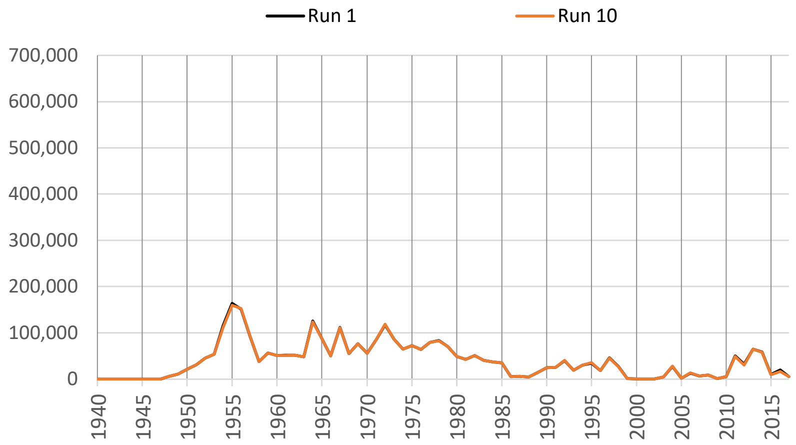
Net River Headgate Diversions



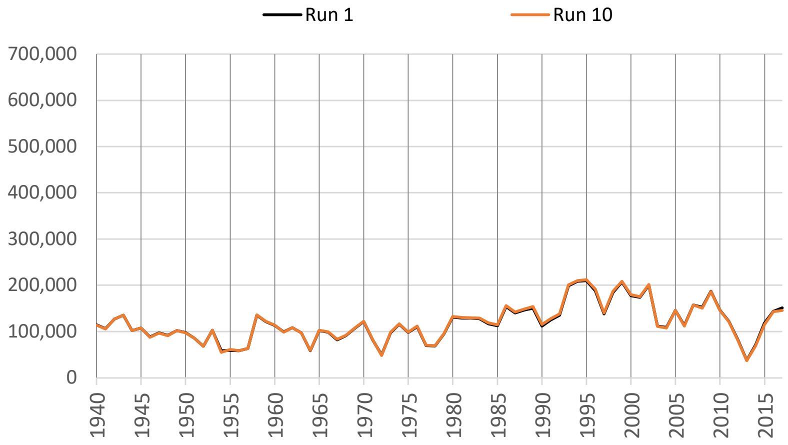
Farm Headgate Deliveries



Pumping



RHG Diversions - FHG Deliveries

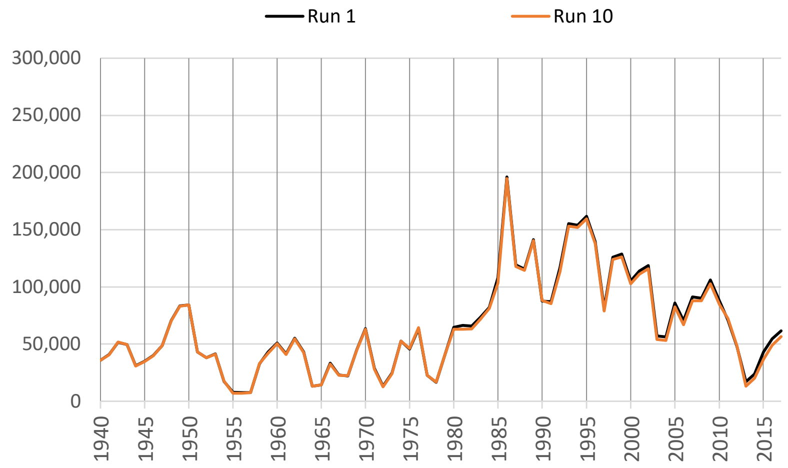


Note: EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

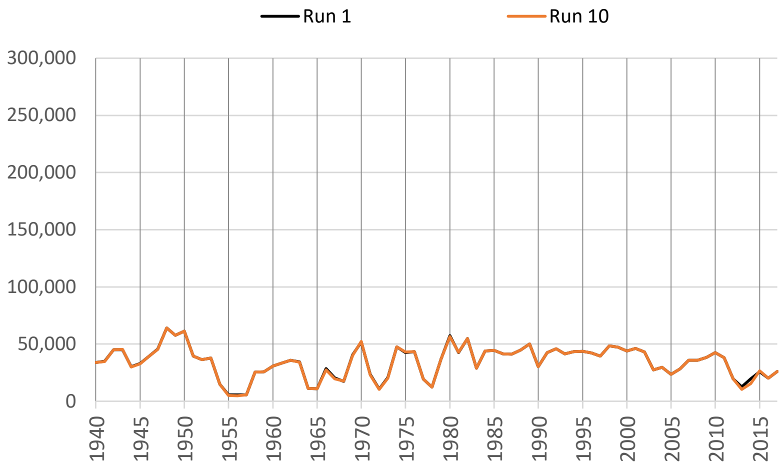
Run 10 - MX Non-Irrigation Pumping Off
Irrigation Season Summary of Irrigation Operations
Run 10 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

HCCRD Total

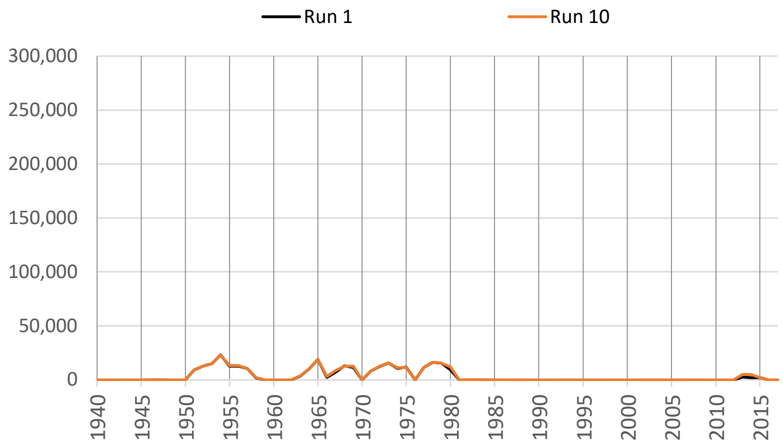
Net River Headgate Diversions



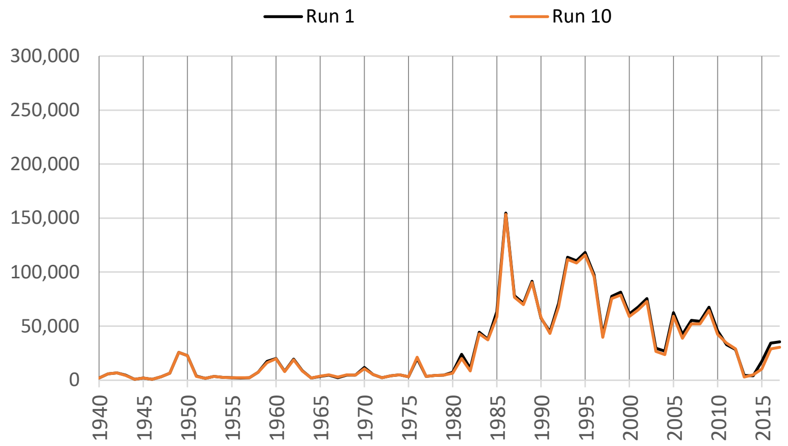
Farm Headgate Deliveries



Pumping



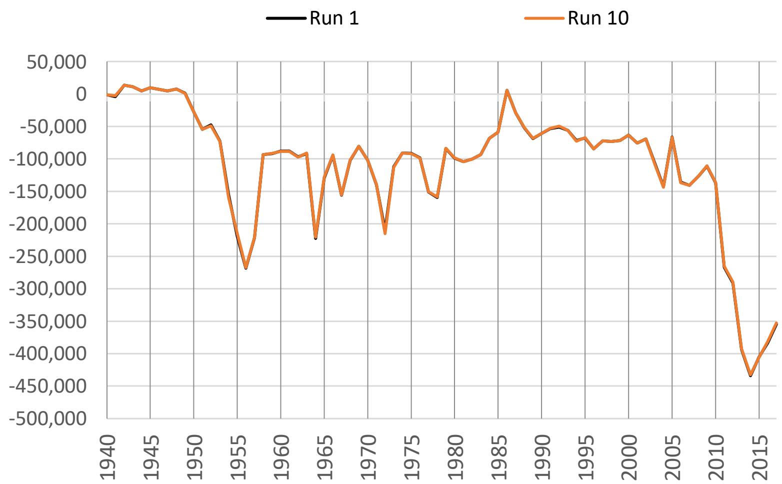
RHG Diversions - FHG Deliveries



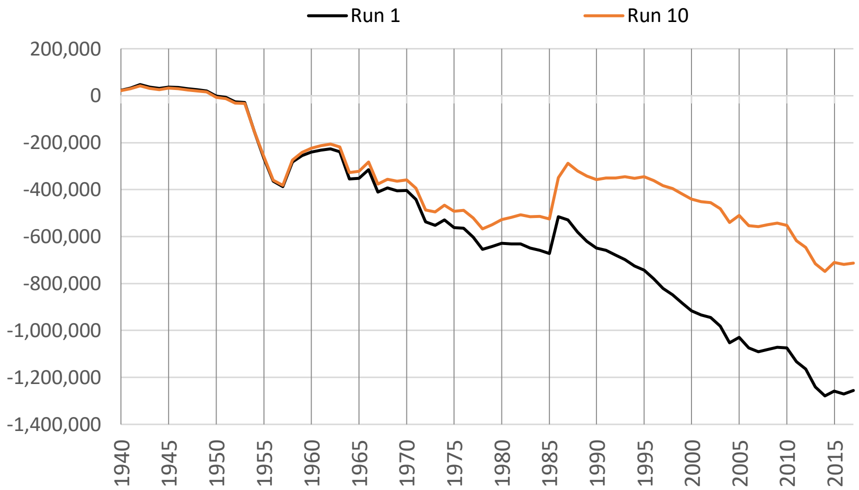
Note: HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

Run 10 - MX Non-Irrigation Pumping Off
Cumulative Change in Ground Water Storage
Run 10 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

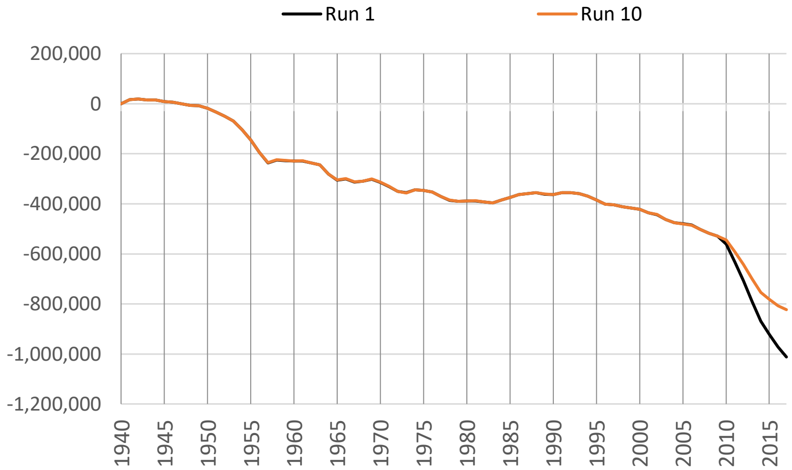
Rincon-Mesilla Alluvial Aquifer



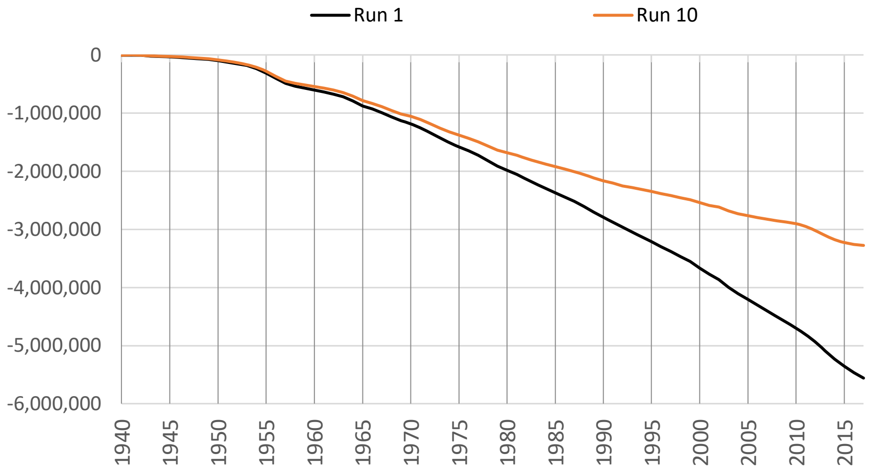
Hueco Alluvial Aquifer



Rincon-Mesilla Non-Alluvial Aquifer

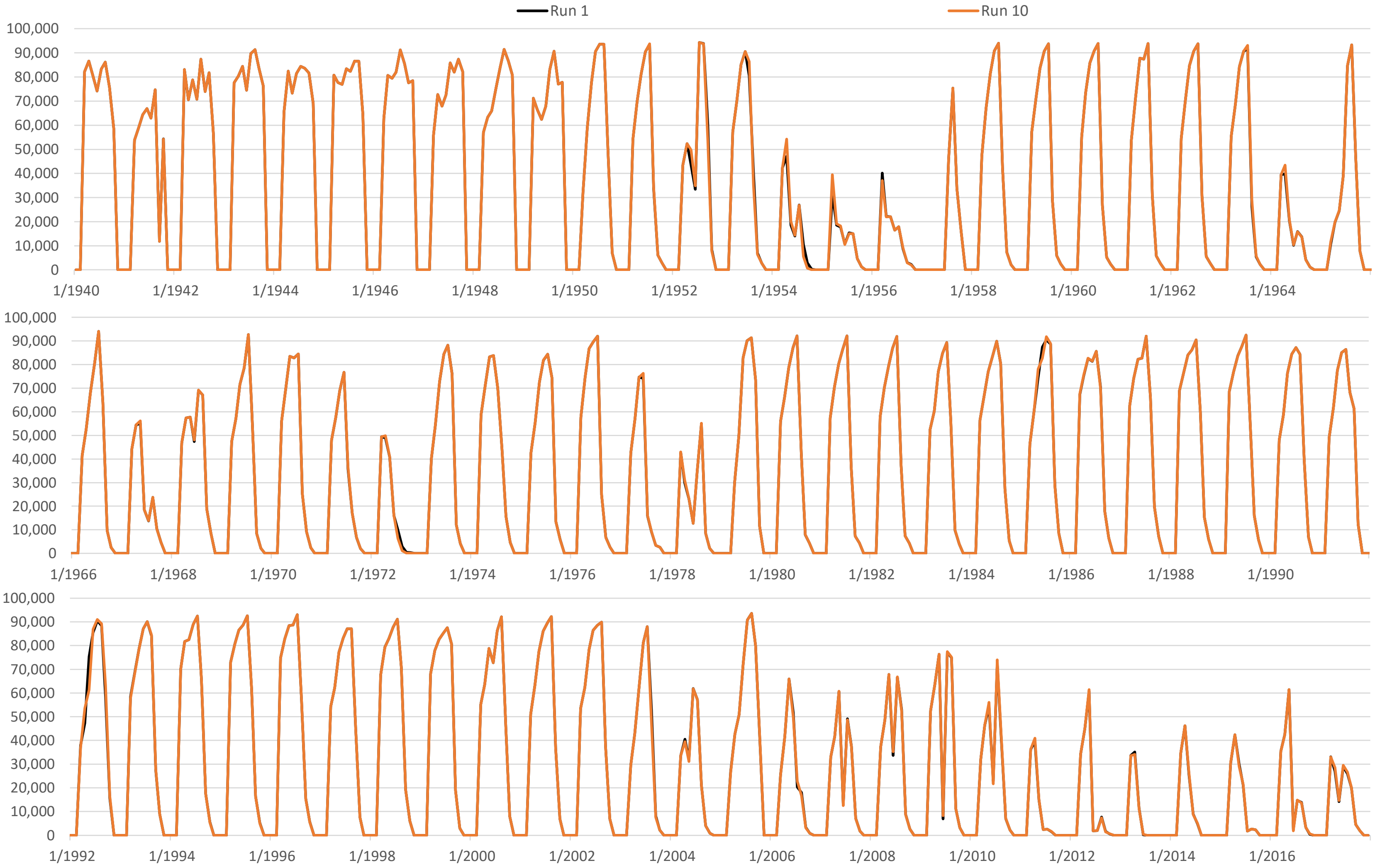


Hueco Non-Alluvial Aquifer



***Note different scales.**

Run 10 - MX Non-Irrigation Pumping Off
Monthly Net RHG Diversions
Run 10 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)
EBID Total



Note: EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).

Run 10 - MX Non-Irrigation Pumping Off

Monthly Net RHG Diversions

Run 10 v. Run 1

ILRG Model

1940 - 2017 (acre-feet)

EPCWID Total

Note: EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

Run 10 - MX Non-Irrigation Pumping Off

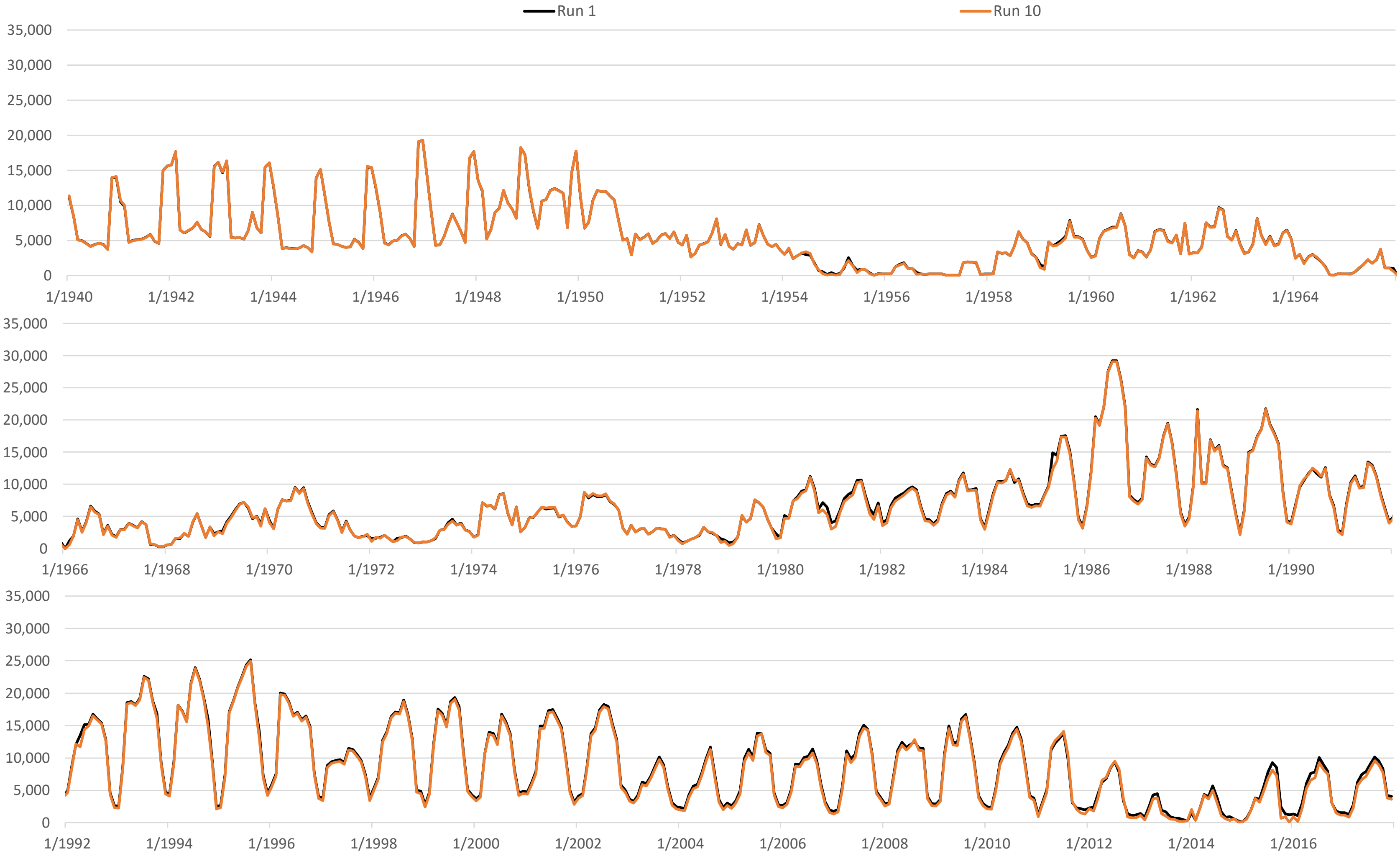
Monthly Net RHG Diversions

Run 10 v. Run 1

ILRG Model

1940 - 2017 (acre-feet)

HCCRD Total



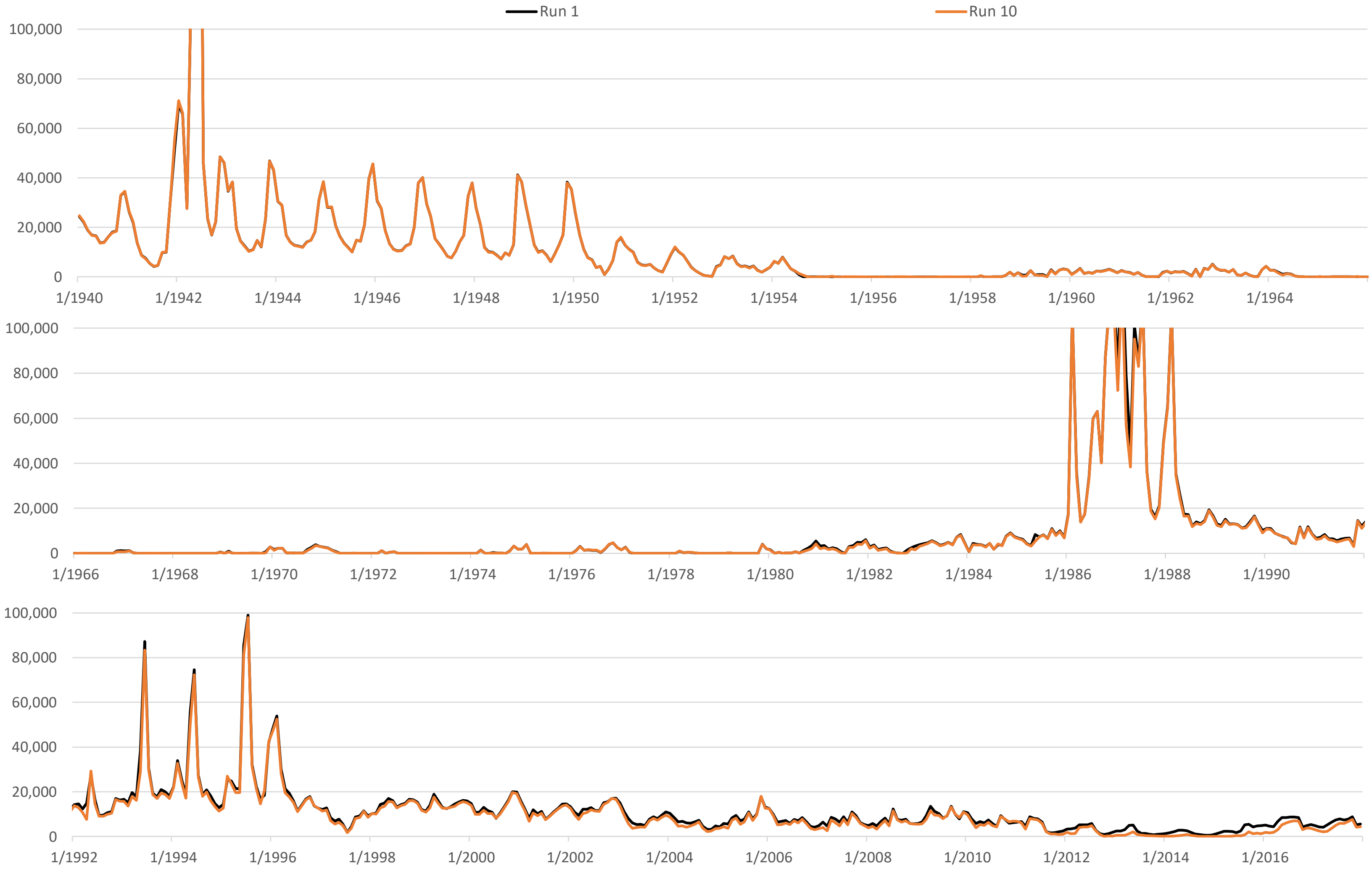
Note: HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

Run 10 - MX Non-Irrigation Pumping Off
End of Month Reservoir Storage (Elephant Butte + Caballo)
Run 10 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

Run 10 - MX Non-Irrigation Pumping Off
Monthly Caballo Releases
Run 10 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

Run 10 - MX Non-Irrigation Pumping Off
Monthly Rio Grande at El Paso Flow
Run 10 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

Run 10 - MX Non-Irrigation Pumping Off
Monthly Rio Grande at Fort Quitman Flow
Run 10 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)



Appendix 30K

Comparison of ILRG Model Runs
Run 11 v. Run 1

Model Run Specifications

Model Version: LRG_v116

Name: **Run 11 - D1/D2**

Run ID: LRG_v116_Operational_Run11
Date: 8/25/2020

Name: **Run 1 - Historical Base Run (All Pumping On)**

Run ID: LRG_v116_Operational_Run1
Date: 8/23/2020

Selected Model Inputs

Pumping and Returns	**Run 11**	**Run 1**
Irrigation Pumping	On	On
Irrigated Area	Hist	Hist
Non-Irrigation Pumping	On	On
Non-Irrigation Pumping Returns	On	On
Las Cruces Jornada Pumping Returns	On	On

Project Allocation Rules		
1950-2005	D1/D2	D1/D2
2006-2007	D1/D2	D3
2008-2017	D1/D2	D3 + CO

EPCWID Operations		
Charge EPCWID for Use of WWTP Returns	Off	Off
ACE and Haskell Credits for EPCWID	On	On
Increased EPCWID Use of Fabens Drain Flows	Off	Off
Charge EPCWID for Fabens Drain Flow Use	Off	Off

Run 11 - D1/D2
Comparison of ILRG Model Runs
Run 11 v. Run 1
2006 - 2017 Annual Average
(1,000 acre-feet)

Run No.	1	11	11 - 1	
Simulated Input or Output	**Run 1**	**Run 11**	**Run 11 minus Run 1**	
Effects of Alternate Scenario				
FHG Deliveries (Mar - Oct)				***% Diff.***
EBID	79.2	133.8	54.6	*69%*
EPCWID (incl. EPW)	138.0	120.8	-17.2	*-12%*
HCCRD	28.6	27.5	-1.0	*-4%*
Total	245.8	282.1	36.4	*15%*
FHG Deliveries (Nov - Feb)				
EBID	0.0	0.0	0.0	*17091%*
EPCWID (incl. EPW)	0.0	0.1	0.0	*80%*
HCCRD	1.1	1.2	0.1	*10%*
Total	1.2	1.3	0.2	*13%*
Irrigation Pumping				
EBID	215.4	164.0	-51.4	*-24%*
EPCWID (Mesilla Valley)	5.3	4.0	-1.4	*-25%*
EPCWID (El Paso Valley)	20.0	29.6	9.7	*48%*
HCCRD	0.6	1.2	0.7	*124%*
Total	241.2	198.8	-42.4	*-18%*
Other Inflows/Outflows				
Net Reservoir Evaporation	97.1	96.7	-0.4	*0%*
Riparian ET	58.0	56.3	-1.7	*-3%*
River Evaporation + Incidental Canal Loss	24.0	26.3	2.3	*10%*
Total	179.2	179.4	0.2	*0%*
Rio Grande at Fort Quitman				
Reservoir Spills	0.0	0.0	0.0	*0%*
Nov-Feb Flows	19.0	25.9	6.9	*36%*
Mar - Oct Flows	46.8	38.6	-8.2	*-18%*
Underflow (GW Model)	0.3	0.3	0.0	*-1%*
Total	66.1	64.8	-1.4	*-2%*

Run 11 - D1/D2

Comparison of ILRG Model Runs

Run 11 v. Run 1

2006 - 2017 Annual Average

(1,000 acre-feet)

Run No.	1	11	11 - 1	
Simulated Input or Output	**Run 1**	**Run 11**	**Run 11 minus Run 1**	
Effects of Alternate Scenario (continued)				
Change in Storage				***% Diff.***
Reservoir Storage	2.1	-8.8	-10.9	*-519%*
Alluvial GW Storage (RW Model)	-42.8	-30.6	12.3	*-29%*
Non-alluvial GW Storage (GW Models)	-157.5	-159.1	-1.6	*1%*
Soil Moisture Storage	-1.6	-0.8	0.8	*-52%*
Total	-199.8	-199.2	0.6	*0%*
Summary of Effects				
FHG Deliveries (Mar-Oct)	245.8	282.1	36.4	*15%*
FHG Deliveries (Nov-Feb)	1.2	1.3	0.2	*13%*
Irrigation Pumping	241.2	198.8	-42.4	*-18%*
Riparian ET + Evaporation	179.2	179.4	0.2	*0%*
Fort Quitman Flow	66.1	64.8	-1.4	*-2%*
Change in Storage	-199.8	-199.2	0.6	*0%*
Total	533.6	527.2	-6.4	*-1%*
Other Effects of Alternate Scenario				
Rio Grande at El Paso				***% Diff.***
Reservoir Spills	0.0	0.0	0.0	*0%*
Nov-Feb Flows	9.2	21.5	12.4	*135%*
Mar - Oct Flows	243.9	212.1	-31.9	*-13%*
Total	253.1	233.6	-19.5	*-8%*
Rio Grande below Caballo				
Reservoir Spills	0.0	0.0	0.0	*0%*
Nov-Feb Flows	0.0	0.0	0.0	*0%*
Mar - Oct Flows	489.2	499.7	10.5	*2%*
Total	489.2	499.7	10.5	*2%*
Surface Water Diversions (Mar - Oct)				
EBID	195.2	289.5	94.2	*48%*
EPCWID (incl. EPW)	220.0	197.1	-23.0	*-10%*
HCCRD	63.7	56.6	-7.1	*-11%*
Total	479.0	543.1	64.1	*13%*
Surface Water Diversions (Nov - Feb)				
EBID	0.0	0.0	0.0	*0%*
EPCWID (incl. EPW)	6.3	7.1	0.7	*12%*
HCCRD	8.7	8.1	-0.6	*-7%*
Total	15.1	15.2	0.1	*1%*

Run 11 - D1/D2

Annual Differences in ILRG Model Outputs

Run 11 minus Run 1

1940 - 2017 (acre-feet)

	Net River Headgate Diversions						Farm Headgate Deliveries						Annual Flows		
	EBID		EPCWID (incl. EPW)		HCCRD		EBID		EPCWID (incl. EPW)		HCCRD				
Year	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Caballo Releases	Rio Grande at El Paso	Rio Grande at Fort Quitman
1940															
1941															
1942															
1943															
1944															
1945															
1946															
1947															
1948															
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1968															
1969															
1970															
1971															
1972															
1973															
1974															
1975															
1976															
1977															
1978															

Run 11 - D1/D2

Annual Differences in ILRG Model Outputs

Run 11 minus Run 1

1940 - 2017 (acre-feet)

	Net River Headgate Diversions						Farm Headgate Deliveries						Annual Flows		
	EBID		EPCWID (incl. EPW)		HCCRD		EBID		EPCWID (incl. EPW)		HCCRD				
Year	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Caballo Releases	Rio Grande at El Paso	Rio Grande at Fort Quitman
1979															
1980															
1981															
1982															
1983															
1984															
1985															
1986															
1987															
1988															
1989															
1990															
1991															
1992															
1993															
1994															
1995															
1996															
1997															
1998															
1999															
2000															
2001															
2002															
2003															
2004															
2005															
2006	-2,318	-2,318	-21,840	-22,016	-3,624	-4,032	1,147	1,147	-16,792	-16,795	0	0	-40,298	-32,575	-7,891
2007	105,518	105,518	1,611	2,044	-774	-1,064	65,944	65,944	-73	-58	0	0	40,410	727	-3,346
2008	175,741	175,741	-4,880	-4,055	-1,238	-946	110,051	110,084	-4,269	-4,187	0	0	100,466	26,446	24,011
2009	128,086	128,086	-60,467	-58,754	-16,601	-16,208	89,124	89,180	-28,590	-28,501	0	0	-14,061	-23,199	4,308
2010	141,743	141,743	-6,682	-4,476	-551	-52	91,927	91,930	-6,891	-6,821	0	0	4,213	9,211	25,221
2011	37,824	37,824	-104,867	-103,646	-34,648	-38,314	8,843	8,843	-76,777	-76,743	-10,844	-10,982	-135,777	-113,986	-14,325
2012	72,262	72,262	21,557	21,691	-1,824	-5,752	29,618	29,618	13,160	13,174	3,877	3,994	73,942	16,011	-14,434
2013	-64,871	-64,871	-53,898	-53,822	-11,112	-11,127	-22,953	-22,953	-39,147	-39,142	-6,363	-6,601	-150,058	-57,269	-8,516
2014	95,057	95,057	51,805	51,821	7,587	7,963	41,984	41,984	30,982	30,986	4,187	4,956	170,150	52,864	-982
2015	92,044	92,044	-18,815	-18,534	-3,665	-3,260	38,865	38,865	-14,008	-13,996	-3,981	-3,186	21,403	-34,637	3,112
2016	77,151	77,151	-61,804	-61,395	-12,527	-13,555	35,806	35,806	-47,324	-47,309	0	0	-55,466	-73,162	-24,959
2017	272,360	272,360	-17,385	-15,748	-6,295	-6,492	164,455	164,473	-16,423	-16,366	698	715	110,551	-4,466	1,585
Averages															
1951-2017															
1951-1978															
1979-2005															
2006-2017	94,216	94,216	-22,972	-22,241	-7,106	-7,737	54,568	54,577	-17,179	-17,147	-1,035	-925	10,456	-19,503	-1,351
1985-2017															
1985-2005															

Notes:

EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).

EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

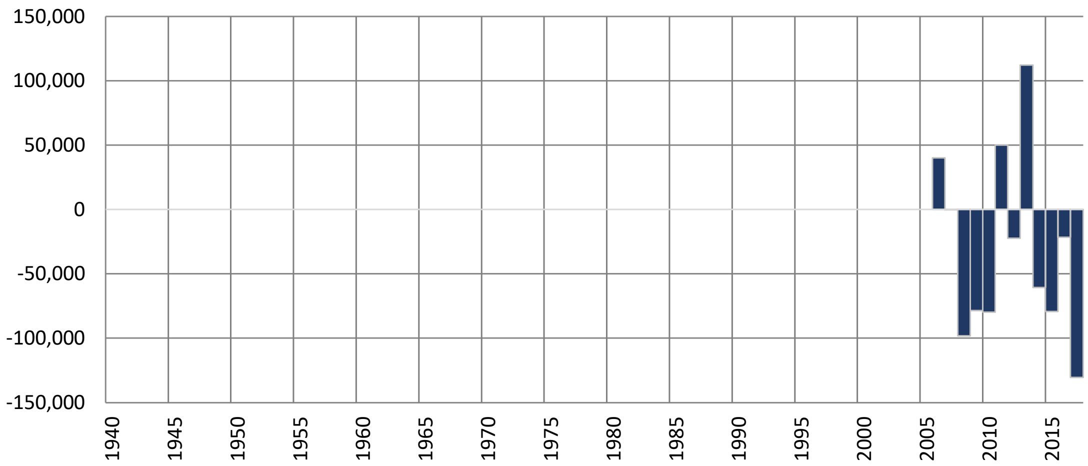
Run 11 - D1/D2

Simulated Differences in ILRG Model Outputs

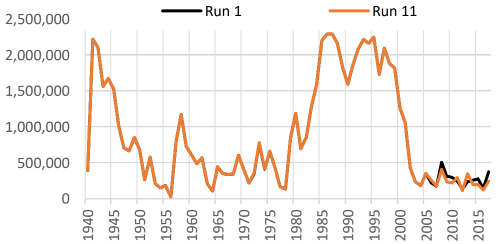
Run 11 minus Run 1

1940 - 2017 (acre-feet)

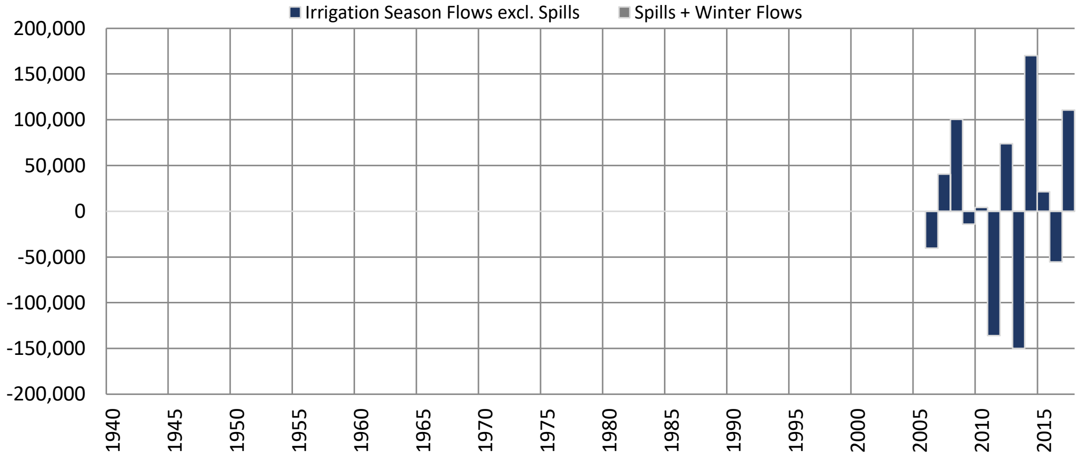
Total Project Storage (Year End)



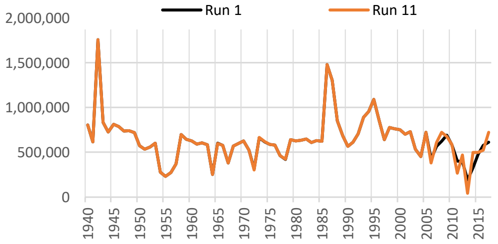
Period	Average Difference
1951-2017	
1951-1978	
1979-2005	
2006-2017	-10,874
1985-2017	
1985-2005	



Caballo Reservoir Outflows (Annual)



	Average Difference		
Period	Irr Season (excl. Spills)	Nov-Feb and Spills	Annual
1951-2017			
1951-1978			
1979-2005			
2006-2017	10,456	0	10,456
1985-2017			
1985-2005			



Notes:

Reservoir storage does not include storage attributed to SJC, CO, or NM credit waters.

Average differences calculated as (Final Storage - Initial Storage)/(no. years).

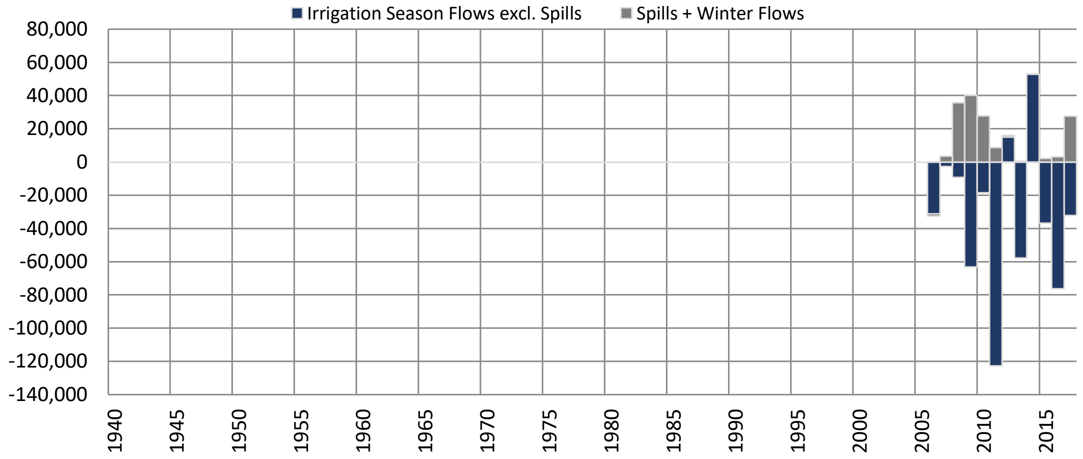
Run 11 - D1/D2

Simulated Differences in ILRG Model Outputs

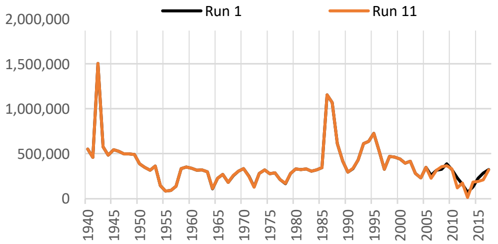
Run 11 minus Run 1

1940 - 2017 (acre-feet)

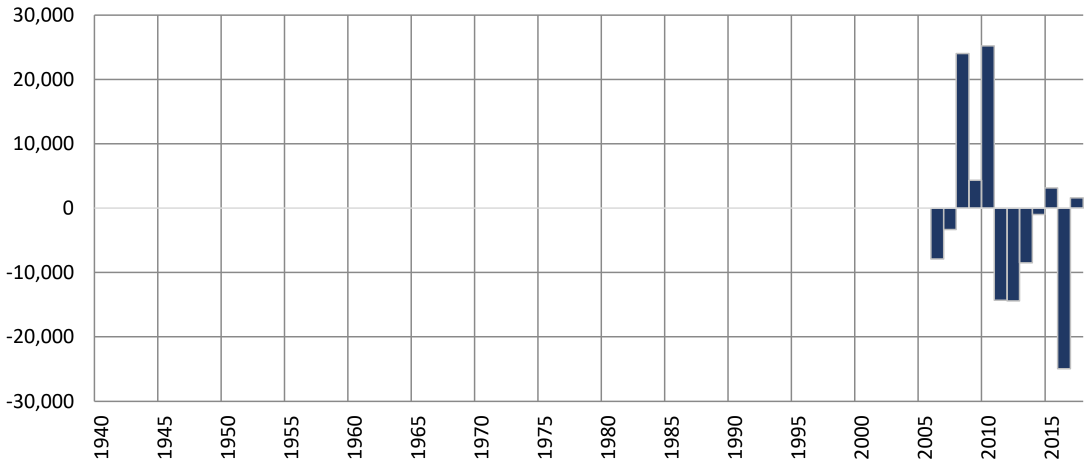
Rio Grande at El Paso (Annual)



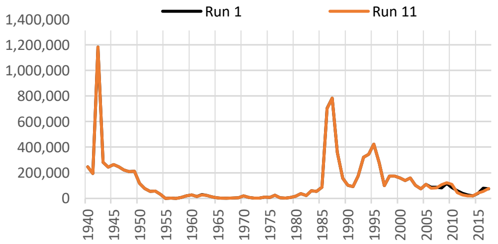
	Average Difference		
Period	Irr Season (excl. Spills)	Nov-Feb and Spills	Annual
1951-2017			
1951-1978			
1979-2005			
2006-2017	-31,871	12,368	-19,503
1985-2017			
1985-2005			



Rio Grande at Fort Quitman (Annual)



Period	Average Difference
1951-2017	
1951-1978	
1979-2005	
2006-2017	-1,349
1985-2017	
1985-2005	



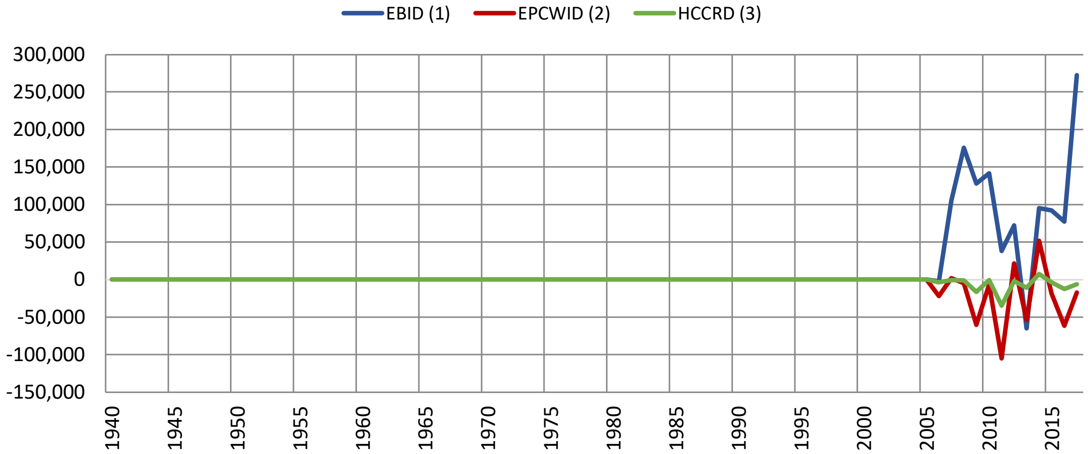
Run 11 - D1/D2

Simulated Differences in ILRG Model Outputs

Run 11 minus Run 1

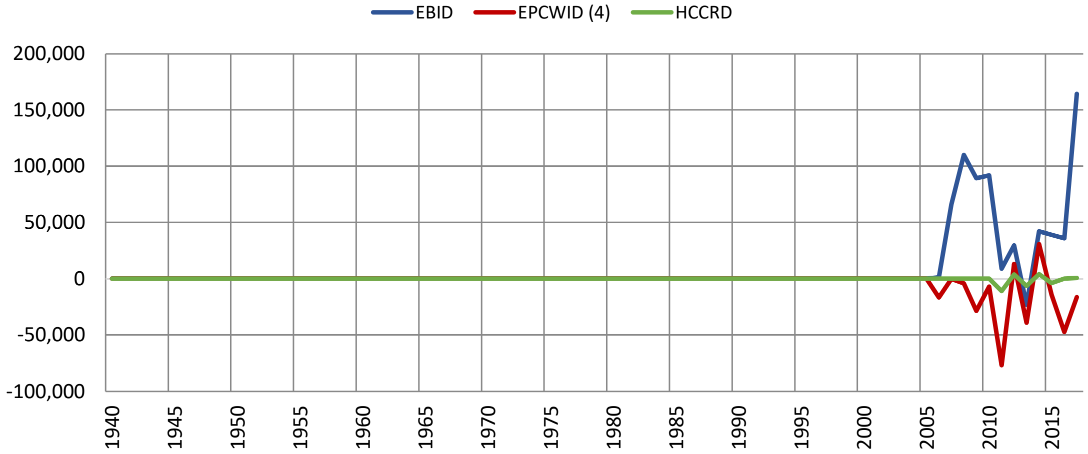
1940 - 2017 (acre-feet)

River Headgate (RHG) Diversions (Irrigation Season)



	Average Difference		
Period	EBID	EPCWID	HCCRD
1951-2017			
1951-1978			
1979-2005			
2006-2017	94,216	-22,972	-7,106
1985-2017			
1985-2005			

Farm Headgate (FHG) Deliveries (Irrigation Season)



	Average Difference		
Period	EBID	EPCWID	HCCRD
1951-2017			
1951-1978			
1979-2005			
2006-2017	54,568	-17,179	-1,035
1985-2017			
1985-2005			

Notes:

(1) EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).

(2) EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

(3) HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

(4) EPCWID FHG values include deliveries to Rogers WTP and R/U WTP.

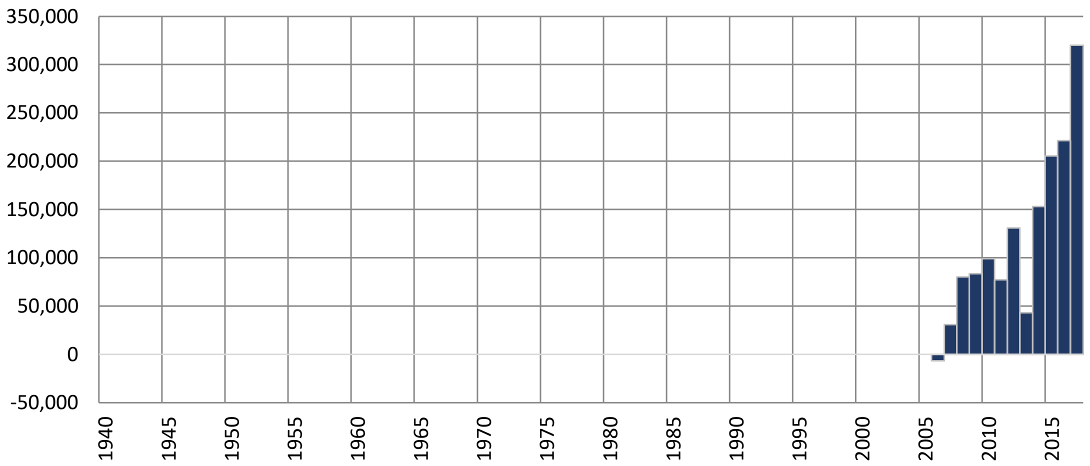
Run 11 - D1/D2

Simulated Differences in ILRG Model Outputs

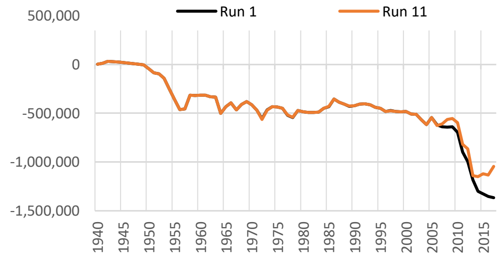
Run 11 minus Run 1

1940 - 2017 (acre-feet)

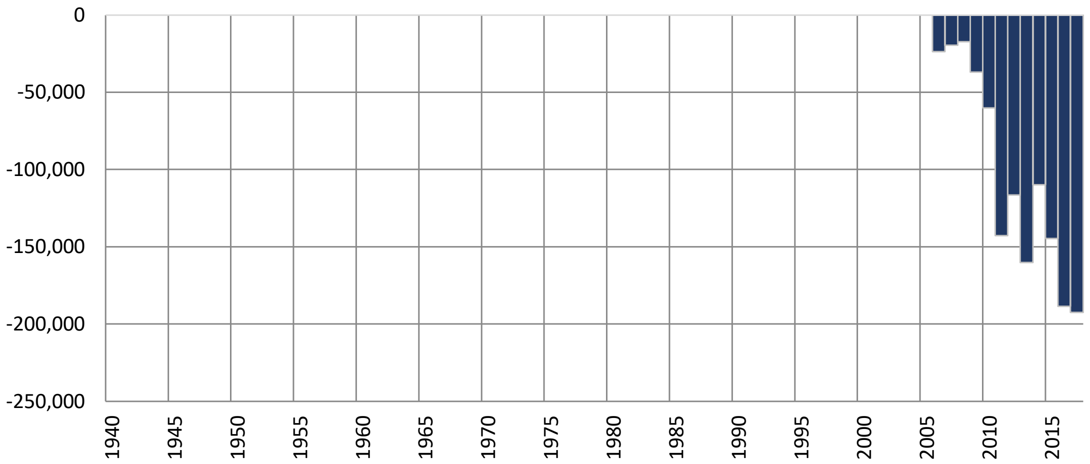
Cumulative Annual Rincon-Mesilla Groundwater Storage



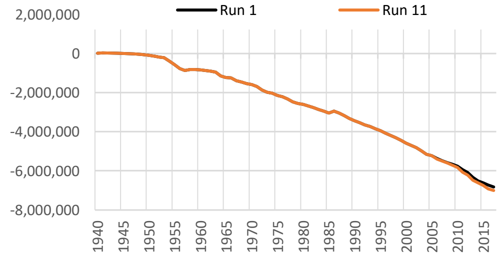
Period	Average Difference
1951-2017	
1951-1978	
1979-2005	
2006-2017	26,667
1985-2017	
1985-2005	



Cumulative Annual Hueco Groundwater Storage



Period	Average Difference
1951-2017	
1951-1978	
1979-2005	
2006-2017	-16,051
1985-2017	
1985-2005	



Notes:

Cumulative storage change in alluvial and non-alluvial aquifers.

Average differences calculated as (Final Storage - Initial Storage)/(no. years).

Run 11 - D1/D2

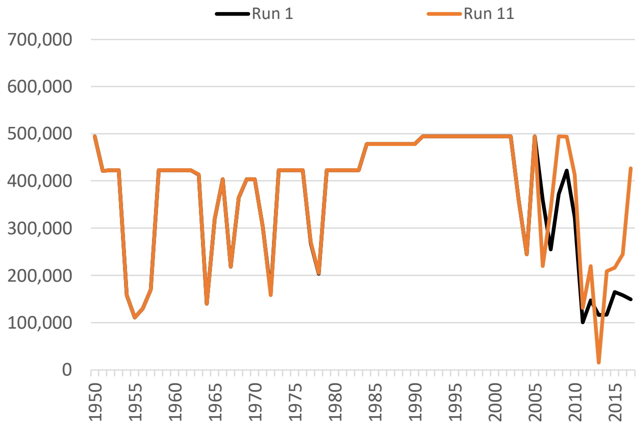
Annual Allocation and Charges

Run 11 v. Run 1

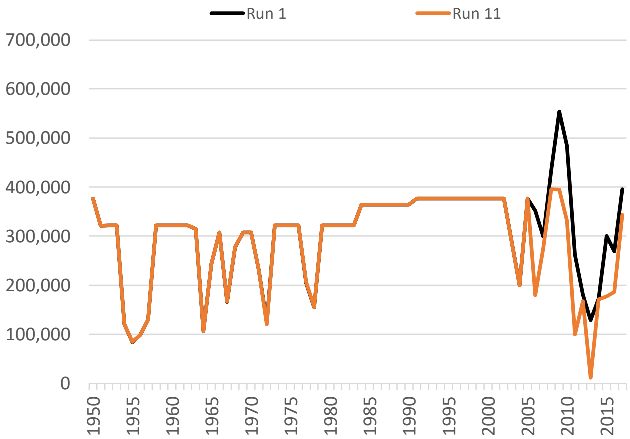
ILRG Model

1950 - 2017 (acre-feet)

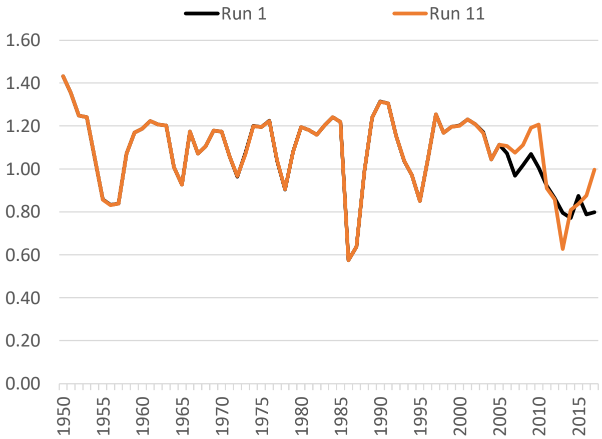
Total Allocation - EBID



Total Allocation - EPCWID



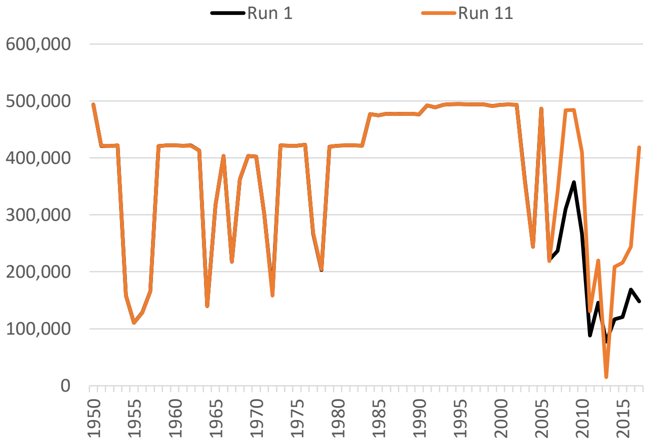
Diversion Ratio



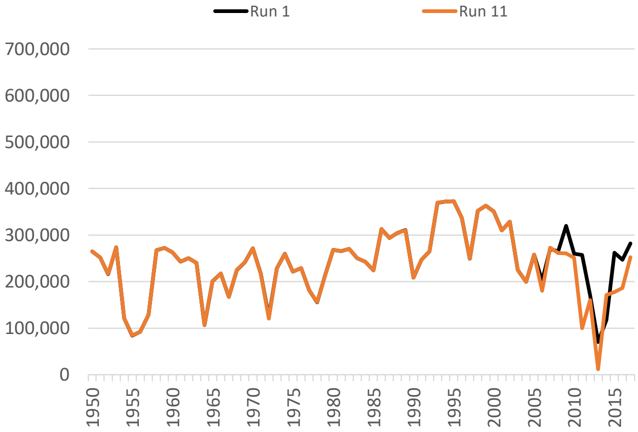
Note:

Computed as Total Charges/Caballo Release.

Annual Delivery Charges - EBID



Annual Delivery Charges - EPCWID



Run 11 - D1/D2

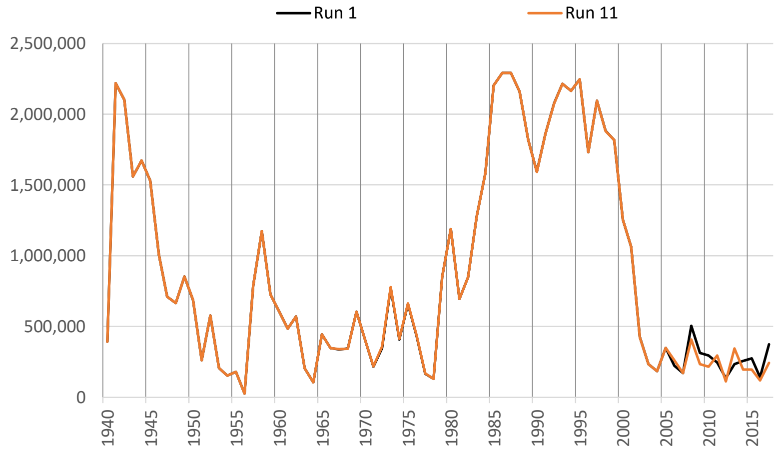
Annual Summary of Project Storage and Rio Grande Flows

Run 11 v. Run 1

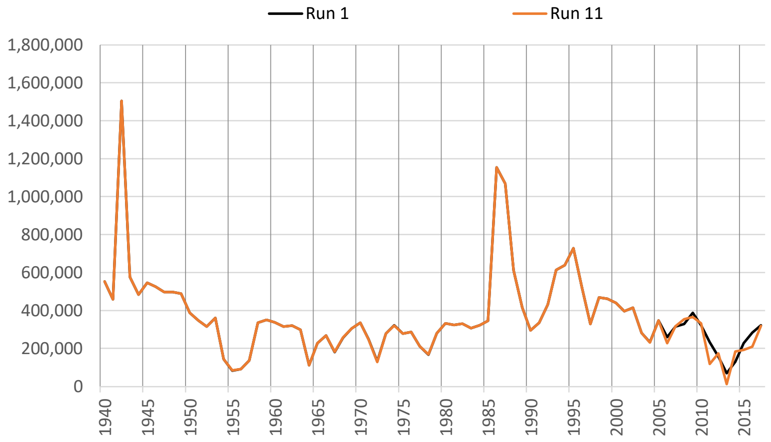
ILRG Model

1940 - 2017 (acre-feet)

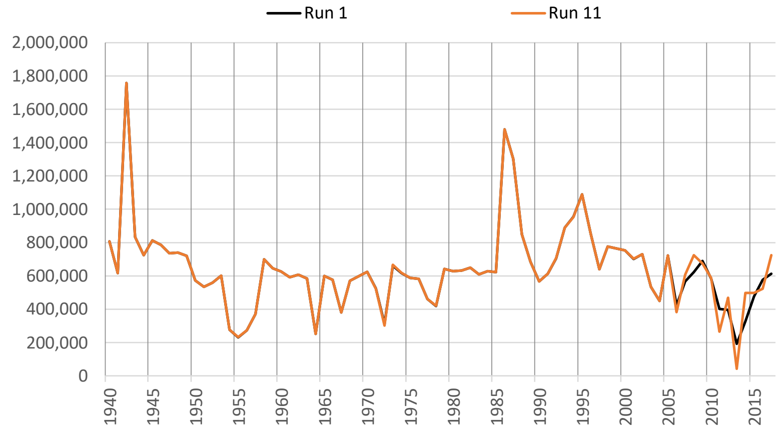
Total Year-End Project Reservoir Storage



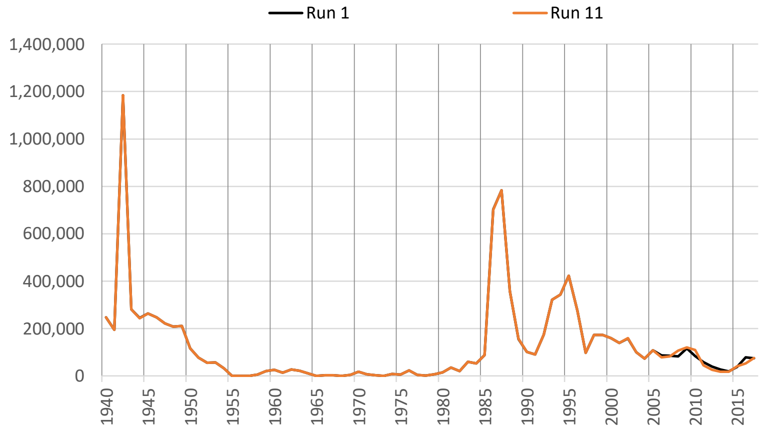
Rio Grande at El Paso



Rio Grande Below Caballo



Rio Grande at Fort Quitman



***Note different scales.**

Run 11 - D1/D2

Irrigation Season Summary of Irrigation Operations

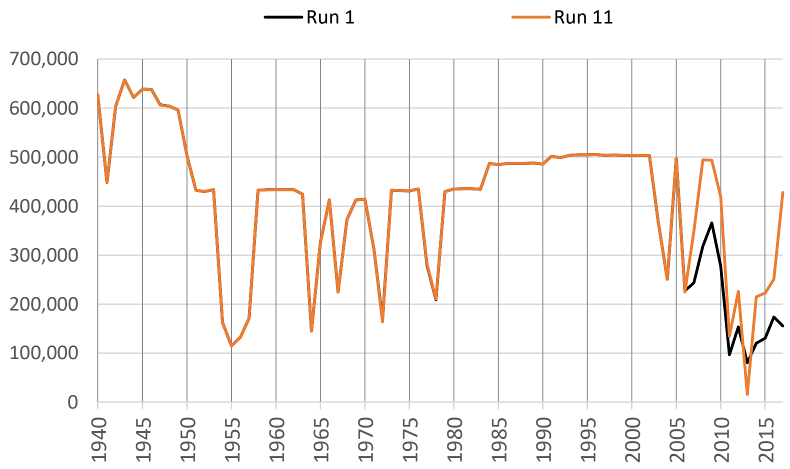
Run 11 v. Run 1

ILRG Model

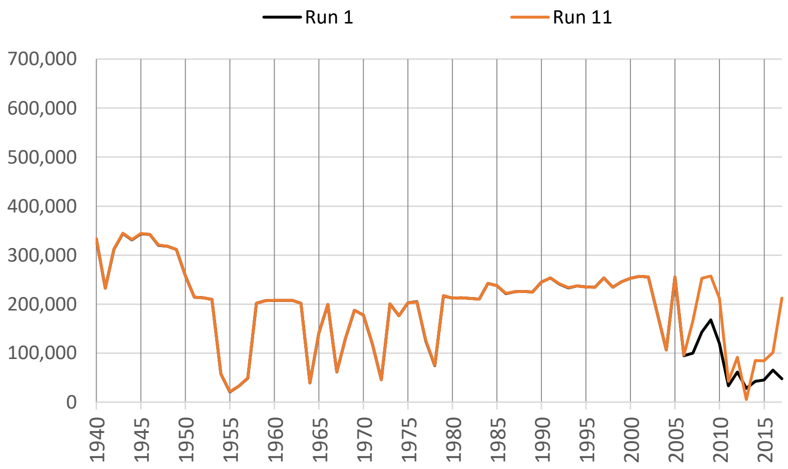
1940 - 2017 (acre-feet)

EBID Total

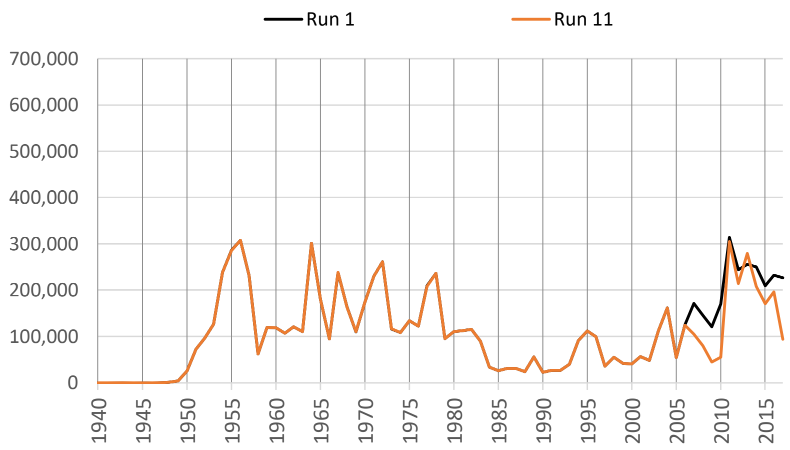
Net River Headgate Diversions



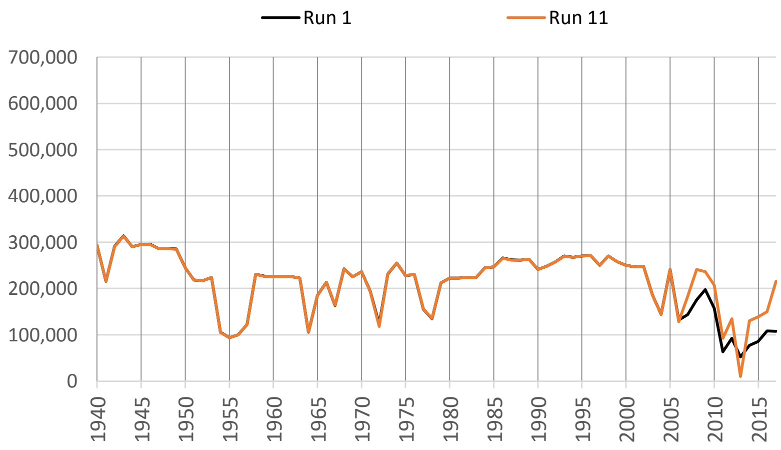
Farm Headgate Deliveries



Pumping



RHG Diversions - FHG Deliveries



Notes: EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).
Pumping includes Supplemental and Primary groundwater pumping.

Run 11 - D1/D2

Irrigation Season Summary of Irrigation Operations

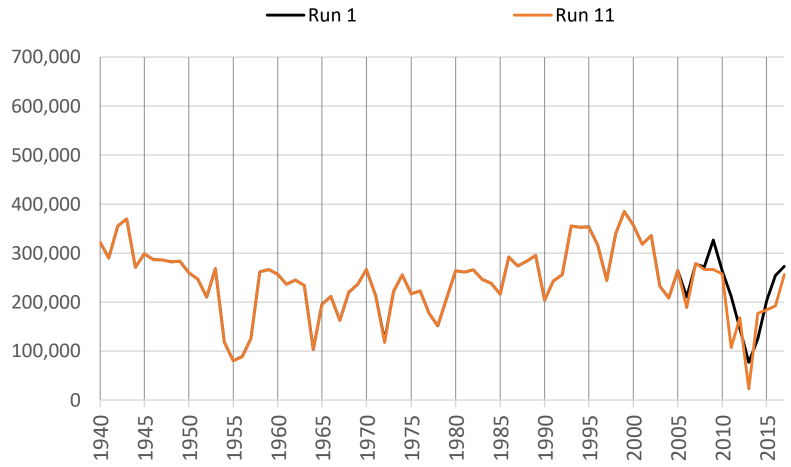
Run 11 v. Run 1

ILRG Model

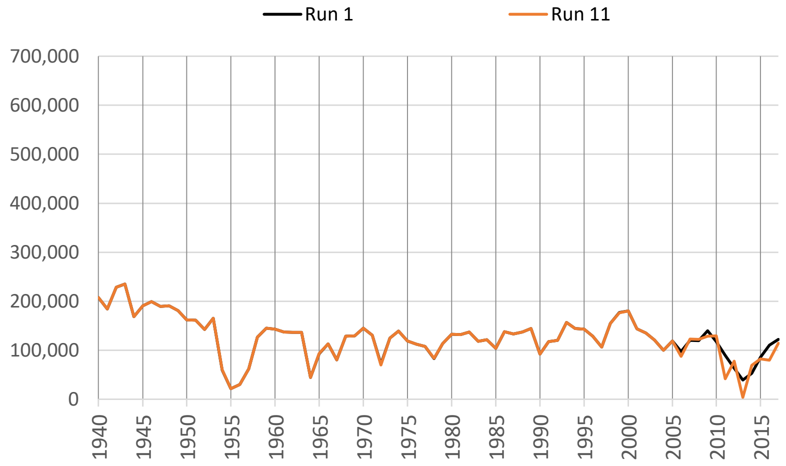
1940 - 2017 (acre-feet)

EPCWID Total

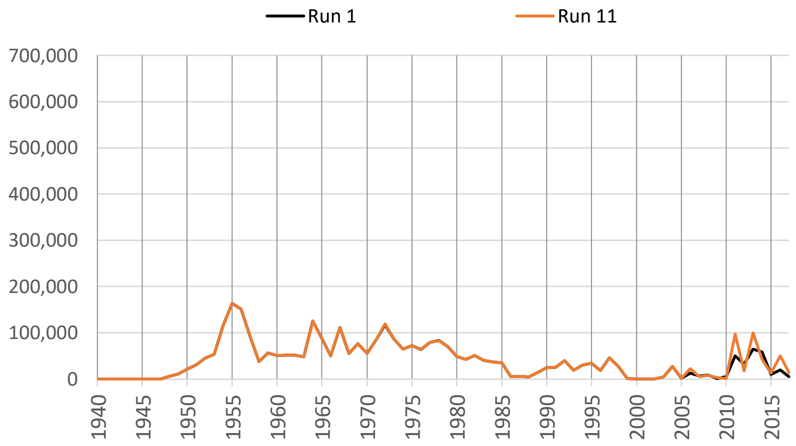
Net River Headgate Diversions



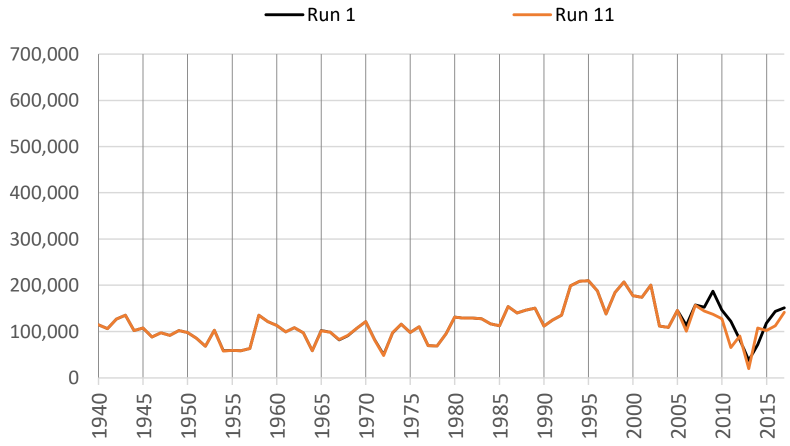
Farm Headgate Deliveries



Pumping



RHG Diversions - FHG Deliveries

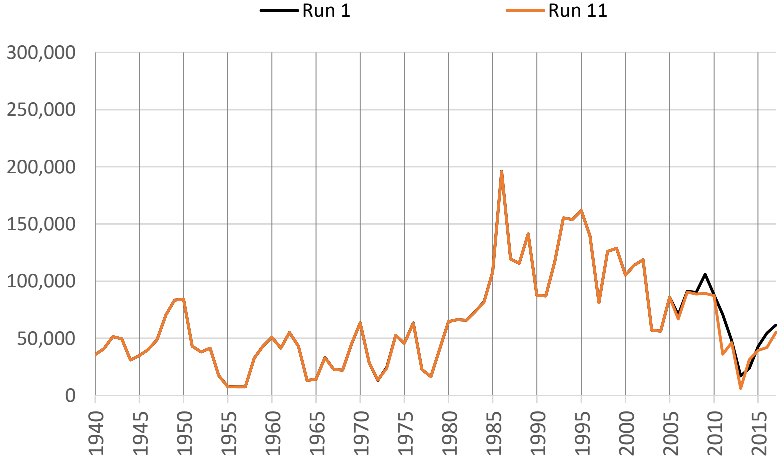


Note: EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

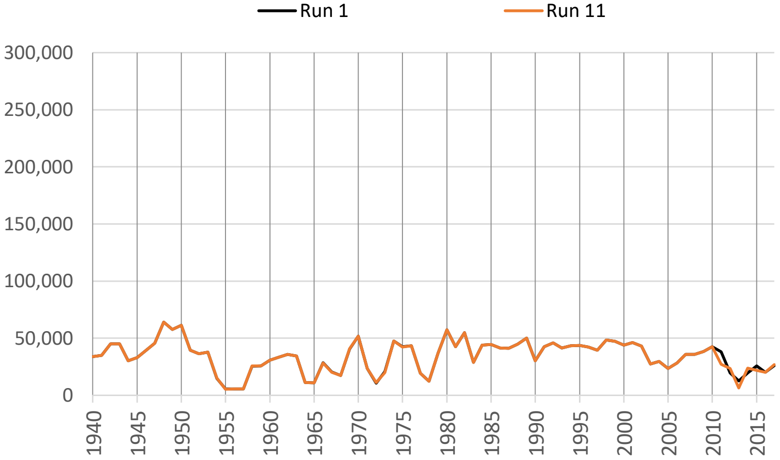
Run 11 - D1/D2
Irrigation Season Summary of Irrigation Operations
Run 11 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

HCCRD Total

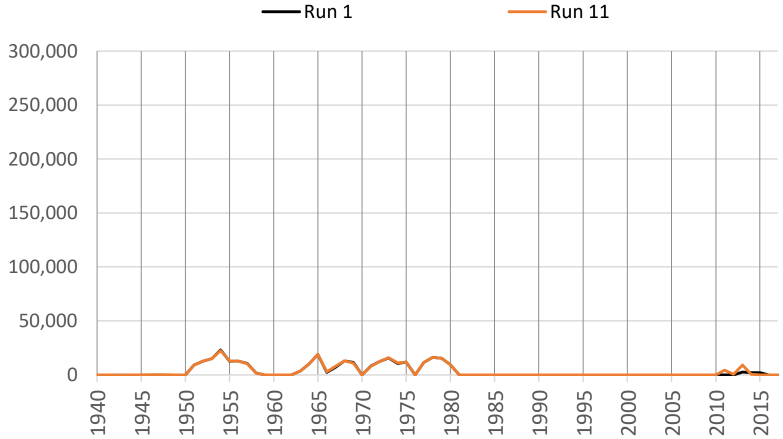
Net River Headgate Diversions



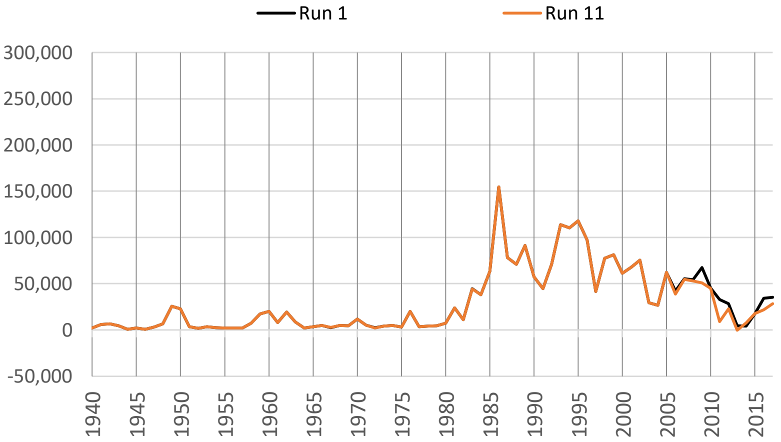
Farm Headgate Deliveries



Pumping



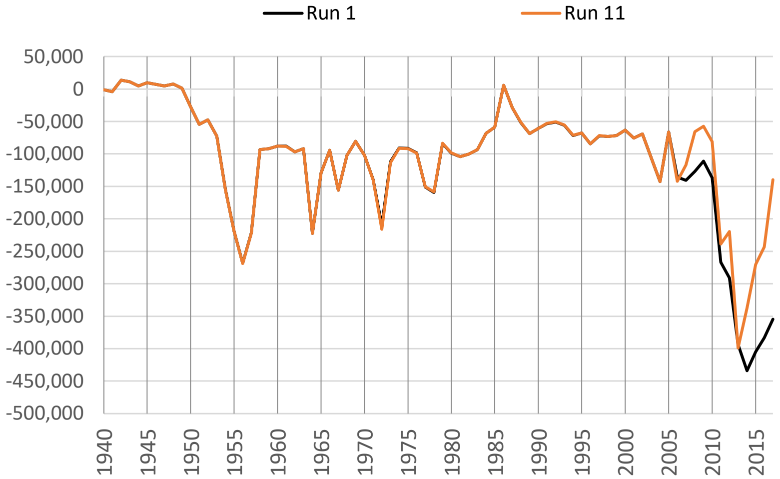
RHG Diversions - FHG Deliveries



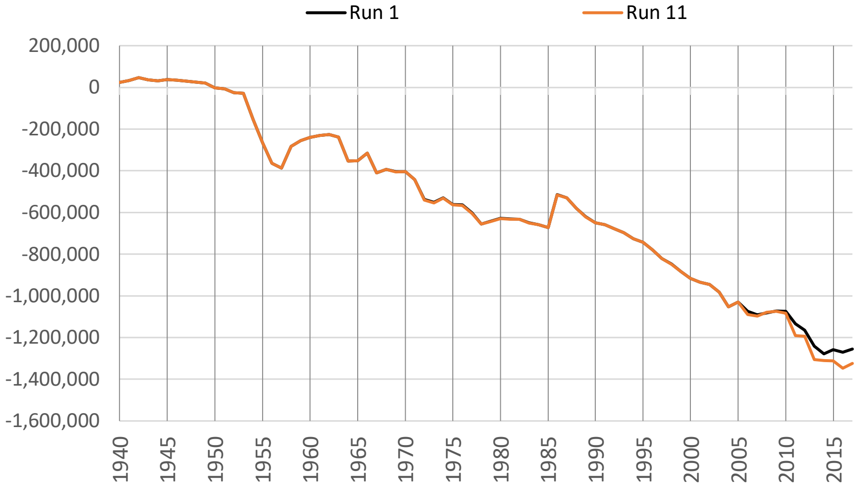
Note: HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

Run 11 - D1/D2
Cumulative Change in Ground Water Storage
Run 11 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

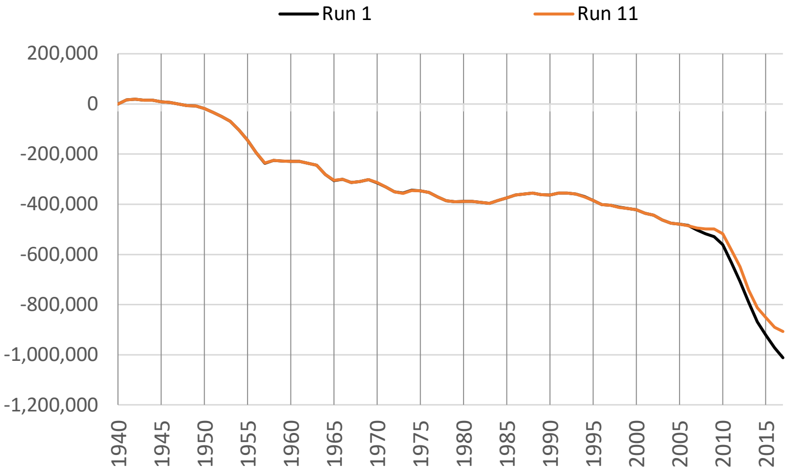
Rincon-Mesilla Alluvial Aquifer



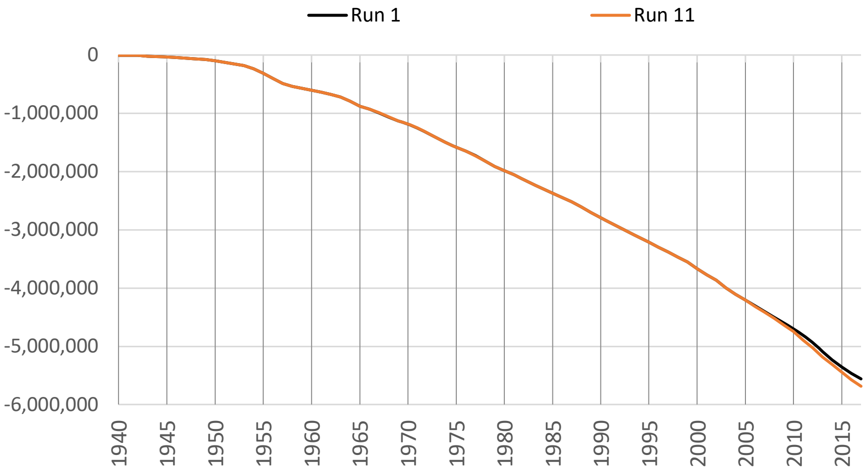
Hueco Alluvial Aquifer



Rincon-Mesilla Non-Alluvial Aquifer

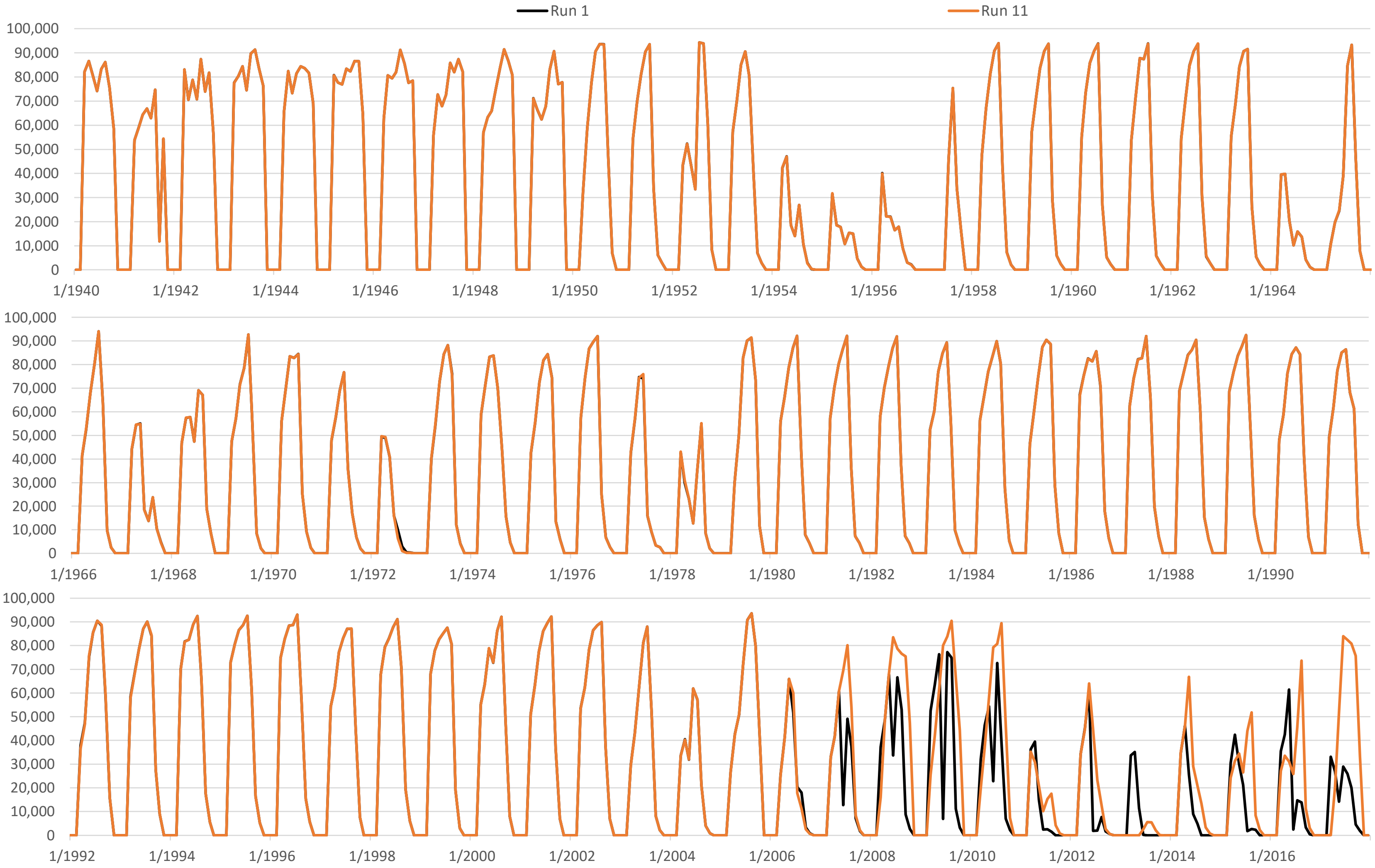


Hueco Non-Alluvial Aquifer



***Note different scales.**

Run 11 - D1/D2
Monthly Net RHG Diversions
Run 11 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)
EBID Total

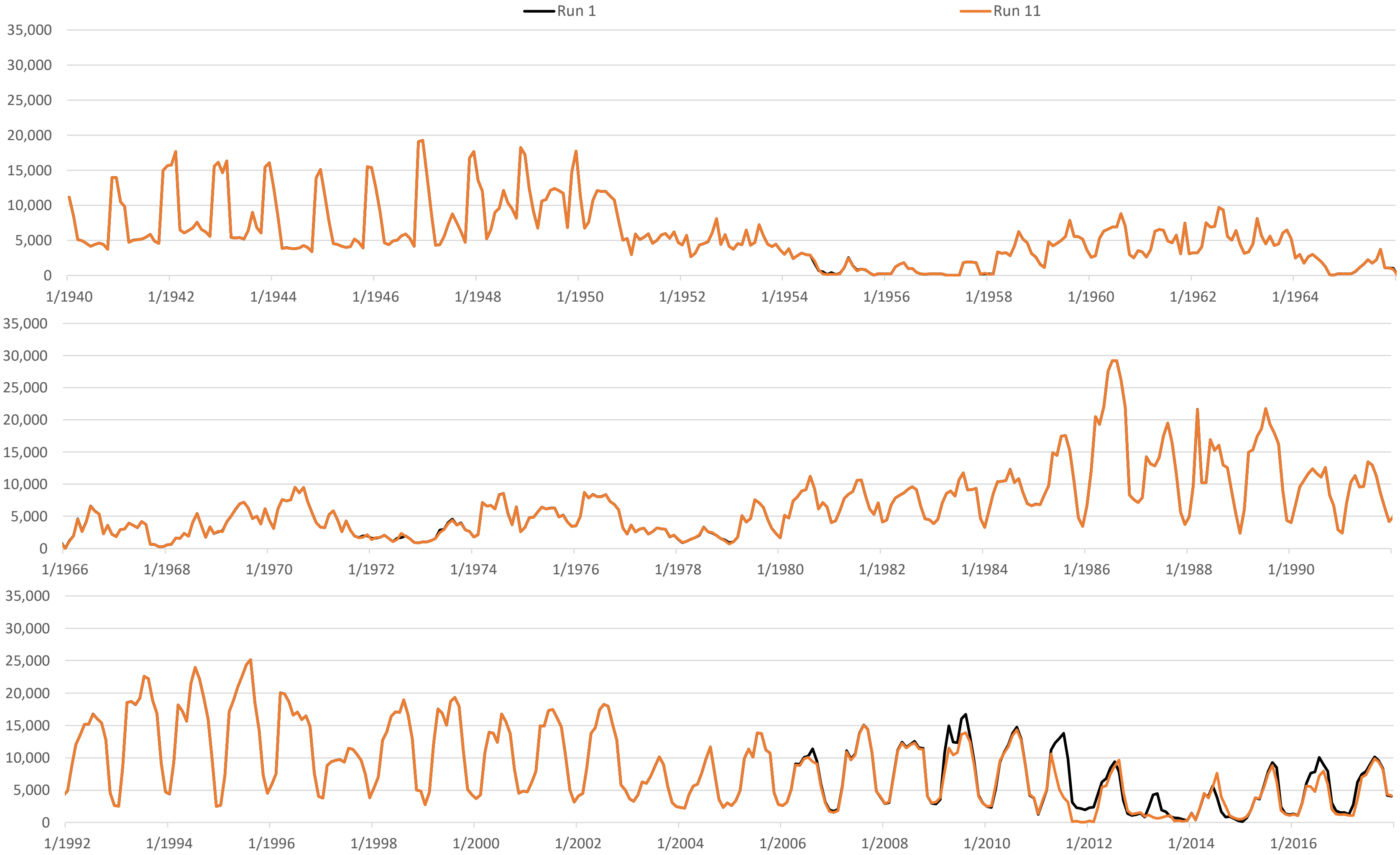


Note: EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).

Run 11 - D1/D2
Monthly Net RHG Diversions
Run 11 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)
EPCWID Total

Note: EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

Run 11 - D1/D2
Monthly Net RHG Diversions
Run 11 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)
HCCRD Total



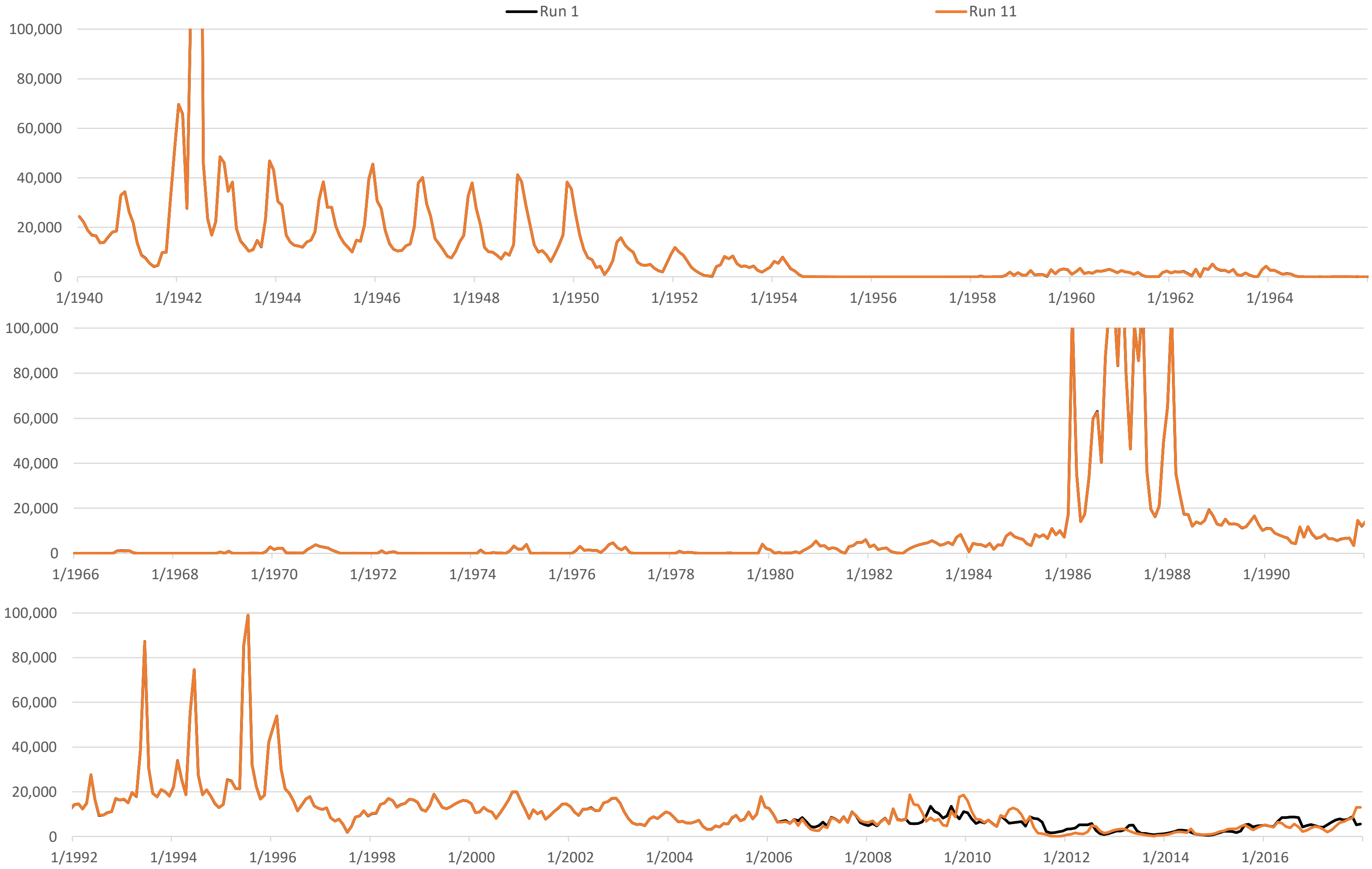
Note: HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

Run 11 - D1/D2
End of Month Reservoir Storage (Elephant Butte + Caballo)
Run 11 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

Run 11 - D1/D2
Monthly Caballo Releases
Run 11 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

Run 11 - D1/D2
Monthly Rio Grande at El Paso Flow
Run 11 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

Run 11 - D1/D2
Monthly Rio Grande at Fort Quitman Flow
Run 11 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)



Appendix 30L

Comparison of ILRG Model Runs
Run 12 v. Run 11

Model Run Specifications

Model Version: LRG_v116

Name: **Run 12 - D3 + Carryover Allocation (All Pumping On)**

Run ID: LRG_v116_Operational_Run12
Date: 8/31/2020

Name: **Run 11 - D1/D2 Allocation (All Pumping On)**

Run ID: LRG_v116_Operational_Run11
Date: 8/25/2020

Selected Model Inputs

Pumping and Returns	**Run 12**	**Run 11**
Irrigation Pumping	On	On
Irrigated Area	Hist	Hist
Non-Irrigation Pumping	On	On
Non-Irrigation Pumping Returns	On	On
Las Cruces Jornada Pumping Returns	On	On

Project Allocation Rules		
1950-2005	D3 + CO	D1/D2
2006-2007	D3 + CO	D1/D2
2008-2017	D3 + CO	D1/D2

EPCWID Operations		
Charge EPCWID for Use of WWTP Returns	Off	Off
ACE and Haskell Credits for EPCWID	On	On
Increased EPCWID Use of Fabens Drain Flows	Off	Off
Charge EPCWID for Fabens Drain Flow Use	Off	Off

Run 12 - D3 + Carryover Allocation (All Pumping On)

Comparison of ILRG Model Runs

Run 12 v. Run 11

1951 - 2017 Annual Average

(1,000 acre-feet)

Run No.	11	12	12 - 11	
Simulated Input or Output	**Run 11**	**Run 12**	**Run 12 minus Run 11**	
Effects of Alternate Scenario				
FHG Deliveries (Mar - Oct)				***% Diff.***
EBID	177.4	157.6	-19.8	*-11%*
EPCWID (incl. EPW)	136.8	145.0	8.2	*6%*
HCCRD	32.7	33.4	0.7	*2%*
Total	346.9	335.9	-10.9	*-3%*
FHG Deliveries (Nov - Feb)				
EBID	0.0	0.0	0.0	*377%*
EPCWID (incl. EPW)	0.2	0.2	0.0	*17%*
HCCRD	2.4	2.3	-0.1	*-6%*
Total	2.6	2.5	-0.1	*-3%*
Irrigation Pumping				
EBID	131.2	153.3	22.1	*17%*
EPCWID (Mesilla Valley)	7.1	7.9	0.8	*12%*
EPCWID (El Paso Valley)	41.8	40.2	-1.6	*-4%*
HCCRD	4.3	3.7	-0.6	*-15%*
Total	184.5	205.2	20.7	*11%*
Other Inflows/Outflows				
Net Reservoir Evaporation	125.3	119.8	-5.5	*-4%*
Riparian ET	70.6	71.4	0.8	*1%*
River Evaporation + Incidental Canal Loss	30.8	29.7	-1.1	*-3%*
Total	226.6	220.9	-5.8	*-3%*
Rio Grande at Fort Quitman				
Reservoir Spills	33.3	23.2	-10.0	*-30%*
Nov-Feb Flows	22.6	29.5	6.9	*30%*
Mar - Oct Flows	39.6	44.0	4.4	*11%*
Underflow (GW Model)	0.2	0.2	0.0	*2%*
Total	95.7	97.0	1.3	*1%*

Run 12 - D3 + Carryover Allocation (All Pumping On)

Comparison of ILRG Model Runs

Run 12 v. Run 11
1951 - 2017 Annual Average
(1,000 acre-feet)

Run No.	11	12	12 - 11	
Simulated Input or Output	**Run 11**	**Run 12**	**Run 12 minus Run 11**	
Effects of Alternate Scenario (continued)				
Change in Storage				***% Diff.***
Reservoir Storage	-6.6	-4.3	2.4	*-36%*
Alluvial GW Storage (RW Model)	-21.4	-23.6	-2.2	*10%*
Non-alluvial GW Storage (GW Models)	-96.6	-92.5	4.1	*-4%*
Soil Moisture Storage	0.7	0.7	0.0	*-6%*
Total	-123.9	-119.7	4.3	*-3%*
Summary of Effects				
FHG Deliveries (Mar-Oct)	346.9	335.9	-10.9	*-3%*
FHG Deliveries (Nov-Feb)	2.6	2.5	-0.1	*-3%*
Irrigation Pumping	184.5	205.2	20.7	*11%*
Riparian ET + Evaporation	226.6	220.9	-5.8	*-3%*
Fort Quitman Flow	95.7	97.0	1.3	*1%*
Change in Storage	-123.9	-119.7	4.3	*-3%*
Total	732.4	741.8	9.4	*1%*
Other Effects of Alternate Scenario				
Rio Grande at El Paso				***% Diff.***
Reservoir Spills	49.4	35.5	-13.9	*-28%*
Nov-Feb Flows	25.0	29.9	4.9	*20%*
Mar - Oct Flows	258.0	277.7	19.6	*8%*
Total	332.4	343.1	10.7	*3%*
Rio Grande below Caballo				
Reservoir Spills	65.9	46.7	-19.1	*-29%*
Nov-Feb Flows	0.5	0.1	-0.3	*-69%*
Mar - Oct Flows	543.1	565.9	22.7	*4%*
Total	609.5	612.7	3.3	*1%*
Surface Water Diversions (Mar - Oct)				
EBID	383.3	348.9	-34.4	*-9%*
EPCWID (incl. EPW)	232.6	245.7	13.1	*6%*
HCCRD	66.3	69.3	3.0	*5%*
Total	682.2	663.9	-18.3	*-3%*
Surface Water Diversions (Nov - Feb)				
EBID	0.0	0.0	0.0	*0%*
EPCWID (incl. EPW)	14.5	13.4	-1.1	*-8%*
HCCRD	14.1	14.0	-0.1	*-1%*
Total	28.6	27.4	-1.2	*-4%*

Run 12 - D3 + Carryover Allocation (All Pumping On)

Annual Differences in ILRG Model Outputs

Run 12 minus Run 11

1940 - 2017 (acre-feet)

	Net River Headgate Diversions						Farm Headgate Deliveries						Annual Flows		
	EBID		EPCWID (incl. EPW)		HCCRD		EBID		EPCWID (incl. EPW)		HCCRD				
Year	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Caballo Releases	Rio Grande at El Paso	Rio Grande at Fort Quitman
1940	52	52	-3	4	0	4	2	2	-2	-1	0	0	51	26	75
1941	162	162	6	11	2	4	4	4	1	2	2	4	-42	-69	-18
1942	33	33	0	4	1	1	0	0	-4	-9	0	1	-27	-10	13
1943	64	64	4	11	-2	-1	14	14	12	2	-2	1	23	11	64
1944	81	81	11	10	-28	-12	4	4	-11	-6	-30	-28	19	16	3
1945	70	70	19	9	5	1	0	0	19	35	0	0	60	50	30
1946	33	33	-5	-7	-1	-3	3	3	-7	-7	-1	-1	-3	-2	-4
1947	51	51	4	-4	2	-3	3	3	4	-3	5	5	7	9	0
1948	52	52	10	12	1	3	0	0	1	5	-3	-3	19	20	19
1949	80	80	10	14	3	2	-2	-2	2	3	0	0	22	20	20
1950	30,829	30,829	1,266	1,298	66	166	18,515	18,528	776	802	0	-1	29,277	12,269	7,978
1951	26,584	26,584	1,318	1,327	136	234	16,194	16,201	1,060	1,074	106	138	13,490	7,710	5,889
1952	111,891	111,891	1,890	2,017	227	508	74,596	74,746	1,199	1,316	226	408	103,759	47,194	31,334
1953	-80,311	-80,311	-63	-34	637	846	-53,275	-53,266	97	119	350	-117	-50,822	3,937	21,289
1954	-78,743	-78,743	11,604	10,069	818	1,110	-30,809	-30,809	13,519	13,569	1,047	1,215	-30,849	16,265	2,777
1955	-7,081	-7,081	-8,553	-9,509	-1,415	-1,309	10,710	10,710	8,851	8,875	-509	-300	-10,273	-1,666	684
1956	-24,496	-24,496	-2,766	-2,789	-1,503	-1,450	-3,158	-3,158	6,590	6,515	-690	-570	-9,547	4,770	0
1957	-52,309	-52,309	-6,266	-7,519	1,980	1,831	-39,066	-39,066	-20,178	-20,045	2,350	2,220	-25,035	2,024	0
1958	-72,569	-72,569	7,554	6,430	1,179	-1,906	-47,425	-47,425	4,745	5,005	-744	-1,271	26,874	2,490	103
1959	103,855	103,855	9,707	8,121	-138	-1,925	55,476	55,484	5,671	5,681	-52	-203	84,645	10,009	980
1960	153,259	153,259	8,358	10,056	800	1,508	88,827	88,853	5,179	5,241	0	0	75,841	32,148	15,035
1961	-972	-972	1,028	3,202	624	1,514	-1,742	-1,735	1,405	1,443	335	-325	-30,283	8,918	7,770
1962	27,179	27,179	3,574	4,201	569	838	12,859	12,862	2,685	2,701	-71	-280	9,885	5,201	5,602
1963	-117,287	-117,287	-1,826	-1,349	262	656	-73,442	-73,443	-774	-779	89	91	-47,901	-4,334	2,650
1964	-76,720	-76,720	13,824	12,622	509	-60	-28,167	-28,167	19,122	19,054	1,644	1,575	-17,463	24,682	3,598
1965	-183,009	-183,009	-5,191	-10,167	593	-398	-100,610	-100,610	-3,263	-3,144	678	-36	-103,844	-810	-36
1966	-123,581	-123,581	35,625	29,691	9,934	8,964	-93,472	-93,472	15,707	16,051	709	-2,401	63,606	31,208	9,875
1967	-100,411	-100,411	48,775	45,832	5,419	7,772	-40,983	-40,983	32,693	32,157	4,398	7,027	67,665	59,222	-36
1968	-156,391	-156,391	-13,400	-18,056	4,442	6,892	-89,425	-89,425	-6,588	-6,901	4,383	6,659	-51,952	-14,832	-174
1969	-152,598	-152,598	-2,081	-6,947	1,576	-2,836	-102,936	-102,937	-2,322	-2,366	1,524	1,188	-10,606	-15,018	-3,509
1970	-31,586	-31,586	5,280	1,875	469	-2,514	-30,258	-30,258	3,021	3,004	7	-50	35,155	-7,058	-2,952
1971	-122,803	-122,803	32,591	29,256	10,277	9,965	-69,136	-69,136	13,408	13,427	7,744	8,136	3,360	46,389	6,310
1972	-49,146	-49,146	6,259	3,264	1,164	2,327	-22,057	-22,057	4,580	4,762	921	1,943	6,419	12,283	128
1973	-176,222	-176,222	-5,237	-9,279	2,045	1,155	-107,769	-107,769	-3,180	-3,209	1,925	903	-54,117	-7,185	-5
1974	-107,244	-107,244	6,069	2,496	696	-1,486	-73,676	-73,676	1,476	1,448	729	1,077	13,899	-8,092	-2,659
1975	-79,664	-79,664	39,530	36,616	18,246	16,402	-68,710	-68,710	19,701	19,667	8,292	3,702	44,681	33,014	11,103
1976	45,284	45,284	4,546	2,385	1,187	7	20,705	20,706	2,740	2,743	-1,658	-5,752	48,398	-2,684	6,547
1977	-82,332	-82,332	-3,061	-4,530	286	724	-42,717	-42,717	-2,527	-2,532	288	668	-37,475	-293	218
1978	-86,422	-86,422	15,261	11,226	-1,932	-417	-40,207	-40,207	13,455	13,891	-1,719	-145	-5,689	22,294	-44

Run 12 - D3 + Carryover Allocation (All Pumping On)

Annual Differences in ILRG Model Outputs

Run 12 minus Run 11

1940 - 2017 (acre-feet)

	Net River Headgate Diversions						Farm Headgate Deliveries						Annual Flows		
	EBID		EPCWID (incl. EPW)		HCCRD		EBID		EPCWID (incl. EPW)		HCCRD				
Year	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Caballo Releases	Rio Grande at El Paso	Rio Grande at Fort Quitman
1979	-242,940	-242,940	14,971	10,250	1,356	1,835	-156,411	-156,421	10,865	11,121	883	1,513	-79,820	-6,878	-6,271
1980	-57,521	-57,521	12,992	7,840	2,657	-271	-45,374	-45,375	5,690	5,722	2,749	1,535	50,842	-10,431	-3,544
1981	-748	-748	18,265	16,460	3,544	1,830	-5,809	-5,809	7,694	7,675	0	0	42,949	5,862	575
1982	104,358	104,358	13,207	12,473	2,894	2,147	60,225	60,234	5,313	5,332	-1,707	-3,455	74,615	17,105	8,645
1983	170,632	170,632	17,092	18,975	7,635	8,539	104,548	104,634	6,781	6,900	0	0	133,843	61,115	27,926
1984	35,030	35,030	14,349	15,942	1,945	2,596	24,687	24,721	5,912	6,017	0	0	17,038	38,153	14,801
1985	6,224	6,224	20,411	20,491	-18,515	-18,898	13,078	13,095	10,574	10,599	0	0	-19,916	-6,599	-14,535
1986	89,043	89,043	20,391	20,515	1,458	331	48,157	48,259	10,093	10,193	0	0	-184,856	-209,916	-170,620
1987	64,788	64,788	21,344	21,499	6,046	5,967	34,901	35,030	9,499	9,636	0	0	42,456	40,189	17,285
1988	54,473	54,473	21,898	22,008	5,315	5,043	25,545	25,632	10,639	10,735	0	0	46,971	30,948	6,113
1989	105,248	105,248	26,533	26,610	6,905	7,176	62,153	62,269	12,555	12,573	0	0	98,846	67,520	44,485
1990	17,227	17,227	20,147	20,216	4,471	4,503	9,923	9,994	9,154	9,100	0	0	26,132	47,336	30,703
1991	12,089	12,089	15,726	15,769	3,713	3,497	6,353	6,416	6,052	6,099	0	0	23,248	31,909	21,446
1992	39,535	39,535	20,145	20,169	710	383	31,853	31,945	7,828	7,839	0	0	13,262	1,908	-11,486
1993	56,305	56,305	10,680	11,014	-5,873	-6,338	36,926	37,056	3,396	3,871	0	0	-61,025	-77,452	-87,516
1994	117,979	117,979	16,860	16,986	2,585	2,904	71,694	71,834	7,618	7,756	0	0	2,660	-24,835	-38,838
1995	131,993	131,993	10,952	11,028	886	1,942	82,128	82,277	4,619	4,693	0	0	-61,578	-56,465	-50,980
1996	146,042	146,042	9,917	10,080	793	972	90,723	90,865	3,799	3,959	0	0	51,975	19,613	2,113
1997	55,506	55,506	3,912	4,061	-439	-286	36,960	37,060	1,900	1,913	0	0	46,476	61,669	44,636
1998	84,253	84,253	6,290	6,357	1,596	1,713	51,308	51,406	1,999	2,124	0	0	44,739	37,759	33,955
1999	43,156	43,156	6,649	7,382	2,880	3,596	37,267	37,333	19,325	19,416	0	0	37,842	36,998	21,371
2000	39,017	39,017	8,726	9,939	1,802	2,389	26,263	26,320	6,525	6,593	0	0	33,339	40,172	32,565
2001	64,767	64,767	20,040	20,866	3,869	4,408	40,984	41,085	14,015	14,117	0	0	85,456	69,677	49,561
2002	-81,134	-81,134	465	1,904	1,207	1,739	-45,642	-45,641	923	934	0	0	-75,916	3,212	9,507
2003	-171,521	-171,521	-12,182	-13,689	-1,146	-1,838	-103,803	-103,803	-9,180	-9,213	0	0	-93,896	-33,791	-7,607
2004	-61,471	-61,471	-3,524	-4,646	-625	-1,084	-32,540	-32,540	-1,631	-1,661	0	0	-5,144	-9,344	-8,898
2005	-254,960	-254,960	2,796	1,921	584	128	-159,228	-159,263	2,365	2,293	0	0	-122,256	-28,376	-23,335
2006	-64,437	-64,437	71,350	69,120	16,825	17,365	-35,240	-35,241	39,361	39,311	0	0	103,380	63,812	10,643
2007	-161,645	-161,645	-5,201	-6,645	820	1,171	-99,591	-99,591	-1,820	-1,858	0	0	-44,861	-11,410	63
2008	-204,071	-204,071	2,692	1,152	595	-66	-128,644	-128,677	2,651	2,547	0	0	-98,995	-33,272	-29,321
2009	-144,518	-144,518	58,899	56,730	16,250	15,737	-98,878	-98,935	27,421	27,316	0	0	22,399	18,220	-8,941
2010	-176,701	-176,701	5,848	3,188	352	-190	-113,110	-113,114	6,358	6,273	0	0	-9,069	-12,390	-28,117
2011	-53,706	-53,706	103,760	102,380	34,226	37,633	-17,354	-17,354	76,088	76,048	10,844	10,982	131,185	112,180	12,517
2012	-59,293	-59,293	-8,002	-8,136	5,695	9,903	-25,723	-25,723	-3,345	-3,360	-3,877	-3,994	-40,374	-2,252	19,534
2013	36,192	36,192	45,941	45,865	10,634	10,857	9,211	9,211	33,667	33,662	6,317	6,474	107,830	48,863	11,247
2014	-116,483	-116,483	-28,176	-28,193	-1,382	-1,383	-51,818	-51,818	-16,049	-16,054	63	104	-154,243	-25,601	5,123
2015	-80,123	-80,123	9,829	9,535	3,064	2,772	-31,264	-31,264	8,168	8,155	548	-8	-20,981	25,072	4,469
2016	-79,576	-79,576	59,981	59,552	12,162	13,041	-36,555	-36,555	46,029	46,012	0	0	53,720	71,287	23,793
2017	-275,637	-275,637	17,199	15,537	6,251	6,418	-166,196	-166,214	16,343	16,285	-698	-715	-110,047	4,293	-1,681
Averages															
1951-2017	-34,425	-34,425	13,097	11,985	3,027	2,942	-19,820	-19,793	8,168	8,201	708	566	3,284	10,651	1,252
1951-1978	-53,352	-53,352	7,298	5,375	2,110	1,748	-31,417	-31,409	4,931	4,956	1,154	911	3,994	10,992	4,374
1979-2005	21,014	21,014	12,557	12,312	1,417	1,293	12,847	12,912	6,456	6,531	71	-15	6,233	5,447	-2,146
2006-2017	-115,000	-115,000	27,843	26,674	8,791	9,438	-66,264	-66,273	19,573	19,528	1,100	1,070	-5,005	21,567	1,611
1985-2017	-24,892	-24,892	17,645	17,290	3,749	3,985	-13,035	-12,989	11,119	11,149	400	389	-3,977	9,119	-2,447
1985-2005	26,598	26,598	11,818	11,928	868	869	17,381	17,459	6,289	6,360	0	0	-3,390	2,006	-4,765

Notes:

EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).

EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

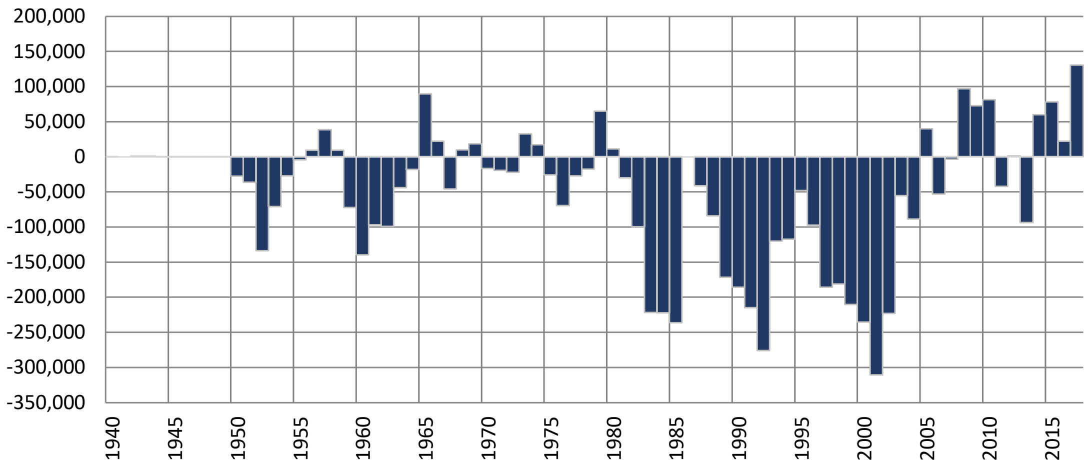
Run 12 - D3 + Carryover Allocation (All Pumping On)

Simulated Differences in ILRG Model Outputs

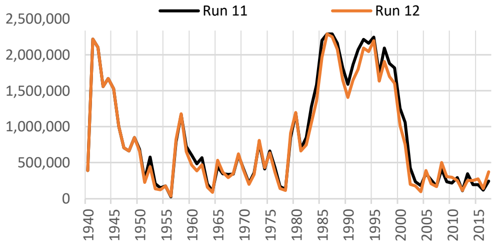
Run 12 minus Run 11

1940 - 2017 (acre-feet)

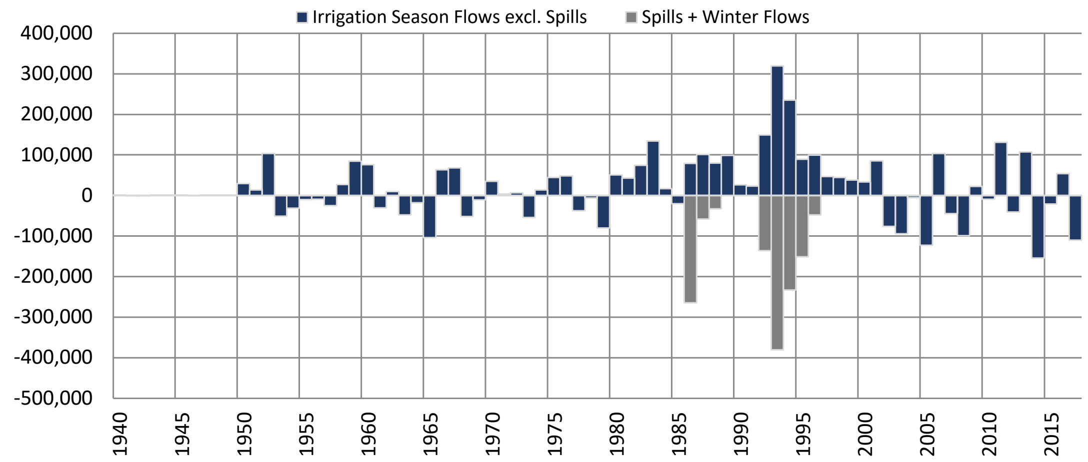
Total Project Storage (Year End)



Period	Average Difference
1951-2017	2,357
1951-1978	356
1979-2005	2,125
2006-2017	7,550
1985-2017	10,688
1985-2005	12,482

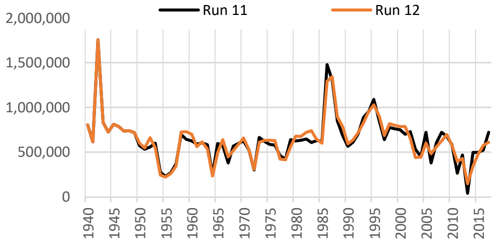


Caballo Reservoir Outflows (Annual)



Average Difference

Period	Irr Season (excl. Spills)	Nov-Feb and Spills	Annual
1951-2017	22,740	-19,455	3,284
1951-1978	3,994	0	3,994
1979-2005	54,511	-48,278	6,233
2006-2017	-5,005	0	-5,005
1985-2017	35,523	-39,500	-3,977
1985-2005	58,682	-62,072	-3,390



Notes:

Reservoir storage does not include storage attributed to SJC, CO, or NM credit waters.

Average differences calculated as (Final Storage - Initial Storage)/(no. years).

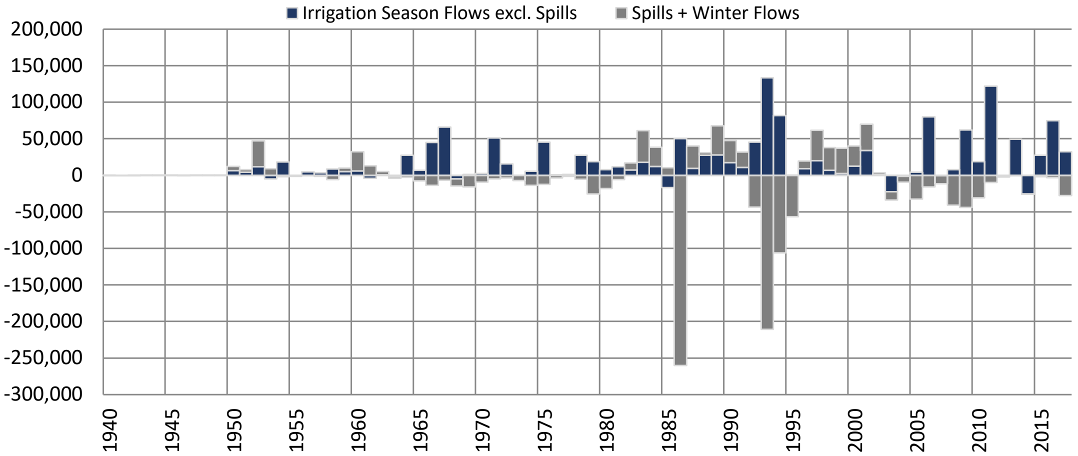
Run 12 - D3 + Carryover Allocation (All Pumping On)

Simulated Differences in ILRG Model Outputs

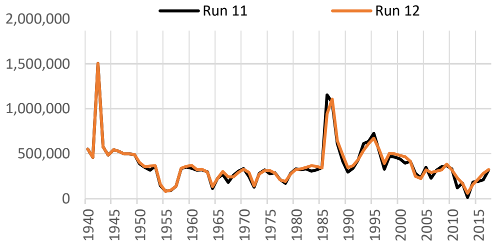
Run 12 minus Run 11

1940 - 2017 (acre-feet)

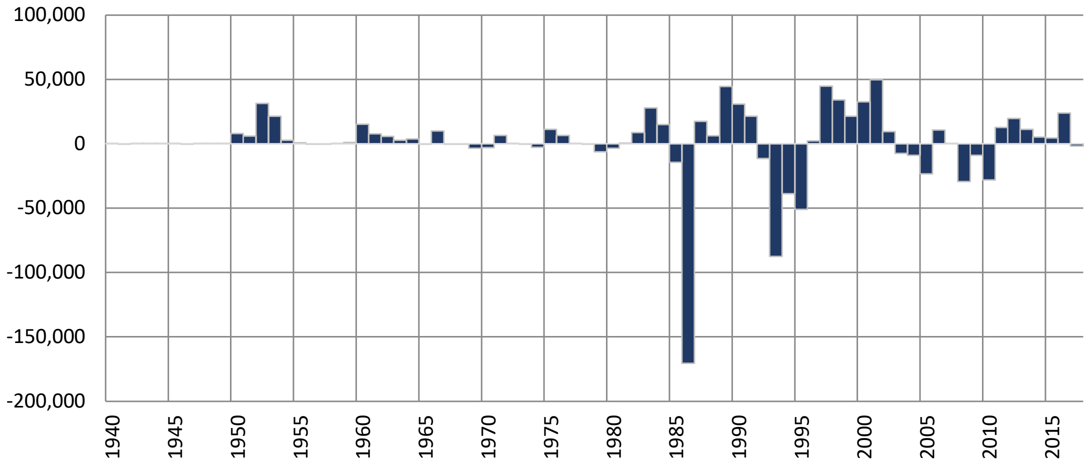
Rio Grande at El Paso (Annual)



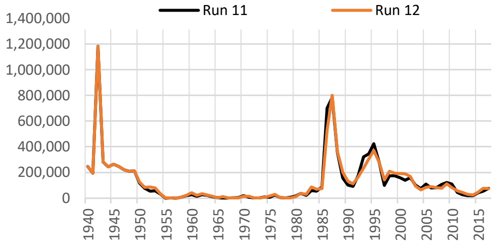
	Average Difference		
Period	Irr Season (excl. Spills)	Nov-Feb and Spills	Annual
1951-2017	19,634	-8,983	10,651
1951-1978	12,214	-1,221	10,992
1979-2005	19,551	-14,104	5,447
2006-2017	37,136	-15,569	21,567
1985-2017	27,217	-18,097	9,119
1985-2005	21,549	-19,542	2,006



Rio Grande at Fort Quitman (Annual)



Period	Average Difference
1951-2017	1,247
1951-1978	4,367
1979-2005	-2,150
2006-2017	1,607
1985-2017	-2,450
1985-2005	-4,768



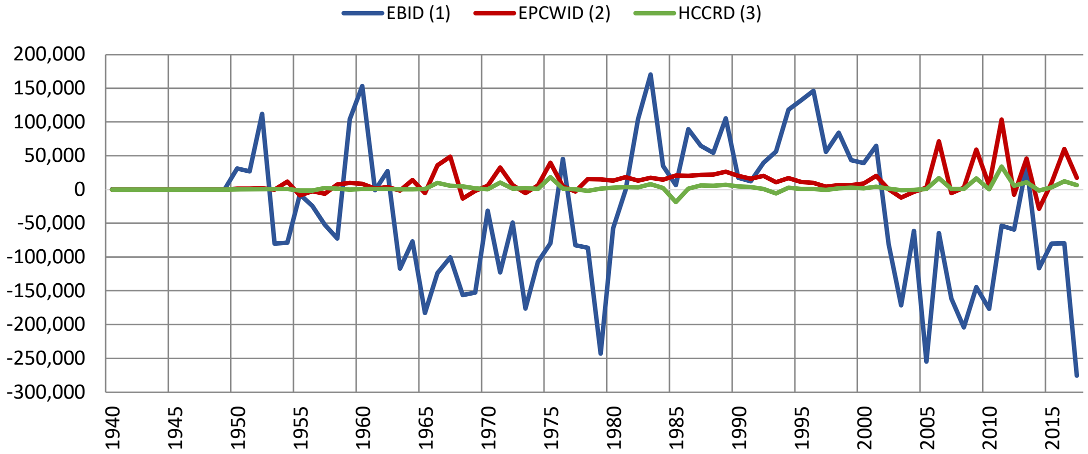
Run 12 - D3 + Carryover Allocation (All Pumping On)

Simulated Differences in ILRG Model Outputs

Run 12 minus Run 11

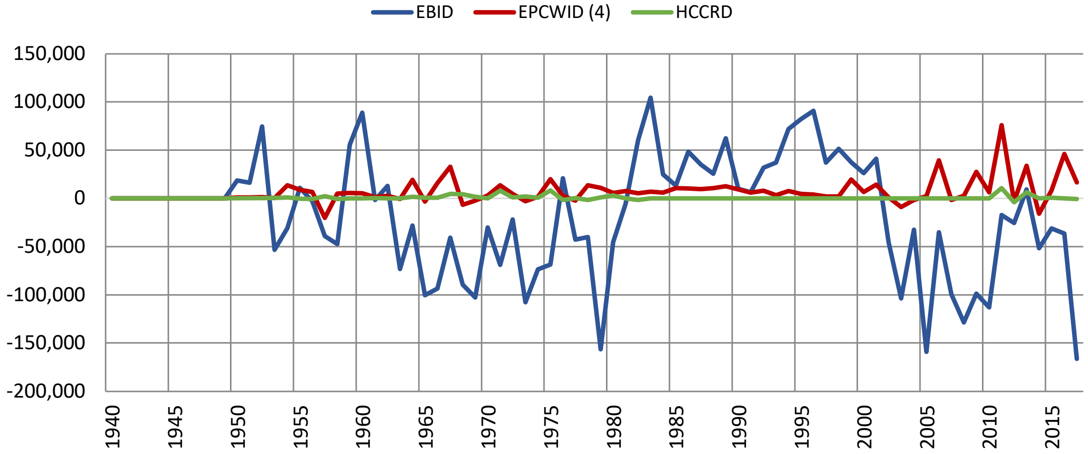
1940 - 2017 (acre-feet)

River Headgate (RHG) Diversions (Irrigation Season)



	Average Difference		
Period	EBID	EPCWID	HCCRD
1951-2017	-34,425	13,097	3,027
1951-1978	-53,352	7,298	2,110
1979-2005	21,014	12,557	1,417
2006-2017	-115,000	27,843	8,791
1985-2017	-24,892	17,645	3,749
1985-2005	26,598	11,818	868

Farm Headgate (FHG) Deliveries (Irrigation Season)



	Average Difference		
Period	EBID	EPCWID	HCCRD
1951-2017	-19,820	8,168	708
1951-1978	-31,417	4,931	1,154
1979-2005	12,847	6,456	71
2006-2017	-66,264	19,573	1,100
1985-2017	-13,035	11,119	400
1985-2005	17,381	6,289	0

Notes:

(1) EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).

(2) EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

(3) HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

(4) EPCWID FHG values include deliveries to Rogers WTP and R/U WTP.

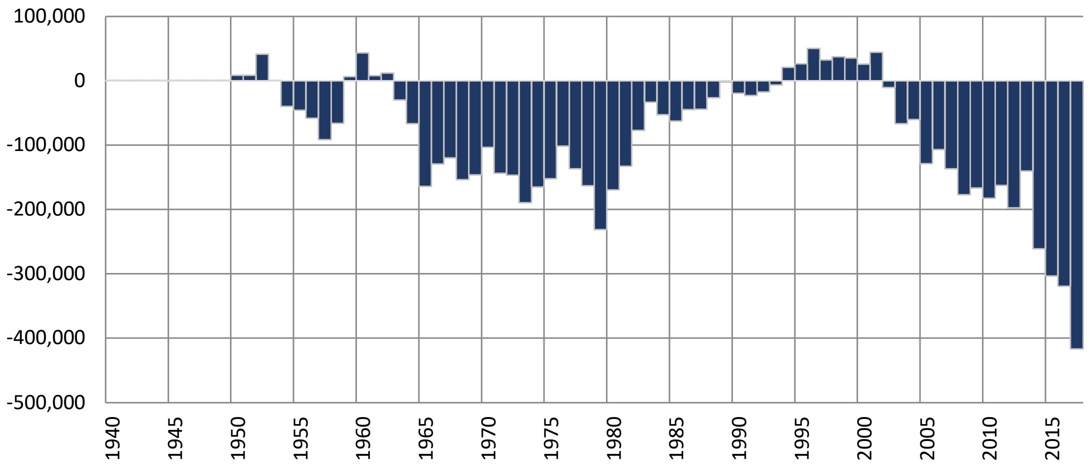
Run 12 - D3 + Carryover Allocation (All Pumping On)

Simulated Differences in ILRG Model Outputs

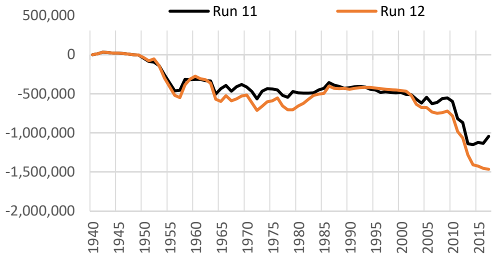
Run 12 minus Run 11

1940 - 2017 (acre-feet)

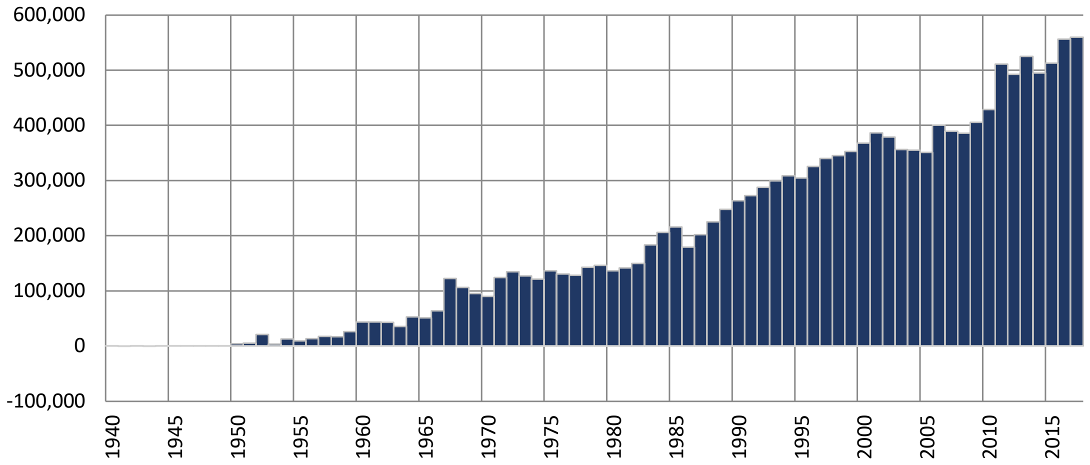
Cumulative Annual Rincon-Mesilla Groundwater Storage



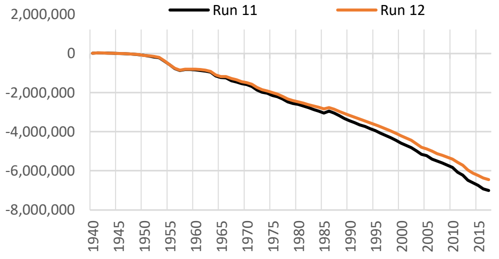
Period	Average Difference
1951-2017	-6,349
1951-1978	-6,126
1979-2005	1,264
2006-2017	-23,995
1985-2017	-11,029
1985-2005	-3,620



Cumulative Annual Hueco Groundwater Storage



Period	Average Difference
1951-2017	8,297
1951-1978	4,943
1979-2005	7,708
2006-2017	17,444
1985-2017	10,723
1985-2005	6,883



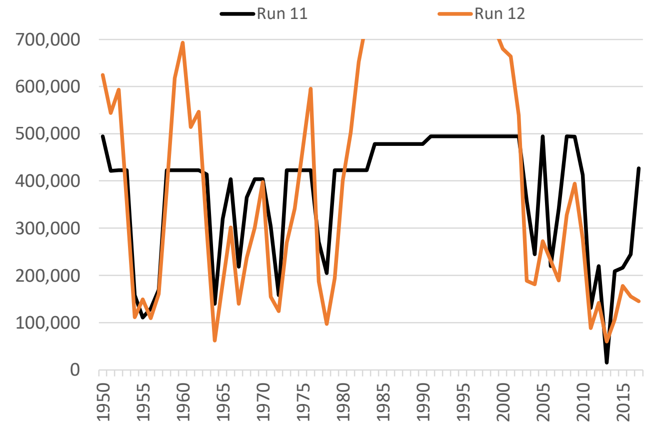
Notes:

Cumulative storage change in alluvial and non-alluvial aquifers.

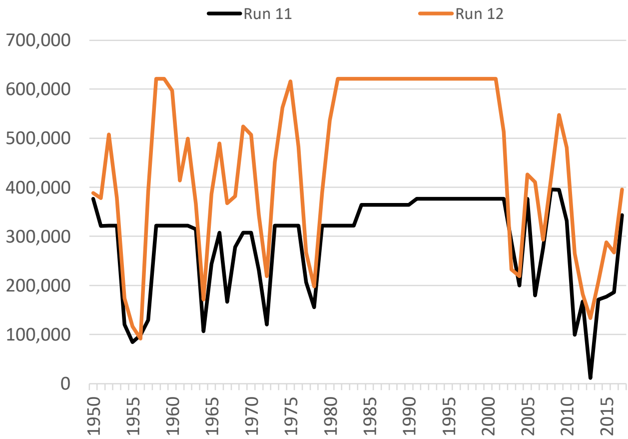
Average differences calculated as (Final Storage - Initial Storage)/(no. years).

Run 12 - D3 + Carryover Allocation (All Pumping On)
Annual Allocation and Charges
Run 12 v. Run 11
ILRG Model
1950 - 2017 (acre-feet)

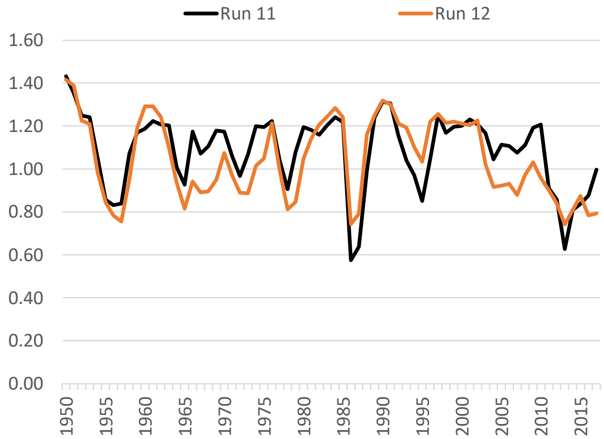
Total Allocation - EBID



Total Allocation - EPCWID

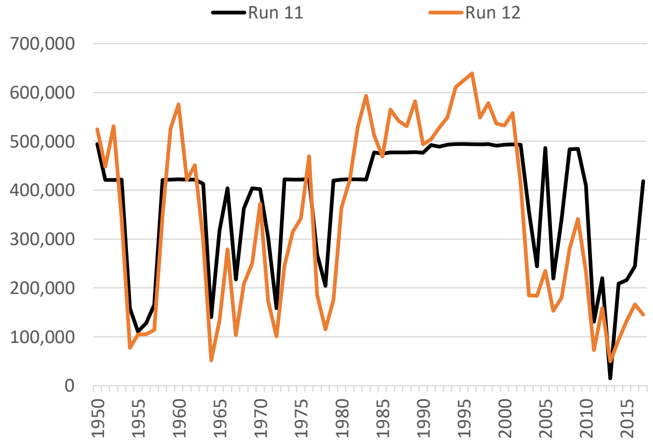


Diversion Ratio

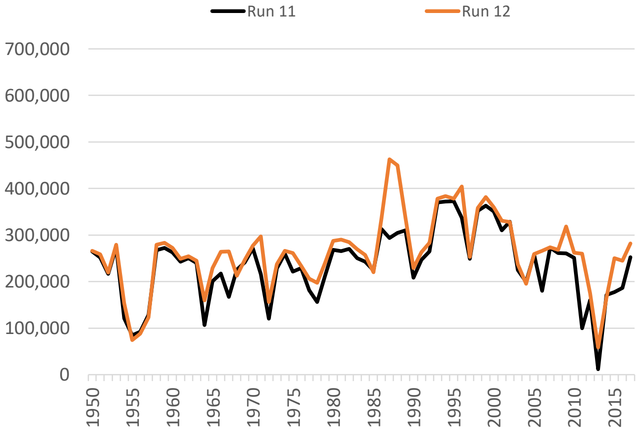


Note:
Computed as Total Charges/Caballo Release.

Annual Delivery Charges - EBID



Annual Delivery Charges - EPCWID



Run 12 - D3 + Carryover Allocation (All Pumping On)

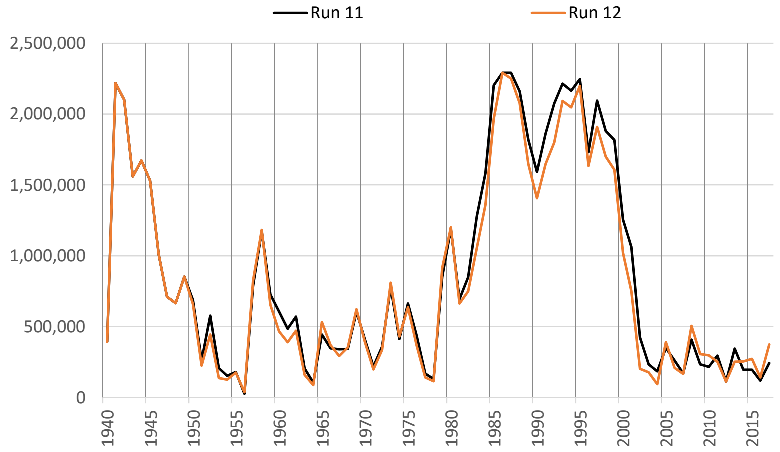
Annual Summary of Project Storage and Rio Grande Flows

Run 12 v. Run 11

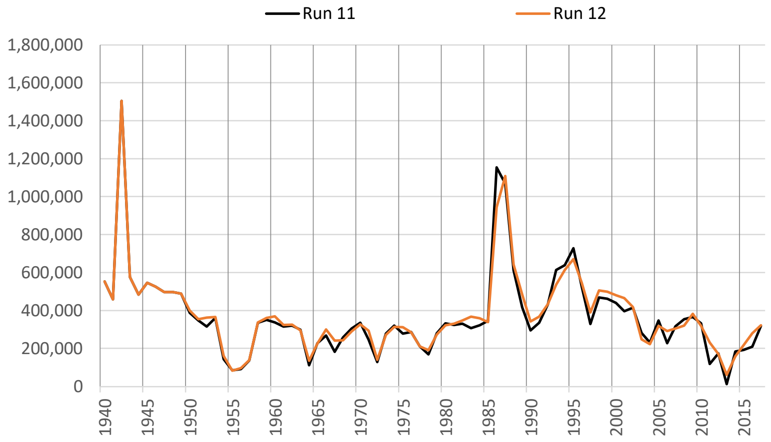
ILRG Model

1940 - 2017 (acre-feet)

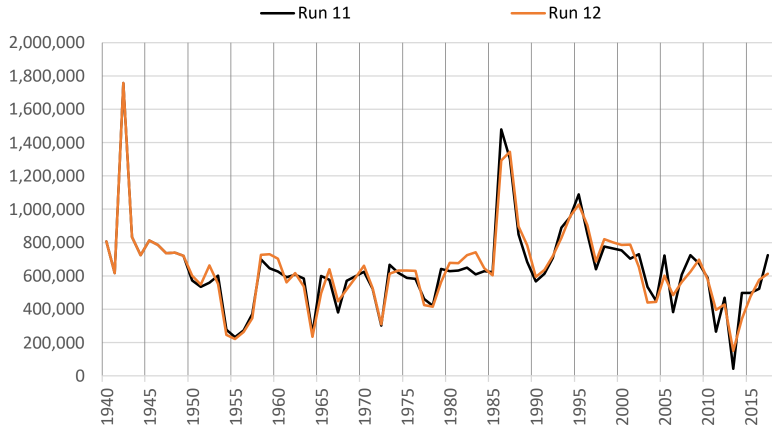
Total Year-End Project Reservoir Storage



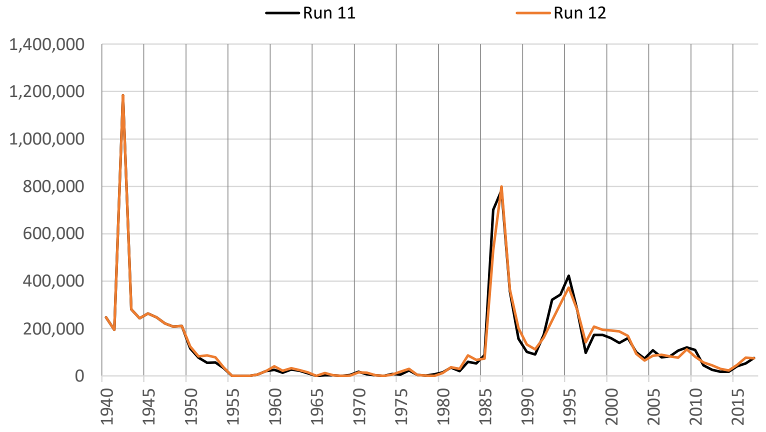
Rio Grande at El Paso



Rio Grande Below Caballo



Rio Grande at Fort Quitman



***Note different scales.**

Run 12 - D3 + Carryover Allocation (All Pumping On)

Irrigation Season Summary of Irrigation Operations

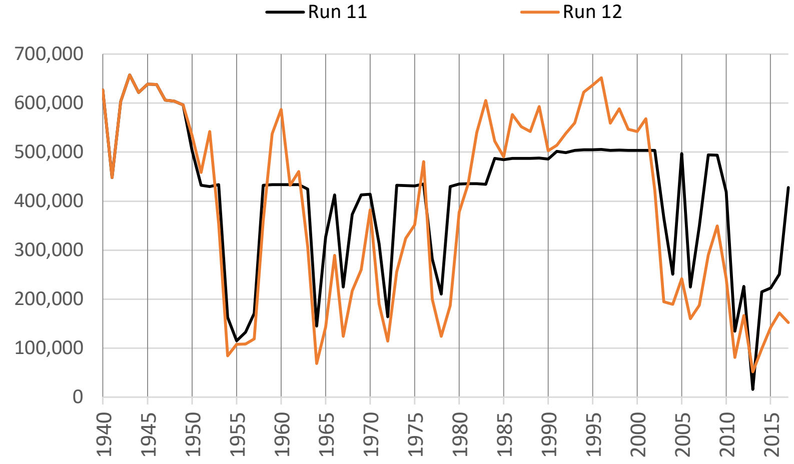
Run 12 v. Run 11

ILRG Model

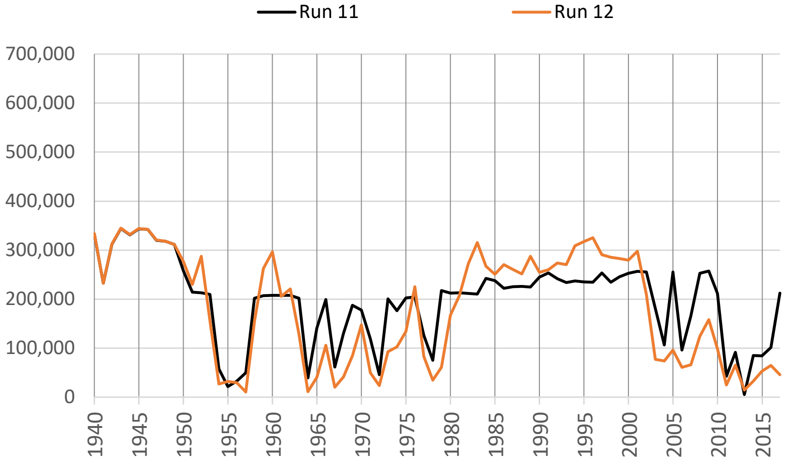
1940 - 2017 (acre-feet)

EBID Total

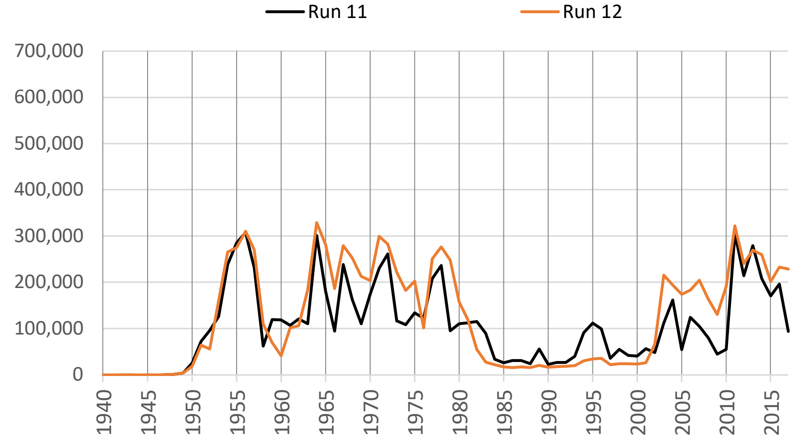
Net River Headgate Diversions



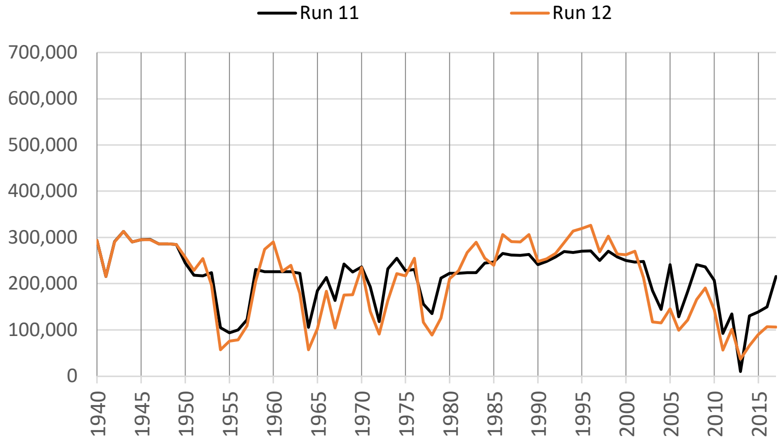
Farm Headgate Deliveries



Pumping



RHG Diversions - FHG Deliveries

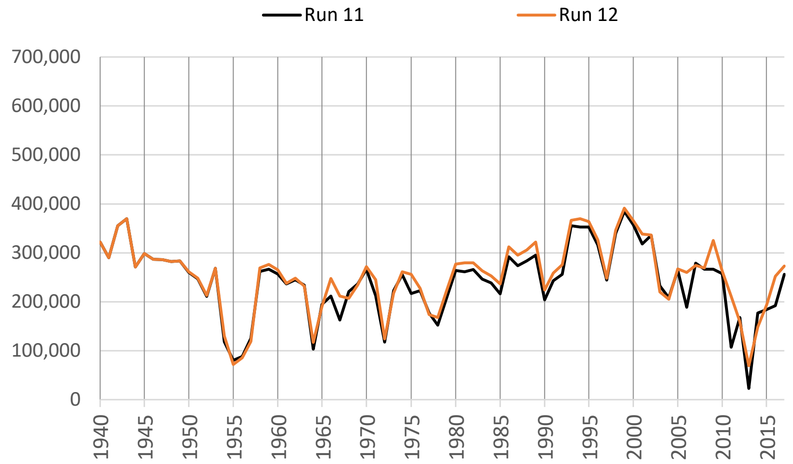


Notes: EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).
Pumping includes Supplemental and Primary groundwater pumping.

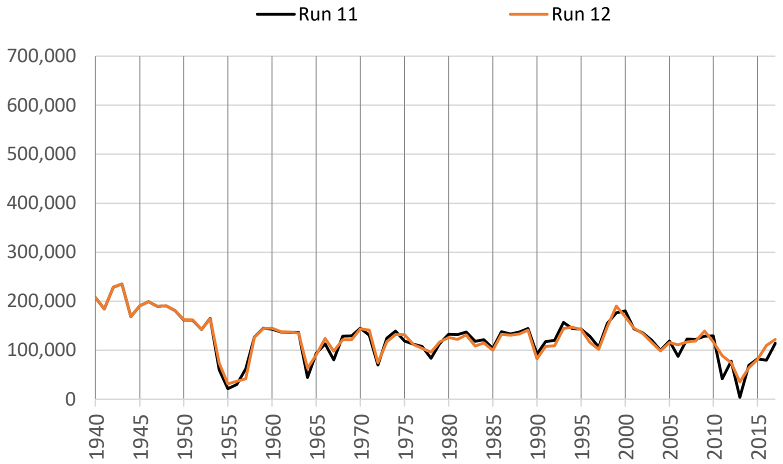
Run 12 - D3 + Carryover Allocation (All Pumping On)
Irrigation Season Summary of Irrigation Operations
Run 12 v. Run 11
ILRG Model
1940 - 2017 (acre-feet)

EPCWID Total

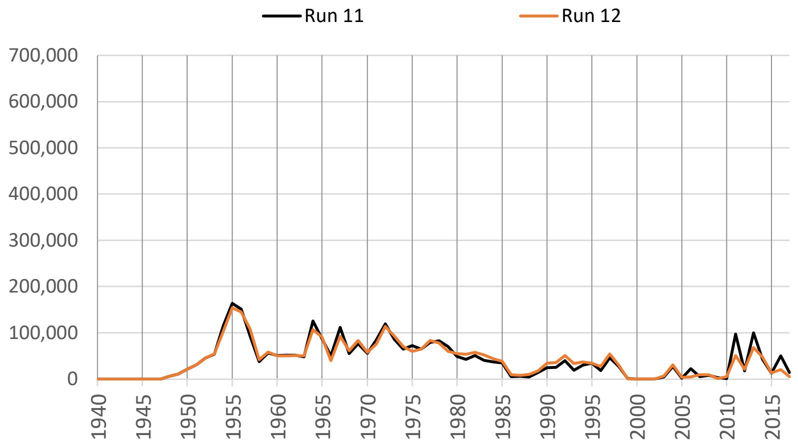
Net River Headgate Diversions



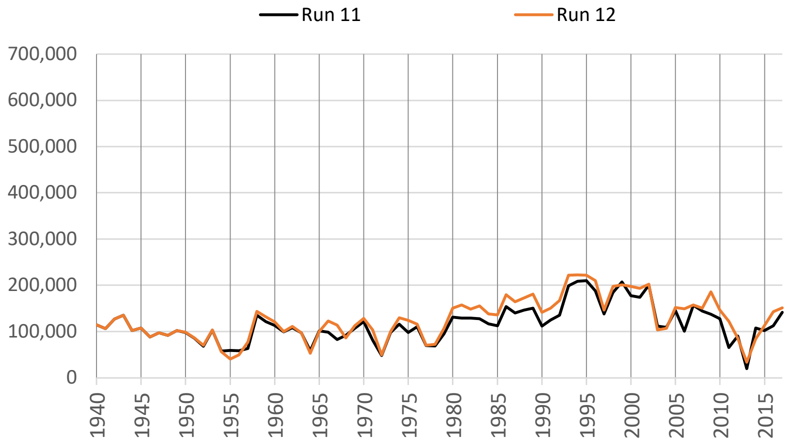
Farm Headgate Deliveries



Pumping



RHG Diversions - FHG Deliveries

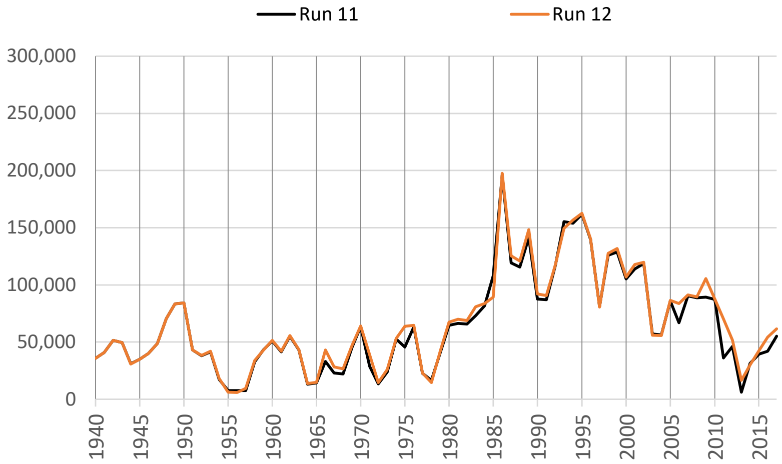


Note: EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

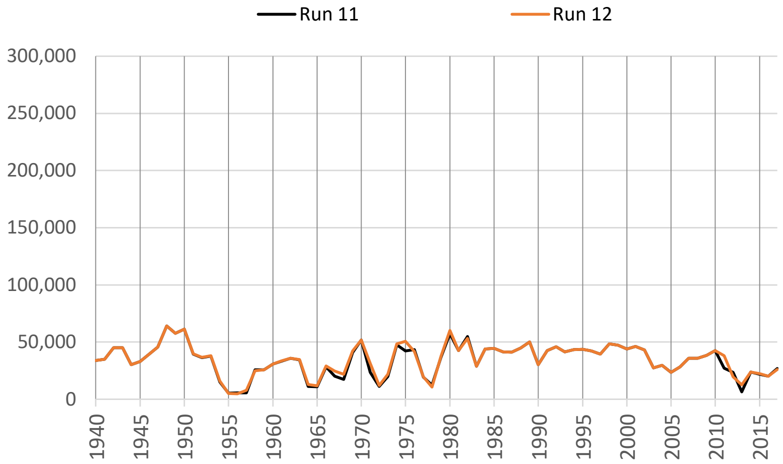
Run 12 - D3 + Carryover Allocation (All Pumping On)
Irrigation Season Summary of Irrigation Operations
Run 12 v. Run 11
ILRG Model
1940 - 2017 (acre-feet)

HCCRD Total

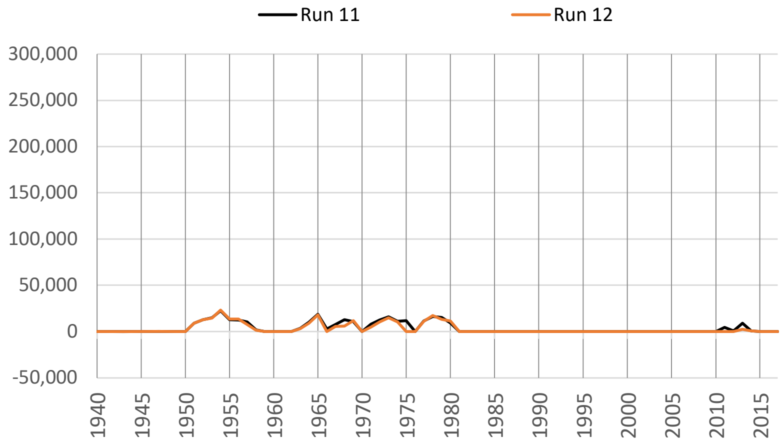
Net River Headgate Diversions



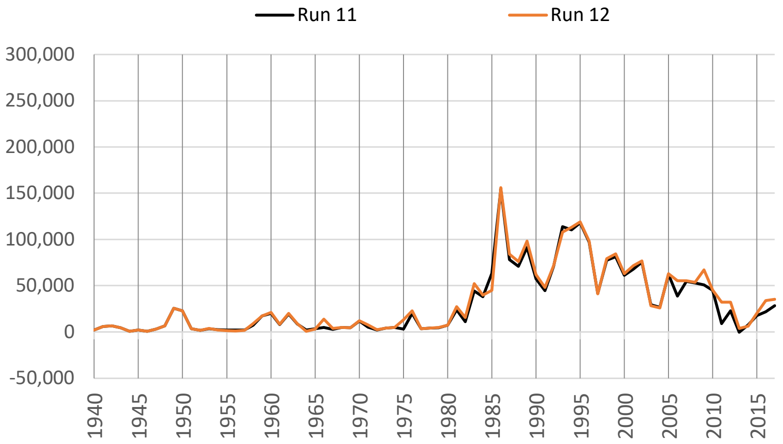
Farm Headgate Deliveries



Pumping



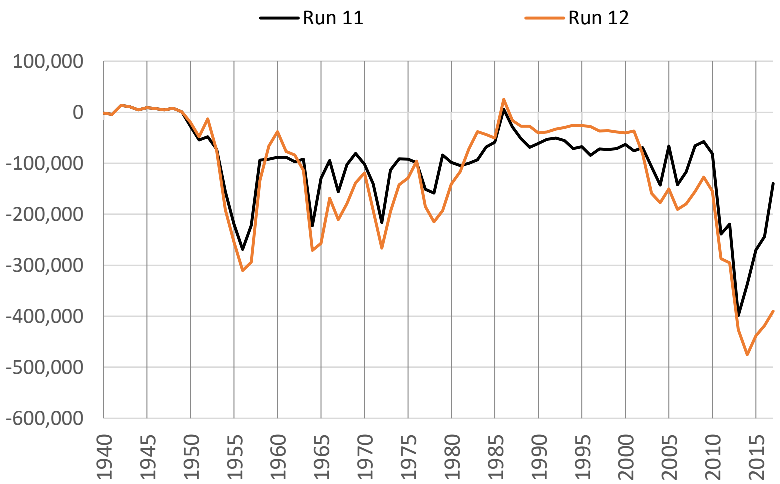
RHG Diversions - FHG Deliveries



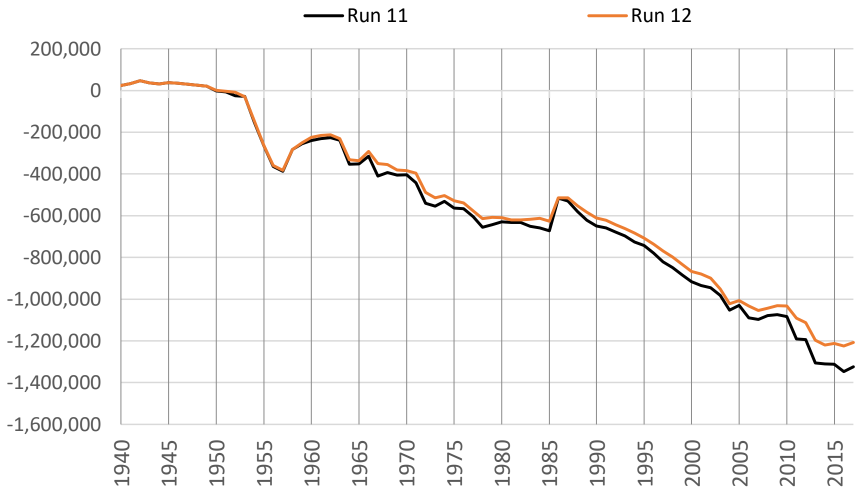
Note: HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

Run 12 - D3 + Carryover Allocation (All Pumping On)
Cumulative Change in Ground Water Storage
Run 12 v. Run 11
ILRG Model
1940 - 2017 (acre-feet)

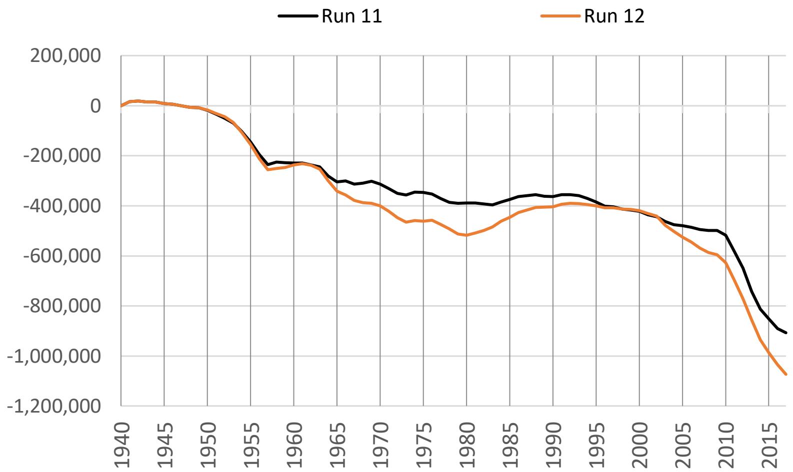
Rincon-Mesilla Alluvial Aquifer



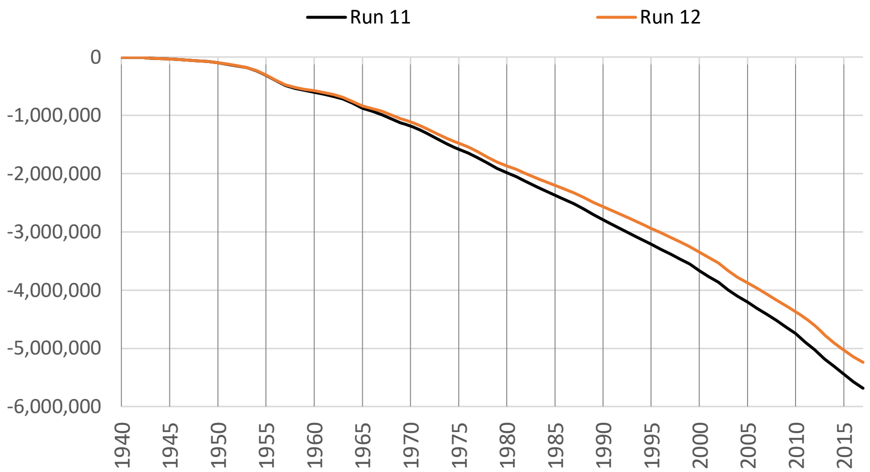
Hueco Alluvial Aquifer



Rincon-Mesilla Non-Alluvial Aquifer

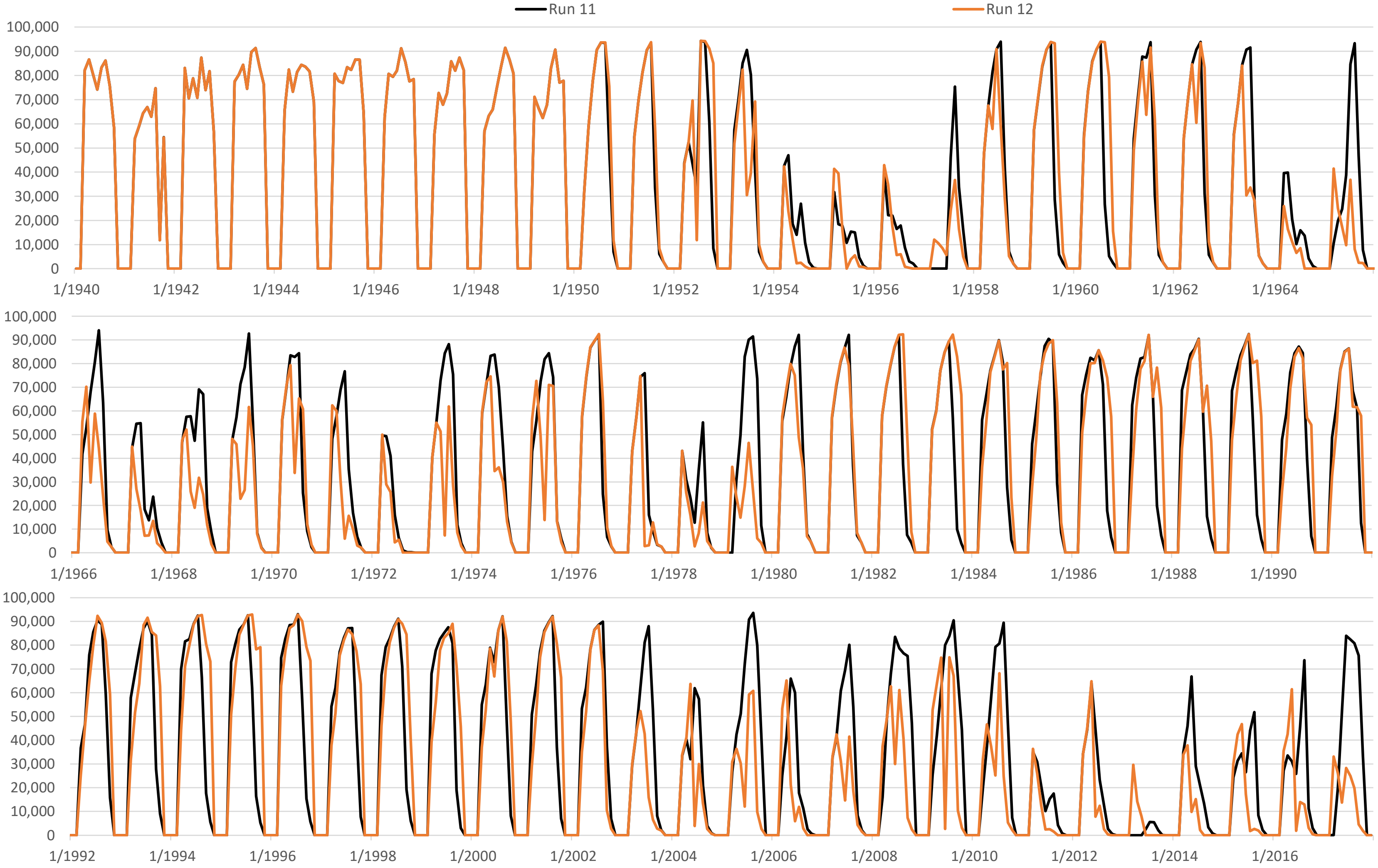


Hueco Non-Alluvial Aquifer



***Note different scales.**

Run 12 - D3 + Carryover Allocation (All Pumping On)
Monthly Net RHG Diversions
Run 12 v. Run 11
ILRG Model
1940 - 2017 (acre-feet)
EBID Total



Note: EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).

Run 12 - D3 + Carryover Allocation (All Pumping On)

Monthly Net RHG Diversions

Run 12 v. Run 11

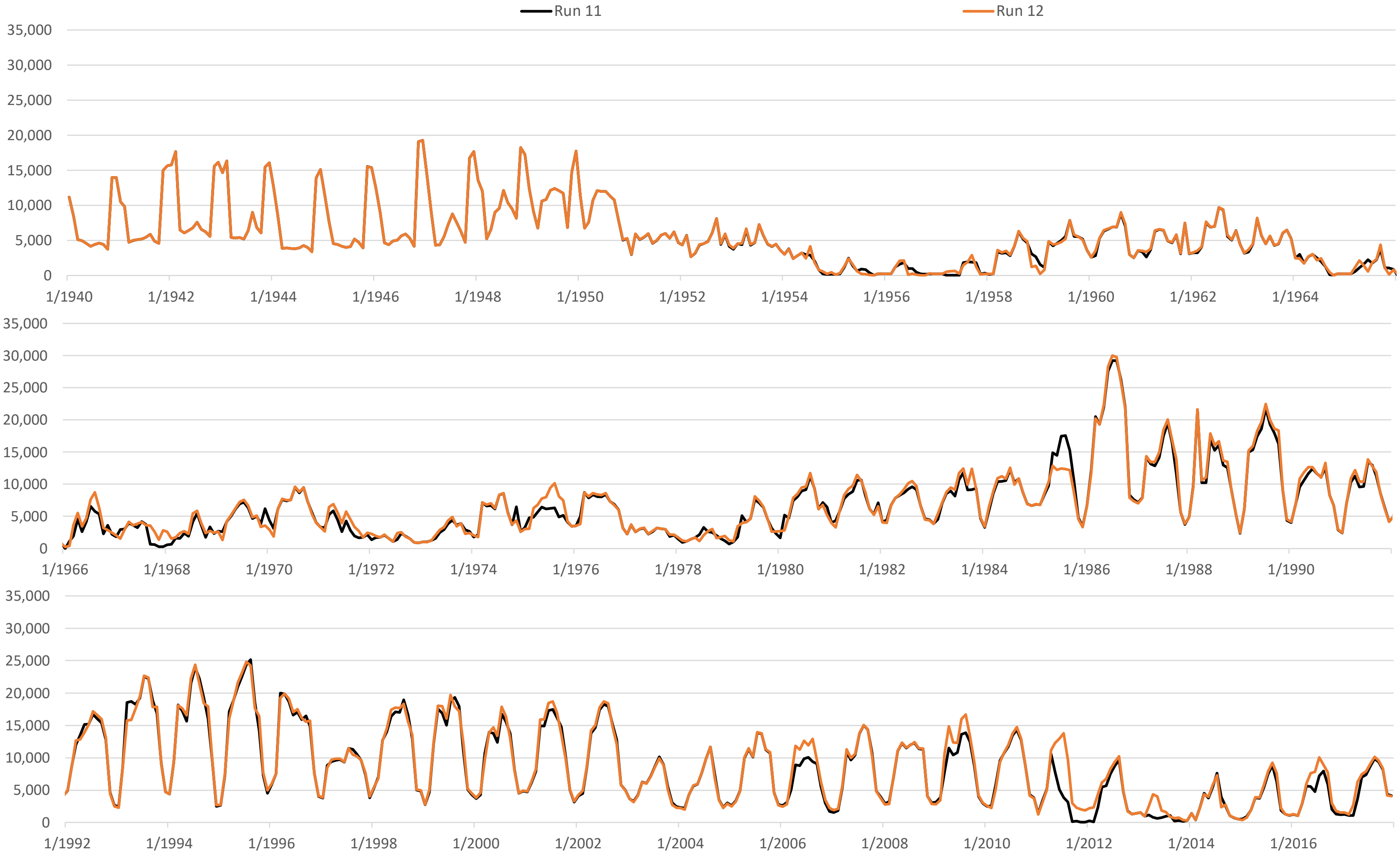
ILRG Model

1940 - 2017 (acre-feet)

EPCWID Total

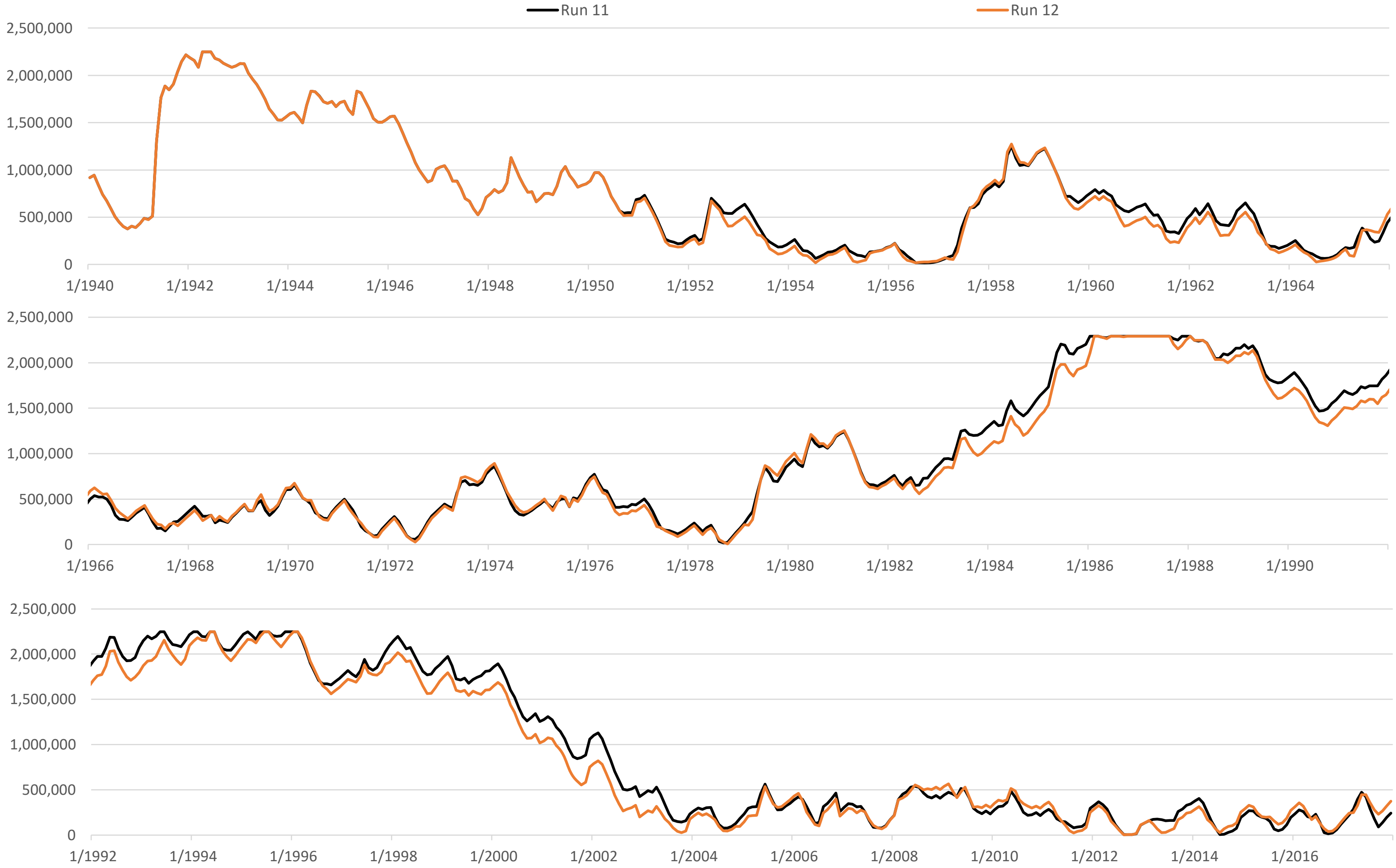
Note: EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

Run 12 - D3 + Carryover Allocation (All Pumping On)
Monthly Net RHG Diversions
Run 12 v. Run 11
ILRG Model
1940 - 2017 (acre-feet)
HCCRD Total



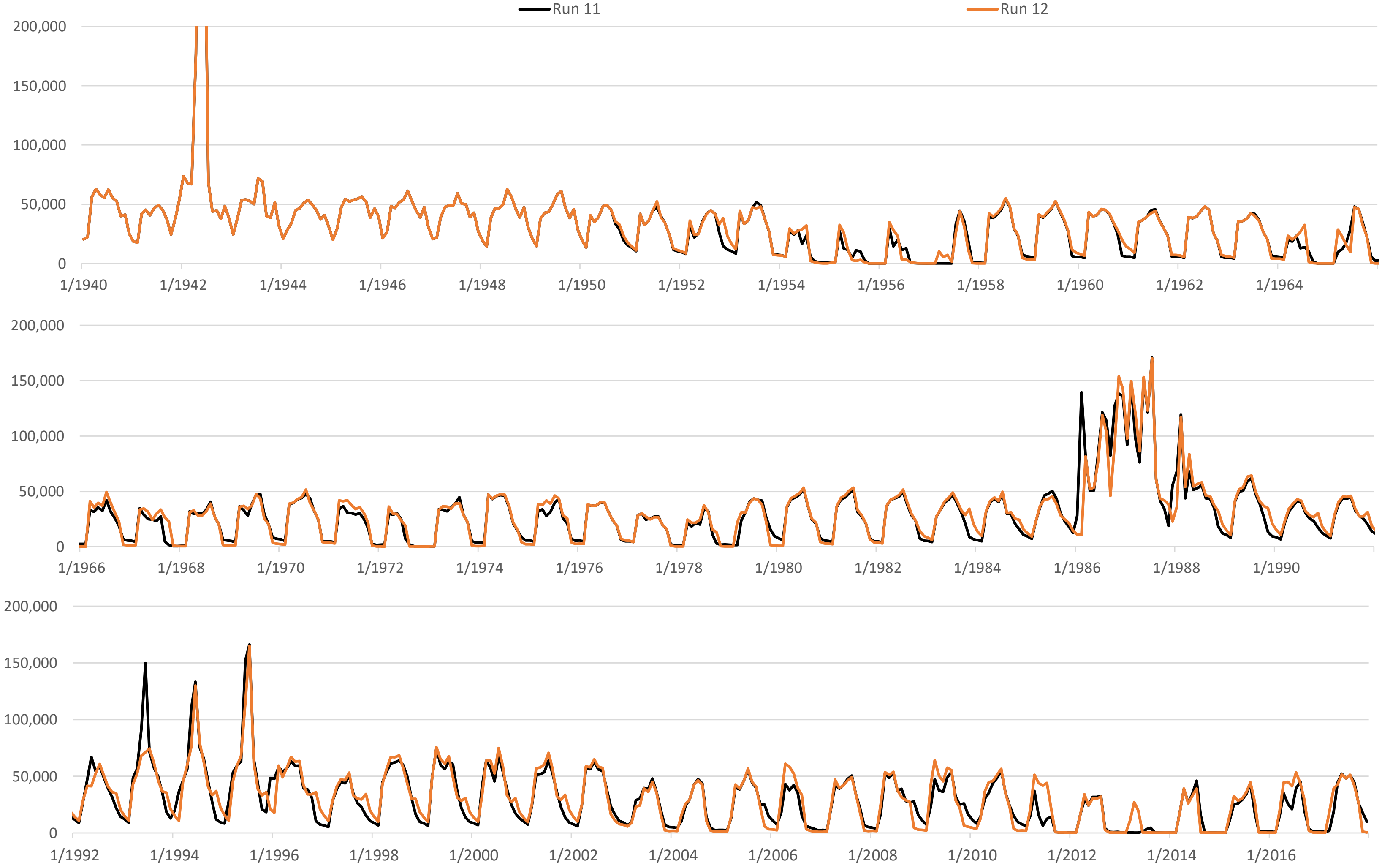
Note: HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

Run 12 - D3 + Carryover Allocation (All Pumping On)
End of Month Reservoir Storage (Elephant Butte + Caballo)
Run 12 v. Run 11
ILRG Model
1940 - 2017 (acre-feet)



Run 12 - D3 + Carryover Allocation (All Pumping On)
Monthly Caballo Releases
Run 12 v. Run 11
ILRG Model
1940 - 2017 (acre-feet)

Run 12 - D3 + Carryover Allocation (All Pumping On)
Monthly Rio Grande at El Paso Flow
Run 12 v. Run 11
ILRG Model
1940 - 2017 (acre-feet)



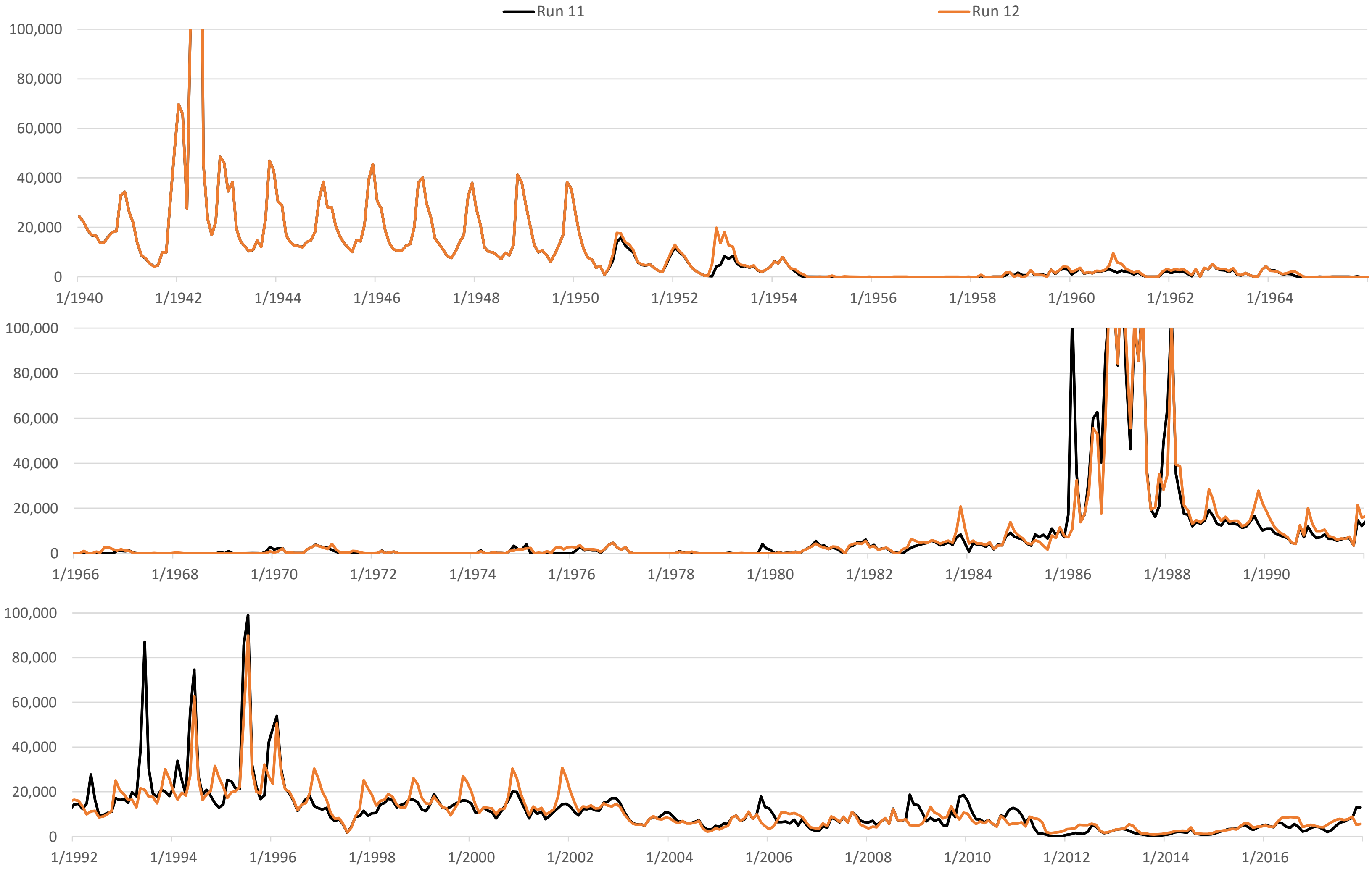
Run 12 - D3 + Carryover Allocation (All Pumping On)

Monthly Rio Grande at Fort Quitman Flow

Run 12 v. Run 11

ILRG Model

1940 - 2017 (acre-feet)



Appendix 30M

Comparison of ILRG Model Runs
Run 13 v. Run 1

Model Run Specifications

Model Version: LRG_v116

Name: **Run 13 - Reduced Waste**

Run ID: LRG_v116_Operational_Run13
Date: 8/27/2020

Name: **Run 1 - Historical Base Run (All Pumping On)**

Run ID: LRG_v116_Operational_Run1
Date: 8/23/2020

Selected Model Inputs

Pumping and Returns	**Run 13**	**Run 1**
Irrigation Pumping	On	On
Irrigated Area	Hist	Hist
Non-Irrigation Pumping	On	On
Non-Irrigation Pumping Returns	On	On
Las Cruces Jornada Pumping Returns	On	On
Project Allocation Rules		
1950-2005	D1/D2	D1/D2
2006-2007	D3	D3
2008-2017	D3 + CO	D3 + CO
EPCWID Operations		
Charge EPCWID for Use of WWTP Returns	Off	Off
ACE and Haskell Credits for EPCWID	On	On
Increased EPCWID Use of Fabens Drain Flows	Off	Off
Charge EPCWID for Fabens Drain Flow Use	Off	Off

Notes:
(1) Limit waste to minimum of tuned percentage or 10% of diversion.

Run 13 - Reduced Waste
Comparison of ILRG Model Runs
Run 13 v. Run 1
1951 - 2017 Annual Average
(1,000 acre-feet)

Run No.	1	13	13 - 1	
Simulated Input or Output	**Run 1**	**Run 13**	**Run 13 minus Run 1**	
Effects of Alternate Scenario				
FHG Deliveries (Mar - Oct)				***% Diff.***
EBID	167.6	201.8	34.2	*20%*
EPCWID (incl. EPW)	139.9	151.1	11.3	*8%*
HCCRD	32.8	28.5	-4.3	*-13%*
Total	340.3	381.4	41.1	*12%*
FHG Deliveries (Nov - Feb)				
EBID	0.0	0.0	0.0	*123%*
EPCWID (incl. EPW)	0.2	5.0	4.8	*2564%*
HCCRD	2.4	3.6	1.2	*49%*
Total	2.6	8.6	6.0	*231%*
Irrigation Pumping				
EBID	140.4	108.7	-31.7	*-23%*
EPCWID (Mesilla Valley)	7.4	5.1	-2.2	*-31%*
EPCWID (El Paso Valley)	40.1	28.6	-11.6	*-29%*
HCCRD	4.2	8.5	4.3	*101%*
Total	192.1	150.9	-41.2	*-21%*
Other Inflows/Outflows				
Net Reservoir Evaporation	125.3	139.7	14.4	*12%*
Riparian ET	70.9	68.9	-2.0	*-3%*
River Evaporation + Incidental Canal Loss	30.3	29.9	-0.4	*-1%*
Total	226.6	238.5	12.0	*5%*
Rio Grande at Fort Quitman				
Reservoir Spills	33.3	45.1	11.8	*35%*
Nov-Feb Flows	21.4	17.3	-4.1	*-19%*
Mar - Oct Flows	41.1	18.9	-22.2	*-54%*
Underflow (GW Model)	0.2	0.2	0.0	*-16%*
Total	96.0	81.4	-14.5	*-15%*

Run 13 - Reduced Waste

Comparison of ILRG Model Runs

Run 13 v. Run 1

1951 - 2017 Annual Average

(1,000 acre-feet)

Run No.	**1**	**13**	**13 - 1**	
Simulated Input or Output	**Run 1**	**Run 13**	**Run 13 minus Run 1**	
Effects of Alternate Scenario (continued)				
Change in Storage				***% Diff.***
Reservoir Storage	-4.7	-9.4	-4.7	*102%*
Alluvial GW Storage (RW Model)	-23.6	-22.0	1.6	*-7%*
Non-alluvial GW Storage (GW Models)	-96.4	-91.7	4.7	*-5%*
Soil Moisture Storage	0.6	0.7	0.1	*25%*
Total	-124.0	-122.3	1.7	*-1%*
Summary of Effects				
FHG Deliveries (Mar-Oct)	340.3	381.4	41.1	*12%*
FHG Deliveries (Nov-Feb)	2.6	8.6	6.0	*231%*
Irrigation Pumping	192.1	150.9	-41.2	*-21%*
Riparian ET + Evaporation	226.6	238.5	12.0	*5%*
Fort Quitman Flow	96.0	81.4	-14.5	*-15%*
Change in Storage	-124.0	-122.3	1.7	*-1%*
Total	733.6	738.6	5.0	*1%*
Other Effects of Alternate Scenario				
Rio Grande at El Paso				***% Diff.***
Reservoir Spills	49.4	71.1	21.7	*44%*
Nov-Feb Flows	22.8	28.0	5.2	*23%*
Mar - Oct Flows	263.8	223.0	-40.8	*-15%*
Total	336.0	322.0	-13.9	*-4%*
Rio Grande below Caballo				
Reservoir Spills	65.9	96.3	30.4	*46%*
Nov-Feb Flows	0.5	0.7	0.2	*52%*
Mar - Oct Flows	541.3	500.9	-40.3	*-7%*
Total	607.6	598.0	-9.6	*-2%*
Surface Water Diversions (Mar - Oct)				
EBID	366.5	399.3	32.8	*9%*
EPCWID (incl. EPW)	236.8	203.3	-33.5	*-14%*
HCCRD	67.5	47.3	-20.3	*-30%*
Total	670.8	649.9	-20.9	*-3%*
Surface Water Diversions (Nov - Feb)				
EBID	0.0	0.0	0.0	*0%*
EPCWID (incl. EPW)	14.3	15.2	0.8	*6%*
HCCRD	14.2	11.6	-2.6	*-19%*
Total	28.5	26.7	-1.8	*-6%*

Run 13 - Reduced Waste

Annual Differences in ILRG Model Outputs

Run 13 minus Run 1

1940 - 2017 (acre-feet)

	Net River Headgate Diversions						Farm Headgate Deliveries						Annual Flows		
	EBID		EPCWID (incl. EPW)		HCCRD		EBID		EPCWID (incl. EPW)		HCCRD				
Year	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Caballo Releases	Rio Grande at El Paso	Rio Grande at Fort Quitman
1940	-35,290	-35,290	-78,398	-69,876	-26,983	-56,255	9,057	9,062	-4,197	53,068	-25,007	-24,622	-114,402	-113,176	-126,923
1941	-18,177	-18,177	-114,977	-115,869	-30,632	-47,816	-5,618	-5,595	-46,587	-20,787	-25,555	-24,328	98,482	82,086	93,807
1942	-57,582	-57,582	-92,628	-97,834	-26,493	-33,919	890	822	-21,207	-15,874	-21,688	-16,092	-36,516	-16,644	25,501
1943	-44,422	-44,422	-70,399	-72,947	-22,798	-28,742	13,171	13,182	-5,977	-716	-21,241	-21,935	-24,940	-32,320	-14,851
1944	-43,709	-43,709	-51,678	-48,747	-20,483	-35,653	1,267	1,244	6,915	37,450	-19,696	-19,746	-66,808	-64,986	-82,464
1945	-40,911	-40,911	-73,157	-71,353	-23,855	-38,413	4,475	4,463	-6,075	21,649	-21,875	-20,788	-102,673	-101,799	-101,548
1946	-39,172	-39,172	-70,441	-78,221	-23,932	-40,349	5,602	5,602	-3,692	18,201	-23,569	-23,076	-97,866	-99,501	-94,810
1947	-39,125	-39,125	-71,355	-69,319	-23,935	-39,885	3,489	3,495	-3,185	25,752	-23,462	-20,369	-80,999	-82,709	-86,369
1948	-38,925	-38,925	-69,801	-68,341	-22,090	-36,420	3,851	3,819	-4,378	21,384	-17,832	-12,026	-79,936	-80,965	-76,334
1949	-55,167	-55,167	-74,184	-72,469	-22,627	-36,212	-7,650	-7,688	-5,836	20,027	-4,170	6,057	-95,748	-85,544	-87,416
1950	-1,520	-1,520	-62,984	-63,472	-28,555	-32,161	23,361	23,371	-9,397	-3,033	-7,885	1,032	-38,075	-56,880	-31,366
1951	-933	-933	-52,876	-50,976	-14,249	-21,670	21,181	21,186	-1,084	11,824	-14,925	-14,977	-52,108	-56,798	-40,236
1952	1,598	1,598	-9,435	-8,415	-5,069	-11,100	19,170	19,165	18,476	28,403	-7,302	-7,701	-42,429	-28,613	-31,164
1953	-1,571	-1,571	-54,995	-55,160	-15,135	-20,384	21,645	21,645	2,814	10,910	-15,858	-17,357	-46,562	-65,808	-41,118
1954	248,417	248,417	88,676	94,047	523	828	162,892	162,892	87,135	93,247	-204	162	250,386	129,033	-16,754
1955	48,707	48,707	37,108	42,874	3,517	5,793	43,591	43,591	48,983	51,419	3,726	5,504	25,188	54,523	8,465
1956	32,089	32,089	27,407	28,124	-1,420	-1,626	25,632	25,632	35,607	35,668	-1,227	-1,887	55,345	32,974	-96
1957	12,068	12,068	-16,175	-14,894	-4,547	-4,562	10,753	10,754	3,301	3,427	-3,267	-3,949	-2,020	-13,951	2
1958	-1,356	-1,356	-59,290	-58,000	-19,070	-19,930	22,144	22,146	427	3,604	-16,291	-14,102	-107,444	-62,867	-5,170
1959	-1,940	-1,940	-53,119	-52,450	-14,433	-16,580	20,926	20,928	-210	3,956	-2,041	1,755	-72,904	-61,204	-17,852
1960	-1,855	-1,855	-49,261	-48,899	-18,748	-23,424	20,737	20,739	-88	5,126	-3,210	-927	-62,018	-58,470	-23,419
1961	-1,972	-1,972	-50,904	-50,479	-16,136	-21,240	20,987	20,989	1,277	6,668	-12,812	-8,362	-63,089	-60,239	-12,660
1962	-1,879	-1,879	-48,380	-48,198	-19,356	-23,949	20,683	20,685	232	5,974	-4,796	-422	-59,998	-58,256	-25,363
1963	7,108	7,108	-49,413	-48,994	-15,550	-20,190	26,417	26,419	451	6,823	-10,782	-5,946	-44,867	-46,724	-17,262
1964	170,840	170,840	91,204	94,468	-980	-1,452	104,329	104,329	90,108	92,922	-1,527	1,043	218,972	115,755	-3,100
1965	38,445	38,445	-14,103	-11,546	-1,870	-2,168	31,677	31,678	24,952	29,061	-1,831	-1,351	-52,801	-4,096	3,816
1966	-716	-716	-15,762	-14,048	-2,834	-5,390	10,853	10,855	14,633	20,301	-2,788	-3,047	-42,808	-12,274	-718
1967	88,267	88,267	30,946	35,362	-1,807	-358	58,628	58,628	43,777	47,610	-3,762	-57	93,593	43,870	-1,250
1968	17,849	17,849	-29,046	-25,901	-508	-420	27,397	27,399	1,986	5,742	-357	-295	-47,989	-18,956	1,184
1969	-1,040	-1,040	-29,376	-28,329	-9,819	-12,699	12,489	12,490	-474	4,789	-9,997	-6,921	-47,161	-30,901	-4,398
1970	-1,695	-1,695	-42,191	-42,246	-20,090	-22,909	23,372	23,373	636	4,214	-12,731	-6,400	-56,523	-51,980	-16,416
1971	99,219	99,219	2,060	2,957	-4,467	-8,872	68,669	68,670	27,153	31,625	-4,051	-3,739	45,528	12,567	-5,338
1972	37,411	37,411	27,087	29,045	-1,757	-1,482	22,008	22,008	32,903	34,531	-3,093	-3,578	62,263	37,788	-1,261
1973	-1,895	-1,895	-25,675	-25,000	-8,211	-8,332	12,842	12,842	3,808	5,919	-8,448	-9,329	-60,326	-26,830	-96
1974	-1,561	-1,561	-34,570	-34,186	-21,183	-22,944	28,072	28,074	3,745	8,978	-21,262	-17,001	-49,774	-40,105	-7,271
1975	-192	-192	-3,354	-3,297	-6,423	-8,415	12,470	12,471	18,413	24,183	-7,470	-4,669	-23,259	-7,817	-5,699
1976	-2,691	-2,691	-32,764	-33,366	-23,773	-25,876	22,075	22,076	2,227	7,373	-8,238	-1,493	-36,647	-41,087	-22,678
1977	99,951	99,951	-1,104	1,110	-3,574	-5,299	69,734	69,734	19,511	23,253	-3,513	-2,951	39,537	8,532	-2,977
1978	64,167	64,167	-2,345	654	-6,930	-7,881	45,706	45,706	18,414	22,066	-6,810	-7,899	27,220	12,268	-765

Run 13 - Reduced Waste
Annual Differences in ILRG Model Outputs
Run 13 minus Run 1
1940 - 2017 (acre-feet)

	Net River Headgate Diversions						Farm Headgate Deliveries						Annual Flows		
	EBID		EPCWID (incl. EPW)		HCCRD		EBID		EPCWID (incl. EPW)		HCCRD				
Year	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Caballo Releases	Rio Grande at El Paso	Rio Grande at Fort Quitman
1979	797	797	-27,278	-26,130	-19,289	-21,579	5,175	5,171	12,243	17,742	-19,739	-22,172	-68,735	-35,812	-2,561
1980	-2,789	-2,789	-61,823	-62,355	-32,388	-38,368	16,721	16,722	-643	6,518	-30,230	-26,216	-80,255	-77,168	-14,394
1981	-2,640	-2,640	-61,340	-61,557	-34,081	-41,371	16,347	16,348	-1,461	4,478	-15,142	-5,783	-77,818	-73,294	-35,450
1982	-2,513	-2,513	-61,635	-61,821	-29,687	-36,701	15,526	15,526	-1,398	4,686	-23,774	-18,856	-79,413	-75,568	-20,088
1983	-2,478	-2,478	-59,760	-59,754	-38,563	-46,150	16,017	16,019	-3,188	3,583	-608	6,615	-73,581	-71,443	-54,057
1984	-2,201	-2,201	-59,796	-59,929	-45,979	-53,585	16,009	16,016	-3,518	4,859	-11,417	-8,851	-52,572	-59,596	-42,024
1985	-933	-933	-7,060	-7,340	-7,253	-14,024	12,315	12,324	21,243	30,151	0	0	265,727	254,055	168,627
1986	-5,011	-5,011	-84,944	-85,405	-33,888	-39,189	18,882	18,912	-14,148	-5,481	0	0	87,161	89,370	71,475
1987	-5,769	-5,769	-70,732	-70,997	-33,189	-39,121	18,319	18,342	-6,811	2,421	0	0	400	2,357	-120,246
1988	-5,658	-5,658	-80,122	-80,241	-36,895	-44,194	16,636	16,656	-10,873	-169	0	0	-60,716	-58,492	-55,578
1989	-4,009	-4,009	-78,561	-78,608	-45,339	-52,468	23,603	23,619	-8,717	1,608	0	0	-65,194	-58,618	-45,194
1990	-1,565	-1,565	-21,373	-21,537	-25,010	-31,527	12,922	12,930	14,892	24,228	0	0	-35,983	-28,884	-39,641
1991	-5,916	-5,916	-65,048	-65,559	-32,102	-39,883	11,514	11,541	-10,317	-145	0	0	-59,438	-65,062	-46,111
1992	-2,854	-2,854	-11,166	-11,548	-11,034	-18,057	12,647	12,664	25,971	35,564	0	0	154,881	156,807	125,813
1993	-4,934	-4,934	-98,794	-98,731	-48,656	-55,772	21,643	21,664	-11,250	278	0	0	-8,245	-10,832	-851
1994	-2,245	-2,245	-90,522	-90,497	-48,162	-55,295	26,310	26,329	-3,383	8,381	0	0	-14,314	-7,216	-2,866
1995	-1,419	-1,419	-87,487	-87,390	-47,559	-54,444	27,612	27,623	-1,602	11,123	0	0	41,059	36,308	26,104
1996	-2,217	-2,217	-93,368	-93,433	-45,352	-52,224	26,499	26,500	-9,675	1,914	0	0	-123,397	-112,183	-86,834
1997	-2,794	-2,794	-69,226	-69,894	-28,524	-37,109	16,169	16,178	-12,075	-1,340	2,924	4,656	-47,636	-52,295	-45,462
1998	-2,465	-2,465	-90,372	-90,368	-45,958	-54,742	24,296	24,307	-7,322	4,961	0	191	-45,974	-40,891	-33,577
1999	-1,498	-1,498	-82,123	-81,876	-21,065	-23,383	12,013	12,016	5,967	8,031	0	0	-61,869	-61,220	-60,524
2000	-1,866	-1,866	-88,078	-87,792	-22,645	-23,593	3,736	3,737	-11,976	-11,971	0	0	-78,031	-66,274	-51,508
2001	-1,186	-1,186	-69,935	-69,976	-44,124	-45,070	17,557	17,559	821	1,019	0	0	-64,682	-69,323	-59,605
2002	-1,211	-1,211	-73,705	-73,441	-39,304	-40,352	18,777	18,778	465	783	0	0	-74,260	-73,819	-68,834
2003	134,326	134,326	-14,539	-14,157	-18,556	-18,731	90,606	90,619	23,290	23,677	0	0	83,308	31,106	-12,243
2004	149,456	149,456	11,872	14,259	-14,268	-12,159	102,298	102,299	42,033	42,447	0	0	73,816	43,082	-8,210
2005	135	135	-42,108	-40,718	-26,848	-25,589	13,958	13,964	4,665	4,882	0	0	-89,756	-34,658	-18,890
2006	101,477	101,477	26,324	27,162	-16,233	-14,439	69,051	69,051	49,963	50,057	0	0	60,724	32,432	-19,830
2007	136,295	136,295	-40,113	-39,104	-30,075	-28,984	95,009	95,009	10,261	10,329	0	0	-11,667	-24,315	-29,651
2008	157,614	157,614	-40,277	-39,435	-27,651	-27,573	109,574	109,582	5,822	6,243	0	0	6,625	-22,648	-24,262
2009	183,751	183,751	-82,015	-80,806	-42,736	-42,425	132,674	132,767	-8,744	-8,522	0	0	18,115	-32,629	-18,582
2010	239,134	239,134	-26,068	-23,553	-25,415	-25,096	161,956	162,036	15,583	15,715	0	0	69,996	31,395	19,912
2011	172,338	172,338	35,867	38,704	-10,889	-4,280	93,337	93,341	59,523	59,592	0	0	90,114	47,702	11,664
2012	27,076	27,076	-3,266	-2,610	-8,290	-3,102	9,184	9,184	23,755	24,215	0	0	-17,635	-8,279	2,543
2013	-33,689	-33,689	-721	-548	-425	938	-16,856	-16,856	10,818	10,998	3,107	3,256	-36,282	-2,184	3,964
2014	11,773	11,773	-8,215	-8,210	-5,521	-4,203	8,288	8,288	15,876	15,879	-5,250	-4,438	-1,185	-12,443	-5,542
2015	806	806	-24,419	-24,405	-16,592	-15,445	2,303	2,303	13,832	13,836	-4,967	-3,794	-34,295	-34,049	-20,721
2016	8,360	8,360	-23,159	-23,074	-20,670	-19,768	3,723	3,723	20,166	20,172	952	1,017	-29,928	-31,265	-34,275
2017	30,645	30,645	-46,459	-46,314	-23,471	-23,411	19,252	19,252	4,882	4,887	-64	-64	-52,743	-56,415	-36,769
Averages															
1951-2017	32,820	32,820	-33,451	-32,608	-20,262	-22,910	34,159	34,166	11,255	16,078	-4,315	-3,139	-9,647	-13,909	-14,535
1951-1978	33,744	33,744	-13,202	-11,634	-9,068	-11,162	35,253	35,254	17,825	22,486	-6,603	-4,853	-5,453	-10,702	-10,343
1979-2005	8,094	8,094	-60,705	-60,622	-32,434	-37,581	22,745	22,754	1,231	8,305	-3,629	-2,608	-20,575	-19,243	-19,731
2006-2017	86,298	86,298	-19,377	-18,516	-18,997	-17,316	57,291	57,307	18,478	18,617	-519	-335	5,153	-9,391	-12,629
1985-2017	38,362	38,362	-46,664	-46,286	-27,385	-29,840	36,843	36,856	7,665	12,296	-100	25	-1,858	-7,254	-15,627
1985-2005	10,970	10,970	-62,257	-62,155	-32,178	-36,996	25,158	25,170	1,486	8,684	139	231	-5,864	-6,032	-17,341

Notes:

EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).

EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

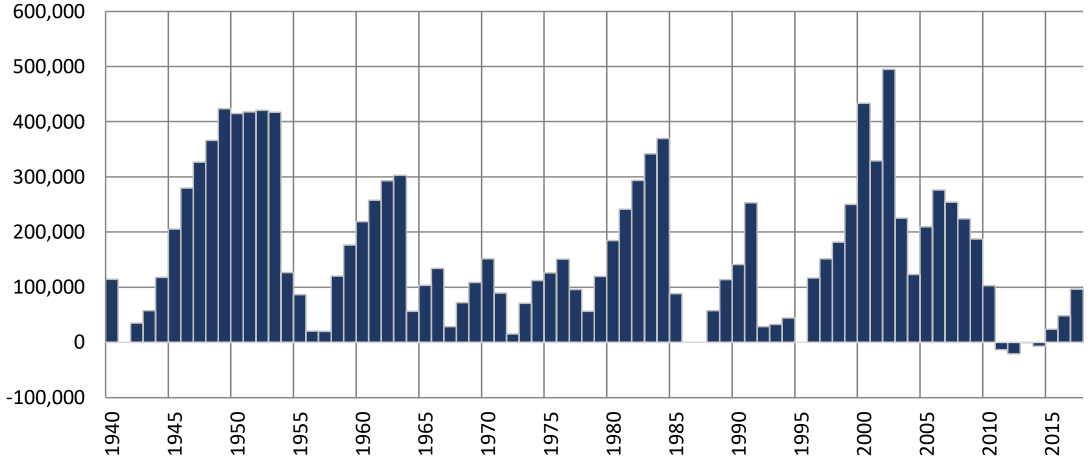
Run 13 - Reduced Waste

Simulated Differences in ILRG Model Outputs

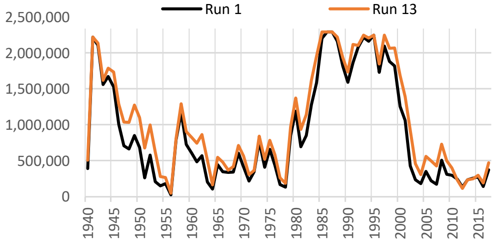
Run 13 minus Run 1

1940 - 2017 (acre-feet)

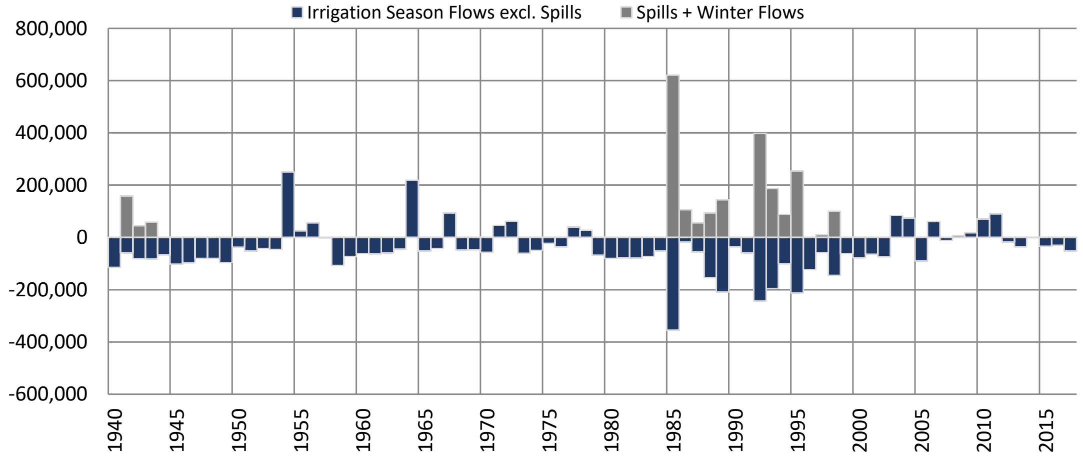
Total Project Storage (Year End)



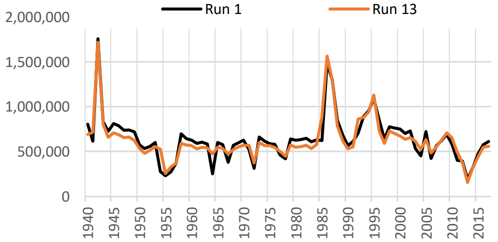
Period	Average Difference
1951-2017	-4,748
1951-1978	-12,793
1979-2005	5,676
2006-2017	-9,431
1985-2017	-8,276
1985-2005	-7,617



Caballo Reservoir Outflows (Annual)



	Average Difference		
Period	Irr Season (excl. Spills)	Nov-Feb and Spills	Annual
1951-2017	-40,335	30,688	-9,647
1951-1978	-5,453	0	-5,453
1979-2005	-96,725	76,151	-20,575
2006-2017	5,153	0	5,153
1985-2017	-64,163	62,305	-1,858
1985-2005	-103,772	97,908	-5,864



Notes:

Reservoir storage does not include storage attributed to SJC, CO, or NM credit waters.

Average differences calculated as (Final Storage - Initial Storage)/(no. years).

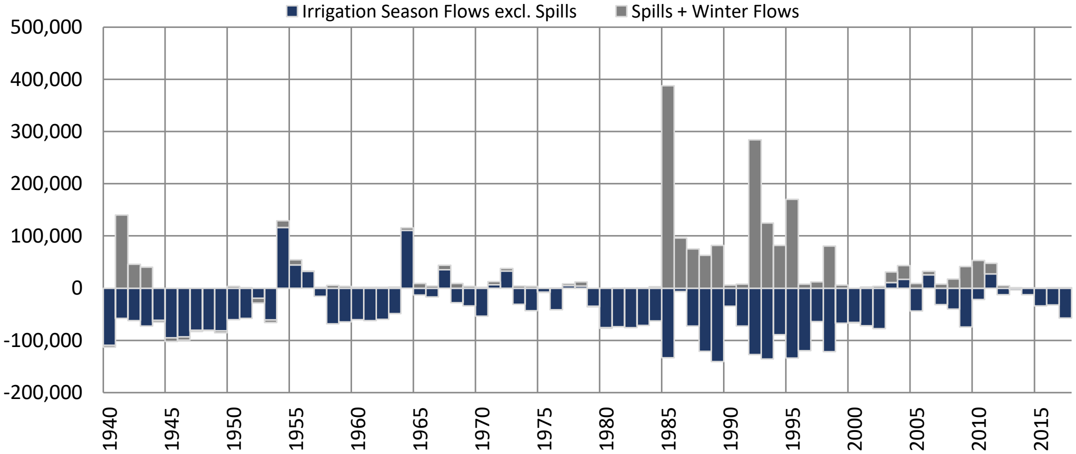
Run 13 - Reduced Waste

Simulated Differences in ILRG Model Outputs

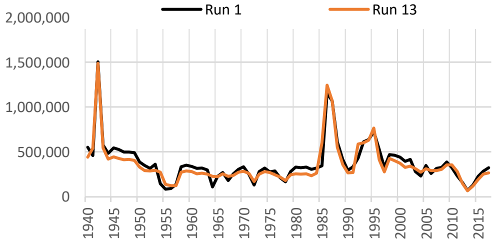
Run 13 minus Run 1

1940 - 2017 (acre-feet)

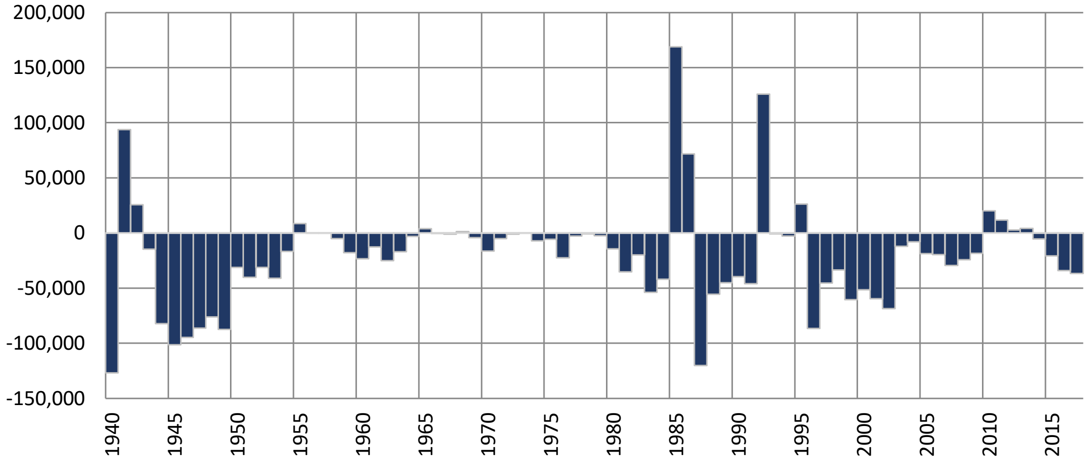
Rio Grande at El Paso (Annual)



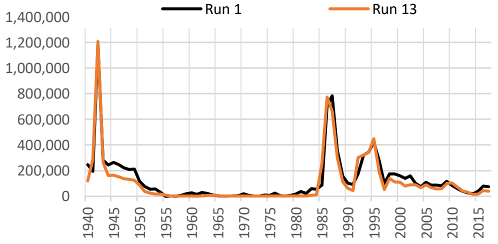
	Average Difference		
Period	Irr Season (excl. Spills)	Nov-Feb and Spills	Annual
1951-2017	-40,751	26,842	-13,909
1951-1978	-14,267	3,565	-10,702
1979-2005	-76,428	57,184	-19,243
2006-2017	-22,276	12,885	-9,391
1985-2017	-58,703	51,449	-7,254
1985-2005	-79,518	73,485	-6,032



Rio Grande at Fort Quitman (Annual)

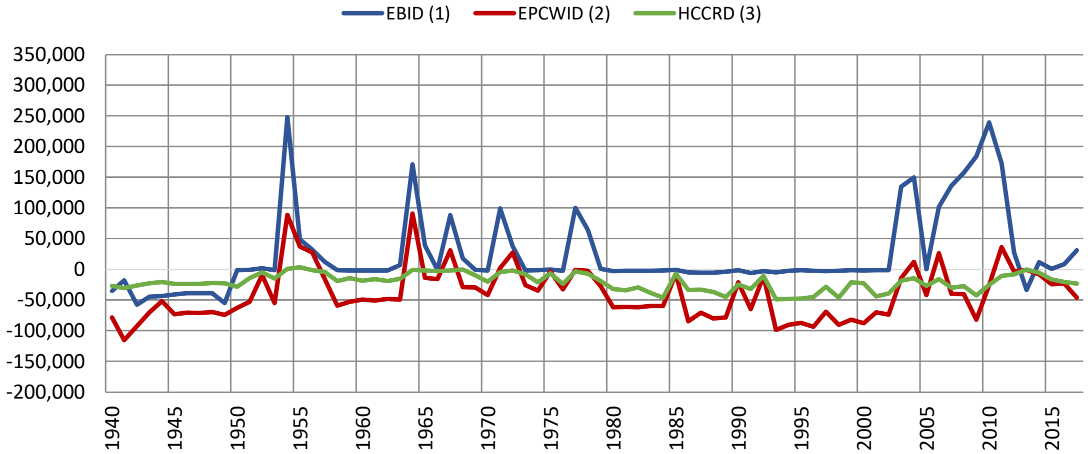


Period	Average Difference
1951-2017	-14,502
1951-1978	-10,313
1979-2005	-19,684
2006-2017	-12,616
1985-2017	-15,598
1985-2005	-17,303



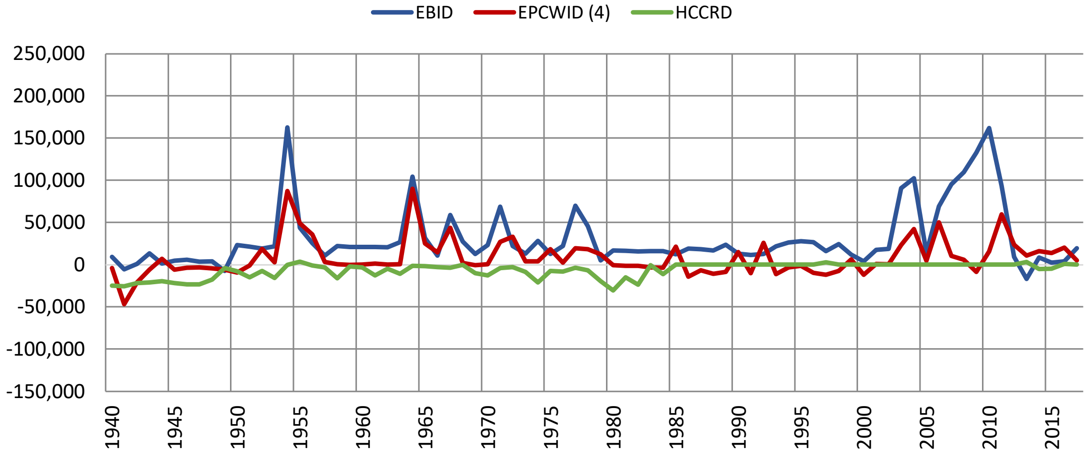
Run 13 - Reduced Waste
Simulated Differences in ILRG Model Outputs
Run 13 minus Run 1
1940 - 2017 (acre-feet)

River Headgate (RHG) Diversions (Irrigation Season)



	Average Difference		
Period	EBID	EPCWID	HCCRD
1951-2017	32,820	-33,451	-20,262
1951-1978	33,744	-13,202	-9,068
1979-2005	8,094	-60,705	-32,434
2006-2017	86,298	-19,377	-18,997
1985-2017	38,362	-46,664	-27,385
1985-2005	10,970	-62,257	-32,178

Farm Headgate (FHG) Deliveries (Irrigation Season)



	Average Difference		
Period	EBID	EPCWID	HCCRD
1951-2017	34,159	11,255	-4,315
1951-1978	35,253	17,825	-6,603
1979-2005	22,745	1,231	-3,629
2006-2017	57,291	18,478	-519
1985-2017	36,843	7,665	-100
1985-2005	25,158	1,486	139

Notes:

(1) EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).

(2) EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

(3) HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

(4) EPCWID FHG values include deliveries to Rogers WTP and R/U WTP.

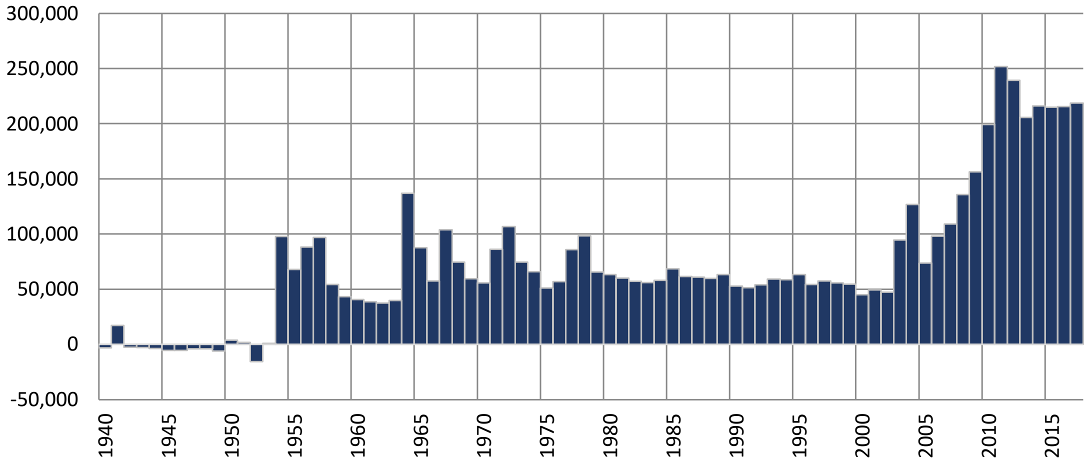
Run 13 - Reduced Waste

Simulated Differences in ILRG Model Outputs

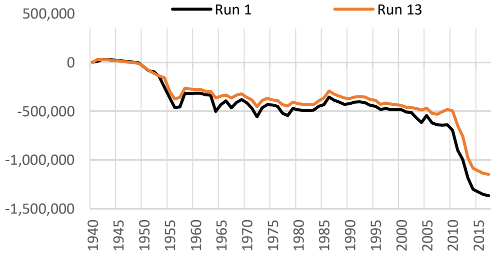
Run 13 minus Run 1

1940 - 2017 (acre-feet)

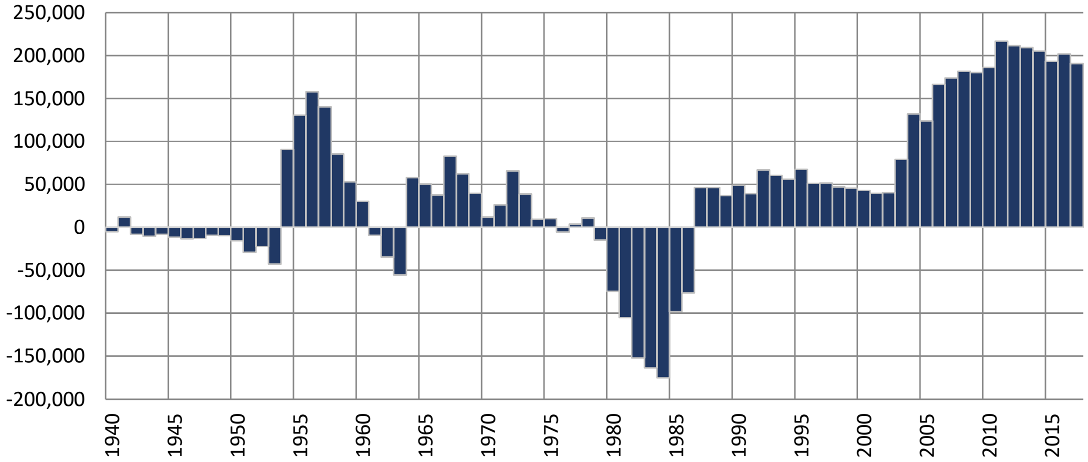
Cumulative Annual Rincon-Mesilla Groundwater Storage



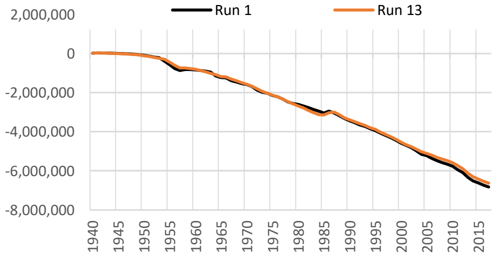
Period	Average Difference
1951-2017	3,209
1951-1978	3,375
1979-2005	-911
2006-2017	12,092
1985-2017	4,870
1985-2005	744



Cumulative Annual Hueco Groundwater Storage



Period	Average Difference
1951-2017	3,078
1951-1978	946
1979-2005	4,181
2006-2017	5,572
1985-2017	11,084
1985-2005	14,234



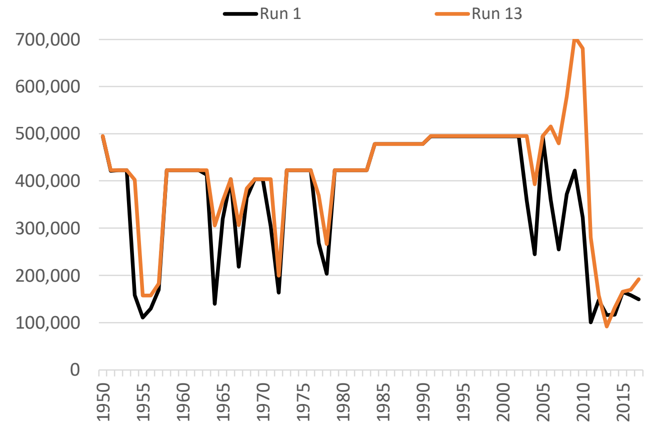
Notes:

Cumulative storage change in alluvial and non-alluvial aquifers.

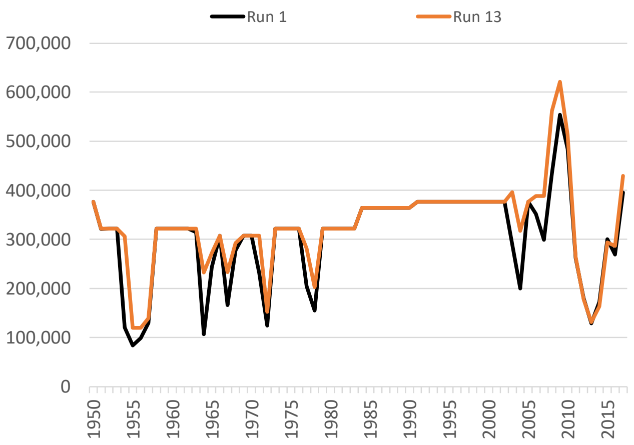
Average differences calculated as (Final Storage - Initial Storage)/(no. years).

Run 13 - Reduced Waste
Annual Allocation and Charges
Run 13 v. Run 1
ILRG Model
1950 - 2017 (acre-feet)

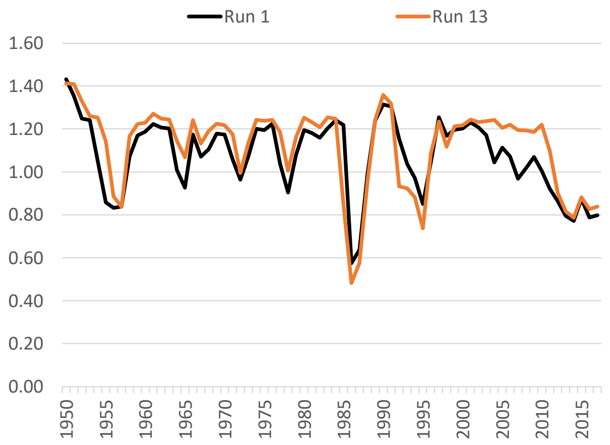
Total Allocation - EBID



Total Allocation - EPCWID



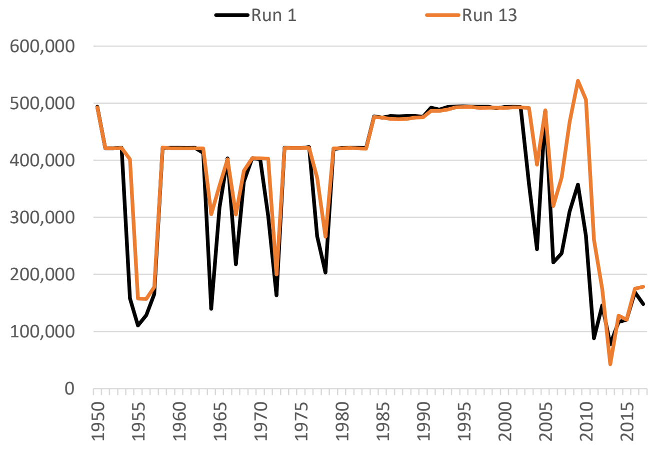
Diversion Ratio



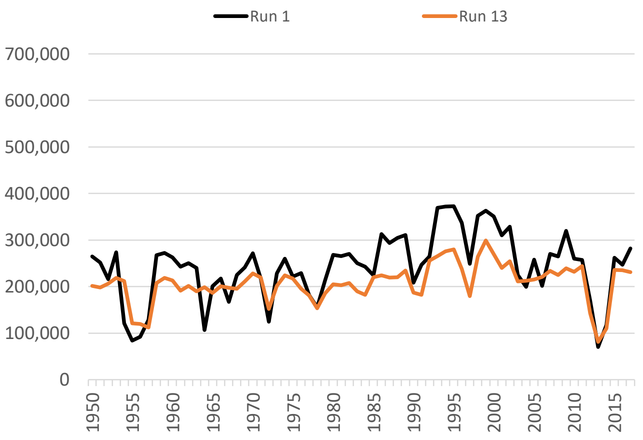
Note:

Computed as Total Charges/Caballo Release.

Annual Delivery Charges - EBID



Annual Delivery Charges - EPCWID



Run 13 - Reduced Waste

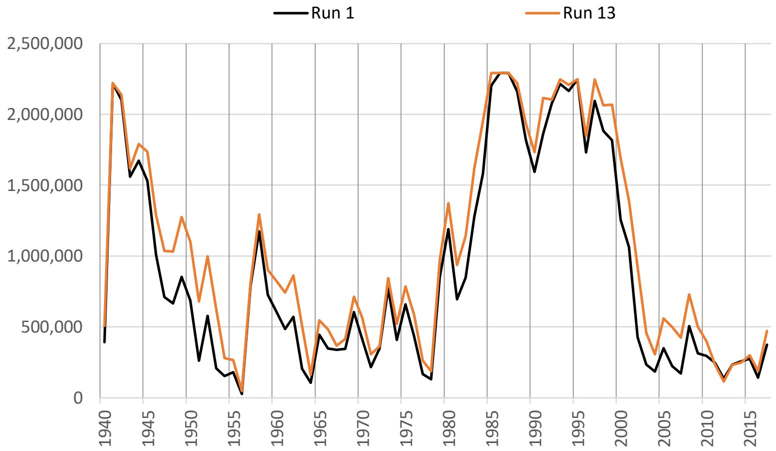
Annual Summary of Project Storage and Rio Grande Flows

Run 13 v. Run 1

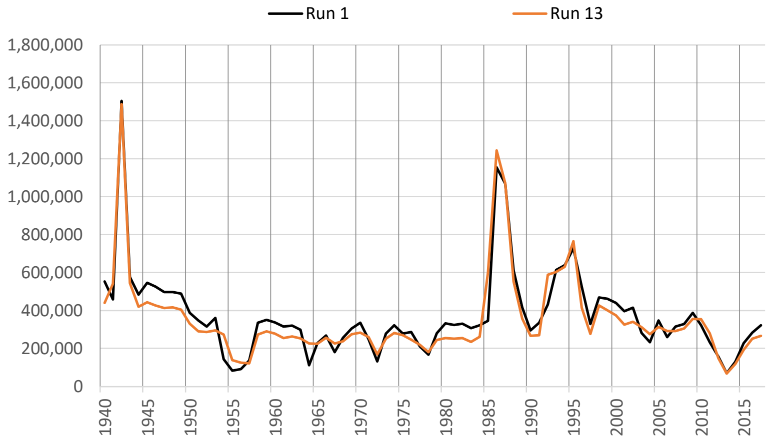
ILRG Model

1940 - 2017 (acre-feet)

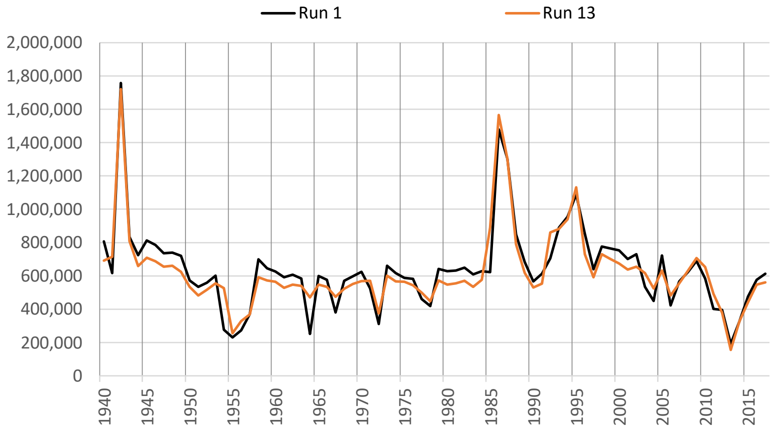
Total Year-End Project Reservoir Storage



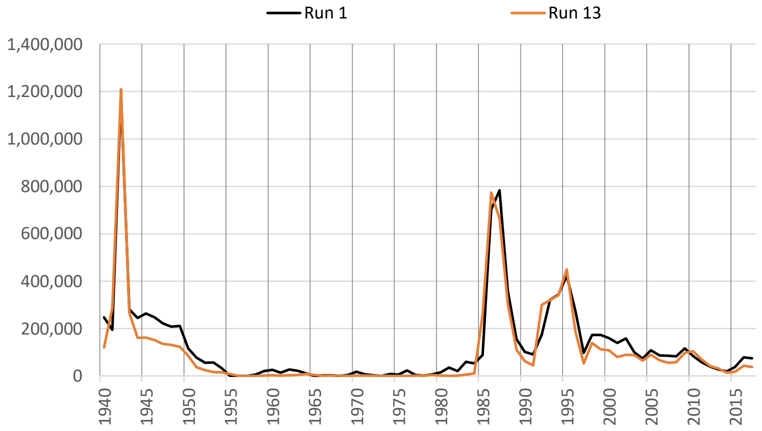
Rio Grande at El Paso



Rio Grande Below Caballo



Rio Grande at Fort Quitman

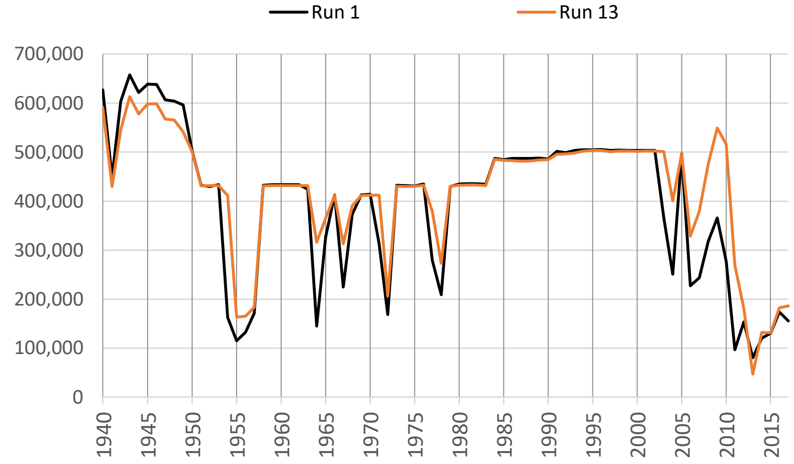


***Note different scales.**

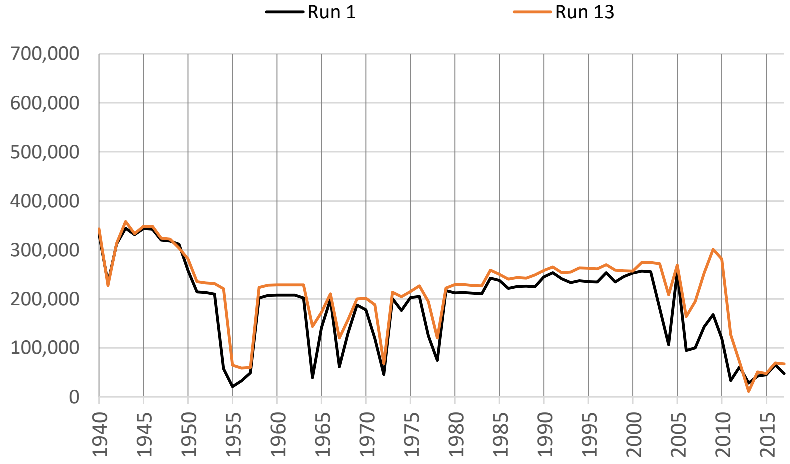
Run 13 - Reduced Waste
Irrigation Season Summary of Irrigation Operations
Run 13 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

EBID Total

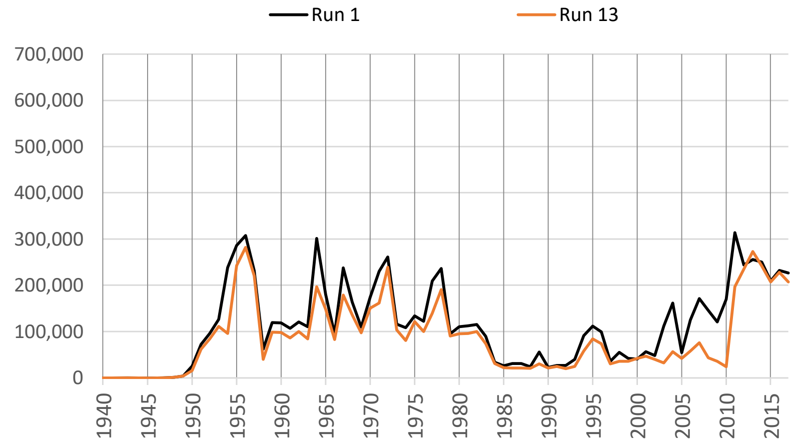
Net River Headgate Diversions



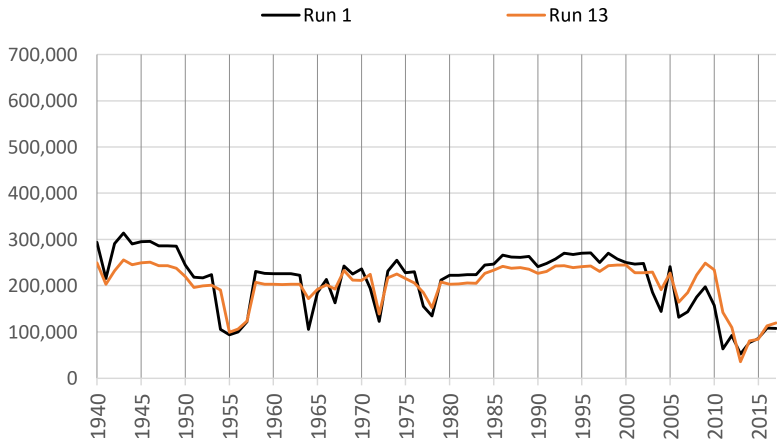
Farm Headgate Deliveries



Pumping



RHG Diversions - FHG Deliveries

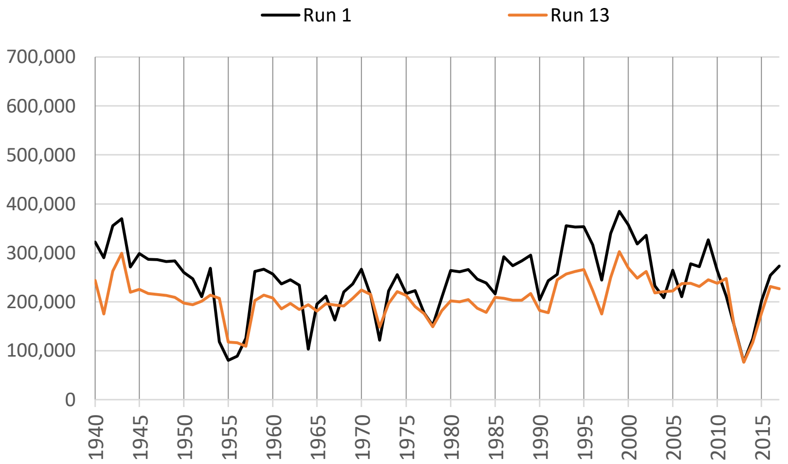


Notes: EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).
Pumping includes Supplemental and Primary groundwater pumping.

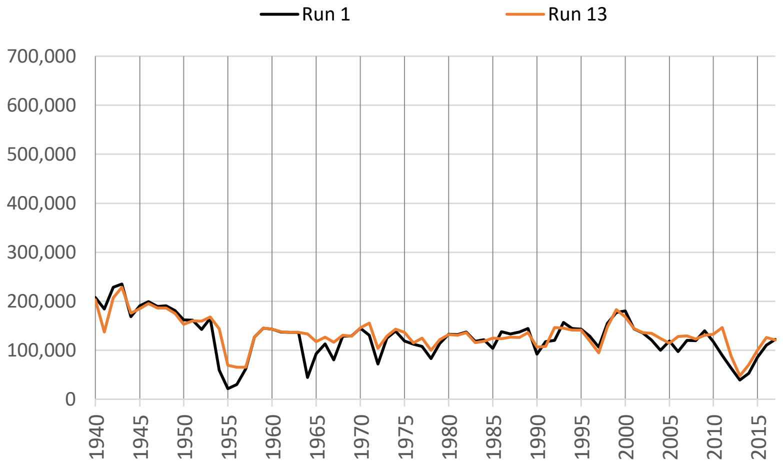
Run 13 - Reduced Waste
Irrigation Season Summary of Irrigation Operations
Run 13 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

EPCWID Total

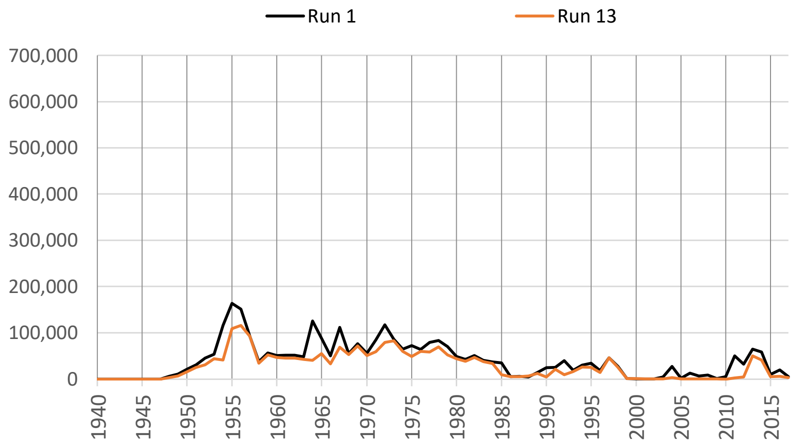
Net River Headgate Diversions



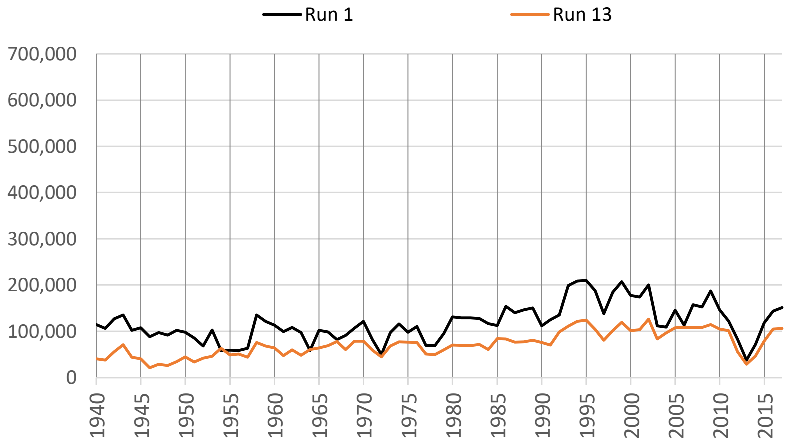
Farm Headgate Deliveries



Pumping



RHG Diversions - FHG Deliveries

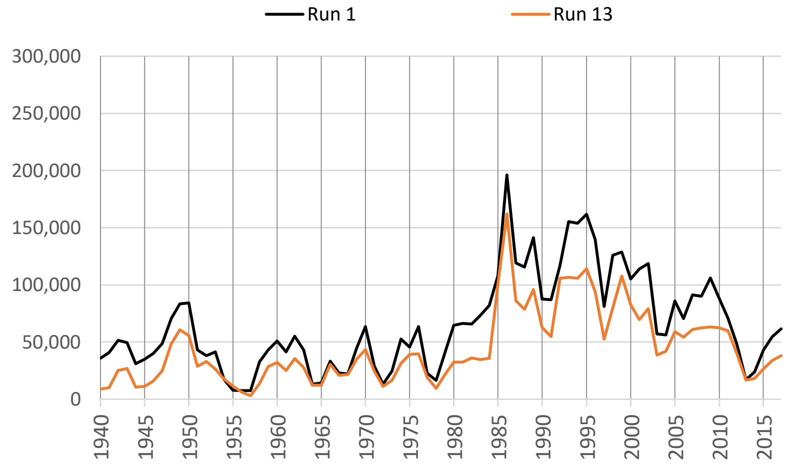


Note: EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

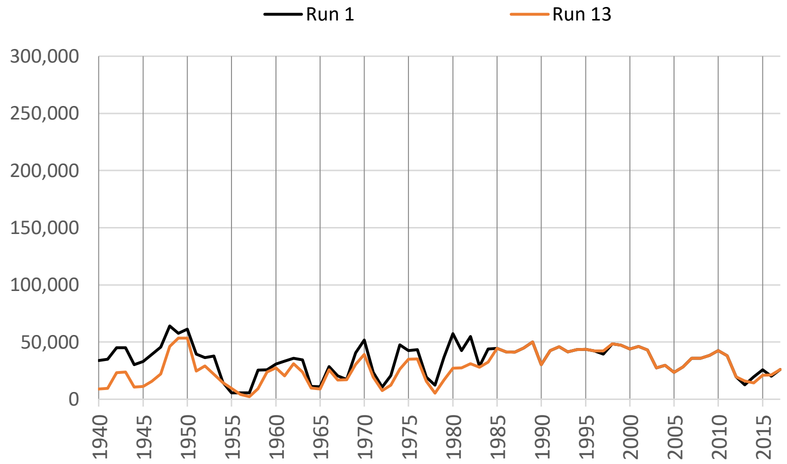
Run 13 - Reduced Waste
Irrigation Season Summary of Irrigation Operations
Run 13 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

HCCRD Total

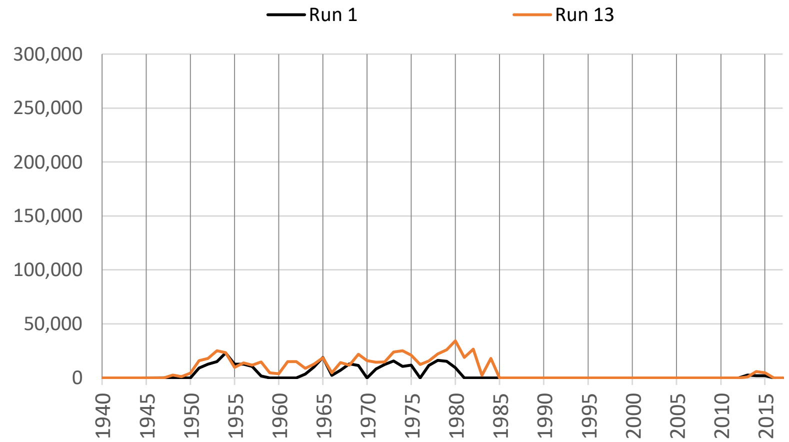
Net River Headgate Diversions



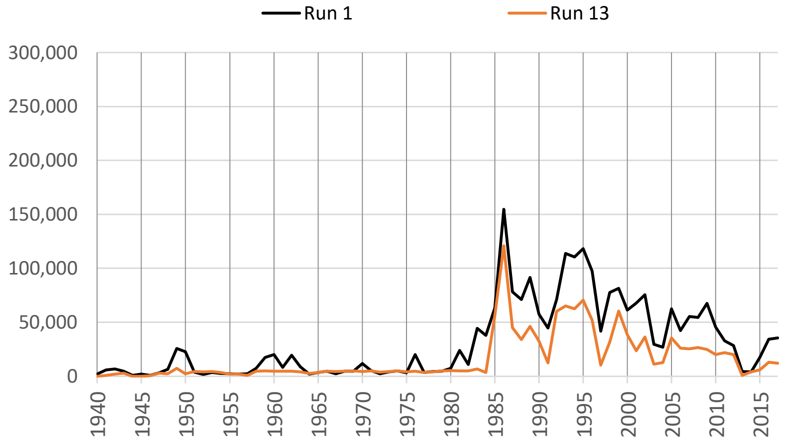
Farm Headgate Deliveries



Pumping



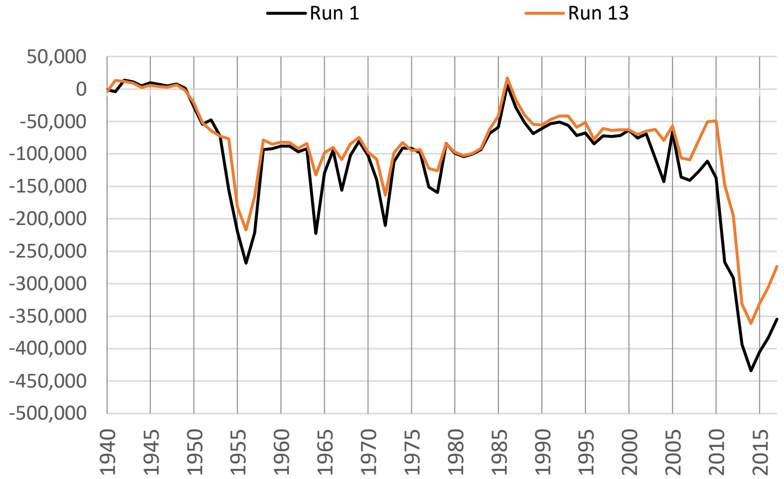
RHG Diversions - FHG Deliveries



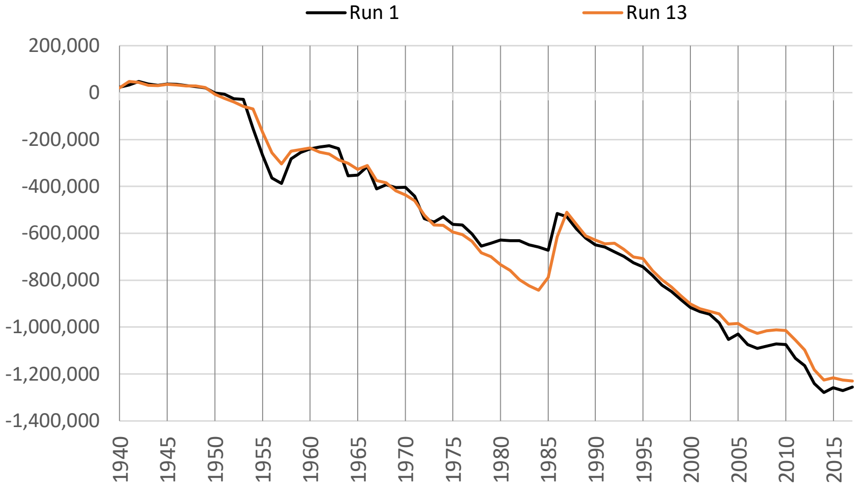
Note: HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

Run 13 - Reduced Waste
Cumulative Change in Ground Water Storage
Run 13 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

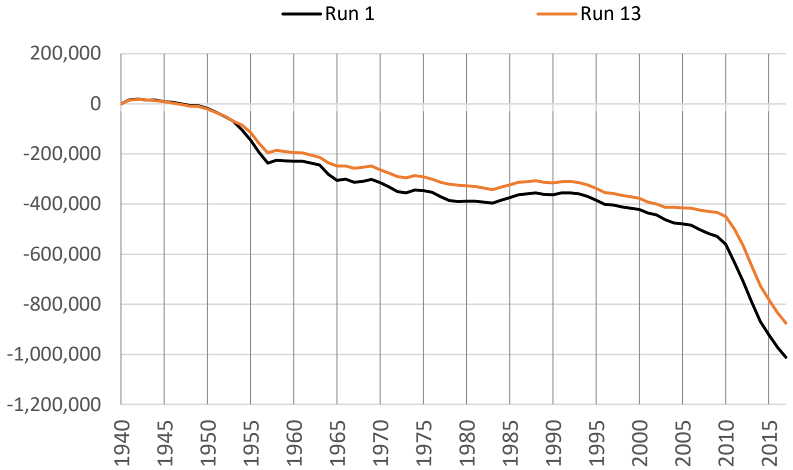
Rincon-Mesilla Alluvial Aquifer



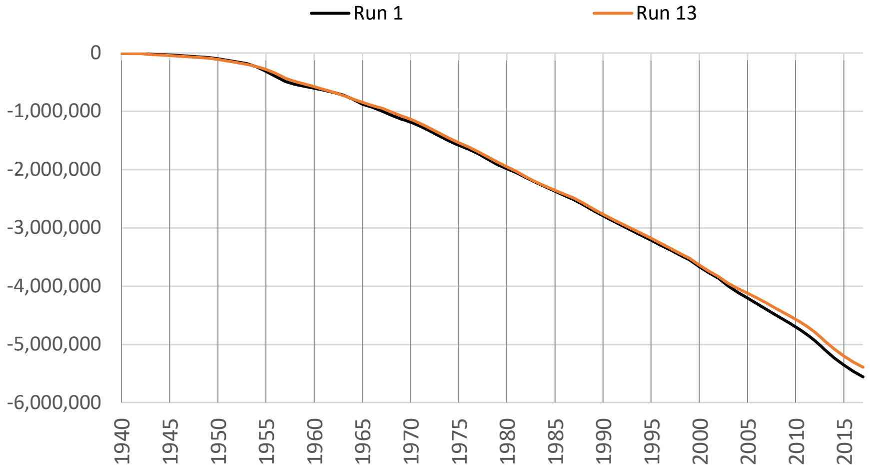
Hueco Alluvial Aquifer



Rincon-Mesilla Non-Alluvial Aquifer

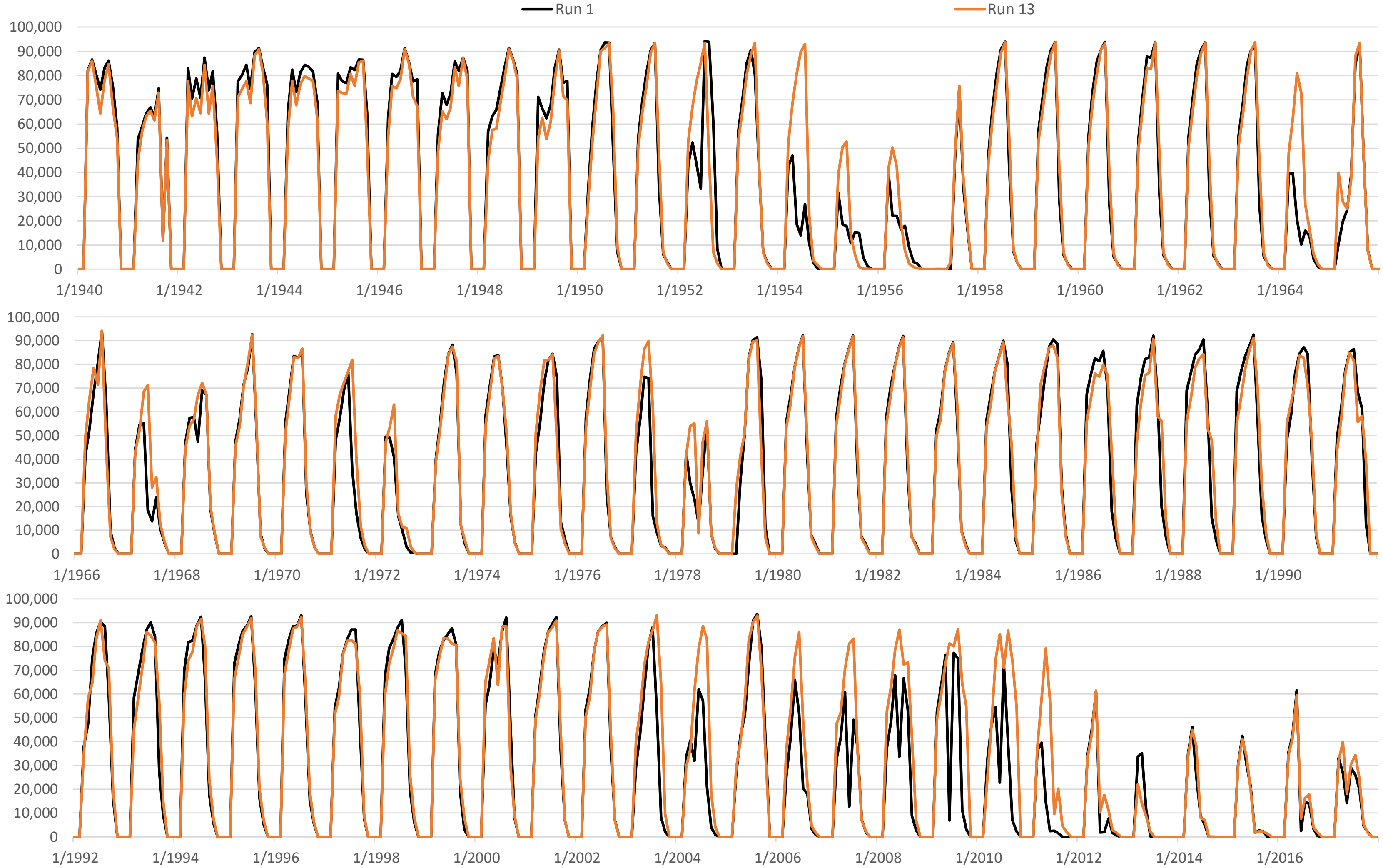


Hueco Non-Alluvial Aquifer



***Note different scales.**

Run 13 - Reduced Waste
Monthly Net RHG Diversions
Run 13 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)
EBID Total

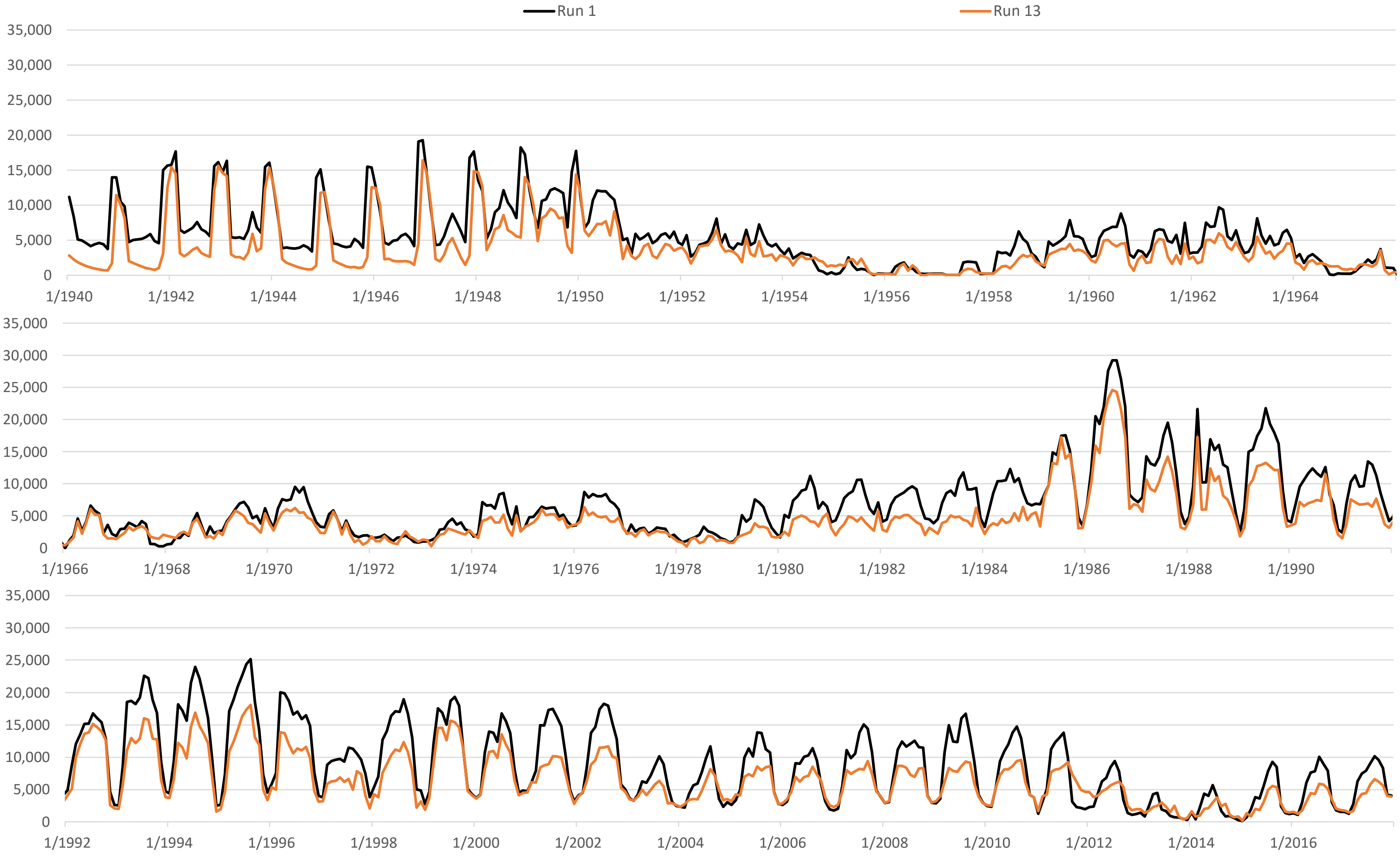


Note: EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).

Run 13 - Reduced Waste
Monthly Net RHG Diversions
Run 13 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)
EPCWID Total

Note: EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

Run 13 - Reduced Waste
Monthly Net RHG Diversions
Run 13 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)
HCCRD Total



Note: HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

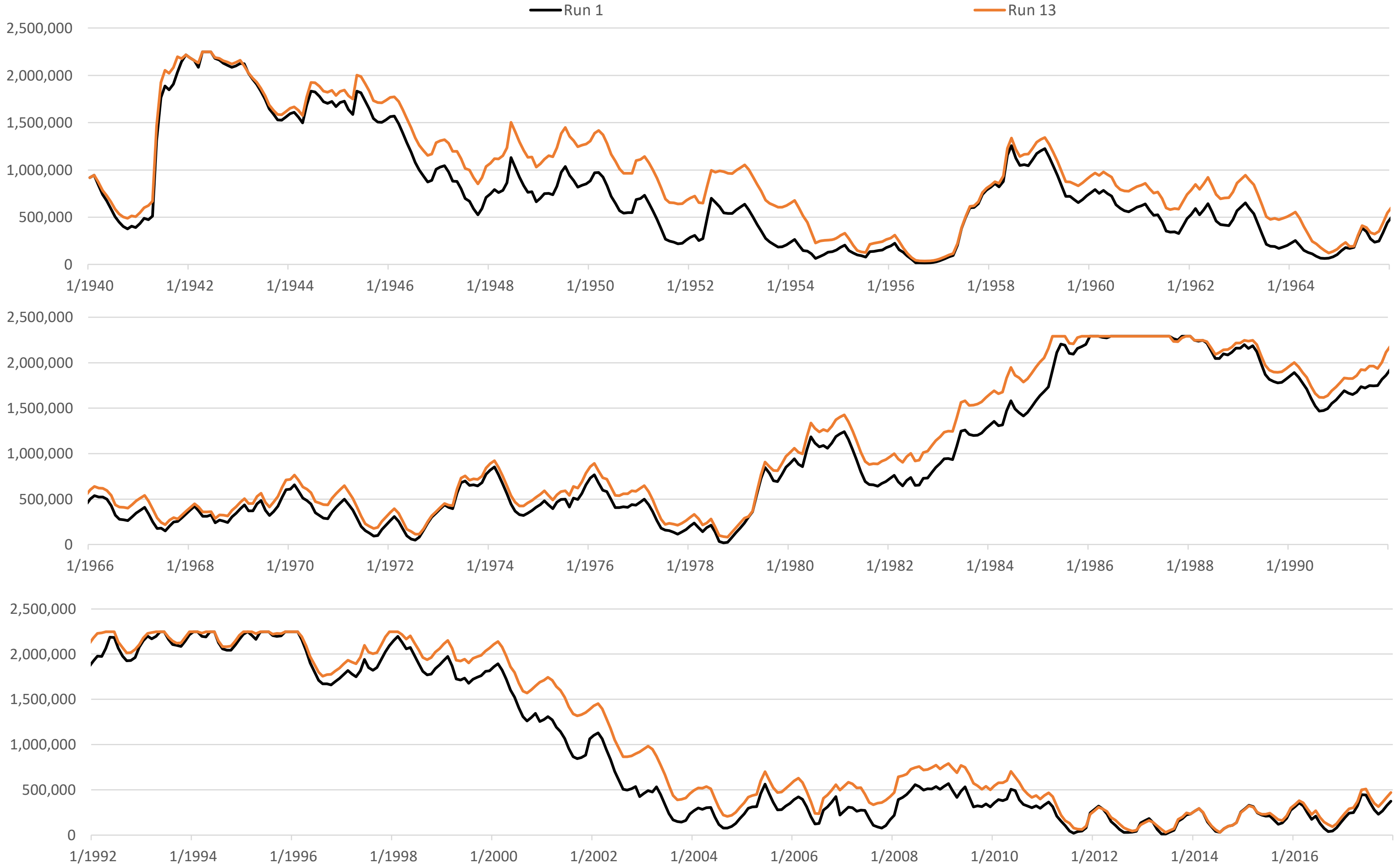
Run 13 - Reduced Waste

End of Month Reservoir Storage (Elephant Butte + Caballo)

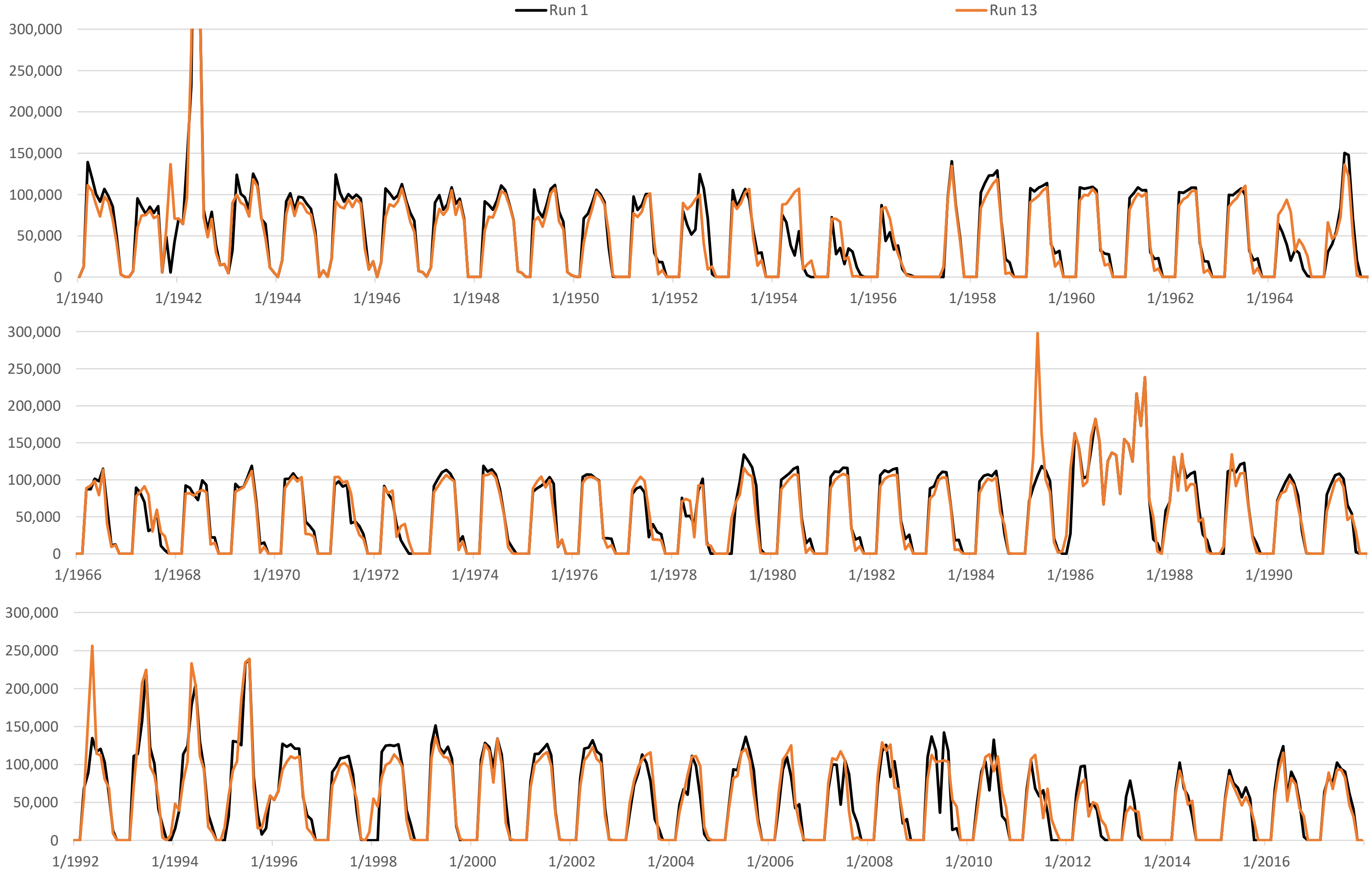
Run 13 v. Run 1

ILRG Model

1940 - 2017 (acre-feet)

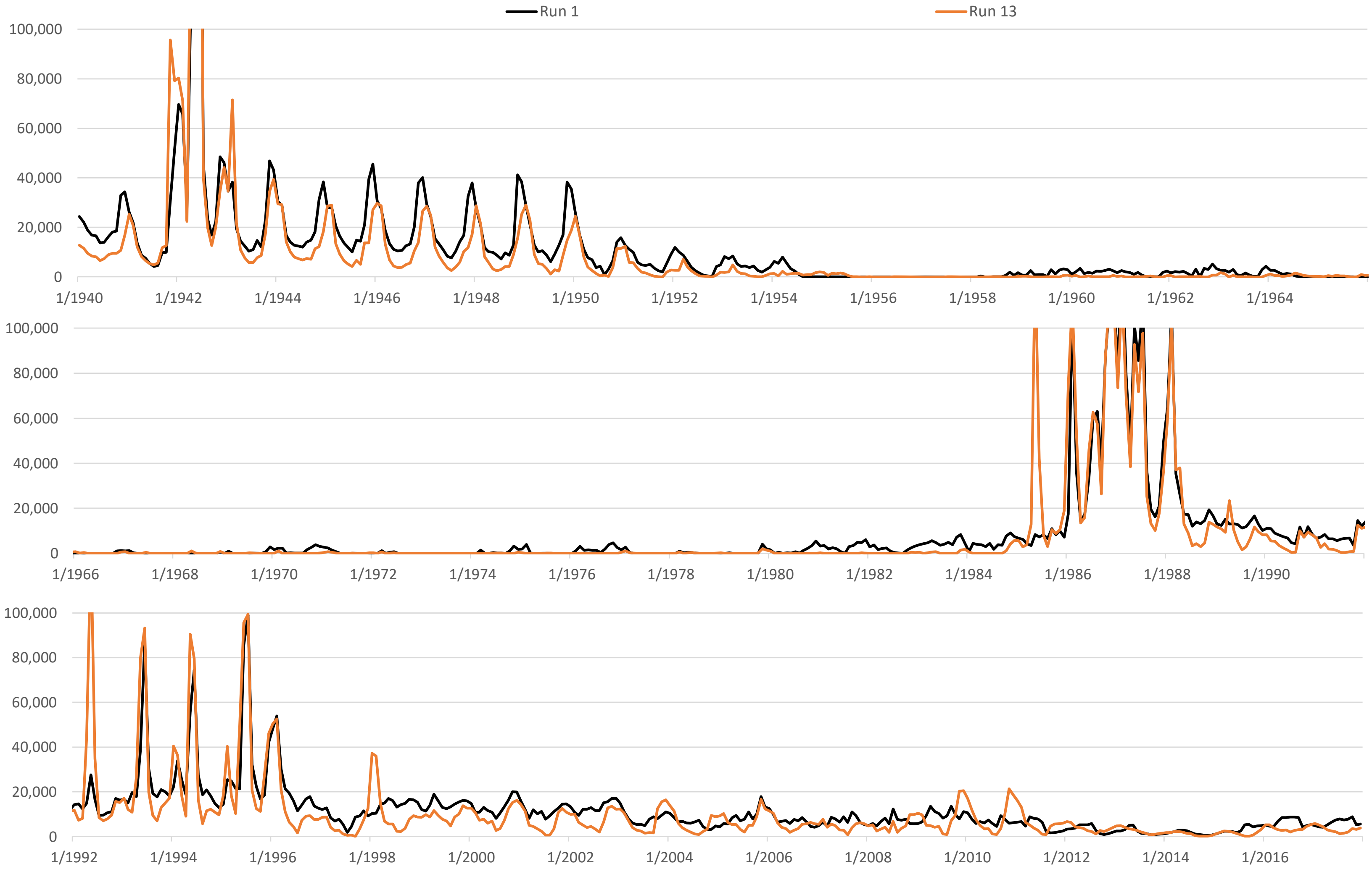


Run 13 - Reduced Waste
Monthly Caballo Releases
Run 13 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)



Run 13 - Reduced Waste
Monthly Rio Grande at El Paso Flow
Run 13 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

Run 13 - Reduced Waste
Monthly Rio Grande at Fort Quitman Flow
Run 13 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)



Appendix 30N

Comparison of ILRG Model Runs
Run 14 v. Run 1

Model Run Specifications

Model Version: LRG_v116

Name: **Run 14 - All Hueco Pumping Off**

Run ID: LRG_v116_Operational_Run14
Date: 8/24/2020

Name: **Run 1 - Historical Base Run (All Pumping On)**

Run ID: LRG_v116_Operational_Run1
Date: 8/23/2020

Selected Model Inputs

Pumping and Returns	**Run 14**	**Run 1**
Irrigation Pumping	Hueco Off	On
Irrigated Area	Hist	Hist
Non-Irrigation Pumping	Hueco Off	On
Non-Irrigation Pumping Returns	Hueco Off	On
Las Cruces Jornada Pumping Returns	On	On

Project Allocation Rules		
1950-2005	D1/D2	D1/D2
2006-2007	D3	D3
2008-2017	D3 + CO	D3 + CO

EPCWID Operations		
Charge EPCWID for Use of WWTP Returns	Off	Off
ACE and Haskell Credits for EPCWID	On	On
Increased EPCWID Use of Fabens Drain Flows	Off	Off
Charge EPCWID for Fabens Drain Flow Use	Off	Off

Run 14 - All Hueco Pumping Off

Comparison of ILRG Model Runs

Run 14 v. Run 1

1951 - 2017 Annual Average

(1,000 acre-feet)

Run No.	1	14	14 - 1		
Simulated Input or Output	**Run 1**	**Run 14**	**Run 14 minus Run 1**		
Pumping Stress					
Irrigation Pumping	107.1	0.0	-107.1		
Non-Irrigation Pumping	181.0	49.5	-131.5		
WWTP Flows	58.0	24.0	-34.1		
Urban Deep Percolation	13.1	7.8	-5.3		
Total Stress	217.0	17.7	-199.3		
	Stress is Pumping minus WWTP and Urban Deep Perc				
Effects of Pumping Stress				***% Chg***	
FHG Deliveries (Mar - Oct)				***Stress***	***% Diff.***
EBID	167.6	169.1	1.5	*-1%*	*1%*
EPCWID (incl. EPW)	139.9	140.6	0.8	*0%*	*1%*
HCCRD	32.8	34.7	1.9	*-1%*	*6%*
Total	340.3	344.5	4.2	*-2%*	*1%*
FHG Deliveries (Nov - Feb)					
EBID	0.0	0.0	0.0	*0%*	*0%*
EPCWID (incl. EPW)	0.2	0.1	-0.1	*0%*	*-31%*
HCCRD	2.4	2.2	-0.2	*0%*	*-8%*
Total	2.6	2.3	-0.2	*0%*	*-10%*
Irrigation Pumping					
EBID	140.4	138.9	-1.5	*1%*	*-1%*
EPCWID (Mesilla Valley)	7.4	7.2	-0.1	*0%*	*-2%*
EPCWID (El Paso Valley)	40.1	0.0	-40.1		
HCCRD	4.2	0.0	-4.2		
Total	147.8	146.1	-1.7	*1%*	*-1%*
	Pumping turned off.	*Other values are simulated responses and are totaled.*			
Other Inflows/Outflows					
Net Reservoir Evaporation	125.3	126.4	1.1	*-1%*	*1%*
Riparian ET	70.9	80.7	9.8	*-5%*	*14%*
River Evaporation + Incidental Canal Loss	30.3	29.6	-0.7	*0%*	*-2%*
Total	226.6	236.7	10.2	*-5%*	*4%*
Rio Grande at Fort Quitman					
Reservoir Spills	33.3	35.3	2.0	*-1%*	*6%*
Nov-Feb Flows	21.4	37.1	15.7	*-8%*	*73%*
Mar - Oct Flows	41.1	67.8	26.7	*-13%*	*65%*
Underflow (GW Model)	0.2	0.3	0.1	*0%*	*28%*
Total	96.0	140.5	44.5	*-22%*	*46%*

Run 14 - All Hueco Pumping Off

Comparison of ILRG Model Runs

Run 14 v. Run 1

1951 - 2017 Annual Average

(1,000 acre-feet)

Run No.	1	14	14 - 1		
Simulated Input or Output	**Run 1**	**Run 14**	**Run 14 minus Run 1**		
Effects of Pumping Stress (continued)				***% Chg***	
Change in Storage				***Stress***	***% Diff.***
Reservoir Storage	-4.7	-4.7	0.0	*0%*	*0%*
Alluvial GW Storage (RW Model)	-23.6	-5.2	18.4	*-9%*	*-78%*
Non-alluvial GW Storage (GW Models)	-96.4	-13.0	83.4	*-42%*	*-87%*
Soil Moisture Storage	0.6	0.5	-0.1	*0%*	*-18%*
Total	-124.0	-22.4	101.6	*-51%*	*-82%*
Summary of Effects					
FHG Deliveries (Mar-Oct)	340.3	344.5	4.2	*-2%*	*1%*
FHG Deliveries (Nov-Feb)	2.6	2.3	-0.2	*0%*	*-10%*
Irrigation Pumping	147.8	146.1	-1.7	*1%*	*-1%*
Riparian ET + Evaporation	226.6	236.7	10.2	*-5%*	*4%*
Fort Quitman Flow	96.0	140.5	44.5	*-22%*	*46%*
Change in Storage	-124.0	-22.4	101.6	*-51%*	*-82%*
Total	689.2	847.8	158.6	*-80%*	*23%*
Other Effects of Pumping Stress				***% Chg***	
Rio Grande at El Paso				***Stress***	***% Diff.***
Reservoir Spills	49.4	46.6	-2.7	*1%*	*-6%*
Nov-Feb Flows	22.8	23.2	0.4	*0%*	*2%*
Mar - Oct Flows	263.8	265.1	1.4	*-1%*	*1%*
Total	336.0	335.0	-0.9	*0%*	*0%*
Rio Grande below Caballo					
Reservoir Spills	65.9	61.3	-4.6	*2%*	*-7%*
Nov-Feb Flows	0.5	0.5	0.1	*0%*	*13%*
Mar - Oct Flows	541.3	544.8	3.6	*-2%*	*1%*
Total	607.6	606.6	-1.0	*0%*	*0%*
Surface Water Diversions (Mar - Oct)					
EBID	366.5	368.4	2.0	*-1%*	*1%*
EPCWID (incl. EPW)	236.8	237.0	0.2	*0%*	*0%*
HCCRD	67.5	75.0	7.5	*-4%*	*11%*
Total	670.8	680.4	9.6	*-5%*	*1%*
Surface Water Diversions (Nov - Feb)					
EBID	0.0	0.0	0.0	*0%*	*0%*
EPCWID (incl. EPW)	14.3	12.6	-1.8	*1%*	*-12%*
HCCRD	14.2	16.3	2.1	*-1%*	*15%*
Total	28.5	28.9	0.3	*0%*	*1%*

Run 14 - All Hueco Pumping Off

Annual Differences in ILRG Model Outputs

Run 14 minus Run 1

1940 - 2017 (acre-feet)

	Net River Headgate Diversions						Farm Headgate Deliveries						Annual Flows		
	EBID		EPCWID (incl. EPW)		HCCRD		EBID		EPCWID (incl. EPW)		HCCRD				
Year	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Caballo Releases	Rio Grande at El Paso	Rio Grande at Fort Quitman
1940	14	14	-833	530	-407	698	-25	-25	845	902	-322	-322	-7,588	-7,284	7,183
1941	-15	-15	-767	-1,279	-1	84	5	5	-43	-104	12	-22	6,749	5,202	7,787
1942	-37	-37	-305	-2,116	-89	-109	13	13	276	-185	-114	-123	1,220	2,376	3,556
1943	-28	-28	-353	-1,483	-100	-122	12	12	325	141	-86	-303	2,571	2,528	2,813
1944	-21	-21	-728	-2,069	-12	-235	-7	-7	-96	-309	-37	-199	-184	-152	2,166
1945	-21	-21	-468	-2,114	55	-501	0	0	-74	-340	48	106	935	868	2,557
1946	-7	-7	-378	-2,349	138	-564	-2	-2	50	-428	94	28	755	716	2,626
1947	-3	-3	-111	-1,571	5	-366	-6	-7	645	196	-19	-1	-512	-497	2,964
1948	13	13	-1,506	-2,685	370	185	-20	-21	439	276	378	155	-3,573	-3,442	7,847
1949	23	23	-2,763	-4,080	1,432	1,684	-8	-9	-58	-83	-138	-281	-3,148	-3,174	13,461
1950	10	10	-4,064	-4,883	1,626	1,968	-44	-44	-99	-100	-27	-47	-3,630	-3,585	10,287
1951	1,028	1,028	-4,701	-5,308	1,593	2,279	555	556	6	5	1,704	1,239	-3,394	-3,479	25,964
1952	86	86	-7,108	-7,724	1,823	2,664	395	394	-442	-444	1,657	933	-9,670	-8,054	24,226
1953	179	179	-8,220	-8,870	3,129	4,635	1,088	1,087	-49	-51	3,522	4,034	-8,077	-8,391	42,118
1954	-17,710	-17,710	-12,313	-14,153	1,122	3,272	-2,036	-2,036	710	706	2,136	3,844	-33,072	-8,404	24,621
1955	32,323	32,323	24,036	20,802	8,932	12,135	16,239	16,239	21,900	22,065	8,565	11,417	66,243	28,186	19,078
1956	-8,443	-8,443	-8,084	-10,443	7,558	10,233	-7,008	-7,008	-464	-752	7,087	9,245	-15,612	-6,786	8,350
1957	42	42	-8,946	-11,312	2,395	6,191	14	14	1,764	1,448	3,075	4,936	-7,152	-5,662	6,336
1958	-5	-5	-22,873	-24,299	7,547	13,212	-98	-98	-1,713	-1,811	-1,169	570	-27,008	-23,145	46,574
1959	6	6	-14,880	-15,728	6,169	9,923	-56	-56	-345	-345	403	682	-19,692	-18,776	55,810
1960	7	7	-13,032	-14,048	4,967	7,439	-50	-51	-779	-779	0	0	-14,804	-14,797	52,470
1961	10	10	-12,889	-13,840	5,145	7,485	-22	-22	618	617	1,527	-417	-13,799	-13,520	54,683
1962	12	12	-12,111	-13,142	4,709	6,988	-31	-31	-170	-170	794	1,225	-13,492	-12,938	51,440
1963	8,881	8,881	-12,259	-13,225	4,725	6,861	4,805	4,805	-455	-453	2,584	2,360	-967	-4,876	54,188
1964	12,029	12,029	7,126	5,110	6,022	8,896	17,743	17,743	11,654	11,852	6,036	7,889	11,142	17,345	41,745
1965	31,802	31,802	5,179	3,068	10,116	14,599	15,775	15,775	16,759	16,798	10,941	13,271	37,909	18,873	45,430
1966	-69	-69	-13,553	-14,249	9,180	13,109	198	198	-254	-250	-2,779	-4,910	-18,684	-9,944	55,788
1967	15,818	15,818	10,877	10,360	8,536	14,595	11,473	11,473	16,071	15,556	6,960	10,714	20,437	12,750	42,262
1968	230	230	-11,091	-11,781	12,756	18,842	127	127	526	126	10,106	7,733	-12,554	-5,021	46,007
1969	2	2	-11,373	-12,396	14,942	19,644	317	317	-218	-217	2,911	-1,892	-13,203	-10,314	59,775
1970	3	3	-8,998	-9,979	8,374	11,883	-1	-1	15	15	-1,274	-2,725	-11,872	-10,703	62,623
1971	20,912	20,912	-8,450	-9,092	9,667	14,109	12,713	12,713	-332	-330	7,941	11,107	2,710	-5,526	54,950
1972	-4,887	-4,887	-3,665	-4,513	13,426	17,542	-5,165	-5,165	-5,841	-5,474	10,467	9,332	-4,162	-2,542	45,402
1973	-186	-186	-7,372	-8,963	22,061	27,344	918	918	421	608	17,776	15,095	-11,386	-7,996	38,170
1974	-48	-48	-4,896	-6,102	19,818	26,111	328	328	673	673	-3,918	-6,168	-6,133	-6,074	74,491
1975	-246	-246	-1,901	-2,999	19,415	25,555	1,129	1,129	155	155	8,282	3,832	-6,108	-3,910	58,376
1976	-15	-15	2,954	1,826	17,146	23,660	718	718	216	216	-1,658	-5,752	53	-345	59,161
1977	23,989	23,989	1,532	1,567	11,908	17,427	14,543	14,543	288	290	11,072	11,094	15,943	6,178	54,566
1978	11,641	11,641	8,133	7,828	11,682	16,655	6,494	6,494	6,106	6,108	11,342	9,864	20,417	17,073	52,161

Run 14 - All Hueco Pumping Off
Annual Differences in ILRG Model Outputs
Run 14 minus Run 1
1940 - 2017 (acre-feet)

	Net River Headgate Diversions						Farm Headgate Deliveries						Annual Flows		
	EBID		EPCWID (incl. EPW)		HCCRD		EBID		EPCWID (incl. EPW)		HCCRD				
Year	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Caballo Releases	Rio Grande at El Paso	Rio Grande at Fort Quitman
1979	-320	-320	-2,957	-3,985	10,541	15,757	-67	-66	-2,755	-2,751	2,790	-150	-1,578	2,941	63,217
1980	-36	-36	3,953	2,840	10,476	13,957	153	153	19	22	-4,659	-9,146	157	2,797	92,428
1981	-21	-21	7,703	6,626	8,970	10,427	192	192	7	7	-56	-413	5,388	6,000	65,726
1982	-16	-16	6,755	5,509	8,448	9,689	81	81	3	4	-2,064	-4,042	6,107	6,895	78,392
1983	-18	-18	10,068	8,682	11,713	13,006	77	77	2	3	0	0	7,842	8,279	58,009
1984	-19	-19	11,784	10,530	14,977	15,774	71	71	7	8	0	0	7,050	7,586	54,871
1985	1	1	14,484	13,837	9,635	10,270	1,612	1,612	277	192	0	0	5,315	5,236	58,414
1986	11	11	19,575	18,988	11,381	10,762	80	76	-9	-11	0	0	-25,668	-23,770	138,291
1987	-15	-15	21,479	20,858	9,642	8,432	4	3	-13	-13	0	0	53	314	70,775
1988	-10	-10	22,771	22,147	9,603	7,884	58	58	1	2	0	0	7,629	6,710	51,845
1989	-18	-18	24,355	23,461	10,677	9,239	101	102	350	-29	0	0	23,502	22,123	53,669
1990	-55	-55	23,467	22,503	13,434	12,257	242	242	326	-190	0	0	11,638	13,047	38,572
1991	-163	-163	10,946	9,864	6,273	5,642	-689	-688	147	-650	0	0	6,321	6,573	46,726
1992	-290	-290	7,216	6,372	4,475	4,511	1,601	1,603	94	-250	0	0	-28,822	-28,584	20,532
1993	-33	-33	-2,073	-2,712	2,806	2,136	187	187	18	15	0	0	-14,909	-14,281	30,195
1994	194	194	-936	-1,626	3,370	2,938	11	11	2,318	2,318	0	0	-1,495	-1,588	47,276
1995	416	416	-1,738	-2,514	2,644	1,837	56	56	2,583	2,525	0	0	5,341	4,358	52,828
1996	-51	-51	-2,925	-3,652	2,297	1,618	313	313	29	29	0	0	-11,095	-8,786	39,048
1997	122	122	-7,251	-9,774	4,329	3,034	-222	-222	-1,092	-2,115	0	0	-5,176	-5,318	44,036
1998	5	5	-585	-1,401	3,391	2,400	-3	-3	539	539	0	0	-4,892	-4,823	49,623
1999	-172	-172	-1,492	-4,668	2,506	3,123	-2	-2	-3,093	-3,093	0	0	0	562	44,877
2000	-1,250	-1,250	10,392	6,623	5,134	6,228	-113	-113	2,648	2,647	0	0	11,450	11,513	38,594
2001	-33	-33	4,631	618	4,029	5,095	-64	-64	-9	-9	0	0	4,629	4,117	33,350
2002	-15	-15	-1,665	-4,332	1,736	2,771	-24	-24	166	166	0	0	-3,922	-3,433	28,007
2003	3,973	3,973	15,245	12,976	4,879	5,206	2,577	2,577	101	102	0	0	25,330	21,301	31,739
2004	-12,540	-12,540	-11,360	-14,585	752	1,456	-6,490	-6,490	-8,003	-8,005	0	0	-12,256	-3,371	28,014
2005	-395	-395	201	-3,350	3,602	5,026	-379	-376	-273	-273	0	0	1,827	-1,589	29,676
2006	-1,769	-1,769	-2,784	-5,594	1,597	2,853	-1,371	-1,371	-2,439	-2,440	0	0	-6,577	-5,451	33,036
2007	-248	-248	1,392	-2,009	3,211	4,643	-199	-199	4,151	4,152	0	0	722	-958	27,667
2008	3,366	3,366	-5,202	-8,453	3,071	3,952	2,192	2,192	-1,295	-1,294	0	0	-6,375	-6,185	34,982
2009	3,986	3,986	-858	-4,740	1,838	2,639	1,867	1,867	213	213	0	0	-56	-978	39,824
2010	13,099	13,099	-957	-5,606	2,560	3,613	8,182	8,182	92	94	0	0	3,438	-716	37,321
2011	7,635	7,635	1,015	-3,280	12,714	17,489	4,234	4,234	3,569	3,571	0	0	4,704	1,608	32,950
2012	-2,798	-2,798	491	-3,334	12,969	16,137	480	480	-4,792	-4,792	0	0	-658	3,703	21,497
2013	-1,109	-1,109	-6,109	-9,574	6,528	8,575	-498	-498	-9,905	-9,905	5,173	6,466	-1,752	2,560	10,859
2014	-2,258	-2,258	-839	-4,572	8,726	13,067	-1,395	-1,395	-52	-52	1,263	3,346	864	3,378	17,223
2015	-868	-868	155	-3,669	6,164	8,373	-600	-600	383	383	-3,308	-2,165	4,184	3,195	32,274
2016	-5,454	-5,454	-774	-5,049	2,828	4,542	-2,674	-2,674	1,254	1,254	0	0	336	716	18,059
2017	848	848	-6,775	-10,554	2,832	4,453	797	797	-435	-435	0	0	-7,871	-7,309	29,379
Averages															
1951-2017	1,956	1,956	178	-1,615	7,487	9,613	1,515	1,515	775	718	1,869	1,678	-974	-932	44,486
1951-1978	4,550	4,550	-5,317	-6,486	9,102	12,975	3,254	3,254	2,386	2,363	4,503	4,234	-2,714	-3,243	44,884
1979-2005	-398	-398	6,742	5,179	6,730	7,055	-24	-23	-208	-326	-148	-509	732	1,289	51,434
2006-2017	1,203	1,203	-1,770	-5,536	5,420	7,528	918	918	-771	-771	261	637	-753	-536	27,923
1985-2017	125	125	3,742	1,309	5,504	6,127	299	299	-368	-465	95	232	-432	-186	39,732
1985-2005	-491	-491	6,892	5,221	5,552	5,327	-54	-54	-138	-291	0	0	-248	15	46,480

Notes:

EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).

EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

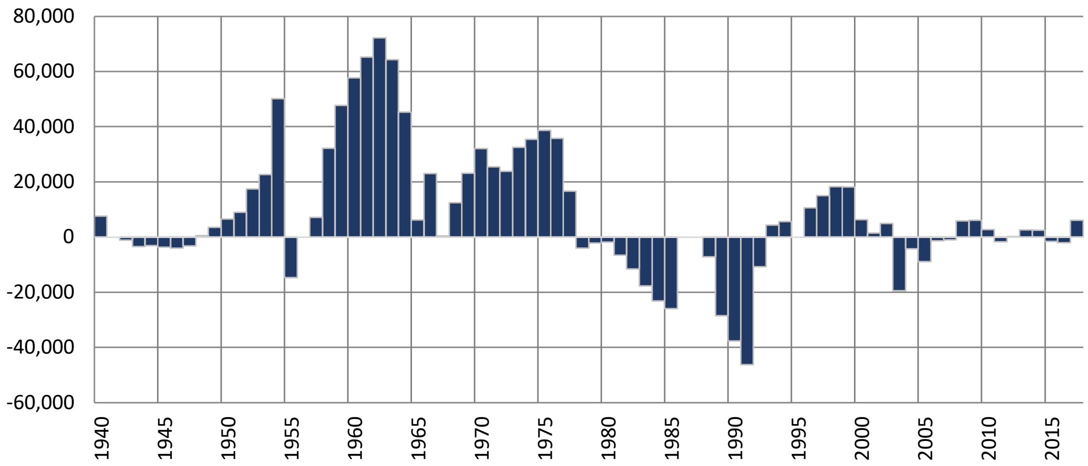
Run 14 - All Hueco Pumping Off

Simulated Differences in ILRG Model Outputs

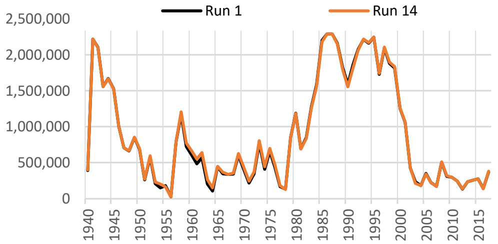
Run 14 minus Run 1

1940 - 2017 (acre-feet)

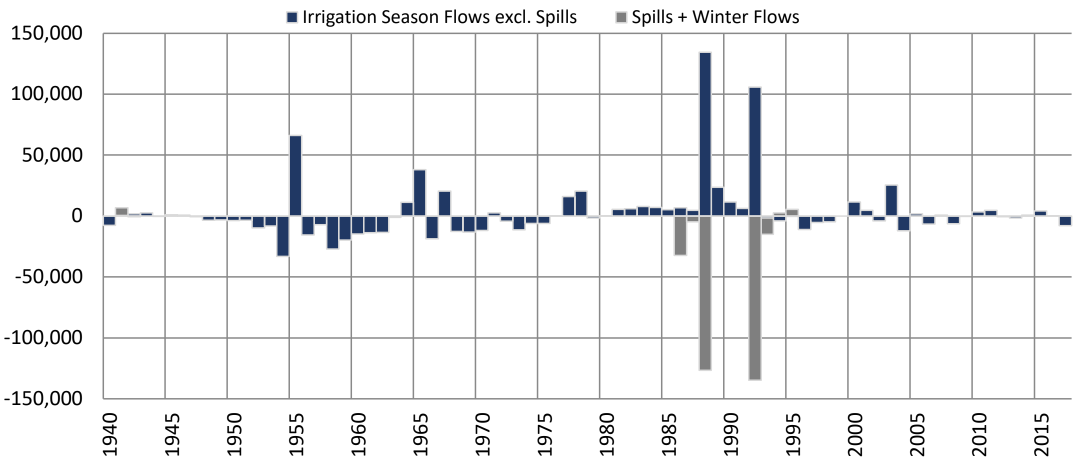
Total Project Storage (Year End)



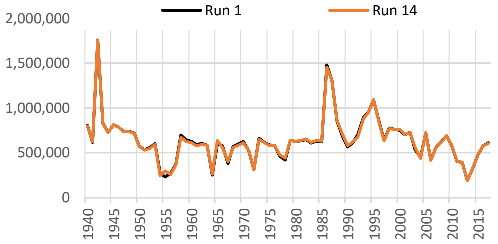
Period	Average Difference
1951-2017	-8
1951-1978	-378
1979-2005	-180
2006-2017	1,243
1985-2017	885
1985-2005	681



Caballo Reservoir Outflows (Annual)



	Average Difference		
Period	Irr Season (excl. Spills)	Nov-Feb and Spills	Annual
1951-2017	3,556	-4,530	-974
1951-1978	-2,714	0	-2,714
1979-2005	11,974	-11,242	732
2006-2017	-753	0	-753
1985-2017	8,767	-9,198	-432
1985-2005	14,207	-14,454	-248



Notes:

Reservoir storage does not include storage attributed to SJC, CO, or NM credit waters.

Average differences calculated as (Final Storage - Initial Storage)/(no. years).

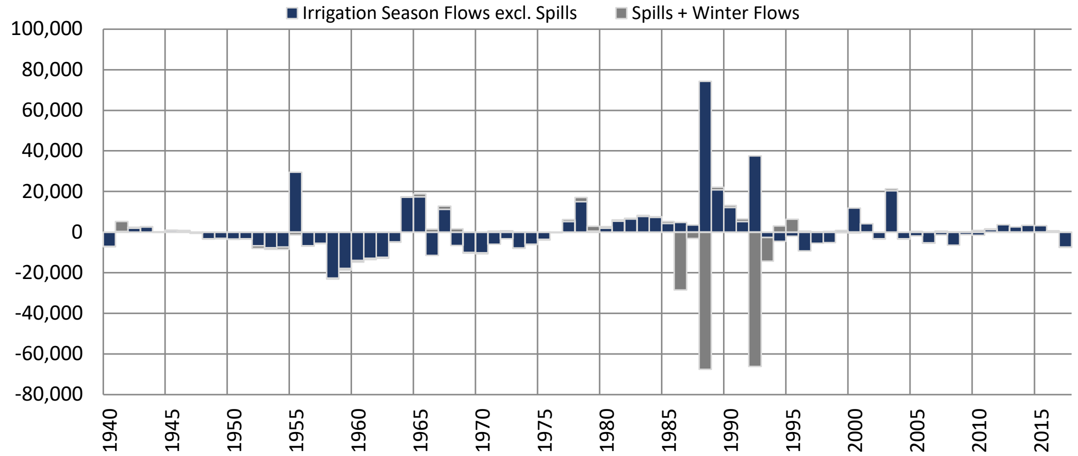
Run 14 - All Hueco Pumping Off

Simulated Differences in ILRG Model Outputs

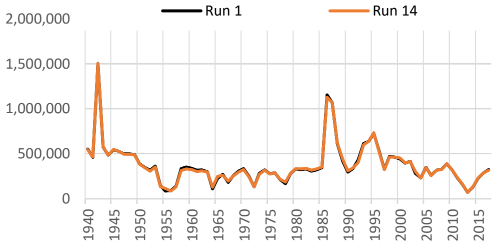
Run 14 minus Run 1

1940 - 2017 (acre-feet)

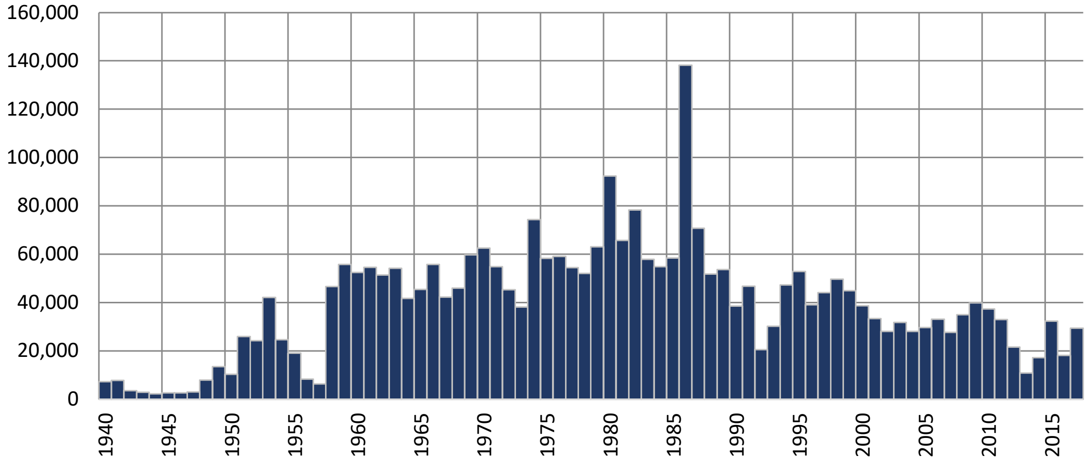
Rio Grande at El Paso (Annual)



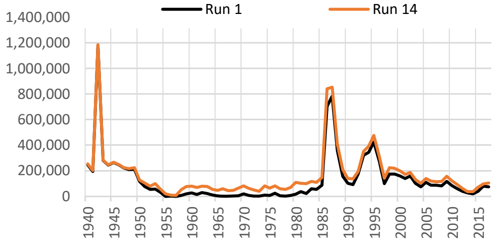
	Average Difference		
Period	Irr Season (excl. Spills)	Nov-Feb and Spills	Annual
1951-2017	1,375	-2,307	-932
1951-1978	-3,254	11	-3,243
1979-2005	7,099	-5,810	1,289
2006-2017	-705	168	-536
1985-2017	4,662	-4,847	-186
1985-2005	7,728	-7,713	15



Rio Grande at Fort Quitman (Annual)



Period	Average Difference
1951-2017	44,426
1951-1978	44,797
1979-2005	51,382
2006-2017	27,909
1985-2017	39,705
1985-2005	46,445



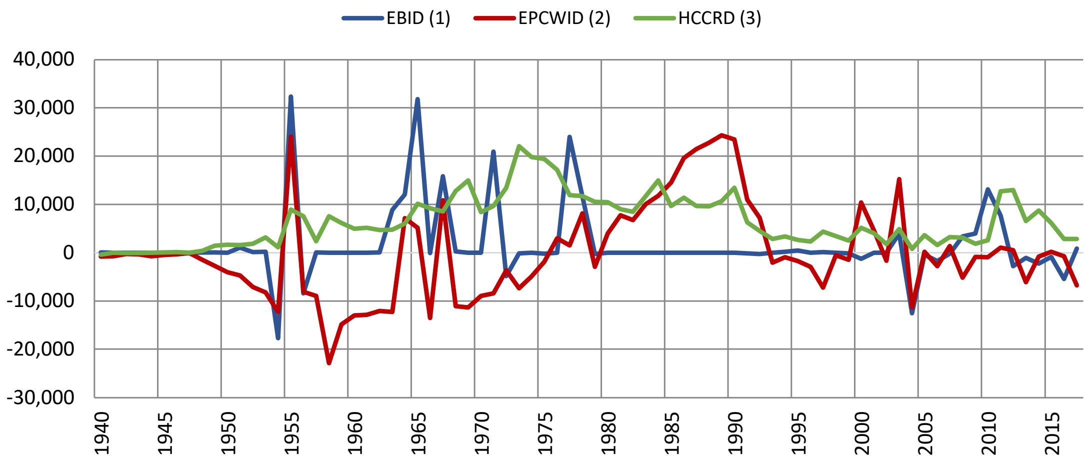
Run 14 - All Hueco Pumping Off

Simulated Differences in ILRG Model Outputs

Run 14 minus Run 1

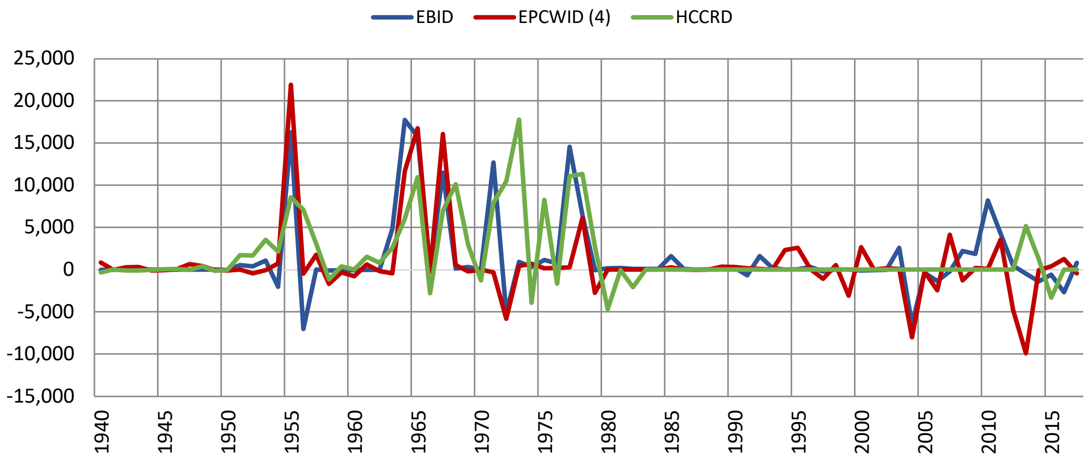
1940 - 2017 (acre-feet)

River Headgate (RHG) Diversions (Irrigation Season)



	Average Difference		
Period	EBID	EPCWID	HCCRD
1951-2017	1,956	178	7,487
1951-1978	4,550	-5,317	9,102
1979-2005	-398	6,742	6,730
2006-2017	1,203	-1,770	5,420
1985-2017	125	3,742	5,504
1985-2005	-491	6,892	5,552

Farm Headgate (FHG) Deliveries (Irrigation Season)



	Average Difference		
Period	EBID	EPCWID	HCCRD
1951-2017	1,515	775	1,869
1951-1978	3,254	2,386	4,503
1979-2005	-24	-208	-148
2006-2017	918	-771	261
1985-2017	299	-368	95
1985-2005	-54	-138	0

Notes:

(1) EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).

(2) EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

(3) HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

(4) EPCWID FHG values include deliveries to Rogers WTP and R/U WTP.

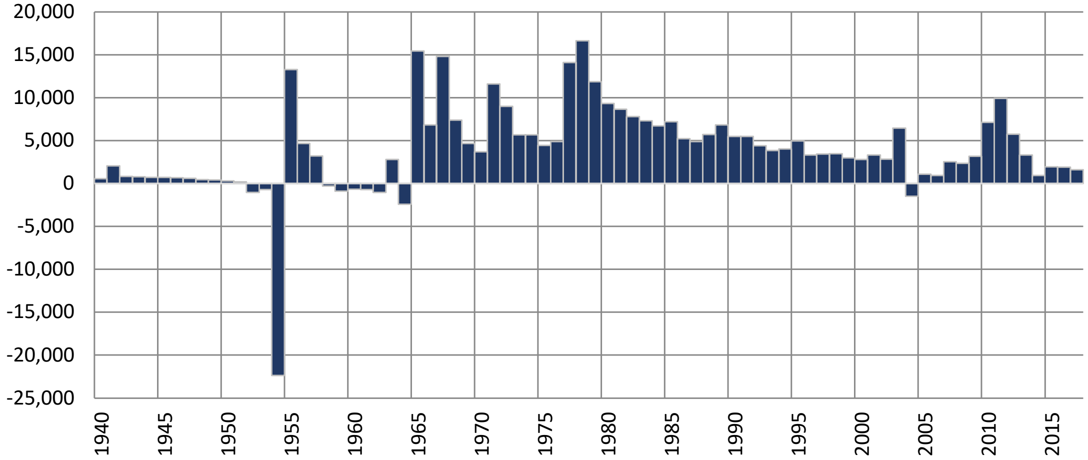
Run 14 - All Hueco Pumping Off

Simulated Differences in ILRG Model Outputs

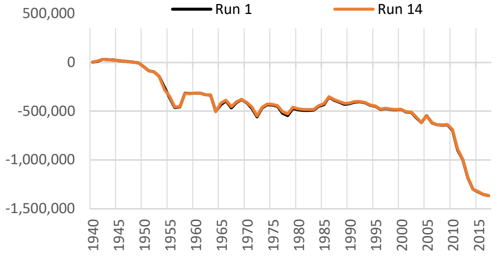
Run 14 minus Run 1

1940 - 2017 (acre-feet)

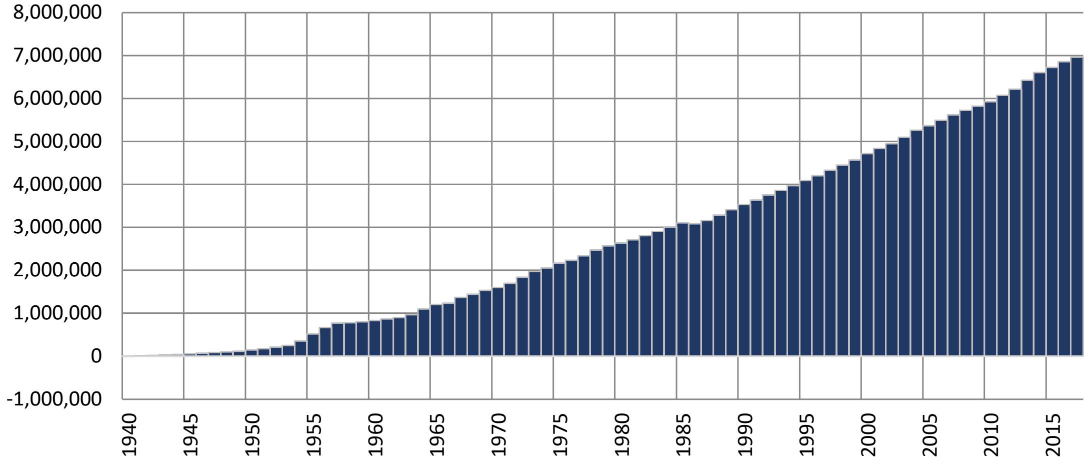
Cumulative Annual Rincon-Mesilla Groundwater Storage



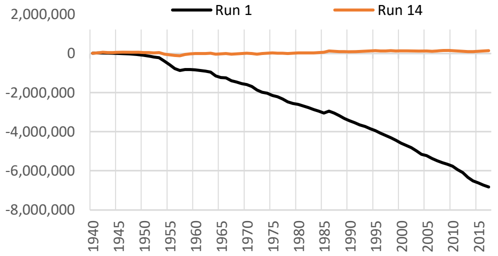
Period	Average Difference
1951-2017	20
1951-1978	584
1979-2005	-575
2006-2017	43
1985-2017	-154
1985-2005	-267



Cumulative Annual Hueco Groundwater Storage



Period	Average Difference
1951-2017	101,742
1951-1978	83,168
1979-2005	107,121
2006-2017	132,976
1985-2017	119,828
1985-2005	112,314

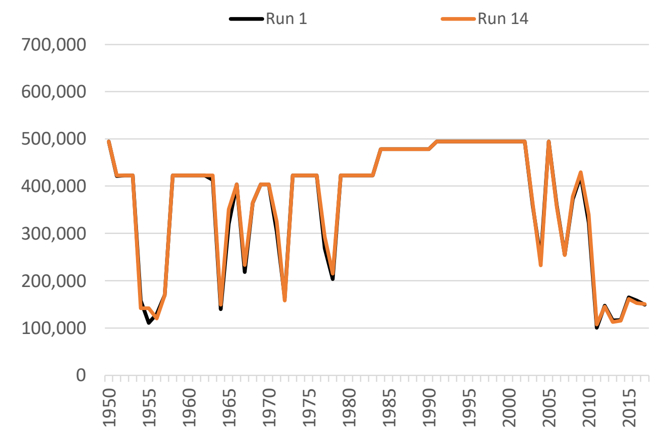


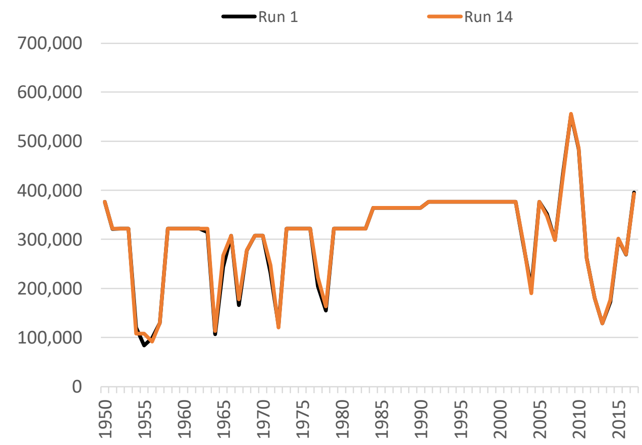
Notes:

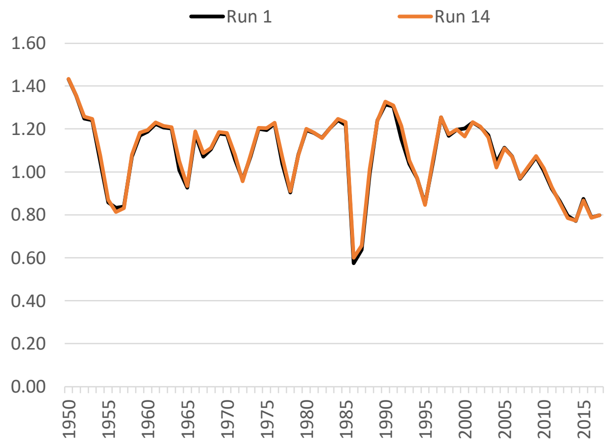
Cumulative storage change in alluvial and non-alluvial aquifers.

Average differences calculated as (Final Storage - Initial Storage)/(no. years).

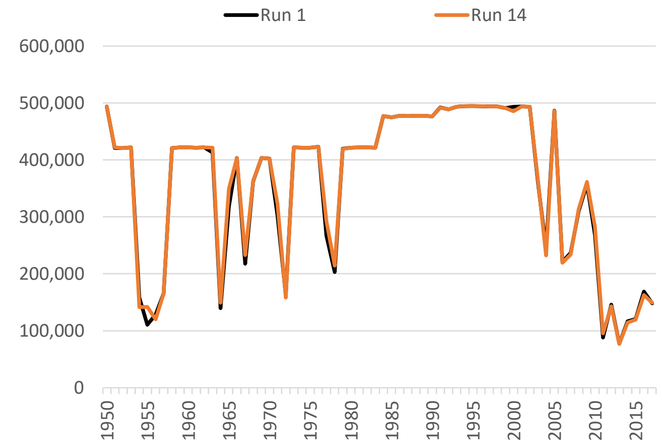
Run 14 - All Hueco Pumping Off
Annual Allocation and Charges
Run 14 v. Run 1
ILRG Model
1950 - 2017 (acre-feet)

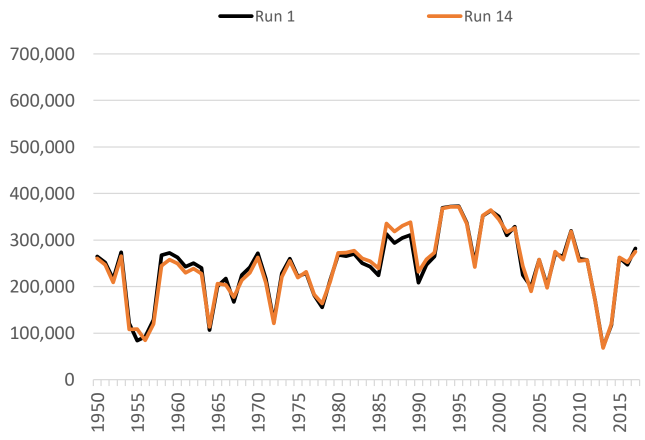

Total Allocation - EBID


Total Allocation - EPCWID

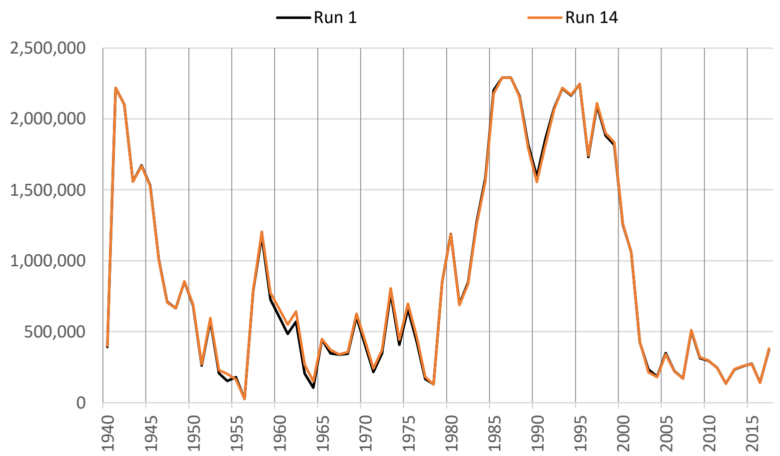

Diversion Ratio

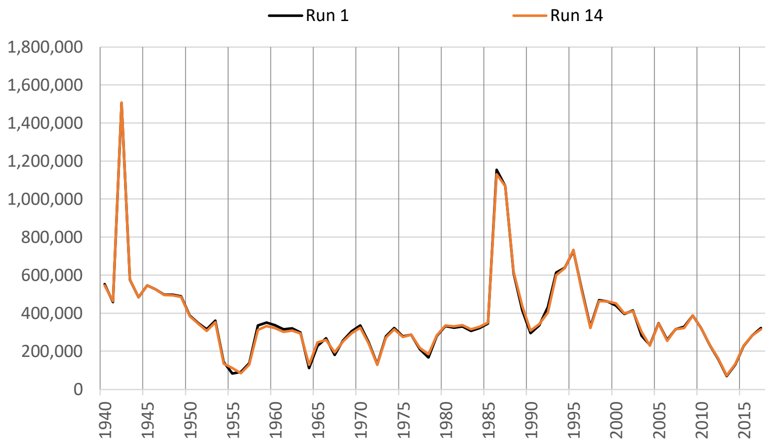
Note:
Computed as Total Charges/Caballo Release.

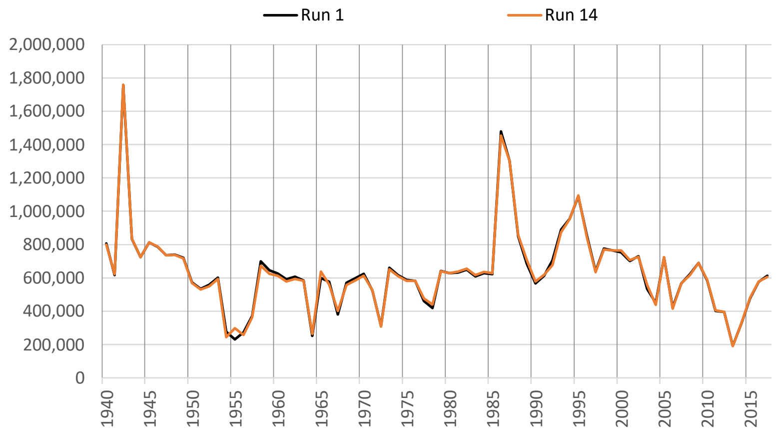

Annual Delivery Charges - EBID

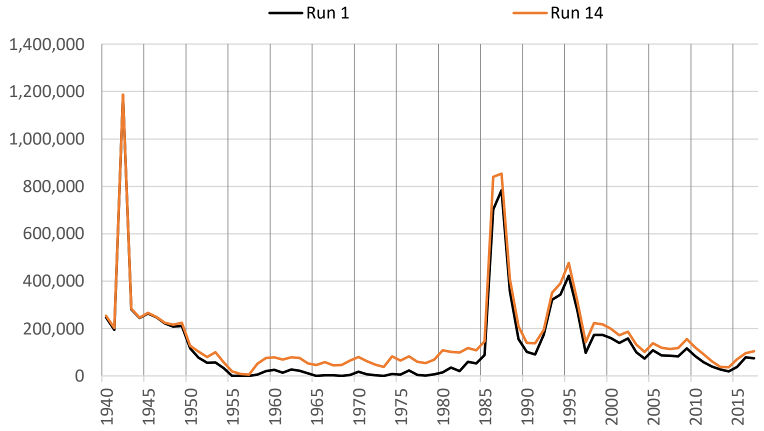

Annual Delivery Charges - EPCWID

Run 14 - All Hueco Pumping Off
Annual Summary of Project Storage and Rio Grande Flows
Run 14 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)


Total Year-End Project Reservoir Storage


Rio Grande at El Paso


Rio Grande Below Caballo


Rio Grande at Fort Quitman

***Note different scales.**

Run 14 - All Hueco Pumping Off

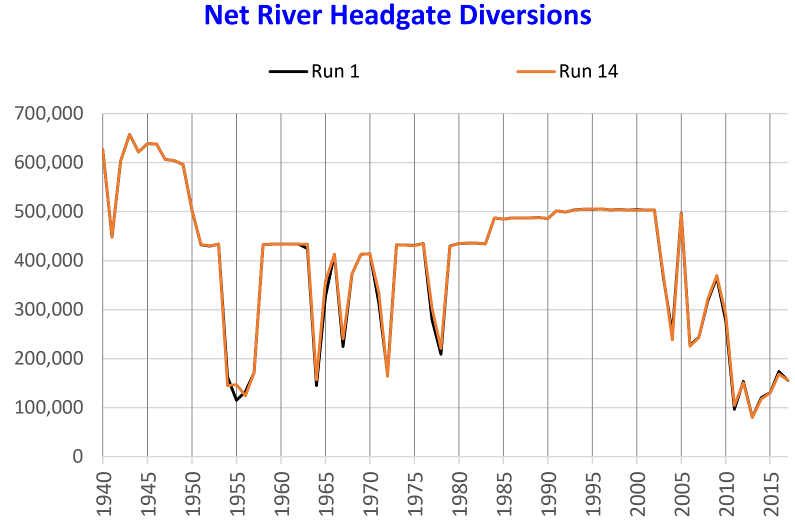
Irrigation Season Summary of Irrigation Operations

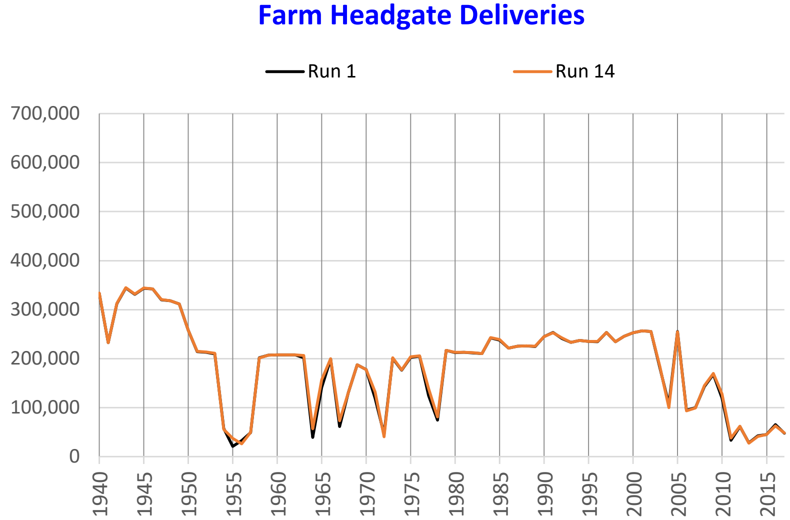
Run 14 v. Run 1

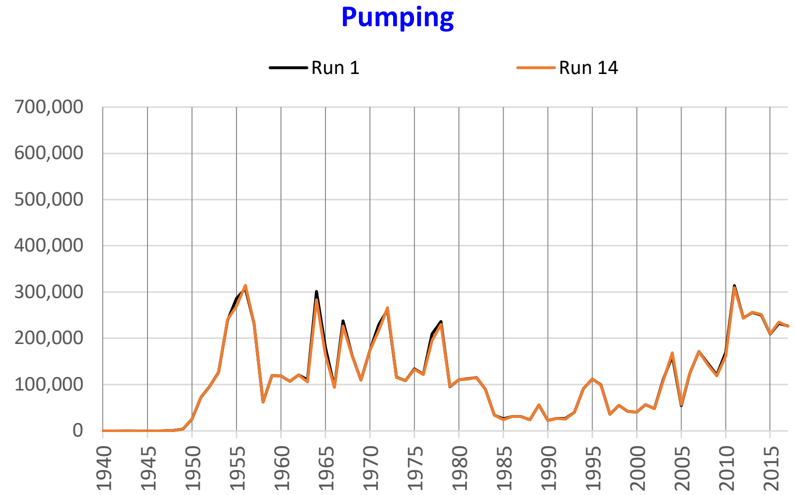
ILRG Model

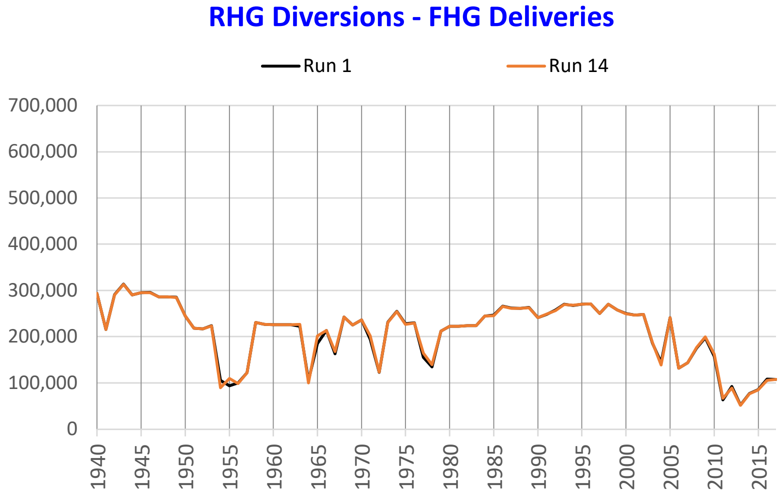
1940 - 2017 (acre-feet)

EBID Total







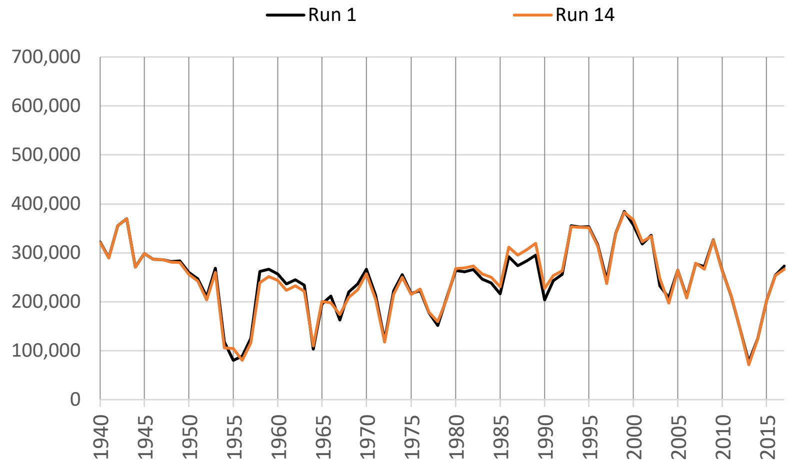


Notes: EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).
Pumping includes Supplemental and Primary groundwater pumping.

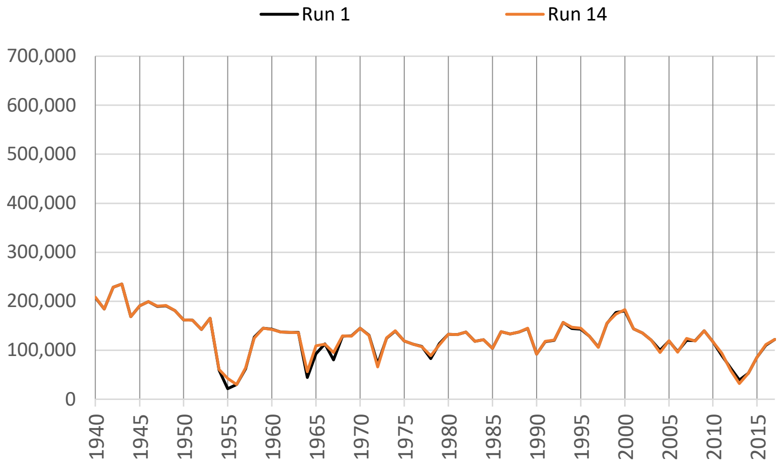
Run 14 - All Hueco Pumping Off
Irrigation Season Summary of Irrigation Operations
Run 14 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

EPCWID Total

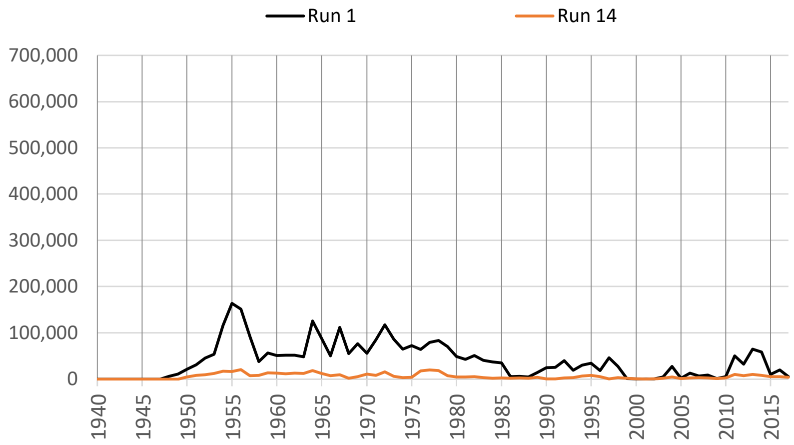
Net River Headgate Diversions



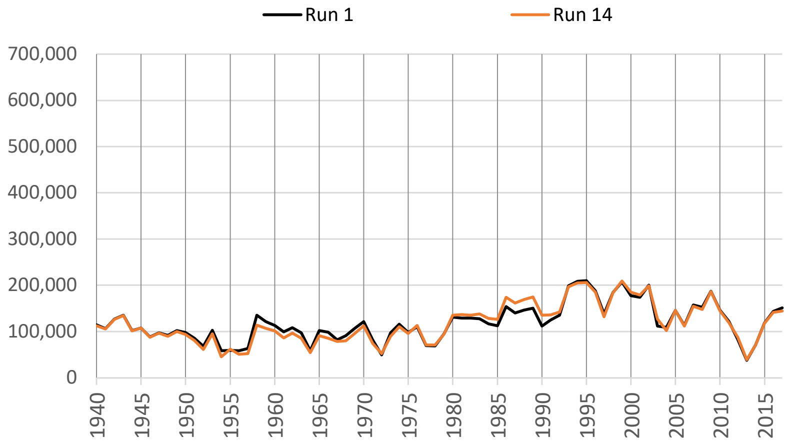
Farm Headgate Deliveries



Pumping



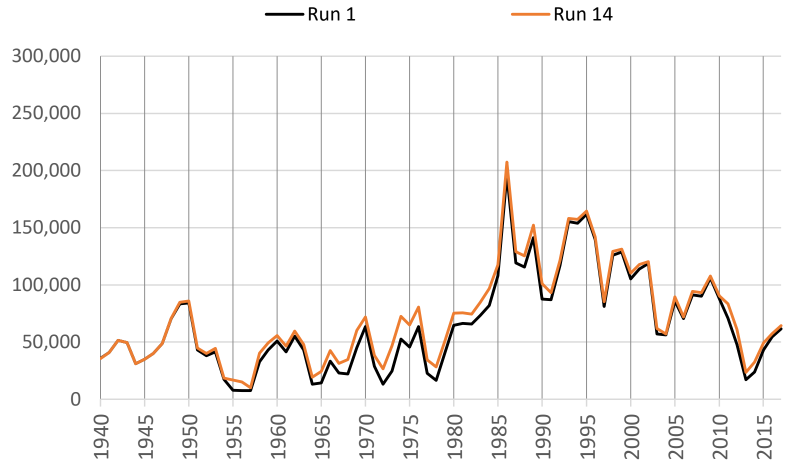
RHG Diversions - FHG Deliveries

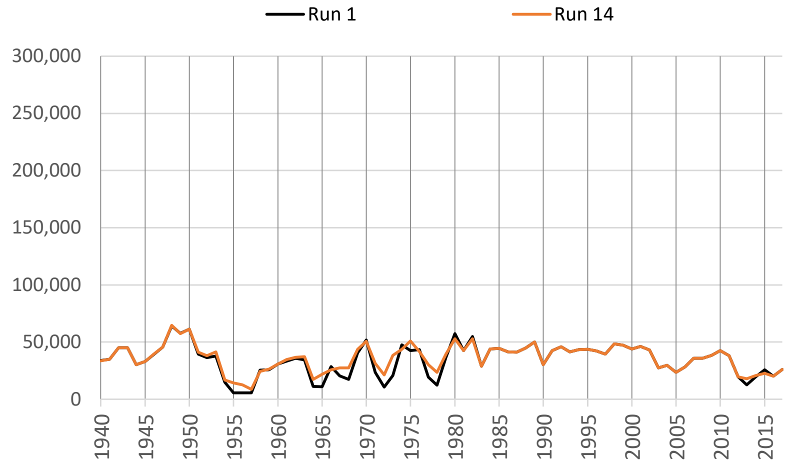


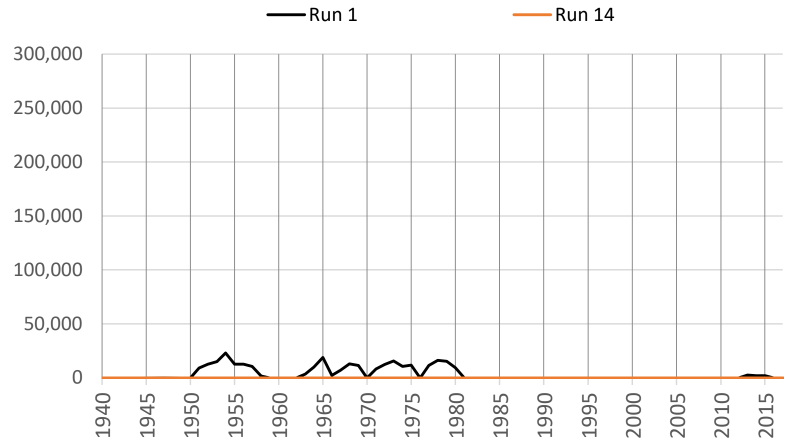
Note: EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

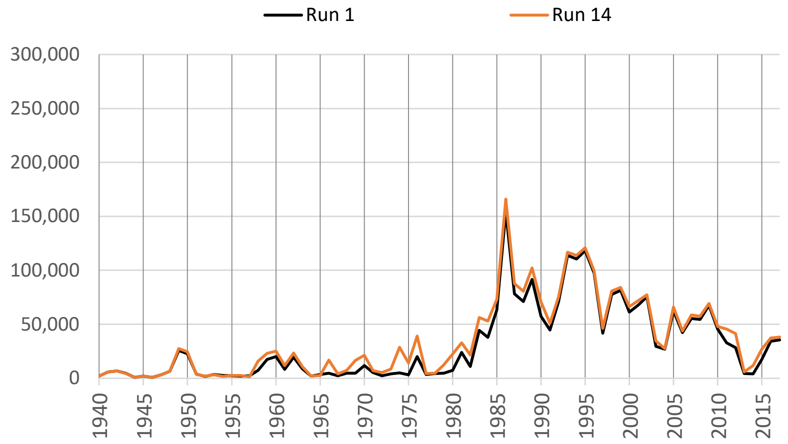
Run 14 - All Hueco Pumping Off
Irrigation Season Summary of Irrigation Operations
Run 14 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

HCCRD Total


Net River Headgate Diversions

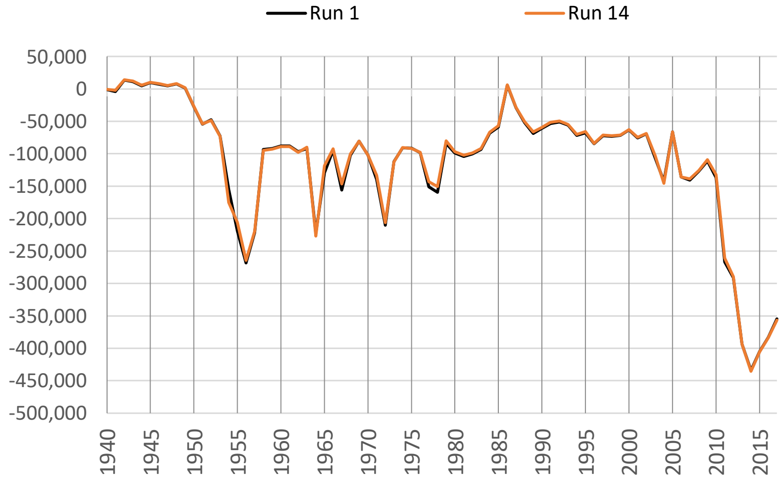

Farm Headgate Deliveries

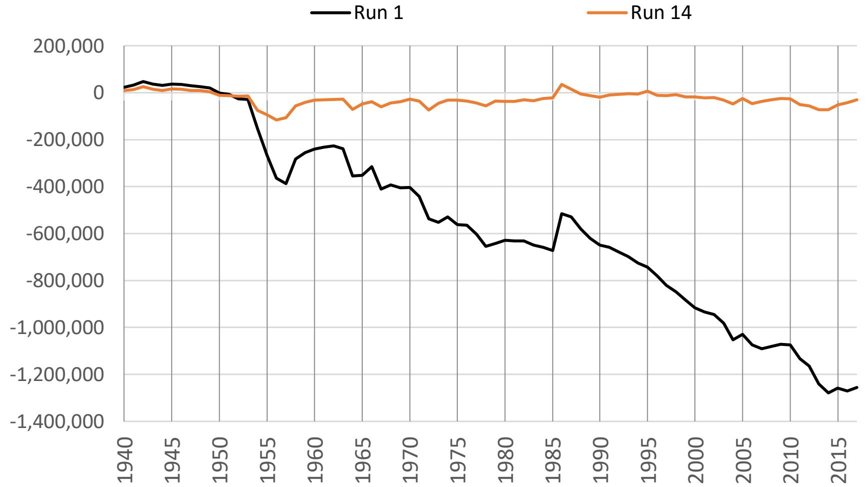

Pumping

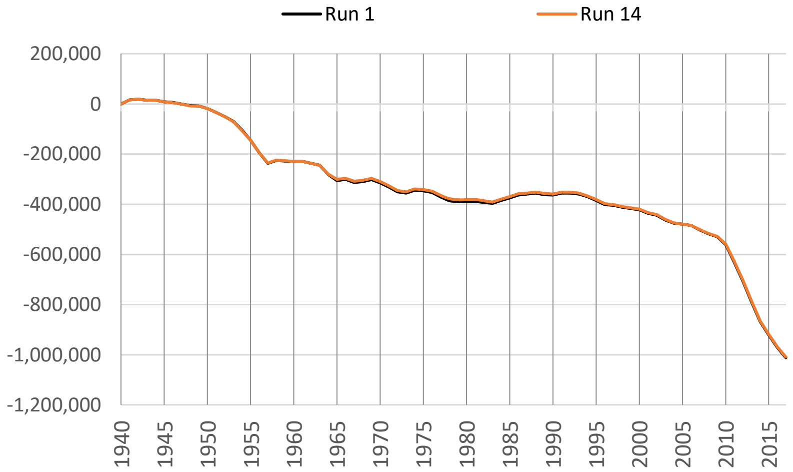

RHG Diversions - FHG Deliveries

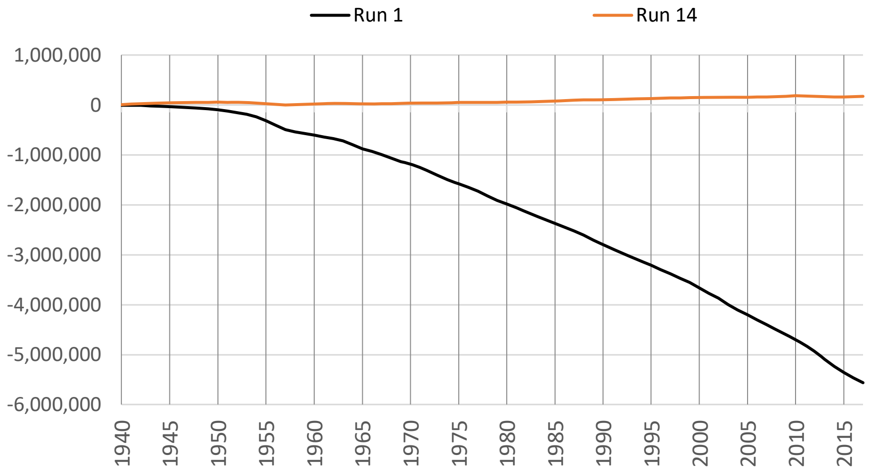
Note: HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

Run 14 - All Hueco Pumping Off
Cumulative Change in Ground Water Storage
Run 14 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)


Rincon-Mesilla Alluvial Aquifer


Hueco Alluvial Aquifer


Rincon-Mesilla Non-Alluvial Aquifer


Hueco Non-Alluvial Aquifer

***Note different scales.**

Run 14 - All Hueco Pumping Off

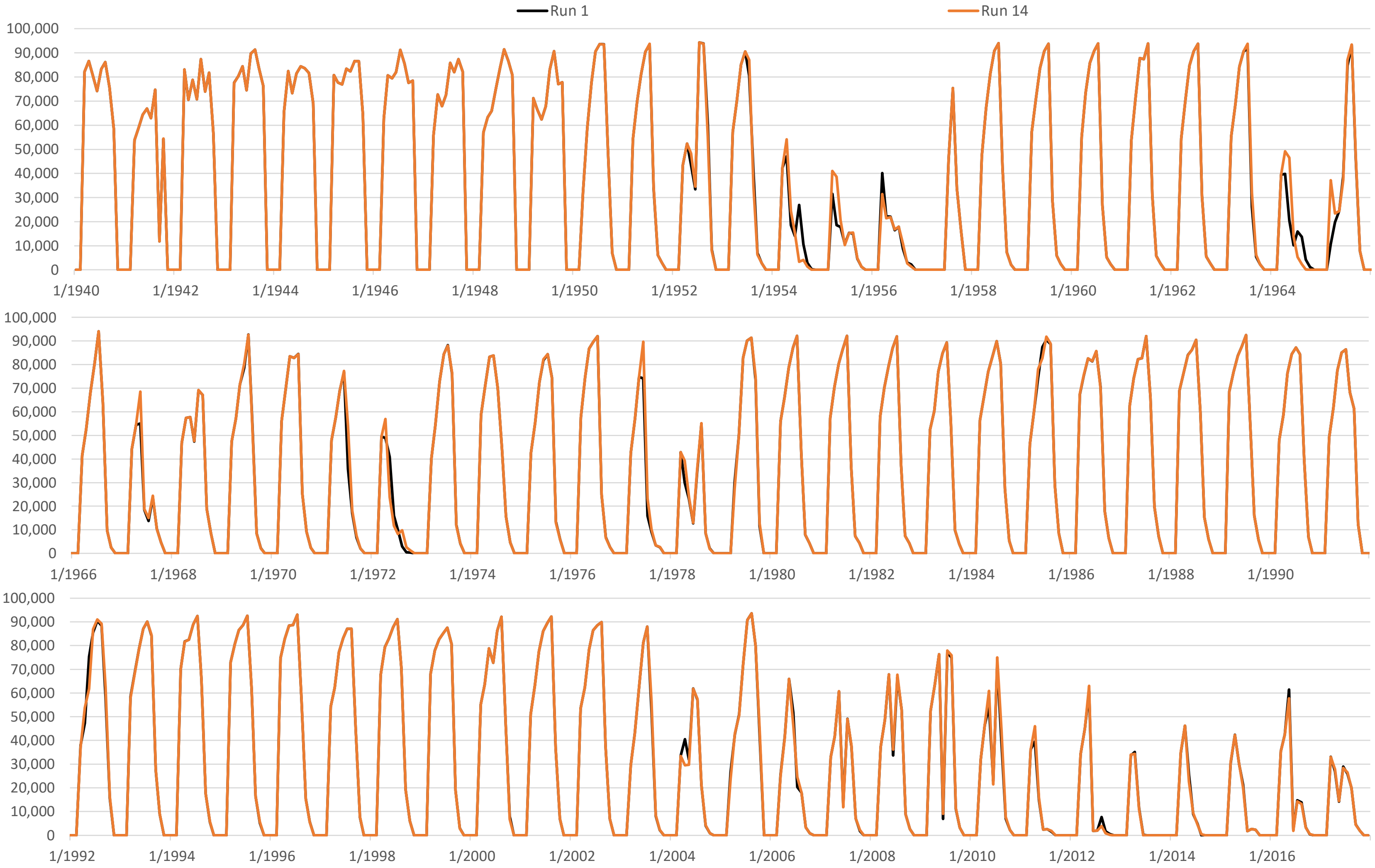
Monthly Net RHG Diversions

Run 14 v. Run 1

ILRG Model

1940 - 2017 (acre-feet)

EBID Total

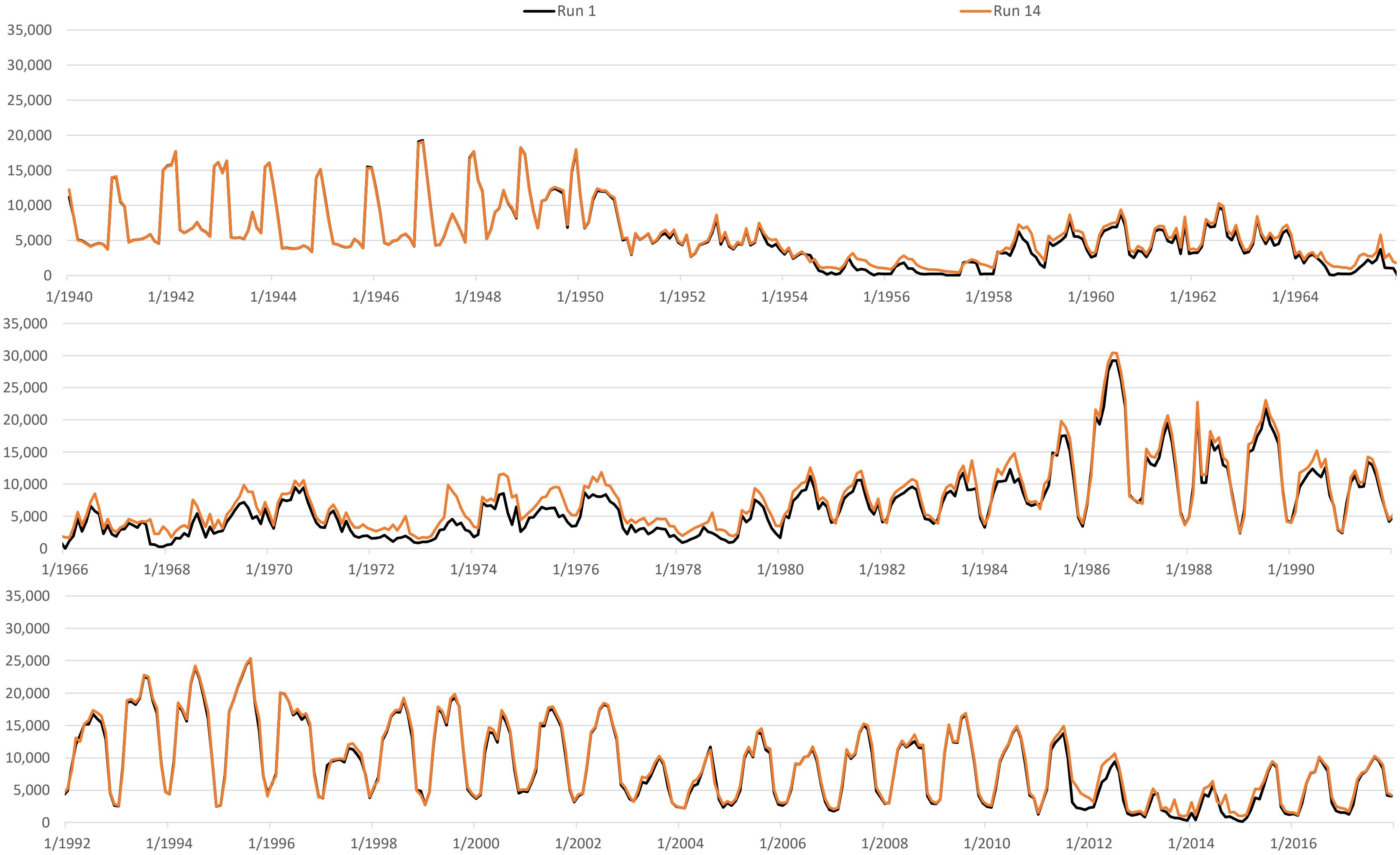


Note: EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).

Run 14 - All Hueco Pumping Off
Monthly Net RHG Diversions
Run 14 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)
EPCWID Total

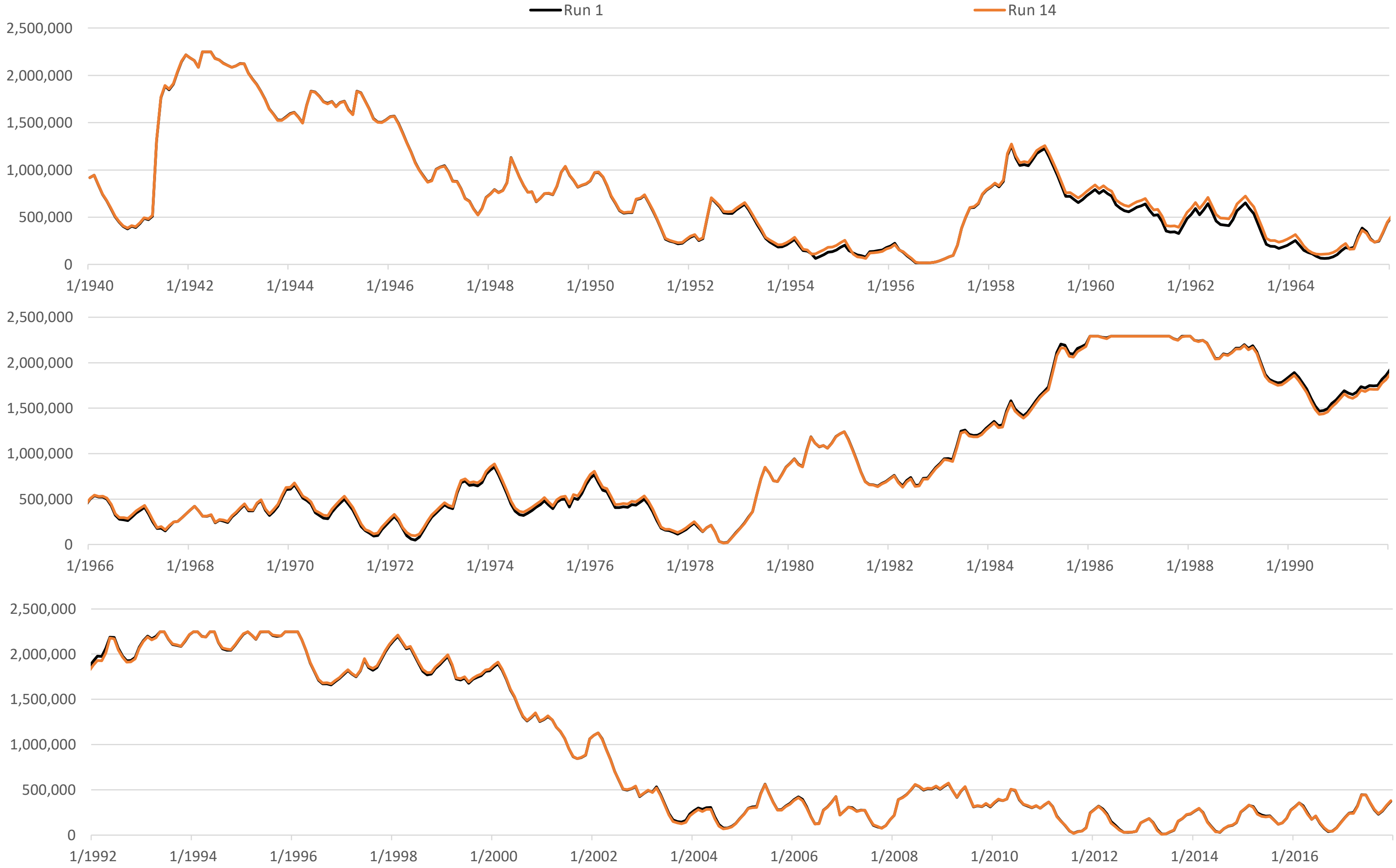
Note: EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

Run 14 - All Hueco Pumping Off
Monthly Net RHG Diversions
Run 14 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)
HCCRD Total



Note: HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

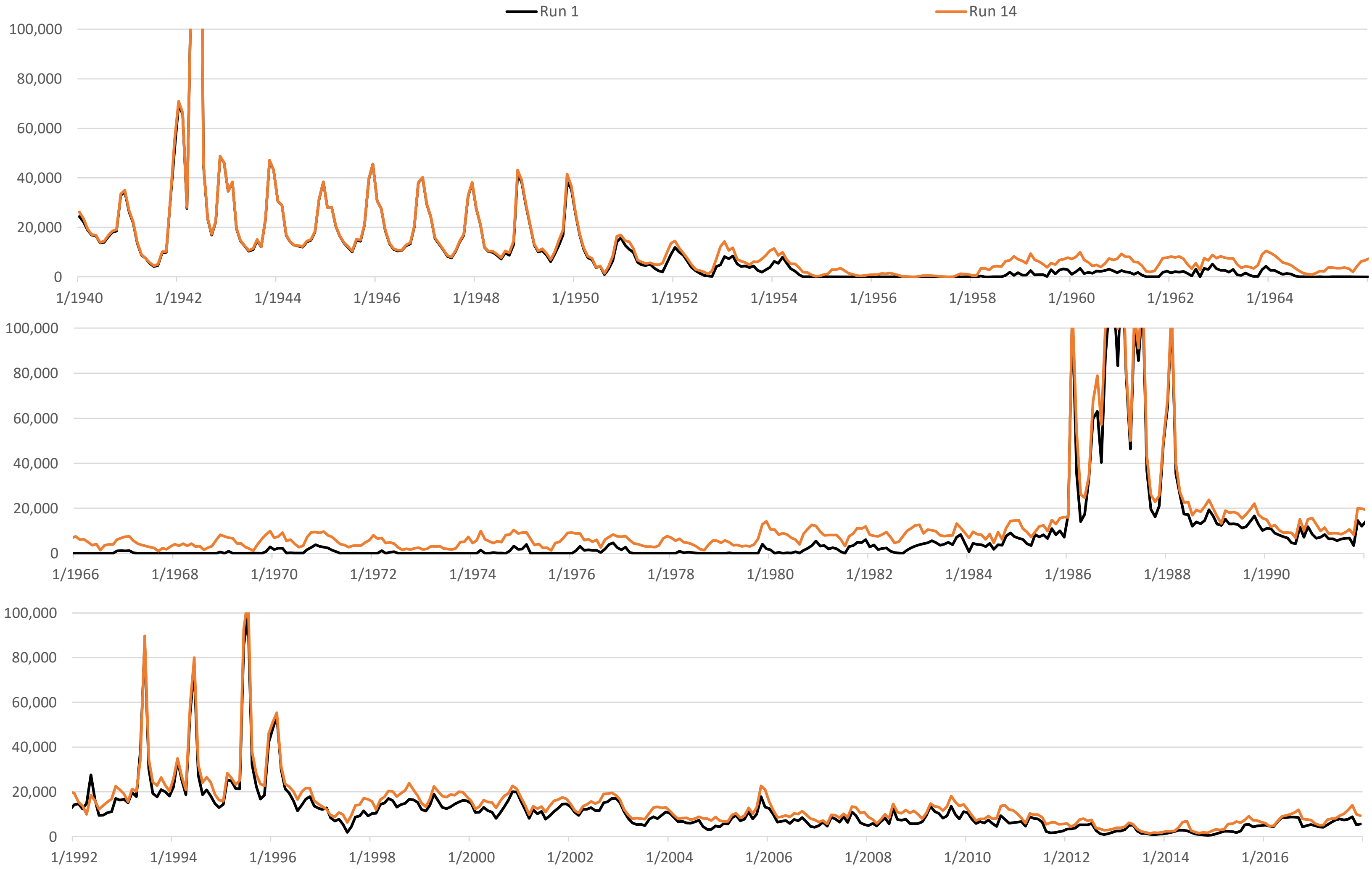
Run 14 - All Hueco Pumping Off
End of Month Reservoir Storage (Elephant Butte + Caballo)
Run 14 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)



Run 14 - All Hueco Pumping Off
Monthly Caballo Releases
Run 14 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

Run 14 - All Hueco Pumping Off
Monthly Rio Grande at El Paso Flow
Run 14 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

Run 14 - All Hueco Pumping Off
Monthly Rio Grande at Fort Quitman Flow
Run 14 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)



Appendix 30O

Comparison of ILRG Model Runs

Run 14a v. Run 1

Model Run Specifications

Model Version: LRG_v116

Name: **Run 14a - TX Hueco Pumping Off**

Run ID: LRG_v116_Operational_Run14a
Date: 8/28/2020

Name: **Run 1 - Historical Base Run (All Pumping On)**

Run ID: LRG_v116_Operational_Run1
Date: 8/23/2020

Selected Model Inputs

Pumping and Returns	**Run 14a**	**Run 1**
Irrigation Pumping	TX Hueco Off	On
Irrigated Area	Hist	Hist
Non-Irrigation Pumping	TX Hueco Off	On
Non-Irrigation Pumping Returns	TX Hueco Off	On
Las Cruces Jornada Pumping Returns	On	On

Project Allocation Rules		
1950-2005	D1/D2	D1/D2
2006-2007	D3	D3
2008-2017	D3 + CO	D3 + CO

EPCWID Operations		
Charge EPCWID for Use of WWTP Returns	Off	Off
ACE and Haskell Credits for EPCWID	On	On
Increased EPCWID Use of Fabens Drain Flows	Off	Off
Charge EPCWID for Fabens Drain Flow Use	Off	Off

Run 14a - TX Hueco Pumping Off

Comparison of ILRG Model Runs

Run 14a v. Run 1

1951 - 2017 Annual Average

(1,000 acre-feet)

Run No.	1	14a	14a - 1		
Simulated Input or Output	**Run 1**	**Run 14a**	**Run 14a minus Run 1**		
Pumping Stress					
Irrigation Pumping	44.3	0.0	-44.3		
Non-Irrigation Pumping	181.0	118.3	-62.6		
WWTP Flows	58.0	46.7	-11.4		
Urban Deep Percolation	13.1	7.8	-5.3		
Total Stress	154.2	63.9	-90.3		
	Stress is Pumping minus WWTP and Urban Deep Perc				
Effects of Pumping Stress				***% Chg***	
FHG Deliveries (Mar - Oct)				***Stress***	***% Diff.***
EBID	167.6	166.7	-1.0	*1%*	*-1%*
EPCWID (incl. EPW)	139.9	139.2	-0.7	*1%*	*0%*
HCCRD	32.8	34.4	1.6	*-2%*	*5%*
Total	340.3	340.3	0.0	*0%*	*0%*
FHG Deliveries (Nov - Feb)					
EBID	0.0	0.0	0.0	*0%*	*3%*
EPCWID (incl. EPW)	0.2	0.1	-0.1	*0%*	*-43%*
HCCRD	2.4	2.4	0.0	*0%*	*-1%*
Total	2.6	2.5	-0.1	*0%*	*-4%*
Irrigation Pumping					
EBID	140.4	141.4	0.9	*-1%*	*1%*
EPCWID (Mesilla Valley)	7.4	7.4	0.0	*0%*	*1%*
EPCWID (El Paso Valley)	40.1	0.0	-40.1		
HCCRD	4.2	0.0	-4.2		
Total	147.8	148.8	1.0	*-1%*	*1%*
	Pumping turned off.	*Other values are simulated responses and are totaled.*			
Other Inflows/Outflows					
Net Reservoir Evaporation	125.3	124.3	-1.1	*1%*	*-1%*
Riparian ET	70.9	75.6	4.7	*-5%*	*7%*
River Evaporation + Incidental Canal Loss	30.3	29.8	-0.6	*1%*	*-2%*
Total	226.6	229.7	3.1	*-3%*	*1%*
Rio Grande at Fort Quitman					
Reservoir Spills	33.3	31.2	-2.1	*2%*	*-6%*
Nov-Feb Flows	21.4	25.3	3.9	*-4%*	*18%*
Mar - Oct Flows	41.1	51.2	10.2	*-11%*	*25%*
Underflow (GW Model)	0.2	0.3	0.0	*0%*	*22%*
Total	96.0	108.0	12.0	*-13%*	*13%*

Run 14a - TX Hueco Pumping Off
Comparison of ILRG Model Runs
Run 14a v. Run 1
1951 - 2017 Annual Average
(1,000 acre-feet)

Run No.	1	14a	14a - 1		
Simulated Input or Output	**Run 1**	**Run 14a**	**Run 14a minus Run 1**		
Effects of Pumping Stress (continued)				***% Chg***	
Change in Storage				***Stress***	***% Diff.***
Reservoir Storage	-4.7	-4.6	0.1	*0%*	*-2%*
Alluvial GW Storage (RW Model)	-23.6	-17.4	6.2	*-7%*	*-26%*
Non-alluvial GW Storage (GW Models)	-96.4	-51.4	45.0	*-50%*	*-47%*
Soil Moisture Storage	0.6	0.6	0.0	*0%*	*5%*
Total	-124.0	-72.7	51.3	*-57%*	*-41%*
Summary of Effects					
FHG Deliveries (Mar-Oct)	340.3	340.3	0.0	*0%*	*0%*
FHG Deliveries (Nov-Feb)	2.6	2.5	-0.1	*0%*	*-4%*
Irrigation Pumping	147.8	148.8	1.0	*-1%*	*1%*
Riparian ET + Evaporation	226.6	229.7	3.1	*-3%*	*1%*
Fort Quitman Flow	96.0	108.0	12.0	*-13%*	*13%*
Change in Storage	-124.0	-72.7	51.3	*-57%*	*-41%*
Total	689.2	756.5	67.2	*-74%*	*10%*
Other Effects of Pumping Stress				***% Chg***	
Rio Grande at El Paso				***Stress***	***% Diff.***
Reservoir Spills	49.4	44.0	-5.4	*6%*	*-11%*
Nov-Feb Flows	22.8	23.2	0.4	*0%*	*2%*
Mar - Oct Flows	263.8	270.5	6.8	*-8%*	*3%*
Total	336.0	337.8	1.8	*-2%*	*1%*
Rio Grande below Caballo					
Reservoir Spills	65.9	57.6	-8.2	*9%*	*-13%*
Nov-Feb Flows	0.5	0.3	-0.2	*0%*	*-40%*
Mar - Oct Flows	541.3	550.7	9.5	*-10%*	*2%*
Total	607.6	608.6	1.0	*-1%*	*0%*
Surface Water Diversions (Mar - Oct)					
EBID	366.5	364.2	-2.3	*3%*	*-1%*
EPCWID (incl. EPW)	236.8	238.7	1.9	*-2%*	*1%*
HCCRD	67.5	72.1	4.5	*-5%*	*7%*
Total	670.8	674.9	4.1	*-5%*	*1%*
Surface Water Diversions (Nov - Feb)					
EBID	0.0	0.0	0.0	*0%*	*0%*
EPCWID (incl. EPW)	14.3	12.3	-2.0	*2%*	*-14%*
HCCRD	14.2	14.7	0.5	*-1%*	*4%*
Total	28.5	27.0	-1.5	*2%*	*-5%*

Run 14a - TX Hueco Pumping Off
Annual Differences in ILRG Model Outputs
Run 14a minus Run 1
1940 - 2017 (acre-feet)

	Net River Headgate Diversions						Farm Headgate Deliveries						Annual Flows		
	EBID		EPCWID (incl. EPW)		HCCRD		EBID		EPCWID (incl. EPW)		HCCRD				
Year	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Caballo Releases	Rio Grande at El Paso	Rio Grande at Fort Quitman
1940	19	19	-619	69	-150	554	-12	-12	377	377	-96	-96	-3,476	-3,370	6,846
1941	47	47	-111	-1,251	218	51	3	4	-2	-200	200	111	3,180	2,886	3,425
1942	-27	-27	-46	-2,051	-175	-176	9	9	465	-155	-197	-220	1,879	1,870	-273
1943	-23	-23	-156	-1,660	-157	-296	24	24	437	192	-101	-403	4,312	4,210	2,309
1944	-24	-24	-480	-1,862	135	-166	-1	0	-234	-446	83	-149	1,829	1,798	2,079
1945	-22	-22	-255	-2,172	218	-416	8	9	-297	-697	193	216	3,058	2,899	2,467
1946	-11	-11	52	-2,535	318	-537	12	12	-48	-862	256	178	3,080	3,024	2,565
1947	-14	-14	476	-1,559	172	-477	4	4	646	54	119	150	2,030	2,011	2,735
1948	2	2	-973	-2,409	568	281	-9	-9	309	1	439	216	-628	-575	4,441
1949	17	17	-2,379	-4,232	1,613	1,557	-2	-3	-378	-403	-149	-300	-571	-606	6,930
1950	8	8	-3,573	-4,509	1,761	1,906	-17	-17	-319	-320	-34	-61	-1,347	-1,337	5,938
1951	-4,399	-4,399	-4,345	-4,807	1,617	2,211	-2,556	-2,557	-324	-326	1,705	1,236	-3,724	-1,800	15,966
1952	-53	-53	-6,283	-6,771	1,700	2,515	37	37	-699	-700	1,528	815	-2,568	-3,106	16,365
1953	13	13	-7,414	-7,903	3,098	4,461	23	23	-298	-299	3,475	3,906	-5,945	-5,478	27,904
1954	3,639	3,639	2,124	267	4,544	6,290	2,144	2,144	4,478	4,478	4,628	6,422	9,508	6,495	18,799
1955	-2,299	-2,299	-1,483	-4,234	8,415	11,136	-1,739	-1,739	1,487	1,468	7,414	9,988	2,979	1,161	11,757
1956	-3,769	-3,769	-5,909	-8,745	6,832	8,807	-2,121	-2,121	1,838	1,468	6,344	7,798	-5,727	-1,690	5,919
1957	54	54	-7,953	-10,992	556	3,539	6	6	1,750	1,462	1,368	2,925	-5,000	-4,484	4,289
1958	1	1	-20,720	-22,492	6,060	10,851	-85	-85	-1,963	-1,933	-1,581	-271	-18,188	-17,795	30,017
1959	5	5	-12,845	-13,769	4,918	7,668	-44	-44	-888	-888	403	682	-10,427	-10,699	34,197
1960	3	3	-10,878	-12,032	3,649	5,007	-28	-28	-1,417	-1,417	0	0	-5,142	-5,563	28,201
1961	2	2	-10,075	-11,187	3,952	5,174	-19	-19	-41	-41	1,465	-545	-2,998	-3,253	30,477
1962	6	6	-9,071	-10,240	3,512	4,742	-2	-2	-838	-838	756	1,152	-2,201	-2,295	28,653
1963	8,875	8,875	-8,043	-9,123	3,610	4,559	4,821	4,821	-1,025	-1,024	2,230	2,071	7,111	3,309	30,373
1964	12,453	12,453	9,210	6,209	5,805	7,277	6,593	6,593	6,651	6,485	5,199	6,565	26,434	16,573	21,351
1965	-4,655	-4,655	-16,350	-18,842	5,165	8,666	-1,577	-1,577	-98	-397	5,949	8,423	-14,991	-6,890	16,949
1966	-8	-8	-10,221	-11,335	6,521	9,497	14	14	-210	-210	-3,939	-6,472	-3,925	-2,191	28,891
1967	7,856	7,856	5,287	3,033	7,605	11,931	4,964	4,964	7,803	7,285	6,523	9,888	12,256	8,025	16,466
1968	-1,210	-1,210	-5,982	-7,548	9,850	14,407	-752	-752	577	177	8,539	8,609	-1,606	1,682	18,616
1969	-8	-8	-6,334	-7,460	12,172	15,084	17	17	-92	-92	3,047	-1,388	-1,505	-845	31,704
1970	-2	-2	-3,951	-5,243	5,132	6,482	18	18	-231	-231	-1,274	-2,725	783	1,051	27,033
1971	696	696	-3,883	-6,224	6,269	7,884	462	462	-775	-775	5,620	7,140	2,506	2,146	20,573
1972	-718	-718	-735	-3,467	8,660	9,962	-566	-566	-1,246	-1,279	7,223	7,285	3,217	3,174	17,992
1973	-4	-4	-2,124	-4,335	17,167	20,154	115	115	157	38	16,715	15,050	2,725	2,761	11,060
1974	-3	-3	-15	-1,330	15,605	19,467	38	38	543	544	-2,741	-4,365	5,865	5,573	40,330
1975	16	16	2,400	1,125	15,104	18,781	-217	-217	-83	-83	10,360	7,050	6,573	6,531	20,479
1976	-9	-9	6,434	5,138	12,322	16,318	170	170	-78	-78	-1,658	-5,692	11,014	10,712	30,609
1977	-16,520	-16,520	4,463	2,189	8,103	10,991	-10,539	-10,539	-840	-841	7,927	8,758	4,876	9,876	15,253
1978	-17,735	-17,735	-13,347	-18,006	5,522	7,523	-8,096	-8,096	-12,428	-12,430	5,638	6,584	-19,421	-8,786	12,153

Run 14a - TX Hueco Pumping Off

Annual Differences in ILRG Model Outputs

Run 14a minus Run 1

1940 - 2017 (acre-feet)

	Net River Headgate Diversions						Farm Headgate Deliveries						Annual Flows		
	EBID		EPCWID (incl. EPW)		HCCRD		EBID		EPCWID (incl. EPW)		HCCRD				
Year	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Caballo Releases	Rio Grande at El Paso	Rio Grande at Fort Quitman
1979	-172	-172	1,609	-1,724	4,557	6,984	-893	-893	-3,309	-3,311	4,586	6,442	16,787	8,542	18,419
1980	32	32	8,675	7,073	6,699	7,677	-94	-94	-12	-14	-1,274	-3,285	16,863	14,242	44,827
1981	10	10	11,950	10,657	5,314	4,545	-165	-165	-14	-15	-56	-223	19,243	17,936	30,951
1982	-6	-6	11,006	9,592	4,986	4,118	16	16	-15	-15	-1,259	-2,736	19,678	19,104	40,847
1983	-8	-8	13,657	12,110	8,229	7,460	37	37	1	1	0	0	20,879	20,259	30,644
1984	44	44	15,052	13,595	10,641	9,392	-199	-198	-12	-12	0	0	17,898	17,642	21,414
1985	1,541	1,541	23,813	23,160	-8,361	-9,945	8,036	8,036	4,863	4,777	0	0	-10,454	-12,057	640
1986	-240	-240	22,259	22,065	7,145	4,626	-515	-522	-419	-425	0	0	-70,987	-68,061	24,683
1987	-92	-92	25,163	24,979	7,559	4,879	-76	-76	19	19	0	0	141	1,265	4,404
1988	-13	-13	26,729	26,545	8,044	5,028	87	87	5	5	0	0	23,859	20,908	3,604
1989	-19	-19	28,377	27,910	9,135	6,425	145	145	353	-26	0	0	40,668	38,459	17,628
1990	-11	-11	25,481	24,326	9,651	6,961	122	122	313	-202	0	0	20,841	21,808	8,571
1991	-152	-152	12,463	11,771	4,117	2,443	-687	-686	34	-762	0	0	16,595	16,374	14,136
1992	-280	-280	8,712	8,270	2,028	1,102	1,544	1,546	4	-340	0	0	-16,091	-16,312	-8,850
1993	-43	-43	-458	-657	966	-678	6	6	-787	-790	0	0	-52,277	-50,568	-48,159
1994	39	39	-213	-409	1,686	172	-64	-65	821	819	0	0	-7,107	-7,243	-5,299
1995	181	181	-732	-972	1,085	-804	11	10	1,488	1,428	0	0	-932	-996	-1,375
1996	18	18	351	176	1,338	-315	-221	-221	-22	-22	0	0	6,868	5,848	1,050
1997	134	134	-4,051	-6,756	3,344	865	-199	-198	-1,709	-2,732	0	0	7,214	6,432	10,770
1998	7	7	3,807	3,072	2,536	412	25	25	540	541	0	0	12,137	11,613	16,405
1999	-1,233	-1,233	-4,439	-7,456	1,169	856	8,464	8,469	5,961	5,972	0	0	0	-7,739	-17,225
2000	-164	-164	4,110	607	1,160	1,054	529	530	-4,883	-4,877	0	0	3,019	9,329	-3,433
2001	-53	-53	8,387	4,389	1,512	1,104	57	57	-101	-100	0	0	8,007	8,521	-6,480
2002	-7	-7	2,234	-417	-756	-1,200	54	54	167	167	0	0	200	1,020	-10,683
2003	-19,382	-19,382	17,140	14,716	2,449	1,332	-11,491	-11,491	-1,656	-1,661	0	0	14,195	19,198	521
2004	-21,145	-21,145	-18,246	-21,590	-3,265	-4,200	-11,462	-11,462	-15,646	-15,653	0	0	-21,496	-12,906	-4,397
2005	-1,488	-1,488	1,143	-2,518	-964	-1,534	-919	-906	-3,166	-3,165	0	0	9,422	-113	-5,572
2006	-7,339	-7,339	-11,517	-14,375	-3,046	-3,486	-4,588	-4,588	-11,417	-11,418	0	0	-23,410	-16,738	-8,296
2007	-2,794	-2,794	2,766	-677	-680	-1,142	-1,468	-1,468	835	833	0	0	1,928	-128	-4,001
2008	-275	-275	1,095	-2,106	-328	-1,149	-249	-249	-613	-614	0	0	1,141	51	-4,034
2009	283	283	3,945	68	-504	-1,172	-28	-28	-319	-320	0	0	4,880	3,918	-2,003
2010	-8,451	-8,451	3,769	-946	598	344	-5,467	-5,467	-321	-323	0	0	2,522	3,953	-1,287
2011	-8,497	-8,497	-519	-4,590	4,024	5,669	-5,043	-5,043	-864	-866	0	0	-6,584	-952	4,630
2012	5,518	5,518	8,250	4,538	5,967	5,945	2,696	2,696	-1,960	-1,960	0	0	18,230	12,479	8,849
2013	-34,776	-34,776	-5,695	-8,826	2,428	2,624	-16,973	-16,973	-11,396	-11,397	2,917	3,172	-33,420	2,513	2,853
2014	-25,093	-25,093	21,899	18,146	9,347	10,537	-11,985	-11,985	8,459	8,458	3,510	3,955	15,091	29,173	12,847
2015	7,474	7,474	-6,019	-9,613	1,212	1,492	4,669	4,669	-9,510	-9,512	-4,130	-3,398	4,130	-3,574	14,063
2016	-11,431	-11,431	-672	-4,699	-1,018	-1,365	-5,243	-5,243	-3,137	-3,139	0	0	-3,894	766	-6,180
2017	-7,953	-7,953	2,928	-486	587	470	-3,769	-3,769	-473	-474	0	0	1,569	3,125	-2,588
Averages															
1951-2017	-2,293	-2,293	1,883	-137	4,538	5,058	-959	-958	-689	-770	1,599	1,564	1,042	1,810	12,019
1951-1978	-635	-635	-4,930	-6,719	6,909	9,335	-319	-319	61	-17	3,674	3,603	-269	150	21,871
1979-2005	-1,574	-1,574	9,036	7,501	3,408	2,176	-291	-290	-636	-755	74	7	3,525	3,056	6,594
2006-2017	-7,778	-7,778	1,686	-1,964	1,549	1,564	-3,954	-3,954	-2,560	-2,561	191	311	-1,485	2,882	1,238
1985-2017	-4,113	-4,113	6,129	3,868	2,126	1,132	-1,636	-1,636	-1,350	-1,447	70	113	-1,030	587	176
1985-2005	-2,019	-2,019	8,668	7,201	2,456	885	-312	-311	-658	-811	0	0	-770	-725	-431

Notes:

EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).

EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

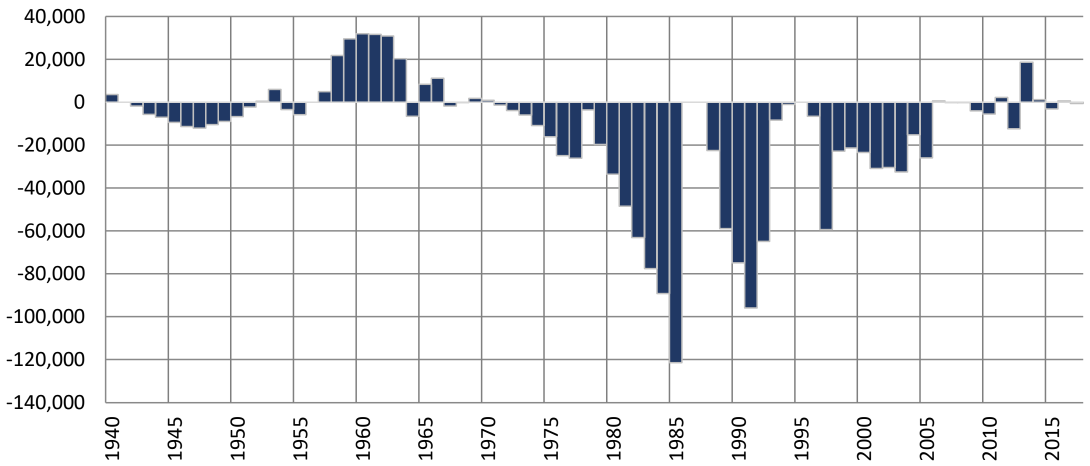
Run 14a - TX Hueco Pumping Off

Simulated Differences in ILRG Model Outputs

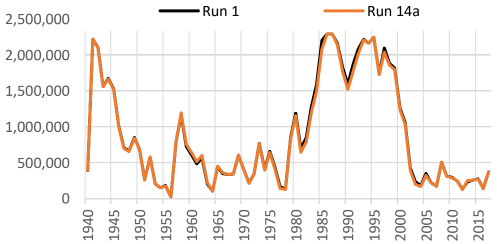
Run 14a minus Run 1

1940 - 2017 (acre-feet)

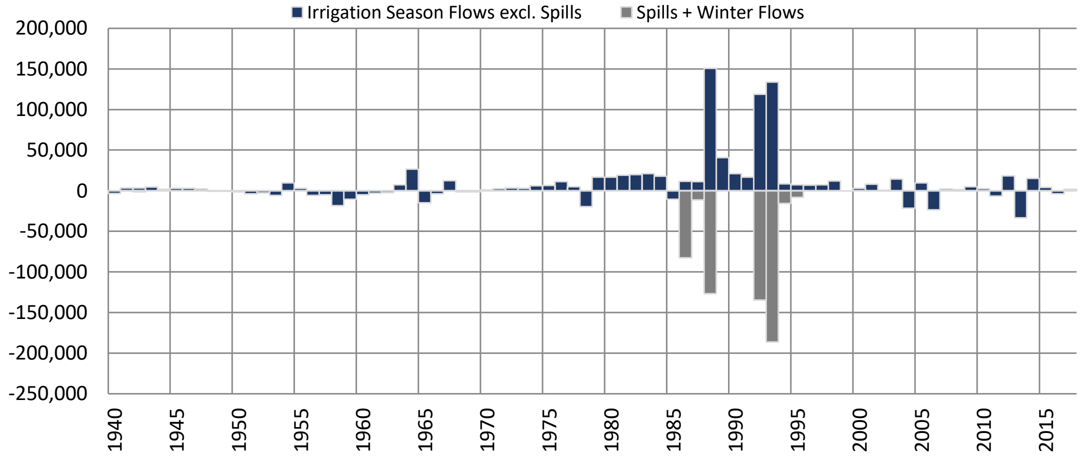
Total Project Storage (Year End)



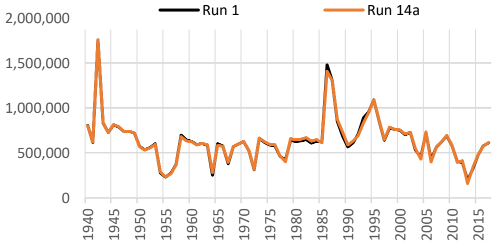
Period	Average Difference
1951-2017	92
1951-1978	112
1979-2005	-828
2006-2017	2,111
1985-2017	2,687
1985-2005	3,017



Caballo Reservoir Outflows (Annual)



	Average Difference		
Period	Irr Season (excl. Spills)	Nov-Feb and Spills	Annual
1951-2017	9,470	-8,428	1,042
1951-1978	-269	0	-269
1979-2005	24,438	-20,914	3,525
2006-2017	-1,485	0	-1,485
1985-2017	16,081	-17,111	-1,030
1985-2005	26,119	-26,889	-770



Notes:

Reservoir storage does not include storage attributed to SJC, CO, or NM credit waters.

Average differences calculated as (Final Storage - Initial Storage)/(no. years).

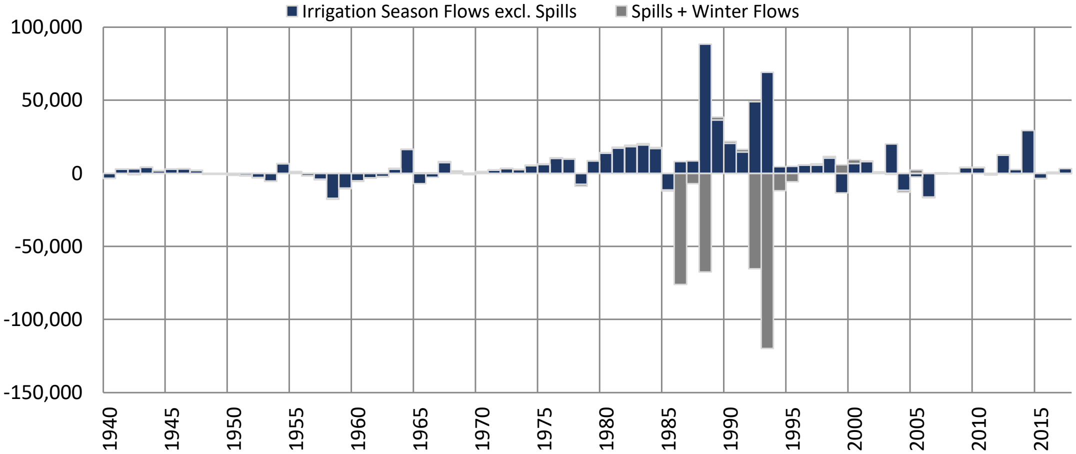
Run 14a - TX Hueco Pumping Off

Simulated Differences in ILRG Model Outputs

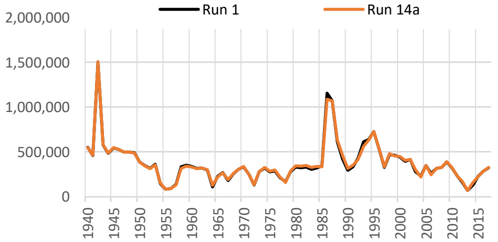
Run 14a minus Run 1

1940 - 2017 (acre-feet)

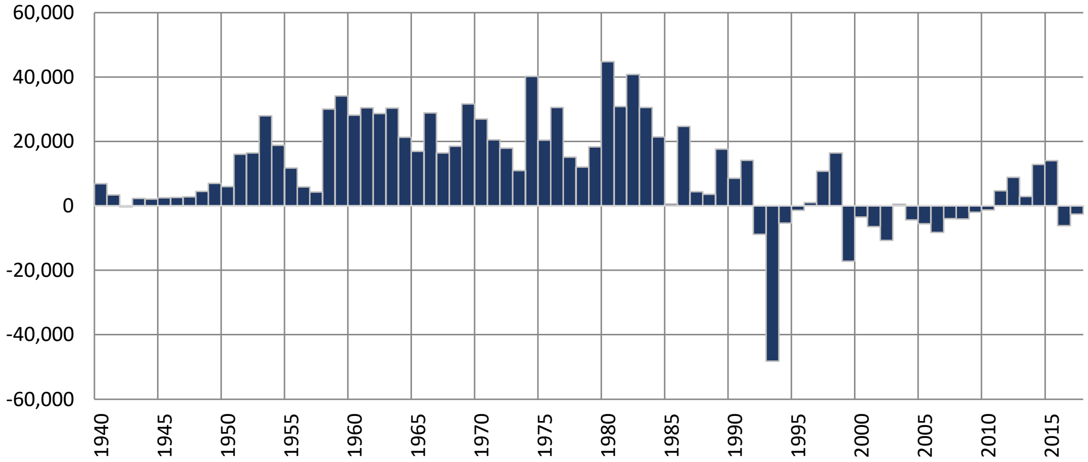
Rio Grande at El Paso (Annual)



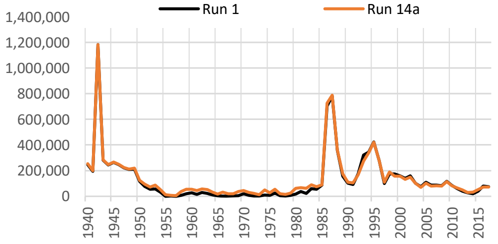
	Average Difference		
Period	Irr Season (excl. Spills)	Nov-Feb and Spills	Annual
1951-2017	6,781	-4,971	1,810
1951-1978	126	24	150
1979-2005	15,374	-12,318	3,056
2006-2017	2,978	-96	2,882
1985-2017	10,818	-10,232	587
1985-2005	15,299	-16,023	-725



Rio Grande at Fort Quitman (Annual)



Period	Average Difference
1951-2017	11,971
1951-1978	21,802
1979-2005	6,551
2006-2017	1,228
1985-2017	154
1985-2005	-460



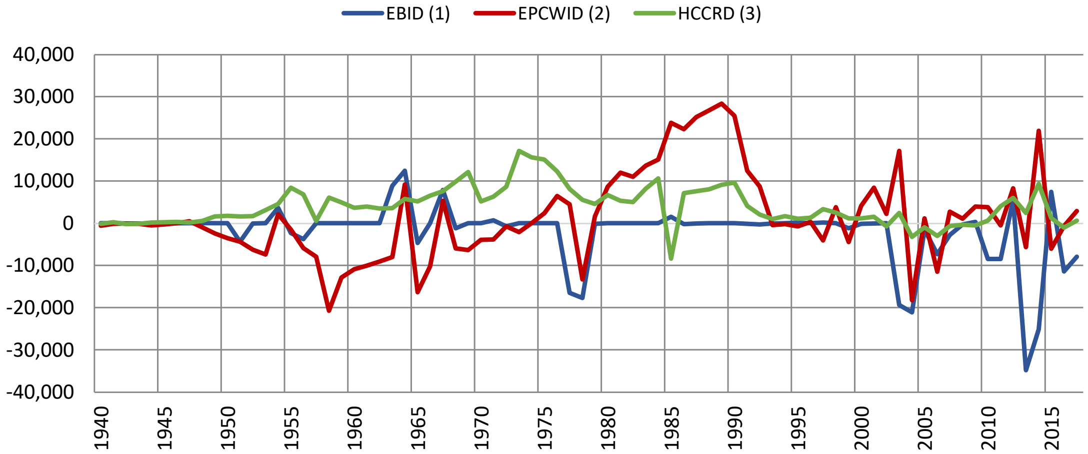
Run 14a - TX Hueco Pumping Off

Simulated Differences in ILRG Model Outputs

Run 14a minus Run 1

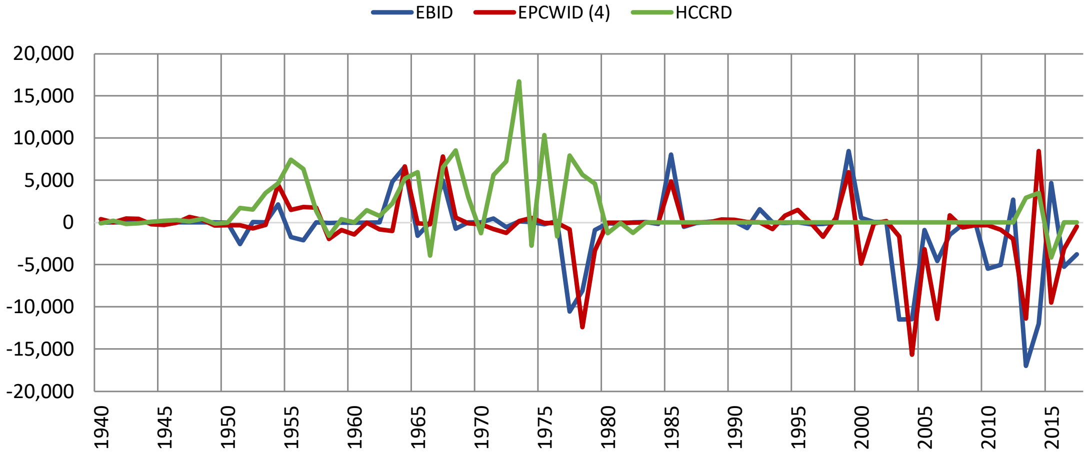
1940 - 2017 (acre-feet)

River Headgate (RHG) Diversions (Irrigation Season)



		Average Difference	
Period	EBID	EPCWID	HCCRD
1951-2017	-2,293	1,883	4,538
1951-1978	-635	-4,930	6,909
1979-2005	-1,574	9,036	3,408
2006-2017	-7,778	1,686	1,549
1985-2017	-4,113	6,129	2,126
1985-2005	-2,019	8,668	2,456

Farm Headgate (FHG) Deliveries (Irrigation Season)



		Average Difference	
Period	EBID	EPCWID	HCCRD
1951-2017	-959	-689	1,599
1951-1978	-319	61	3,674
1979-2005	-291	-636	74
2006-2017	-3,954	-2,560	191
1985-2017	-1,636	-1,350	70
1985-2005	-312	-658	0

Notes:

(1) EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).

(2) EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

(3) HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

(4) EPCWID FHG values include deliveries to Rogers WTP and R/U WTP.

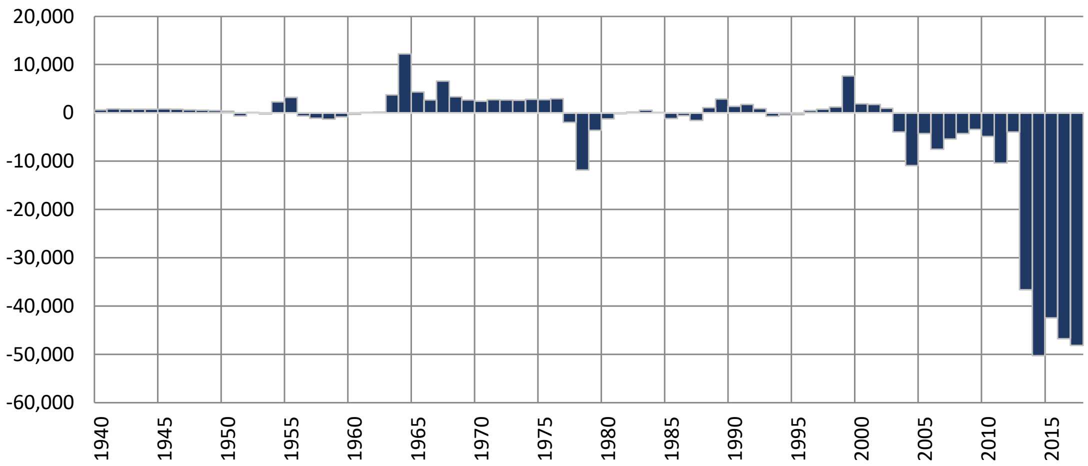
Run 14a - TX Hueco Pumping Off

Simulated Differences in ILRG Model Outputs

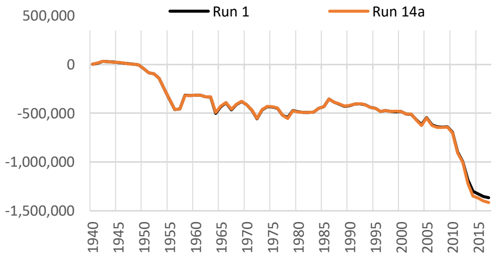
Run 14a minus Run 1

1940 - 2017 (acre-feet)

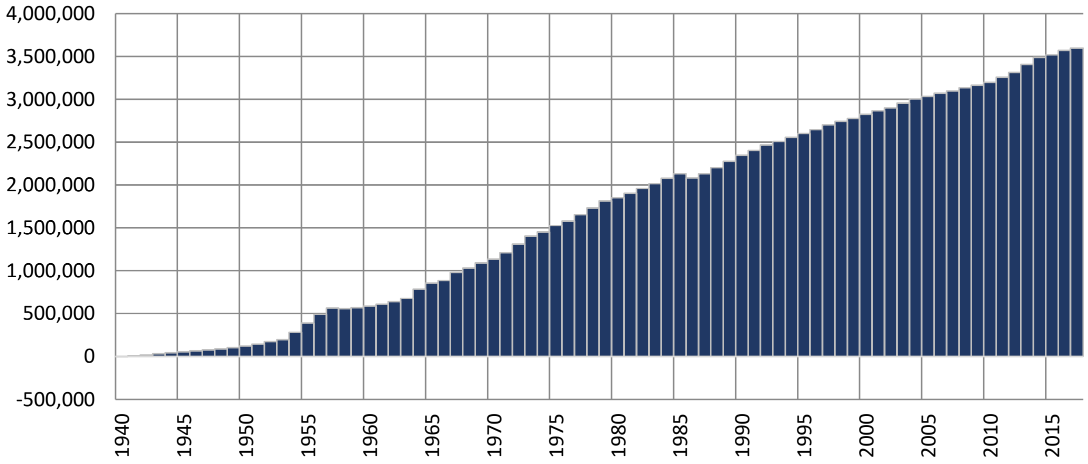
Cumulative Annual Rincon-Mesilla Groundwater Storage



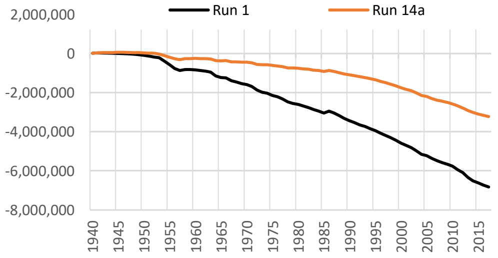
Period	Average Difference
1951-2017	-724
1951-1978	-435
1979-2005	280
2006-2017	-3,654
1985-2017	-1,460
1985-2005	-206



Cumulative Annual Hueco Groundwater Storage



Period	Average Difference
1951-2017	51,892
1951-1978	57,550
1979-2005	48,233
2006-2017	46,924
1985-2017	46,047
1985-2005	45,546

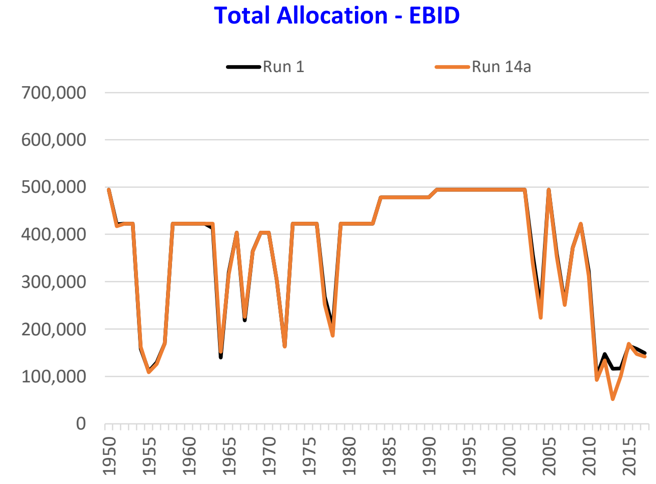


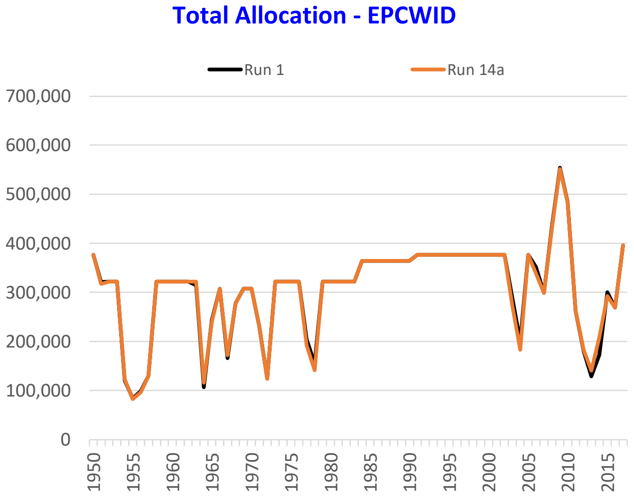
Notes:

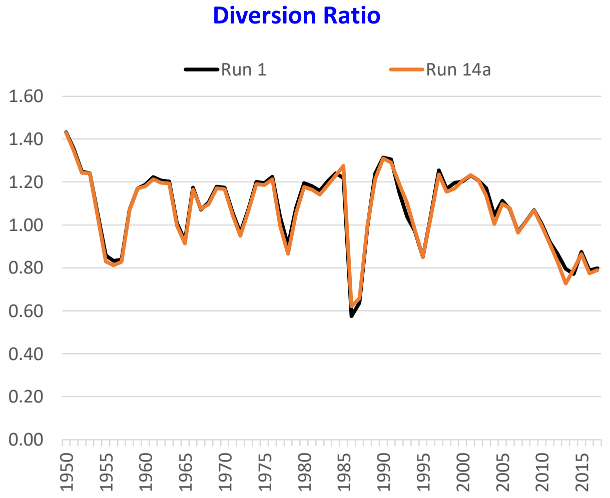
Cumulative storage change in alluvial and non-alluvial aquifers.

Average differences calculated as (Final Storage - Initial Storage)/(no. years).

Run 14a - TX Hueco Pumping Off
Annual Allocation and Charges
Run 14a v. Run 1
ILRG Model
1950 - 2017 (acre-feet)

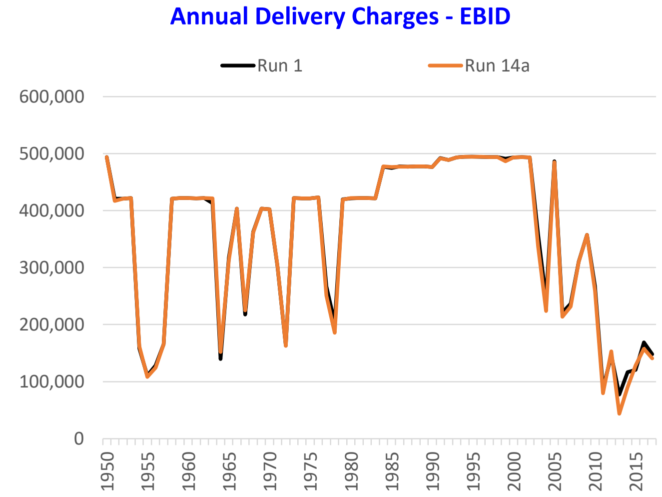


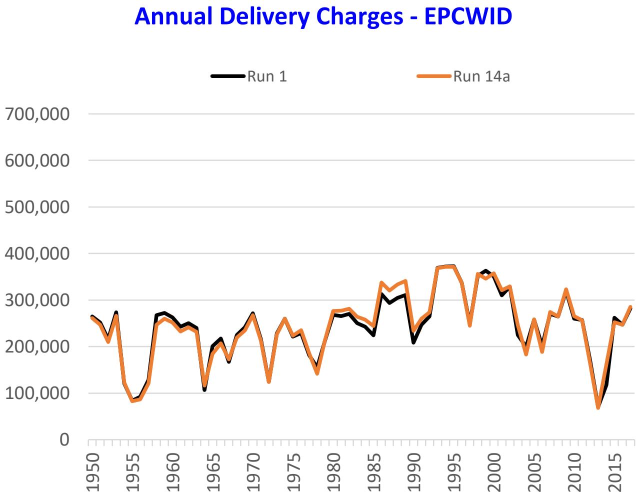




Note:

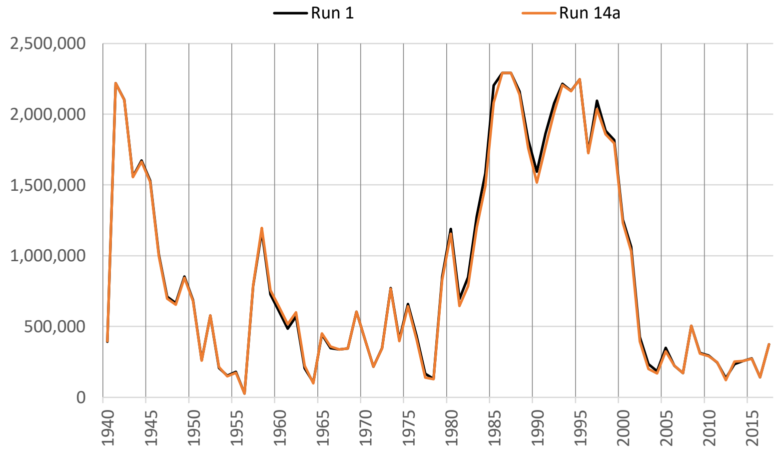
Computed as Total Charges/Caballo Release.



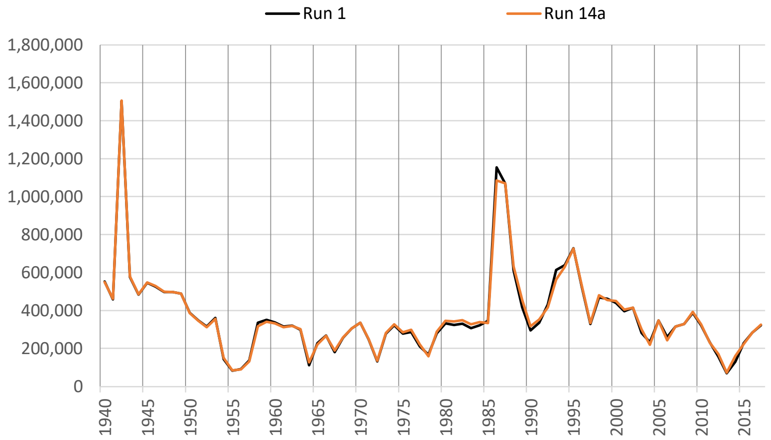


Run 14a - TX Hueco Pumping Off
Annual Summary of Project Storage and Rio Grande Flows
Run 14a v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

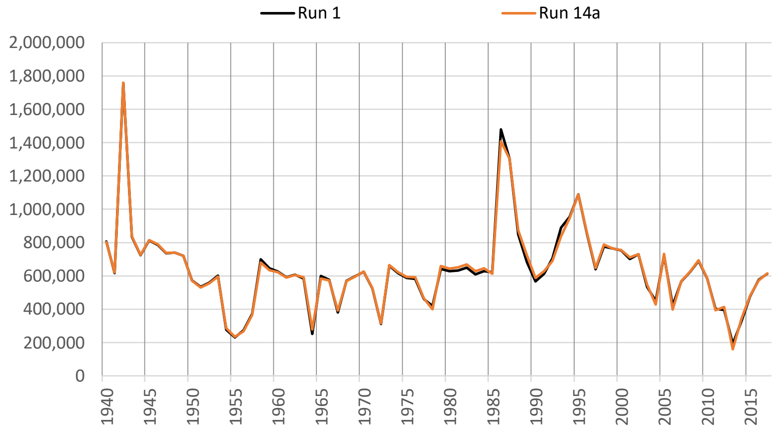
Total Year-End Project Reservoir Storage



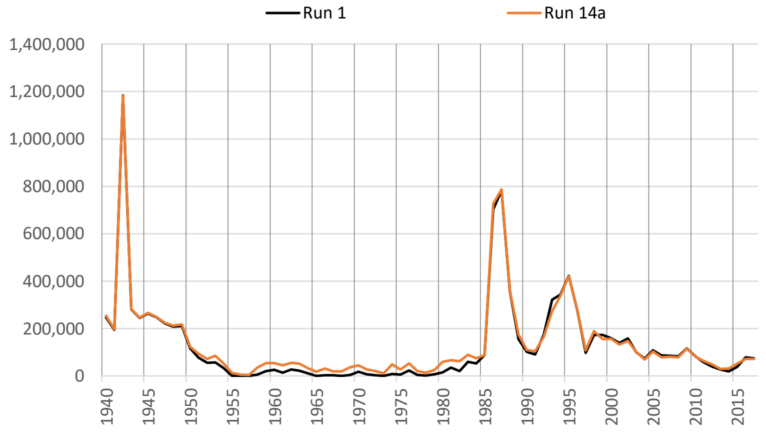
Rio Grande at El Paso



Rio Grande Below Caballo



Rio Grande at Fort Quitman

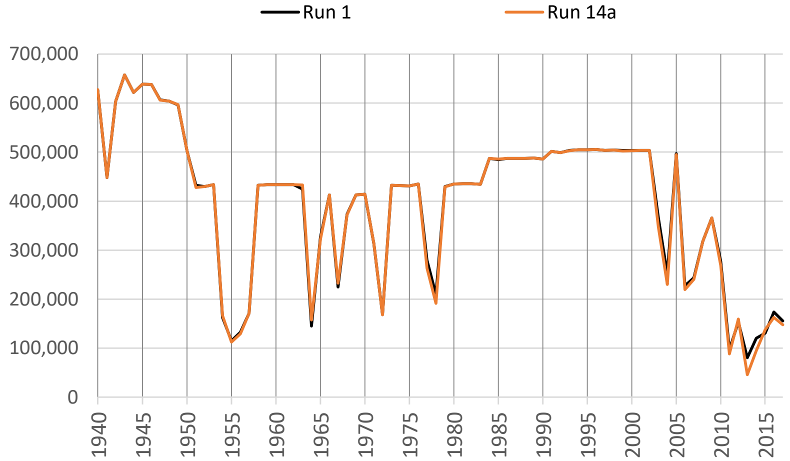


***Note different scales.**

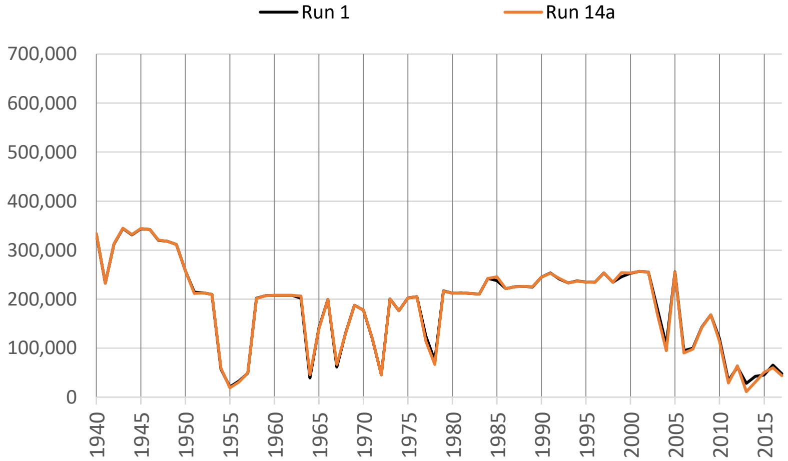
Run 14a - TX Hueco Pumping Off
Irrigation Season Summary of Irrigation Operations
Run 14a v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

EBID Total

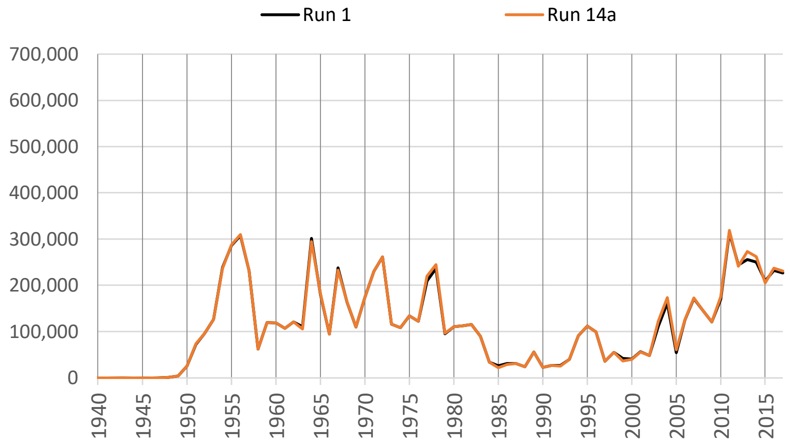
Net River Headgate Diversions



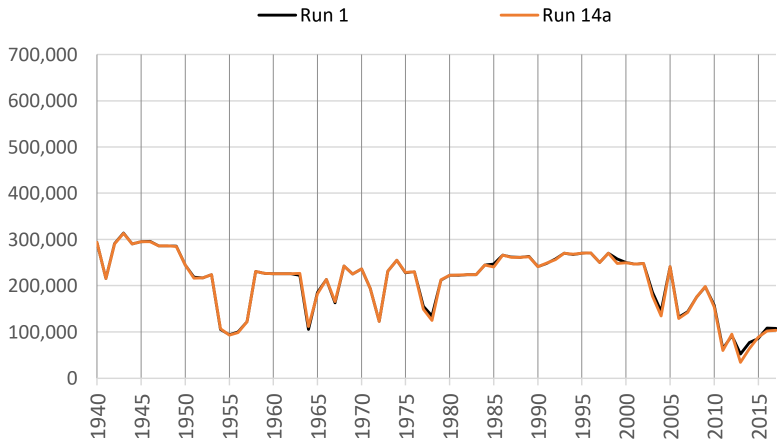
Farm Headgate Deliveries



Pumping



RHG Diversions - FHG Deliveries



Notes: EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).
Pumping includes Supplemental and Primary groundwater pumping.

Run 14a - TX Hueco Pumping Off

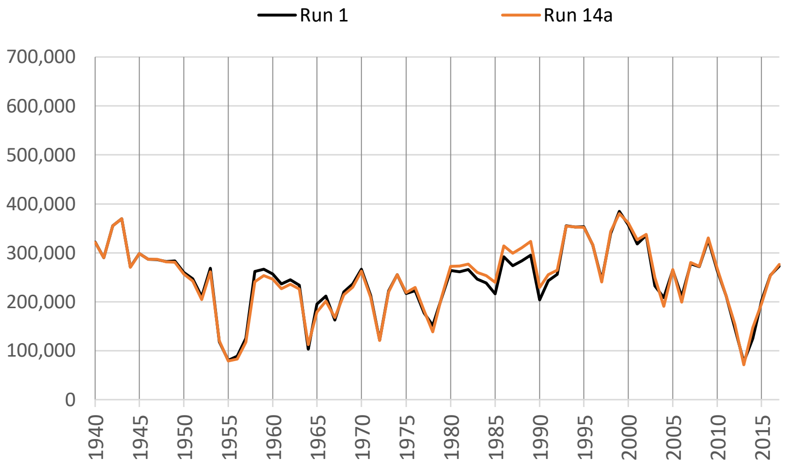
Irrigation Season Summary of Irrigation Operations

Run 14a v. Run 1

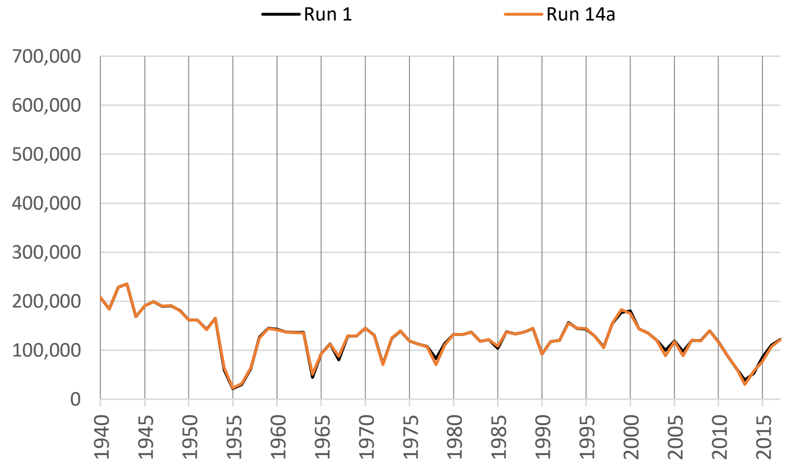
ILRG Model

1940 - 2017 (acre-feet)

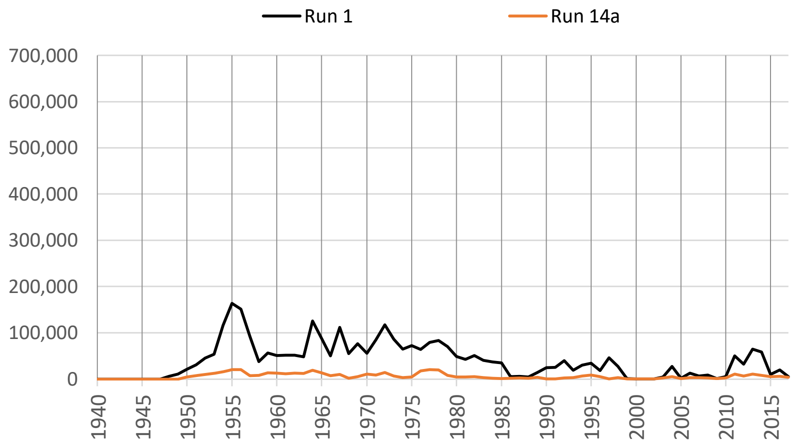
EPCWID Total



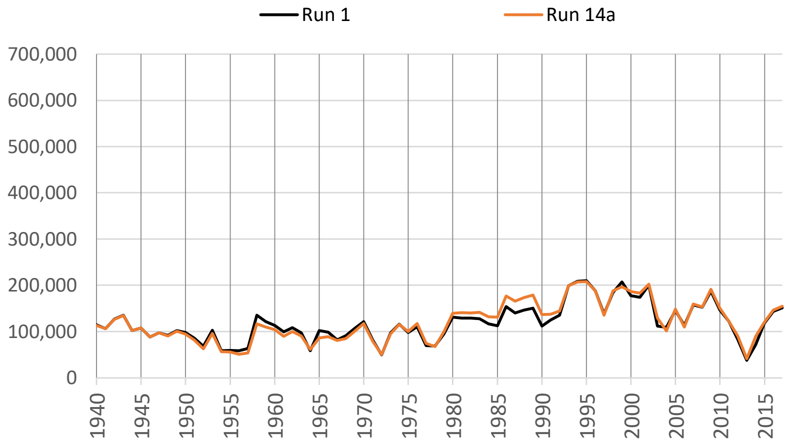
Net River Headgate Diversions



Farm Headgate Deliveries



Pumping



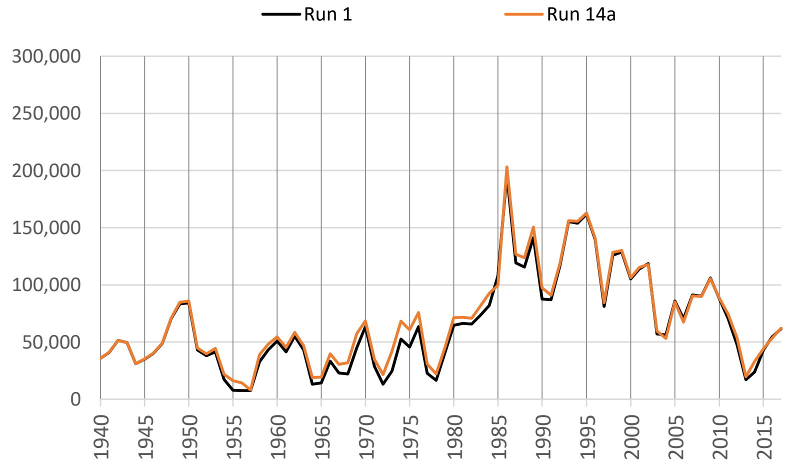
RHG Diversions - FHG Deliveries

Note: EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

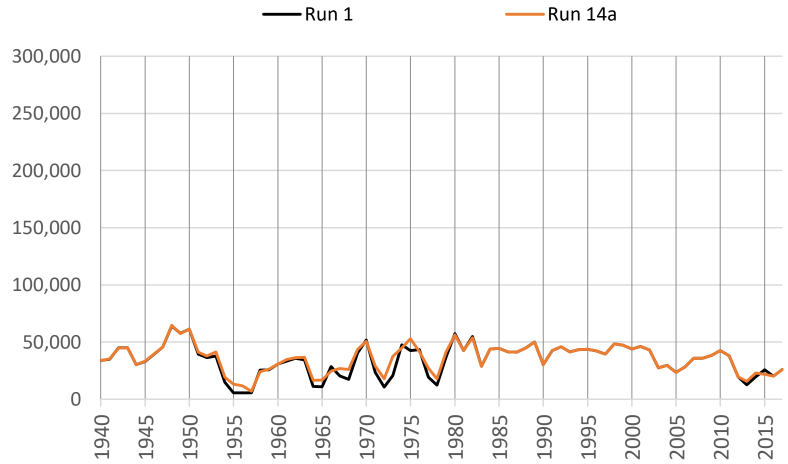
Run 14a - TX Hueco Pumping Off
Irrigation Season Summary of Irrigation Operations
Run 14a v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

HCCRD Total

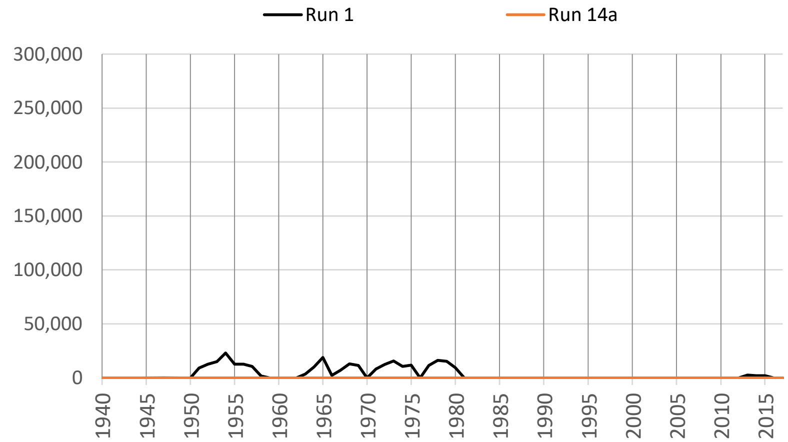
Net River Headgate Diversions



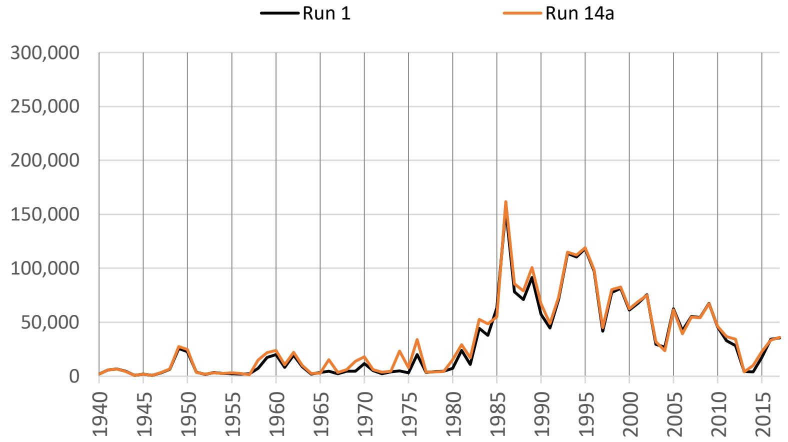
Farm Headgate Deliveries



Pumping



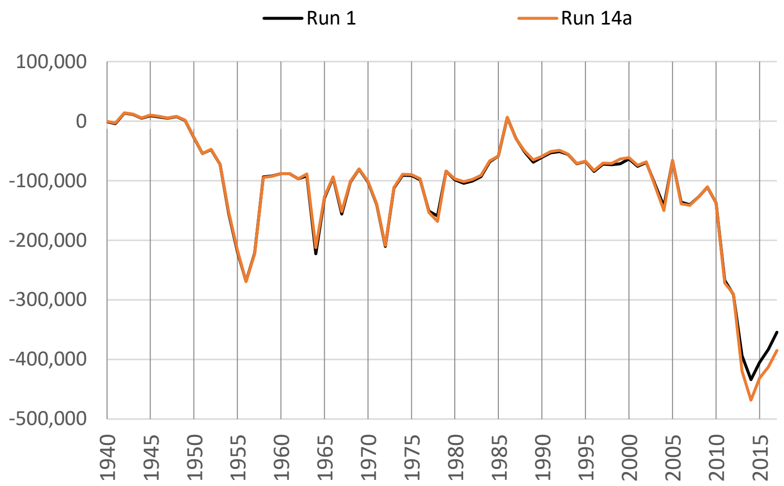
RHG Diversions - FHG Deliveries



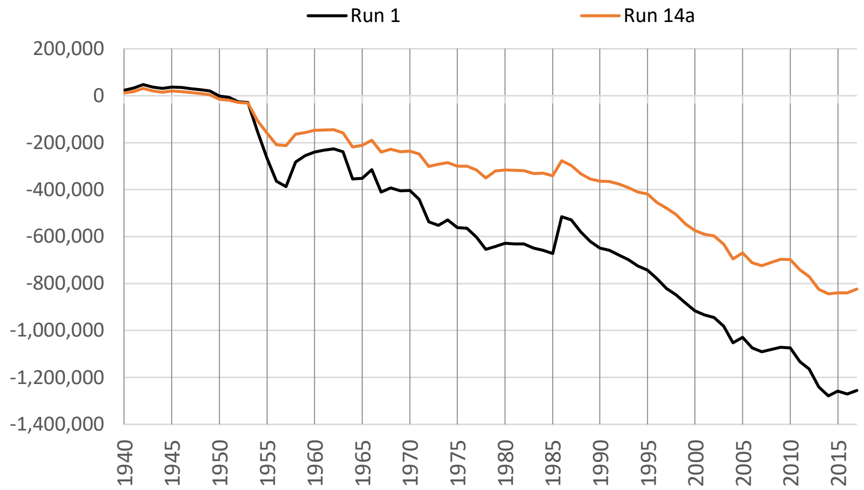
Note: HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

Run 14a - TX Hueco Pumping Off
Cumulative Change in Ground Water Storage
Run 14a v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

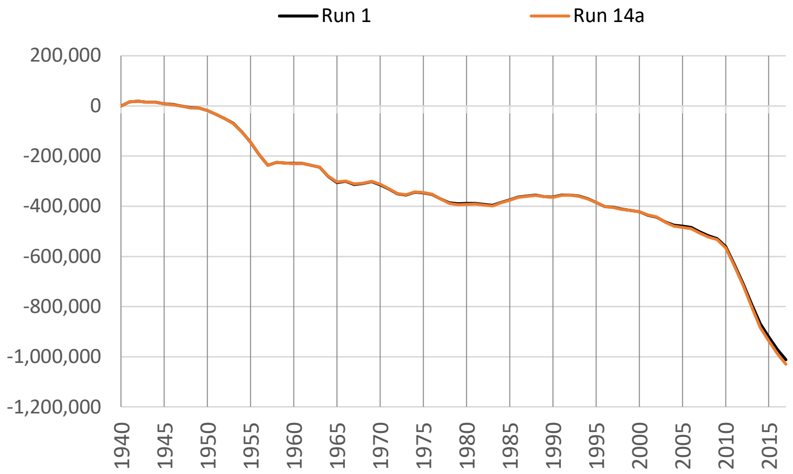
Rincon-Mesilla Alluvial Aquifer



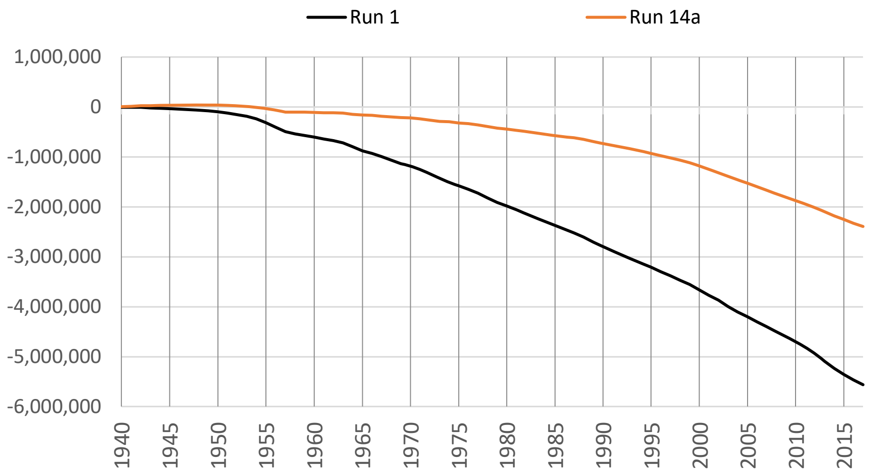
Hueco Alluvial Aquifer



Rincon-Mesilla Non-Alluvial Aquifer

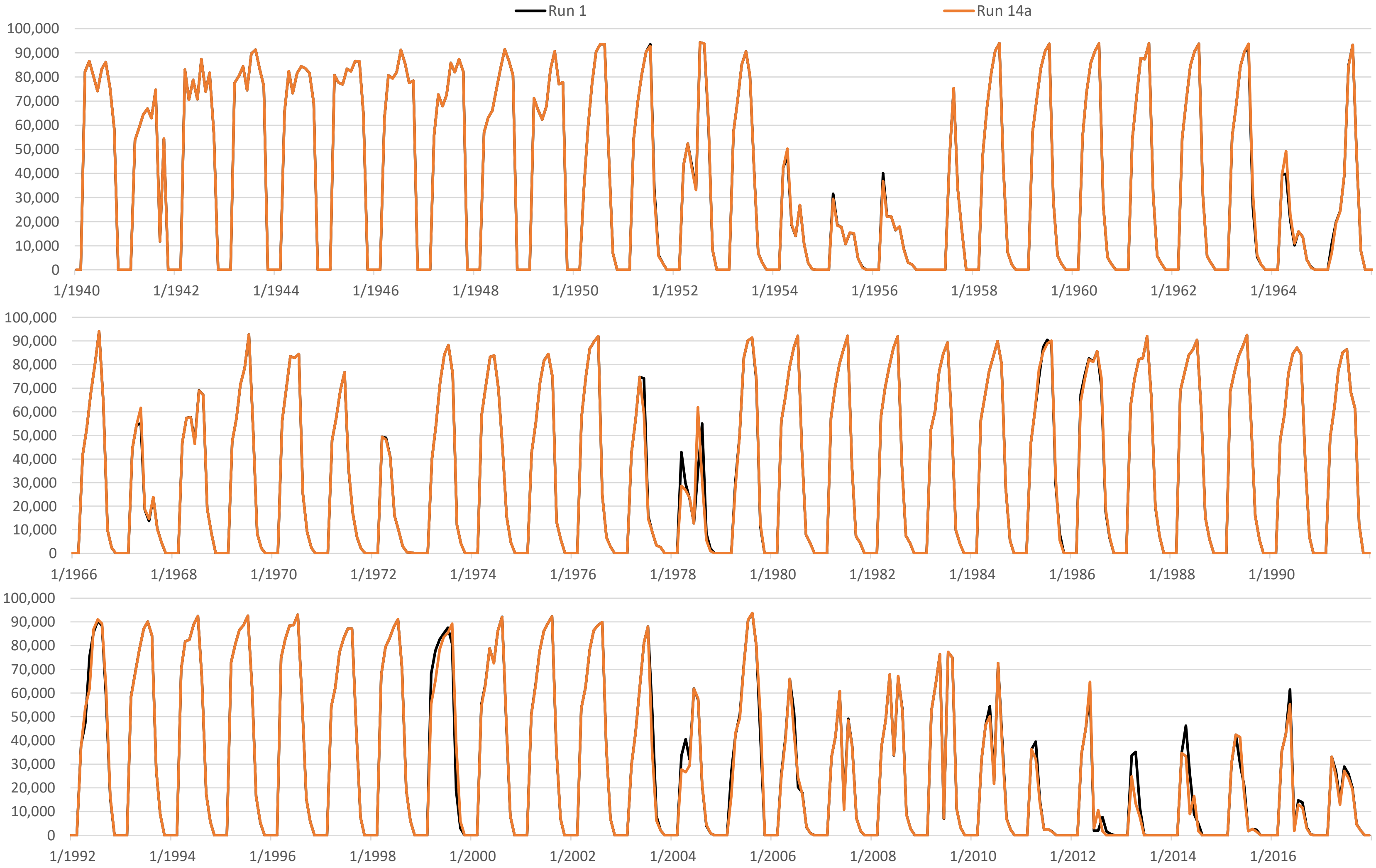


Hueco Non-Alluvial Aquifer



***Note different scales.**

Run 14a - TX Hueco Pumping Off
Monthly Net RHG Diversions
Run 14a v. Run 1
ILRG Model
1940 - 2017 (acre-feet)
EBID Total



Note: EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).

Run 14a - TX Hueco Pumping Off

Monthly Net RHG Diversions

Run 14a v. Run 1

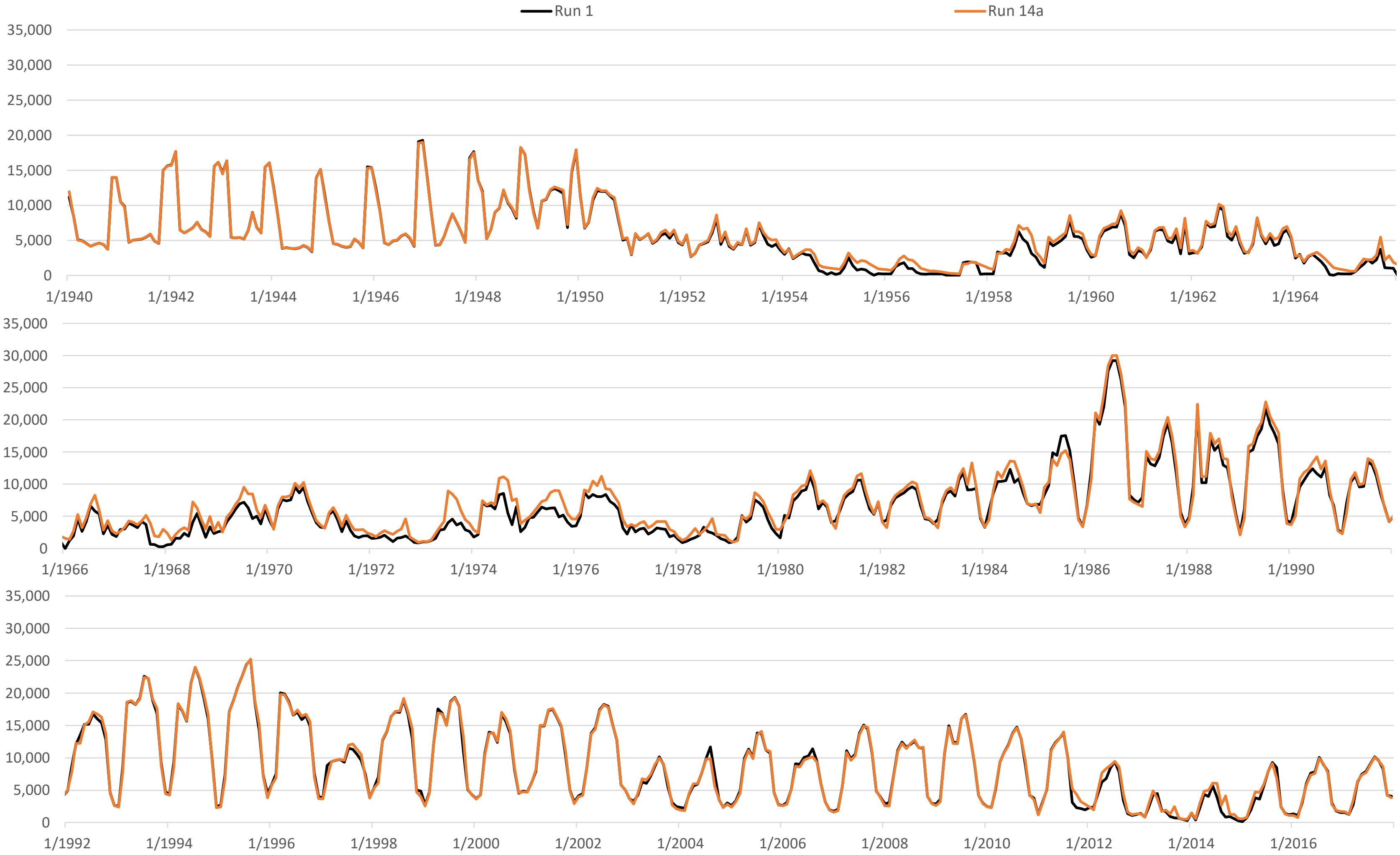
ILRG Model

1940 - 2017 (acre-feet)

EPCWID Total

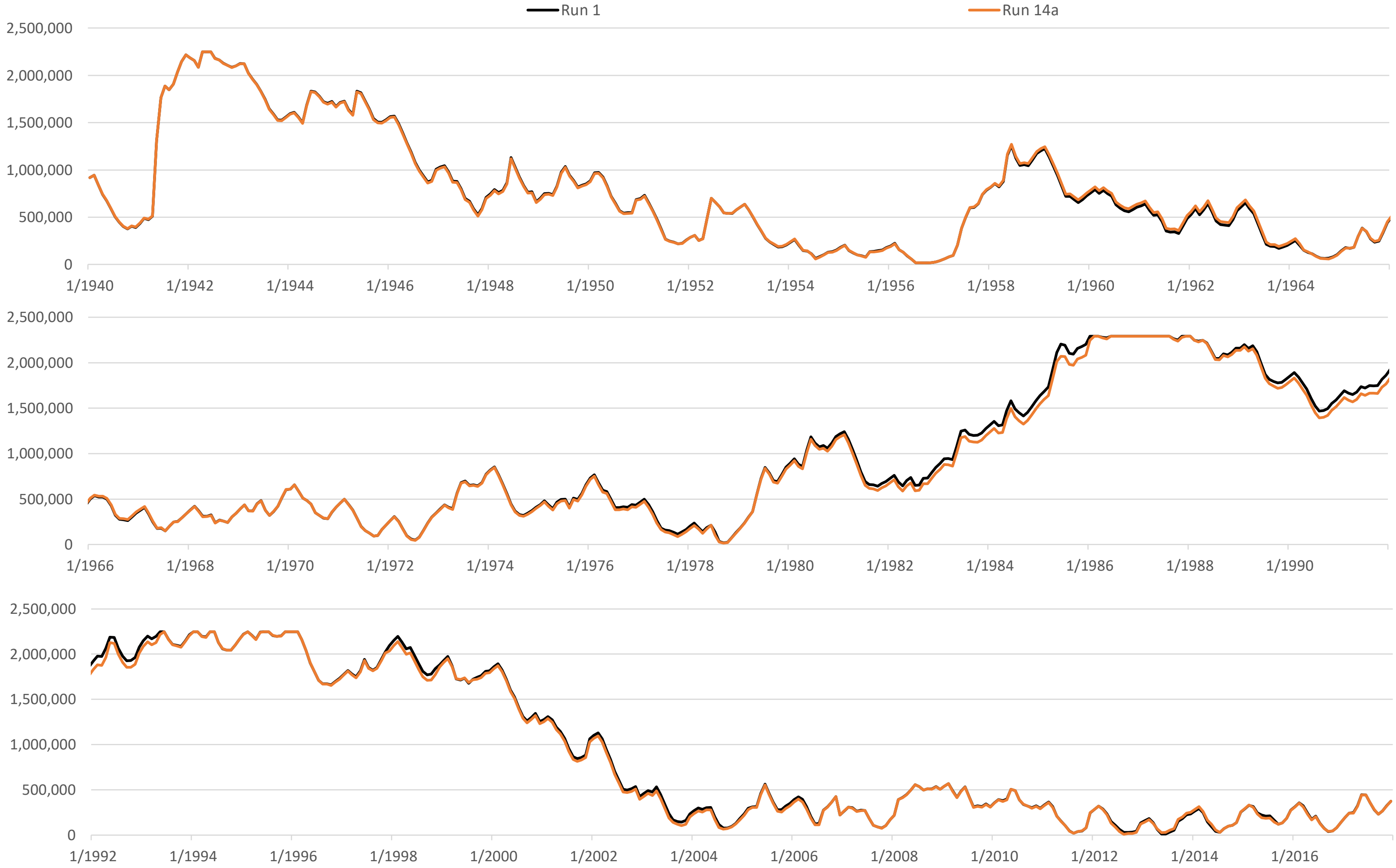
Note: EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

Run 14a - TX Hueco Pumping Off
Monthly Net RHG Diversions
Run 14a v. Run 1
ILRG Model
1940 - 2017 (acre-feet)
HCCRD Total



Note: HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

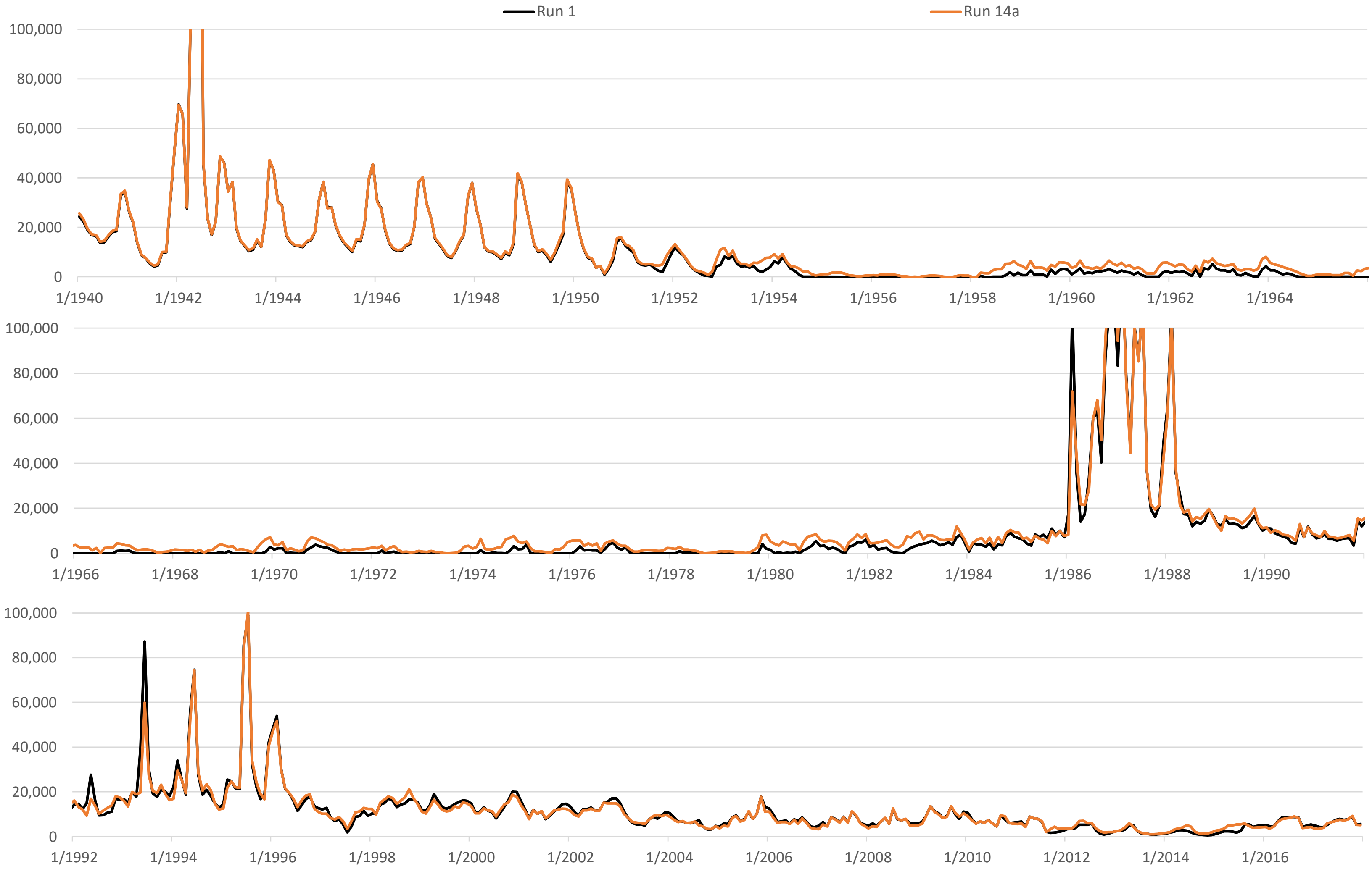
Run 14a - TX Hueco Pumping Off
End of Month Reservoir Storage (Elephant Butte + Caballo)
Run 14a v. Run 1
ILRG Model
1940 - 2017 (acre-feet)



Run 14a - TX Hueco Pumping Off
Monthly Caballo Releases
Run 14a v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

Run 14a - TX Hueco Pumping Off
Monthly Rio Grande at El Paso Flow
Run 14a v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

Run 14a - TX Hueco Pumping Off
Monthly Rio Grande at Fort Quitman Flow
Run 14a v. Run 1
ILRG Model
1940 - 2017 (acre-feet)



Appendix 30P

Comparison of ILRG Model Runs
Run 14b v. Run 1

Model Run Specifications

Model Version: LRG_v116

Name: **Run 14b - MX Hueco Pumping Off**

Run ID: LRG_v116_Operational_Run14b
Date: 8/24/2020

Name: **Run 1 - Historical Base Run (All Pumping On)**

Run ID: LRG_v116_Operational_Run1
Date: 8/23/2020

Selected Model Inputs

Pumping and Returns	Run 14b	Run 1
Irrigation Pumping	MX Hueco Off	On
Irrigated Area	Hist	Hist
Non-Irrigation Pumping	MX Hueco Off	On
Non-Irrigation Pumping Returns	MX Hueco Off	On
Las Cruces Jornada Pumping Returns	On	On

Project Allocation Rules		
1950-2005	D1/D2	D1/D2
2006-2007	D3	D3
2008-2017	D3 + CO	D3 + CO

EPCWID Operations		
Charge EPCWID for Use of WWTP Returns	Off	Off
ACE and Haskell Credits for EPCWID	On	On
Increased EPCWID Use of Fabens Drain Flows	Off	Off
Charge EPCWID for Fabens Drain Flow Use	Off	Off

Run 14b - MX Hueco Pumping Off

Comparison of ILRG Model Runs

Run 14b v. Run 1

1951 - 2017 Annual Average

(1,000 acre-feet)

Run No.	**1**	**14b**	**14b - 1**		
Simulated Input or Output	**Run 1**	**Run 14b**	**Run 14b minus Run 1**		
Pumping Stress					
Irrigation Pumping	62.8	0.0	-62.8		
Non-Irrigation Pumping	181.0	112.0	-68.9		
WWTP Flows	58.0	35.3	-22.7		
Urban Deep Percolation	13.1	13.1	0.0		
Total Stress	172.7	63.6	-109.0		
	Stress is Pumping minus WWTP and Urban Deep Perc				
Effects of Pumping Stress				***% Chg***	
FHG Deliveries (Mar - Oct)				***Stress***	***% Diff.***
EBID	167.6	169.3	1.7	*-2%*	*1%*
EPCWID (incl. EPW)	139.9	141.4	1.5	*-1%*	*1%*
HCCRD	32.8	33.6	0.7	*-1%*	*2%*
Total	340.3	344.3	4.0	*-4%*	*1%*
FHG Deliveries (Nov - Feb)					
EBID	0.0	0.0	0.0	*0%*	*-2%*
EPCWID (incl. EPW)	0.2	0.2	0.0	*0%*	*-7%*
HCCRD	2.4	2.3	-0.1	*0%*	*-3%*
Total	2.6	2.5	-0.1	*0%*	*-4%*
Irrigation Pumping					
EBID	140.4	138.8	-1.6	*2%*	*-1%*
EPCWID (Mesilla Valley)	7.4	7.3	-0.1	*0%*	*-1%*
EPCWID (El Paso Valley)	40.1	38.8	-1.3	*1%*	*-3%*
HCCRD	4.2	2.9	-1.3	*1%*	*-31%*
Total	192.1	187.8	-4.3	*4%*	*-2%*
	Pumping turned off.	*Other values are simulated responses and are totaled.*			
Other Inflows/Outflows					
Net Reservoir Evaporation	125.3	126.4	1.1	*-1%*	*1%*
Riparian ET	70.9	77.1	6.2	*-6%*	*9%*
River Evaporation + Incidental Canal Loss	30.3	30.1	-0.2	*0%*	*-1%*
Total	226.6	233.6	7.1	*-7%*	*3%*
Rio Grande at Fort Quitman					
Reservoir Spills	33.3	36.3	3.0	*-3%*	*9%*
Nov-Feb Flows	21.4	30.5	9.1	*-8%*	*43%*
Mar - Oct Flows	41.1	54.4	13.3	*-12%*	*32%*
Underflow (GW Model)	0.2	0.2	0.0	*0%*	*16%*
Total	96.0	121.5	25.5	*-23%*	*27%*

Run 14b - MX Hueco Pumping Off
Comparison of ILRG Model Runs
Run 14b v. Run 1
1951 - 2017 Annual Average
(1,000 acre-feet)

Run No.	1	14b	14b - 1		
Simulated Input or Output	**Run 1**	**Run 14b**	**Run 14b minus Run 1**		
Effects of Pumping Stress (continued)				*% Chg*	
Change in Storage				*Stress*	*% Diff.*
Reservoir Storage	-4.7	-4.8	-0.1	*0%*	*3%*
Alluvial GW Storage (RW Model)	-23.6	-6.1	17.5	*-16%*	*-74%*
Non-alluvial GW Storage (GW Models)	-96.4	-53.9	42.5	*-39%*	*-44%*
Soil Moisture Storage	0.6	0.5	-0.1	*0%*	*-21%*
Total	-124.0	-64.2	59.8	*-55%*	*-48%*
Summary of Effects					
FHG Deliveries (Mar-Oct)	340.3	344.3	4.0	*-4%*	*1%*
FHG Deliveries (Nov-Feb)	2.6	2.5	-0.1	*0%*	*-4%*
Irrigation Pumping	192.1	187.8	-4.3	*4%*	*-2%*
Riparian ET + Evaporation	226.6	233.6	7.1	*-7%*	*3%*
Fort Quitman Flow	96.0	121.5	25.5	*-23%*	*27%*
Change in Storage	-124.0	-64.2	59.8	*-55%*	*-48%*
Total	733.6	825.5	91.9	*-84%*	*13%*
Other Effects of Pumping Stress				*% Chg*	
Rio Grande at El Paso				*Stress*	*% Diff.*
Reservoir Spills	49.4	48.3	-1.1	*1%*	*-2%*
Nov-Feb Flows	22.8	23.0	0.2	*0%*	*1%*
Mar - Oct Flows	263.8	263.5	-0.3	*0%*	*0%*
Total	336.0	334.8	-1.2	*1%*	*0%*
Rio Grande below Caballo					
Reservoir Spills	65.9	63.5	-2.4	*2%*	*-4%*
Nov-Feb Flows	0.5	0.6	0.1	*0%*	*21%*
Mar - Oct Flows	541.3	542.6	1.3	*-1%*	*0%*
Total	607.6	606.7	-0.9	*1%*	*0%*
Surface Water Diversions (Mar - Oct)					
EBID	366.5	368.9	2.5	*-2%*	*1%*
EPCWID (incl. EPW)	236.8	236.4	-0.3	*0%*	*0%*
HCCRD	67.5	71.5	3.9	*-4%*	*6%*
Total	670.8	676.9	6.0	*-6%*	*1%*
Surface Water Diversions (Nov - Feb)					
EBID	0.0	0.0	0.0	*0%*	*0%*
EPCWID (incl. EPW)	14.3	14.4	0.1	*0%*	*0%*
HCCRD	14.2	16.2	2.0	*-2%*	*14%*
Total	28.5	30.6	2.1	*-2%*	*7%*

Run 14b - MX Hueco Pumping Off
Annual Differences in ILRG Model Outputs
Run 14b minus Run 1
1940 - 2017 (acre-feet)

	Net River Headgate Diversions						Farm Headgate Deliveries						Annual Flows		
	EBID		EPCWID (incl. EPW)		HCCRD		EBID		EPCWID (incl. EPW)		HCCRD				
Year	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Caballo Releases	Rio Grande at El Paso	Rio Grande at Fort Quitman
1940	-42	-42	-151	468	-246	80	-14	-14	466	514	-223	-223	-4,070	-3,847	147
1941	-243	-243	-694	67	-264	30	-3	-3	-34	100	-230	-165	3,530	2,292	4,585
1942	-39	-39	-315	477	107	101	2	2	-278	116	70	87	-669	505	4,053
1943	-54	-54	-321	265	47	163	-24	-24	-262	-152	81	239	-1,966	-1,893	282
1944	-64	-64	-322	68	-200	-106	-12	-12	165	254	-160	-51	-2,153	-2,082	103
1945	-55	-55	-264	256	-269	-39	-9	-9	140	268	-244	-89	-2,209	-2,160	54
1946	-25	-25	-370	343	-171	42	-16	-17	100	447	-167	-212	-2,312	-2,269	176
1947	-41	-41	-687	-59	-212	-199	-13	-14	-135	308	-179	-191	-2,688	-2,639	-5
1948	-35	-35	-610	53	-204	-7	-10	-10	29	323	-77	-49	-2,789	-2,740	3,670
1949	-60	-60	-424	268	-165	135	-5	-5	253	406	12	25	-2,727	-2,686	6,545
1950	14	14	-492	-294	-75	142	102	102	111	110	8	14	-2,434	-2,423	4,153
1951	1,028	1,028	-385	-417	18	149	563	563	255	256	40	108	-1,559	-1,830	8,886
1952	203	203	-506	-528	188	338	276	275	231	229	198	151	-6,475	-4,714	7,173
1953	186	186	-769	-782	106	319	1,161	1,161	203	201	142	85	-1,657	-2,777	12,726
1954	3,311	3,311	2,631	2,615	890	1,033	5,654	5,654	5,731	5,730	1,056	1,254	1,800	6,046	9,406
1955	9,054	9,054	6,488	6,339	-644	-887	4,793	4,793	4,865	4,681	-534	-709	19,188	9,465	338
1956	-2,978	-2,978	-1,942	-1,942	-383	-500	-1,746	-1,746	-1,610	-2,108	-665	-1,011	-4,870	-2,335	-88
1957	8	8	-7	-548	-12	-394	25	24	12	-236	-148	-571	104	-636	-83
1958	23	23	-3,032	-2,955	1,035	3,089	124	124	30	-68	-406	-702	-5,082	-3,076	3,175
1959	13	13	-1,764	-1,795	3,042	4,884	46	45	238	238	6	23	-4,565	-3,875	7,073
1960	13	13	-1,691	-1,593	2,367	3,681	13	13	257	257	0	0	-6,862	-6,373	7,016
1961	21	21	-2,636	-2,409	2,769	4,372	11	11	1,688	1,688	1,289	-856	-9,015	-8,407	15,061
1962	10	10	-2,671	-2,442	2,527	4,034	-20	-20	360	360	425	500	-8,887	-8,474	18,964
1963	8,893	8,893	-3,399	-3,170	2,231	3,701	4,829	4,829	443	444	950	977	-2,551	-5,860	19,841
1964	16,176	16,176	11,686	12,036	4,095	5,201	8,489	8,489	8,122	7,792	3,589	3,821	20,664	11,902	17,143
1965	2,770	2,770	-1,001	-1,037	2,418	4,569	1,377	1,377	905	586	2,289	4,556	-3,982	-292	930
1966	-19	-19	-2,622	-2,309	5,986	8,625	187	186	-24	-22	-3,338	-4,158	-7,879	-4,056	14,037
1967	9,349	9,349	7,328	8,064	4,925	7,019	5,526	5,526	6,761	6,398	4,093	4,601	11,190	7,059	11,991
1968	1,035	1,035	-4,172	-3,451	5,892	7,826	931	931	204	-196	6,262	5,748	-5,134	-2,376	5,000
1969	7	7	-4,612	-4,548	7,022	10,452	187	187	-104	-104	4,641	2,058	-7,734	-5,976	20,721
1970	2	2	-4,544	-4,536	5,295	8,056	34	34	37	37	-1,274	-2,459	-8,899	-7,940	26,242
1971	12,895	12,895	-3,482	-3,050	4,914	7,875	7,727	7,727	284	285	3,953	5,643	891	-4,247	13,309
1972	-1,336	-1,336	-744	-569	4,560	6,732	4,734	4,734	335	255	4,358	4,992	-6,232	352	9,984
1973	-174	-174	-3,740	-3,770	2,377	4,492	50	50	387	321	2,347	2,856	-1,776	-4,553	3,881
1974	3	3	-3,802	-3,861	5,212	10,399	48	48	464	465	1,153	987	-6,475	-6,069	18,460
1975	-203	-203	-3,499	-3,488	8,277	13,817	978	978	138	138	7,507	8,989	-8,109	-6,188	19,561
1976	8	8	-2,550	-2,560	7,515	13,874	371	371	53	53	-924	-3,067	-5,382	-5,369	31,160
1977	21,817	21,817	-2,909	-1,918	7,513	12,671	13,272	13,272	239	240	7,002	8,202	7,192	-1,124	14,078
1978	15,026	15,026	10,723	12,162	5,774	11,467	7,975	7,975	12,580	12,583	5,935	6,941	25,188	16,929	16,108

Run 14b - MX Hueco Pumping Off
Annual Differences in ILRG Model Outputs
Run 14b minus Run 1
1940 - 2017 (acre-feet)

	Net River Headgate Diversions						Farm Headgate Deliveries						Annual Flows		
	EBID		EPCWID (incl. EPW)		HCCRD		EBID		EPCWID (incl. EPW)		HCCRD				
Year	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Caballo Releases	Rio Grande at El Paso	Rio Grande at Fort Quitman
1979	-397	-397	-5,651	-5,282	7,819	12,954	359	359	-1,163	-1,158	3,112	731	-9,645	-3,395	27,070
1980	-67	-67	-3,451	-3,248	6,428	10,767	136	136	41	44	-3,917	-7,984	-7,586	-4,231	51,979
1981	-34	-34	-2,995	-3,007	4,766	7,505	193	193	8	9	-56	-339	-4,932	-3,704	39,817
1982	-23	-23	-3,028	-3,035	4,187	6,761	71	71	8	57	-1,040	-2,366	-4,393	-3,565	48,731
1983	-28	-28	-2,394	-2,435	4,369	6,820	42	42	-32	-32	0	0	-3,252	-2,666	36,214
1984	-51	-51	-2,065	-2,036	6,280	8,563	-1	-1	-8	83	0	0	-962	-806	30,942
1985	-84	-84	-1,902	-1,856	4,756	6,957	-2	-2	-172	-9	0	0	-2,396	-1,927	33,926
1986	-45	-45	-1,974	-2,005	4,120	6,342	257	260	11	14	0	0	20,407	20,077	170,489
1987	-31	-31	-1,932	-1,982	2,712	4,719	8	9	2	3	0	0	-26	-32	70,107
1988	-16	-16	-1,819	-1,874	2,238	4,061	98	98	10	10	0	0	-3,761	-2,877	44,628
1989	-16	-16	-1,906	-1,860	2,226	3,892	8	8	-176	19	0	0	-2,671	-2,359	34,255
1990	-67	-67	-618	-490	4,534	5,949	145	145	-122	160	0	0	550	805	23,748
1991	-117	-117	-436	-445	2,392	3,666	33	33	-106	-17	0	0	-881	-606	34,501
1992	1,198	1,198	72,337	72,255	28,846	31,058	-8,094	-8,101	32,197	32,213	0	0	44,828	47,514	65,451
1993	502	502	-6,312	-6,416	256	1,911	658	654	-2,976	-2,982	0	0	-39,112	-39,201	4,209
1994	65	65	-108	-208	1,662	2,843	-128	-128	868	866	0	0	508	-1,048	31,228
1995	99	99	-307	-275	1,686	2,860	-23	-23	541	750	0	0	2,404	1,669	38,681
1996	-46	-46	-1,263	-1,363	1,526	2,759	334	334	39	39	0	0	-5,230	-3,679	36,716
1997	-34	-34	-1,927	-1,810	1,770	2,621	-48	-48	-97	245	0	0	-2,313	-2,378	27,386
1998	-27	-27	-2,292	-2,391	1,485	2,539	87	87	-150	-29	0	0	-5,375	-4,970	36,580
1999	114	114	-249	-310	2,440	3,693	4	4	1,805	1,884	0	0	0	-531	38,229
2000	-34	-34	-6,389	-6,455	1,777	3,234	-19	-19	-1,818	-1,818	0	0	-6,349	-5,981	36,222
2001	-71	-71	-2,714	-2,794	2,770	4,334	-42	-41	6	6	0	0	-2,243	-2,271	35,313
2002	-44	-44	-2,818	-2,896	2,748	4,283	-18	-18	6	6	0	0	-2,367	-2,311	34,651
2003	14,438	14,438	-1,658	-1,698	2,514	4,166	9,325	9,325	1,022	1,026	0	0	6,651	1,179	26,718
2004	2,384	2,384	1,737	1,772	3,482	5,242	1,713	1,713	2,838	2,842	0	0	2,187	3,227	27,632
2005	-37	-37	-3,895	-3,953	3,862	5,734	44	44	74	75	0	0	-5,310	-3,084	30,933
2006	4,494	4,494	6,388	6,337	4,316	6,207	3,080	3,080	5,583	5,585	0	0	4,849	3,225	33,206
2007	3,085	3,085	2,170	2,206	4,310	6,361	1,547	1,547	5,170	5,172	0	0	5,615	3,889	26,373
2008	6,501	6,501	-6,212	-6,248	3,757	5,672	4,363	4,363	-1,117	-1,114	0	0	-6,635	-5,764	33,820
2009	6,294	6,294	-4,294	-4,391	2,369	3,858	2,949	2,949	51	53	0	0	-3,467	-3,927	36,575
2010	18,287	18,287	-4,022	-4,081	2,172	3,595	11,440	11,440	252	256	0	0	519	-3,581	33,863
2011	12,564	12,564	1,441	1,368	8,260	9,748	6,864	6,864	3,854	3,856	0	0	9,352	2,578	24,339
2012	-509	-509	96	-19	9,587	11,881	792	792	2,853	2,854	0	0	-1,778	32	12,761
2013	-3,483	-3,483	-1,252	-1,365	3,180	4,763	-1,623	-1,623	704	704	1,609	2,143	-4,809	-1,301	5,453
2014	170	170	-1,204	-1,317	5,124	7,209	1,208	1,208	1,816	1,816	2,488	4,125	-153	-880	403
2015	-1,769	-1,769	-7,259	-7,381	3,962	6,188	-1,262	-1,262	-6	-6	-2,409	-1,159	-11,146	-7,436	12,407
2016	-1,663	-1,663	4,788	4,644	4,024	6,261	758	758	8,964	8,965	0	0	12,821	6,613	16,466
2017	7,006	7,006	-10,346	-10,486	2,334	4,288	8,529	8,529	-315	-314	0	0	-10,331	-11,243	24,418
Averages															
1951-2017	2,472	2,472	-349	-288	3,925	5,958	1,663	1,663	1,545	1,532	742	658	-945	-1,190	25,500
1951-1978	3,469	3,469	-629	-445	3,425	5,603	2,415	2,415	1,539	1,447	1,784	1,749	-961	-1,600	11,860
1979-2005	649	649	517	515	4,209	6,157	190	190	1,209	1,271	-70	-369	-1,158	-635	41,347
2006-2017	4,248	4,248	-1,642	-1,728	4,450	6,336	3,220	3,220	2,317	2,319	141	426	-430	-1,483	21,674
1985-2017	2,094	2,094	420	370	4,036	5,724	1,303	1,302	1,867	1,913	51	155	-172	-502	34,597
1985-2005	863	863	1,598	1,569	3,800	5,374	207	206	1,610	1,681	0	0	-24	58	41,981

Notes:

EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).

EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

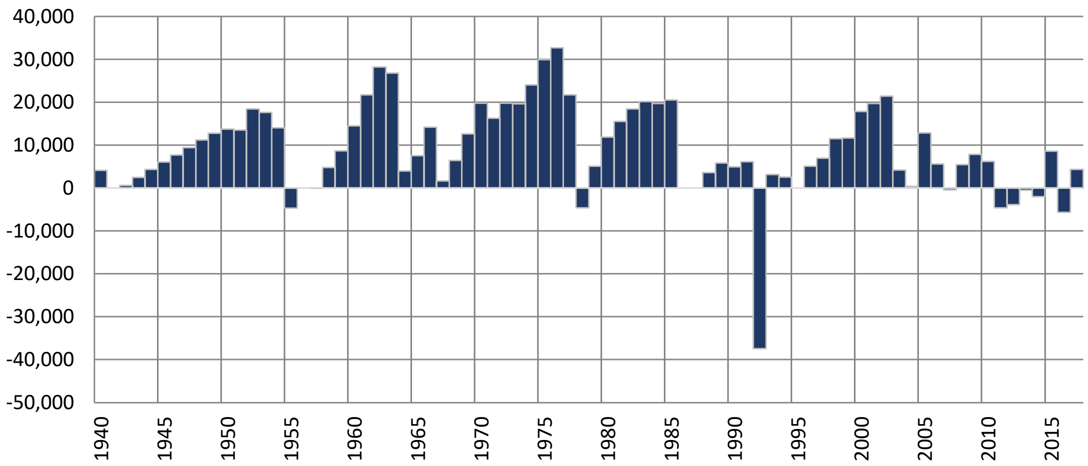
Run 14b - MX Hueco Pumping Off

Simulated Differences in ILRG Model Outputs

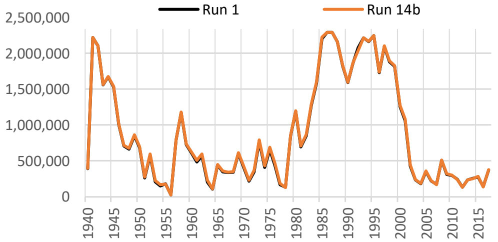
Run 14b minus Run 1

1940 - 2017 (acre-feet)

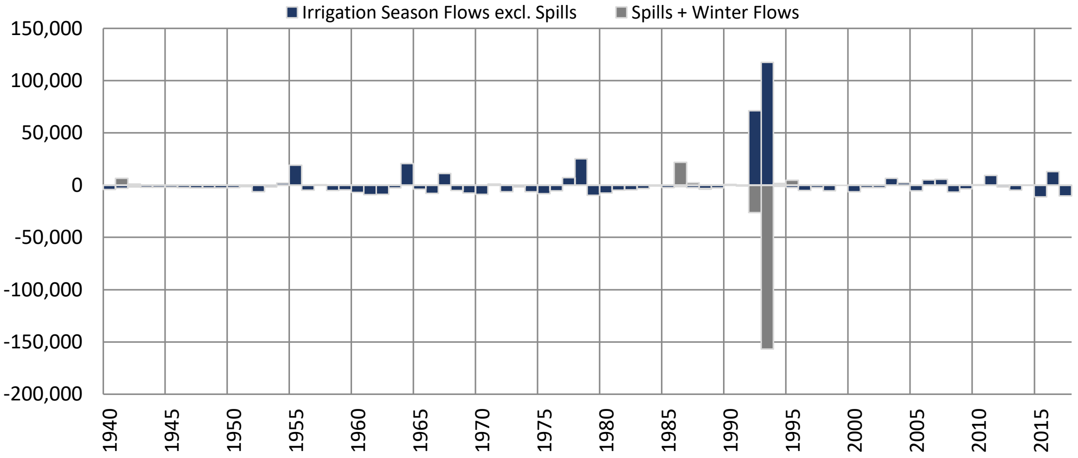
Total Project Storage (Year End)



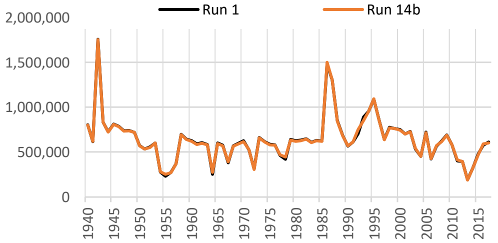
Period	Average Difference
1951-2017	-141
1951-1978	-657
1979-2005	647
2006-2017	-709
1985-2017	-467
1985-2005	-329



Caballo Reservoir Outflows (Annual)



	Average Difference		
Period	Irr Season (excl. Spills)	Nov-Feb and Spills	Annual
1951-2017	1,341	-2,286	-945
1951-1978	-961	0	-961
1979-2005	4,515	-5,673	-1,158
2006-2017	-430	0	-430
1985-2017	4,470	-4,641	-172
1985-2005	7,270	-7,294	-24



Notes:

Reservoir storage does not include storage attributed to SJC, CO, or NM credit waters.

Average differences calculated as (Final Storage - Initial Storage)/(no. years).

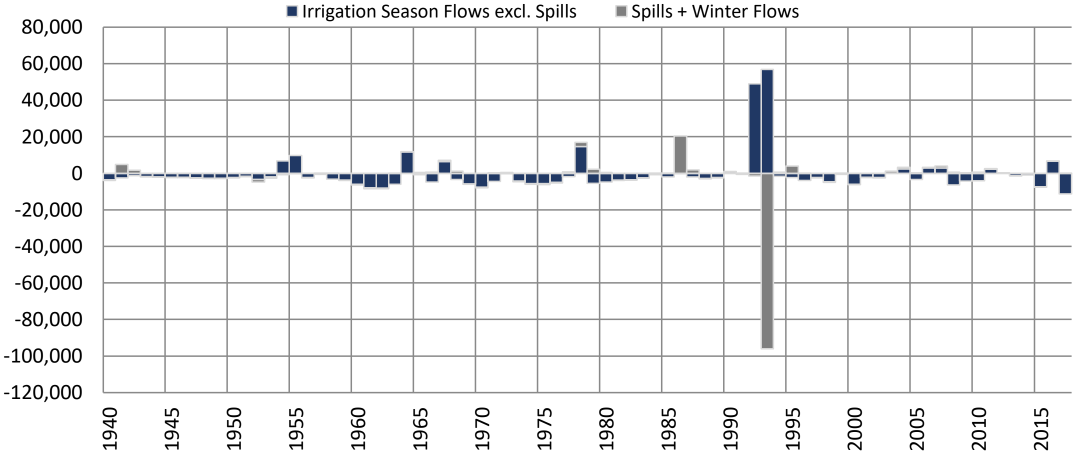
Run 14b - MX Hueco Pumping Off

Simulated Differences in ILRG Model Outputs

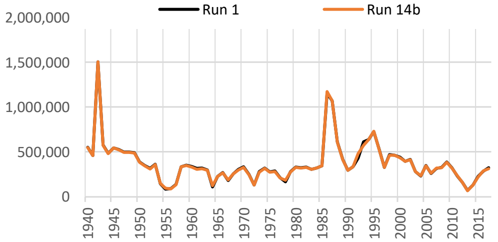
Run 14b minus Run 1

1940 - 2017 (acre-feet)

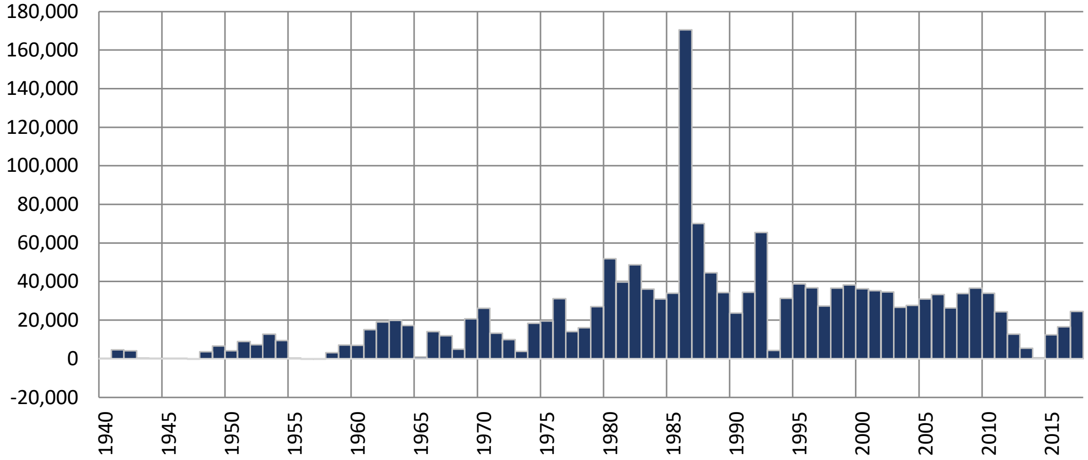
Rio Grande at El Paso (Annual)



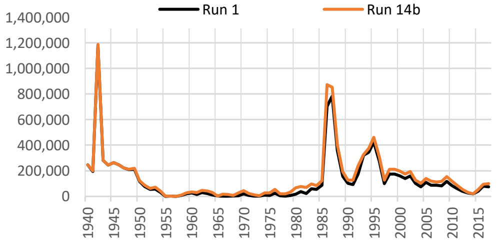
	Average Difference		
Period	Irr Season (excl. Spills)	Nov-Feb and Spills	Annual
1951-2017	-254	-936	-1,190
1951-1978	-1,598	-1	-1,600
1979-2005	1,806	-2,441	-635
2006-2017	-1,754	271	-1,483
1985-2017	1,474	-1,976	-502
1985-2005	3,319	-3,261	58



Rio Grande at Fort Quitman (Annual)



Period	Average Difference
1951-2017	25,466
1951-1978	11,817
1979-2005	41,310
2006-2017	21,665
1985-2017	34,578
1985-2005	41,957



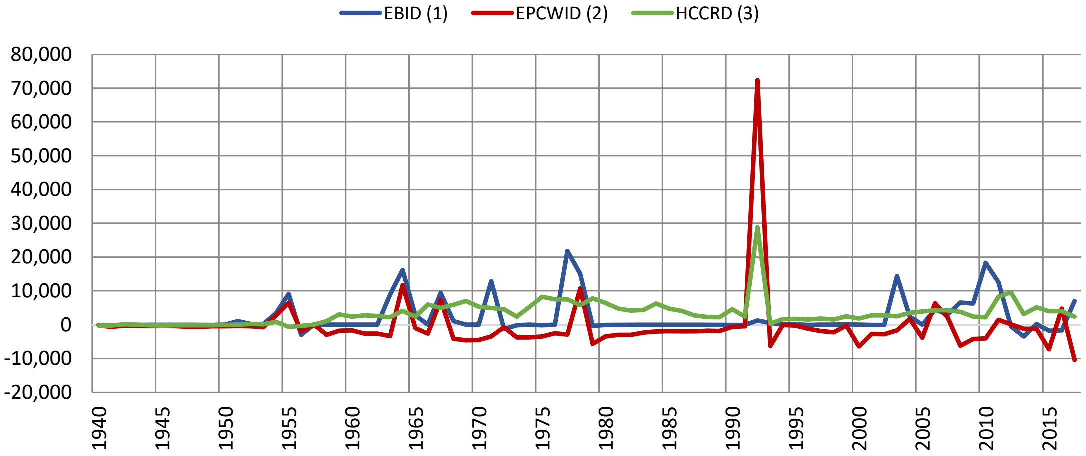
Run 14b - MX Hueco Pumping Off

Simulated Differences in ILRG Model Outputs

Run 14b minus Run 1

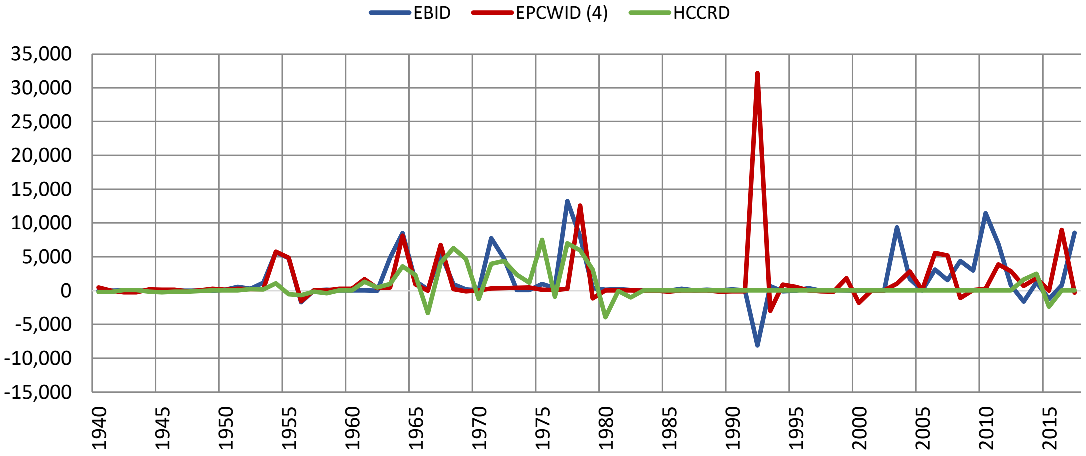
1940 - 2017 (acre-feet)

River Headgate (RHG) Diversions (Irrigation Season)



	Average Difference		
Period	EBID	EPCWID	HCCRD
1951-2017	2,472	-349	3,925
1951-1978	3,469	-629	3,425
1979-2005	649	517	4,209
2006-2017	4,248	-1,642	4,450
1985-2017	2,094	420	4,036
1985-2005	863	1,598	3,800

Farm Headgate (FHG) Deliveries (Irrigation Season)



	Average Difference		
Period	EBID	EPCWID	HCCRD
1951-2017	1,663	1,545	742
1951-1978	2,415	1,539	1,784
1979-2005	190	1,209	-70
2006-2017	3,220	2,317	141
1985-2017	1,303	1,867	51
1985-2005	207	1,610	0

Notes:

(1) EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).

(2) EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

(3) HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

(4) EPCWID FHG values include deliveries to Rogers WTP and R/U WTP.

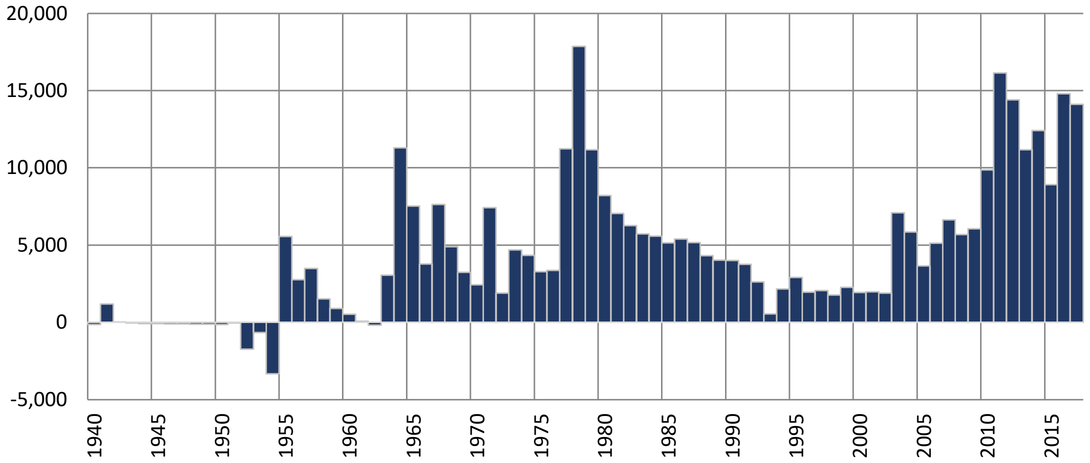
Run 14b - MX Hueco Pumping Off

Simulated Differences in ILRG Model Outputs

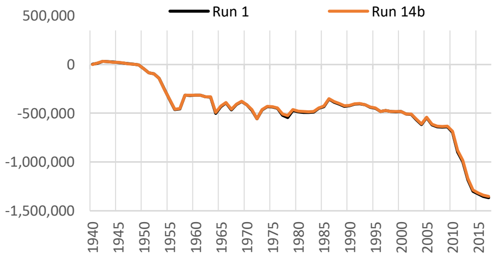
Run 14b minus Run 1

1940 - 2017 (acre-feet)

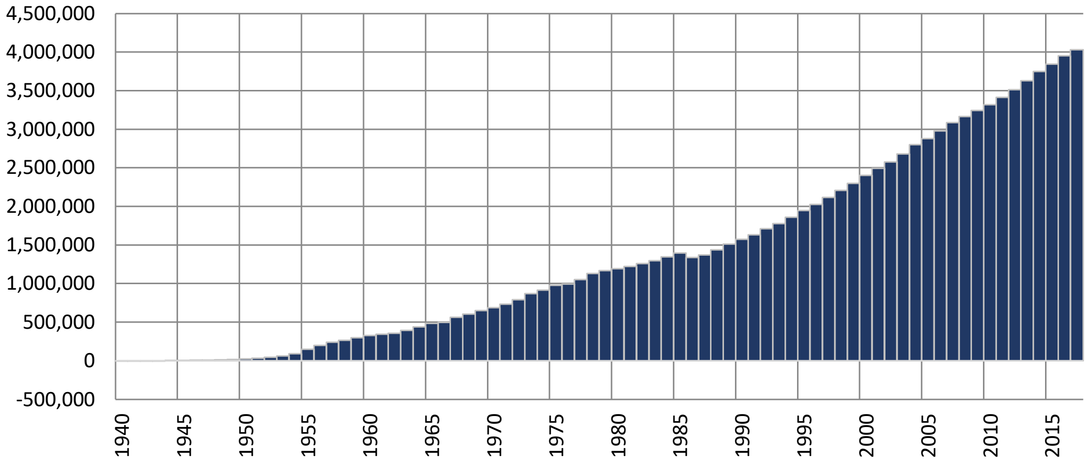
Cumulative Annual Rincon-Mesilla Groundwater Storage



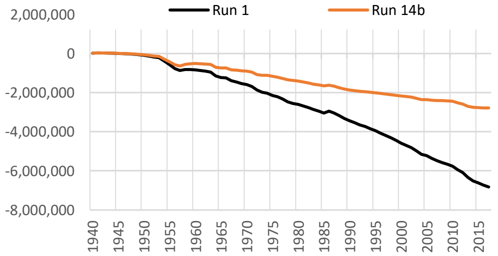
Period	Average Difference
1951-2017	213
1951-1978	643
1979-2005	-526
2006-2017	872
1985-2017	259
1985-2005	-91



Cumulative Annual Hueco Groundwater Storage



Period	Average Difference
1951-2017	59,813
1951-1978	39,526
1979-2005	64,723
2006-2017	96,107
1985-2017	81,328
1985-2005	72,883

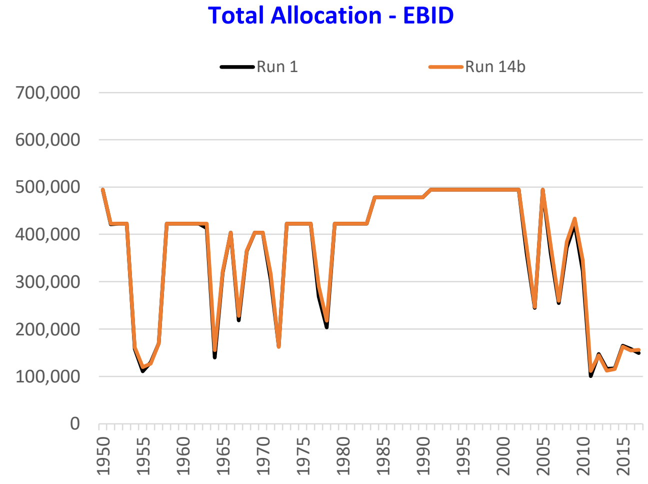


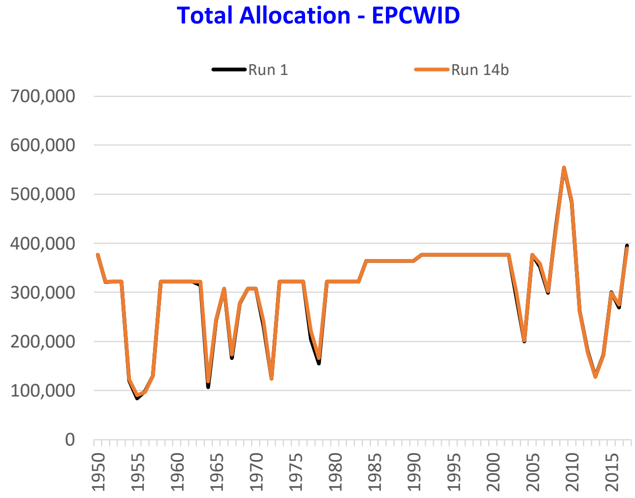
Notes:

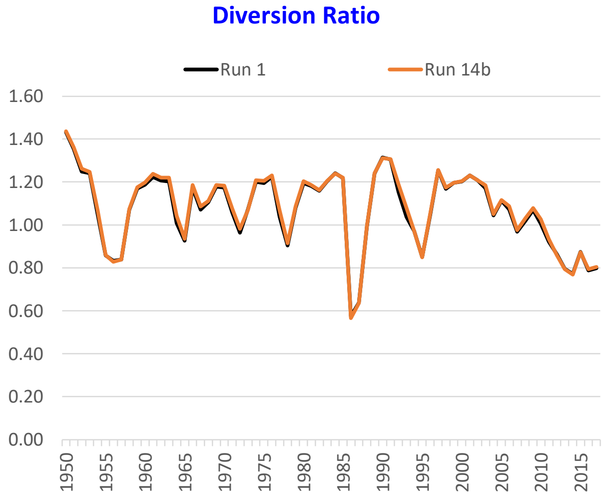
Cumulative storage change in alluvial and non-alluvial aquifers.

Average differences calculated as (Final Storage - Initial Storage)/(no. years).

Run 14b - MX Hueco Pumping Off
Annual Allocation and Charges
Run 14b v. Run 1
ILRG Model
1950 - 2017 (acre-feet)

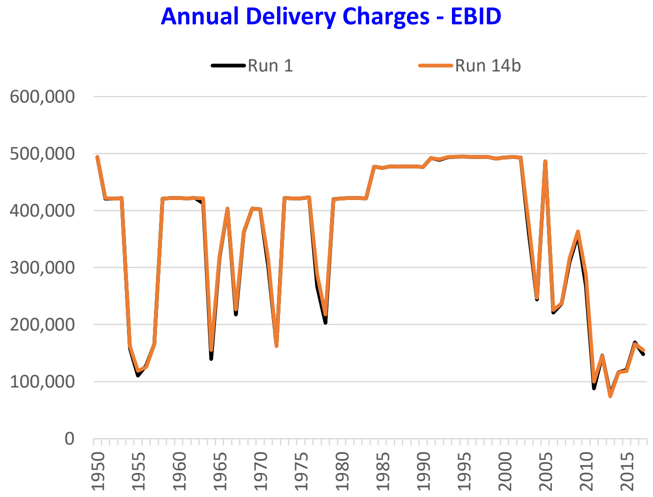


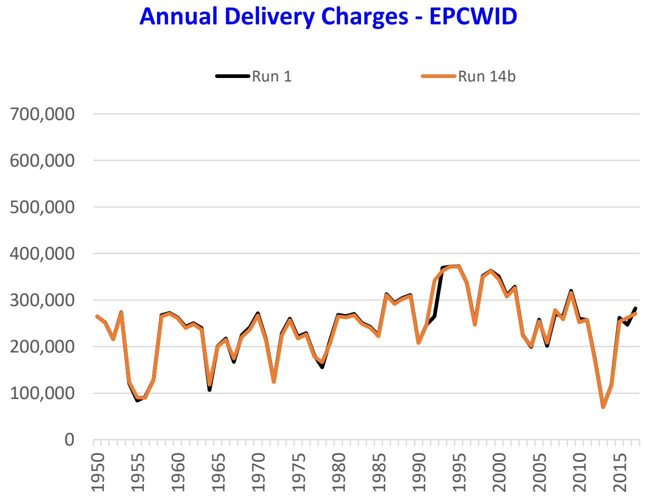




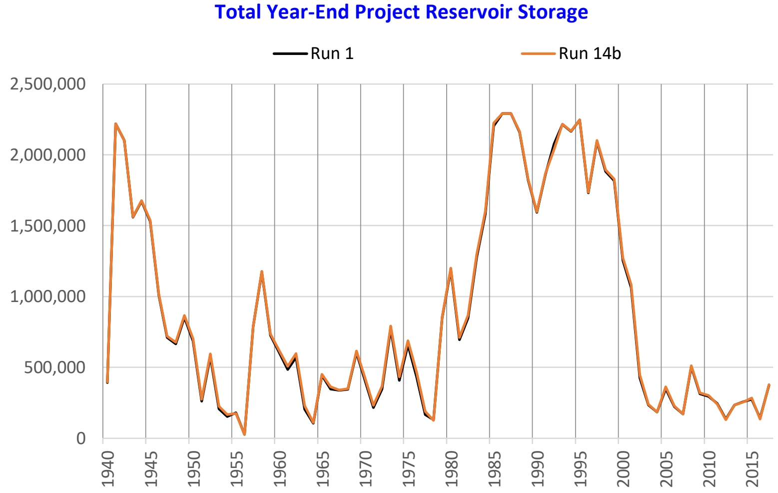
Note:

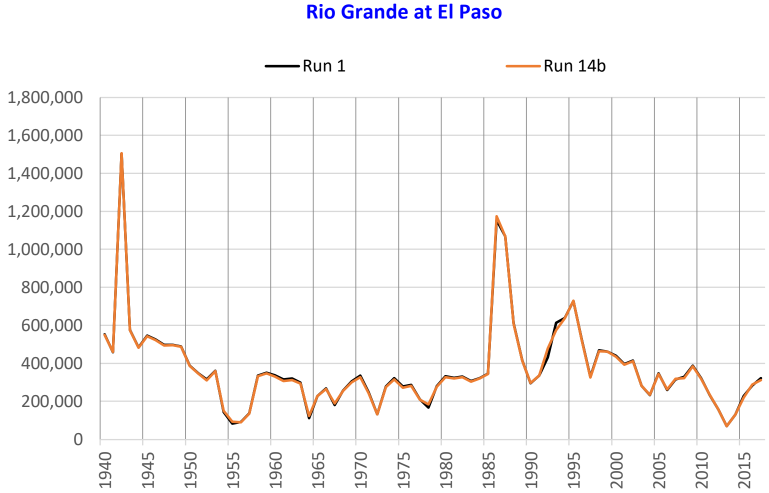
Computed as Total Charges/Caballo Release.

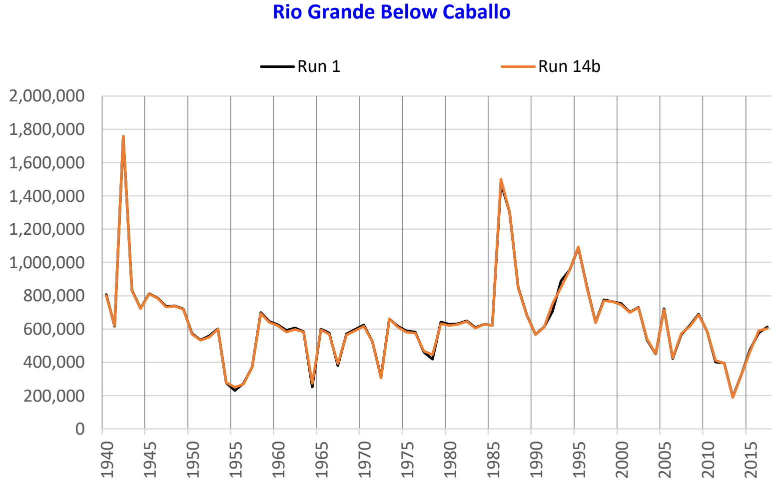


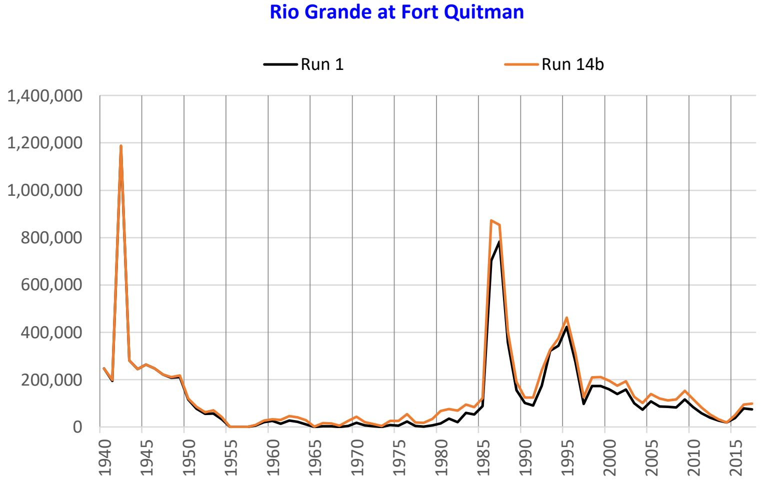


Run 14b - MX Hueco Pumping Off
Annual Summary of Project Storage and Rio Grande Flows
Run 14b v. Run 1
ILRG Model
1940 - 2017 (acre-feet)









***Note different scales.**

Run 14b - MX Hueco Pumping Off

Irrigation Season Summary of Irrigation Operations

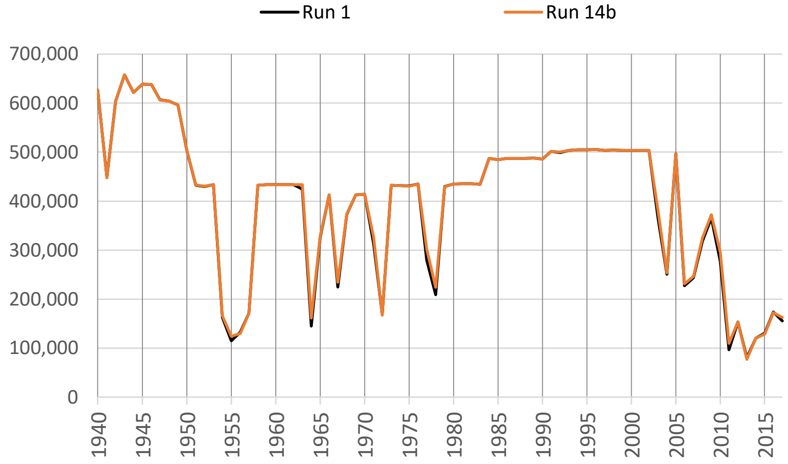
Run 14b v. Run 1

ILRG Model

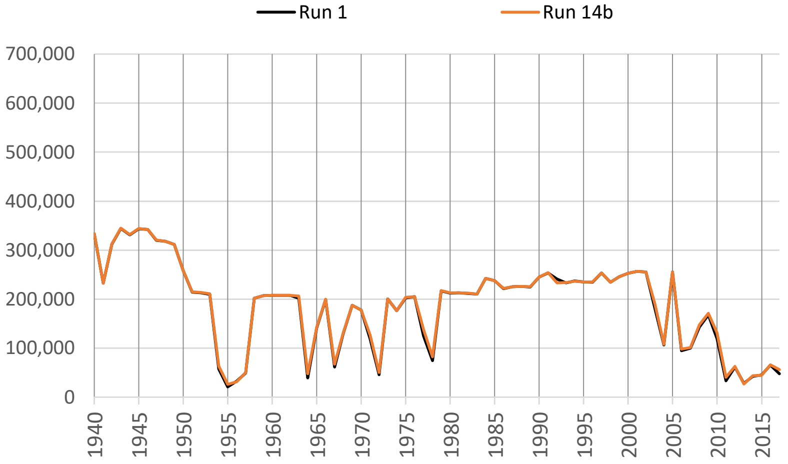
1940 - 2017 (acre-feet)

EBID Total

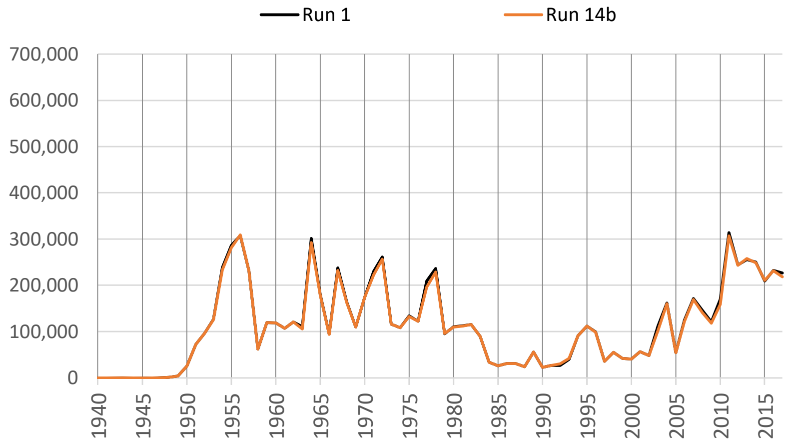
Net River Headgate Diversions



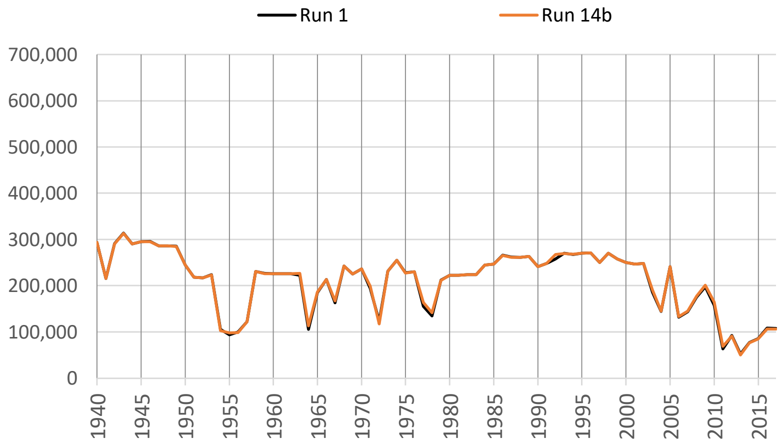
Farm Headgate Deliveries



Pumping



RHG Diversions - FHG Deliveries

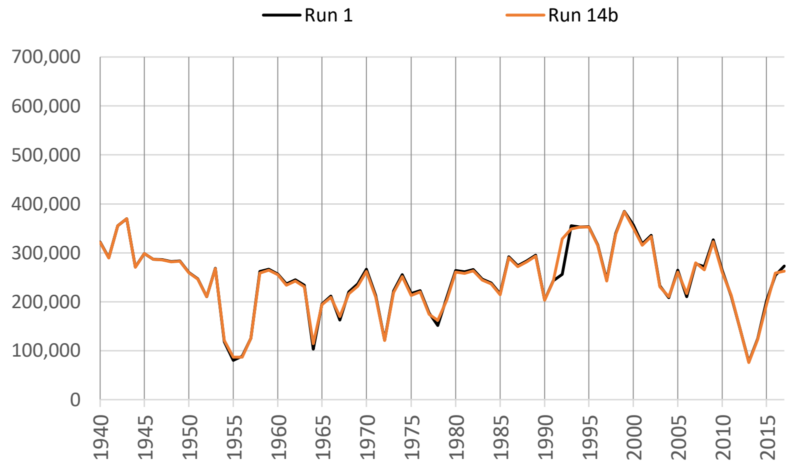


Notes: EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).
Pumping includes Supplemental and Primary groundwater pumping.

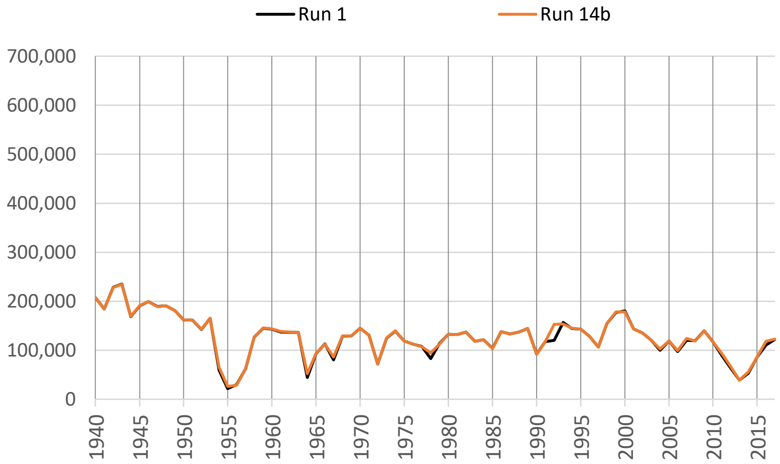
Run 14b - MX Hueco Pumping Off
Irrigation Season Summary of Irrigation Operations
Run 14b v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

EPCWID Total

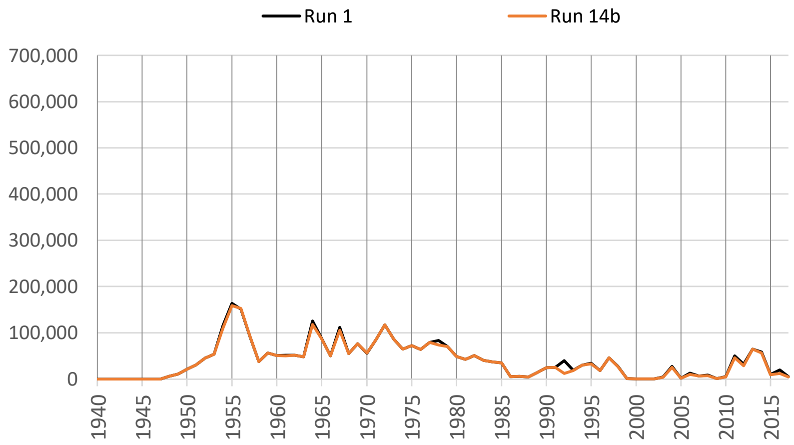
Net River Headgate Diversions



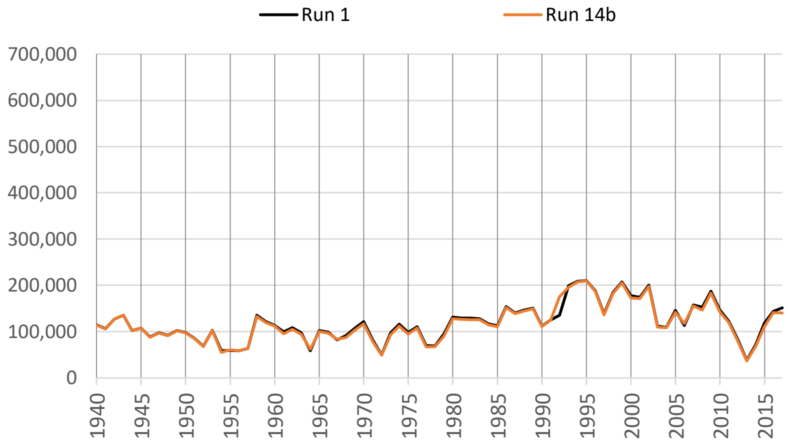
Farm Headgate Deliveries



Pumping



RHG Diversions - FHG Deliveries

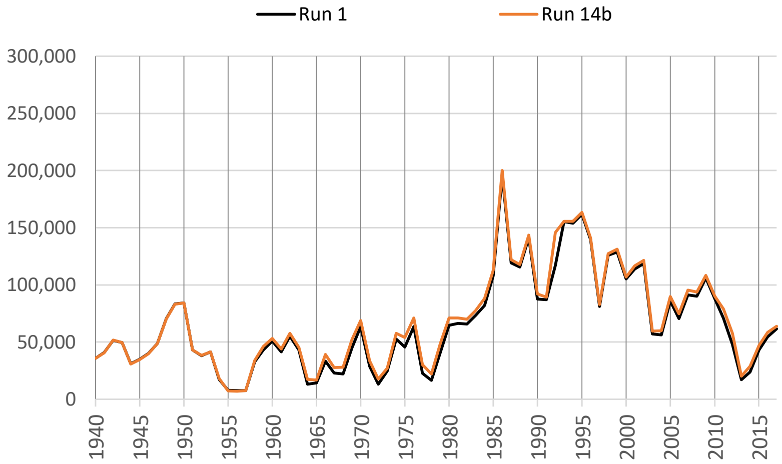


Note: EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

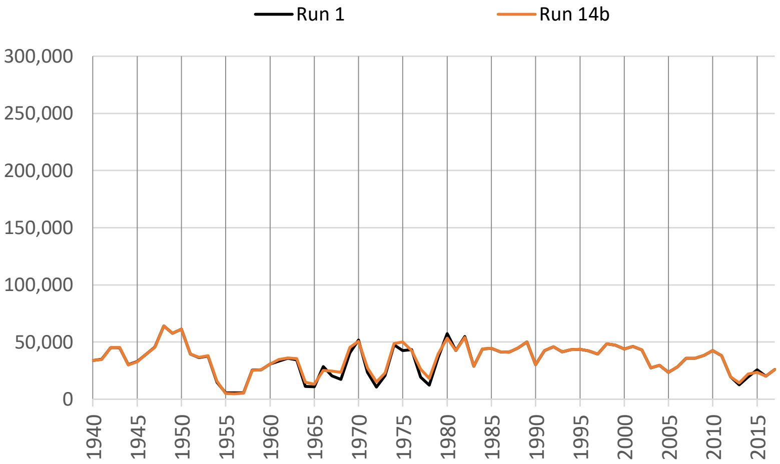
Run 14b - MX Hueco Pumping Off
Irrigation Season Summary of Irrigation Operations
Run 14b v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

HCCRD Total

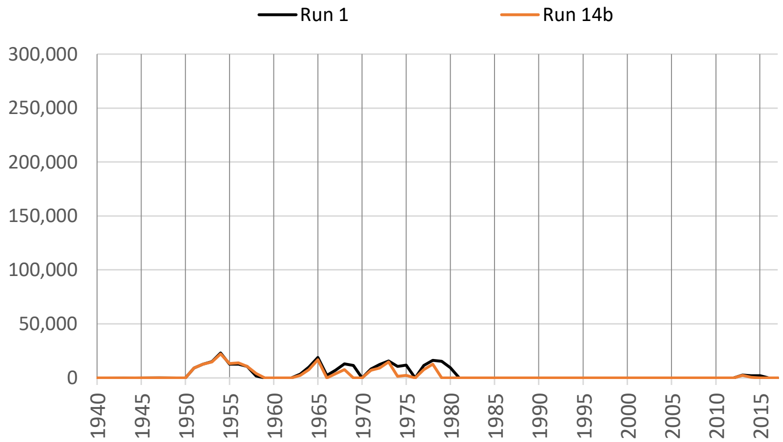
Net River Headgate Diversions



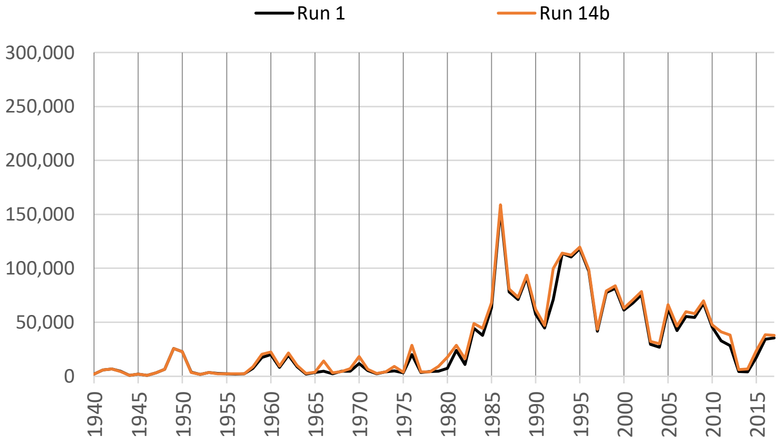
Farm Headgate Deliveries



Pumping



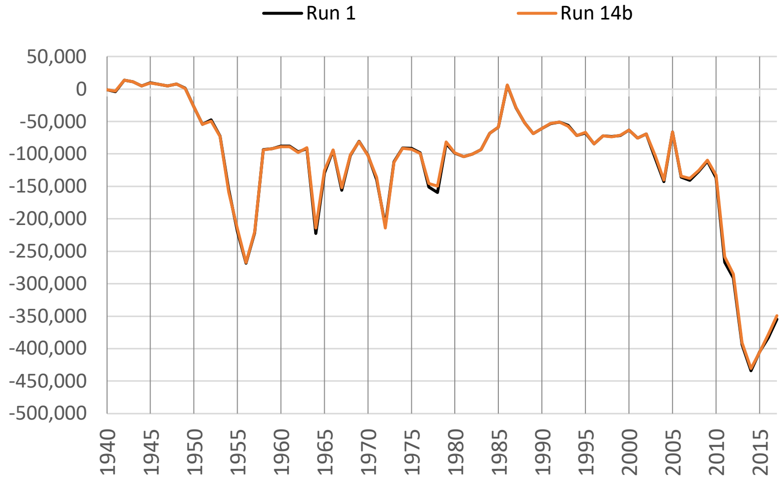
RHG Diversions - FHG Deliveries



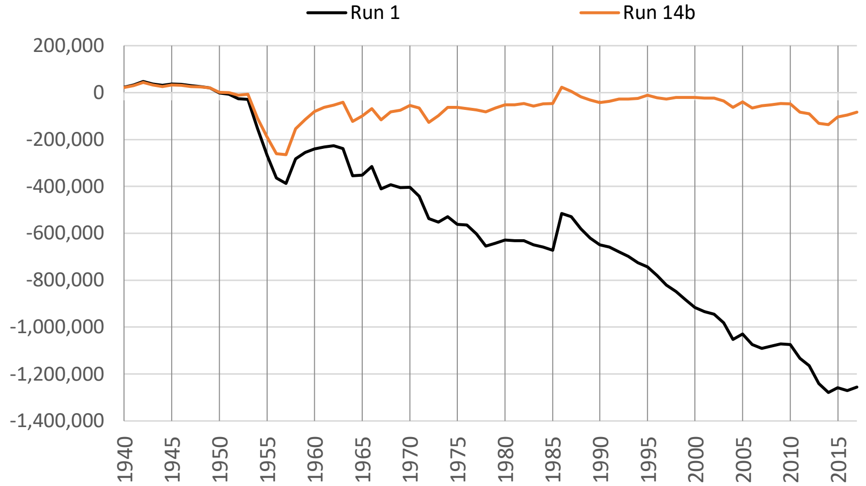
Note: HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

Run 14b - MX Hueco Pumping Off
Cumulative Change in Ground Water Storage
Run 14b v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

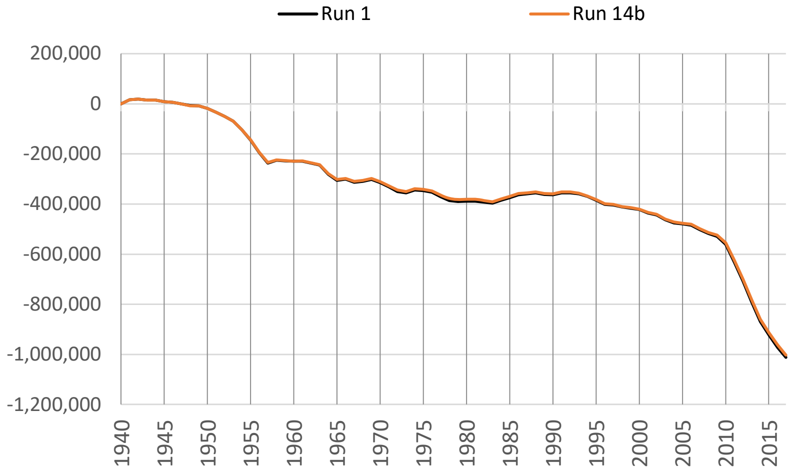
Rincon-Mesilla Alluvial Aquifer



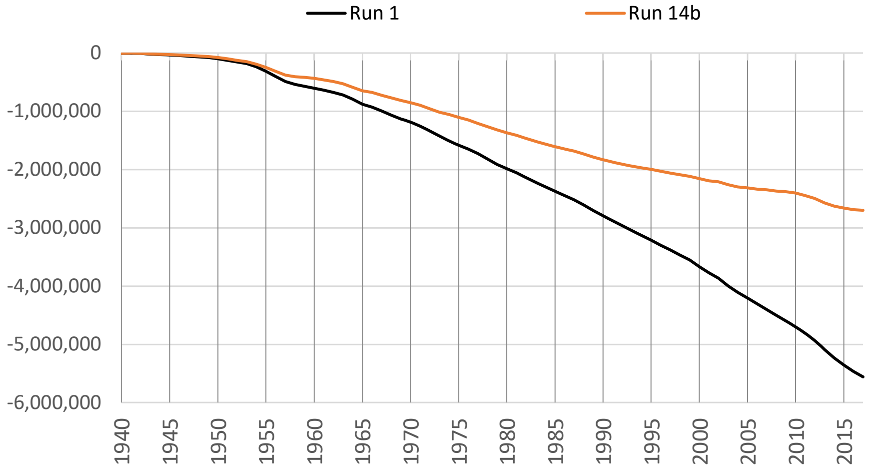
Hueco Alluvial Aquifer



Rincon-Mesilla Non-Alluvial Aquifer



Hueco Non-Alluvial Aquifer



***Note different scales.**

Run 14b - MX Hueco Pumping Off

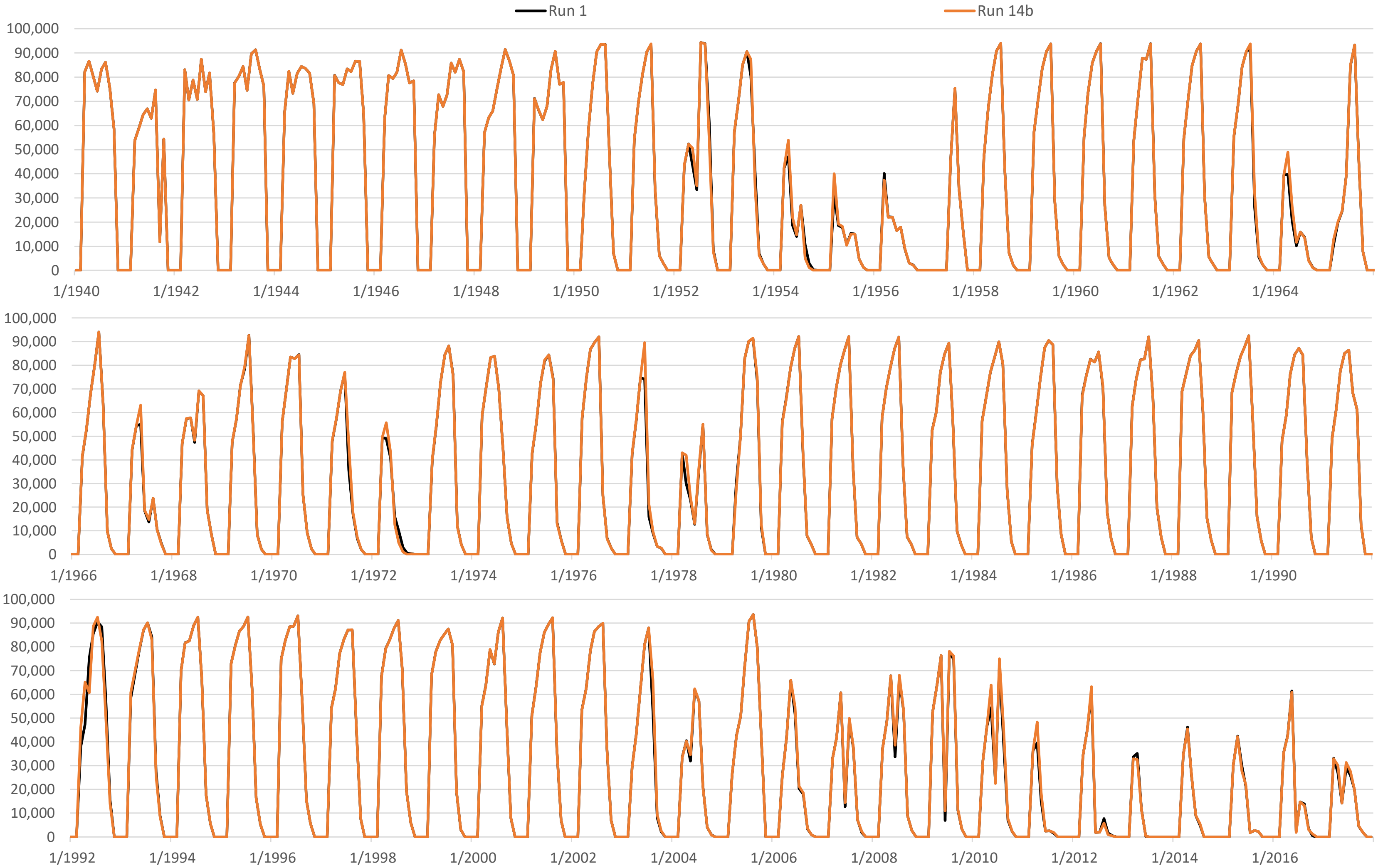
Monthly Net RHG Diversions

Run 14b v. Run 1

ILRG Model

1940 - 2017 (acre-feet)

EBID Total



Note: EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).

Run 14b - MX Hueco Pumping Off

Monthly Net RHG Diversions

Run 14b v. Run 1

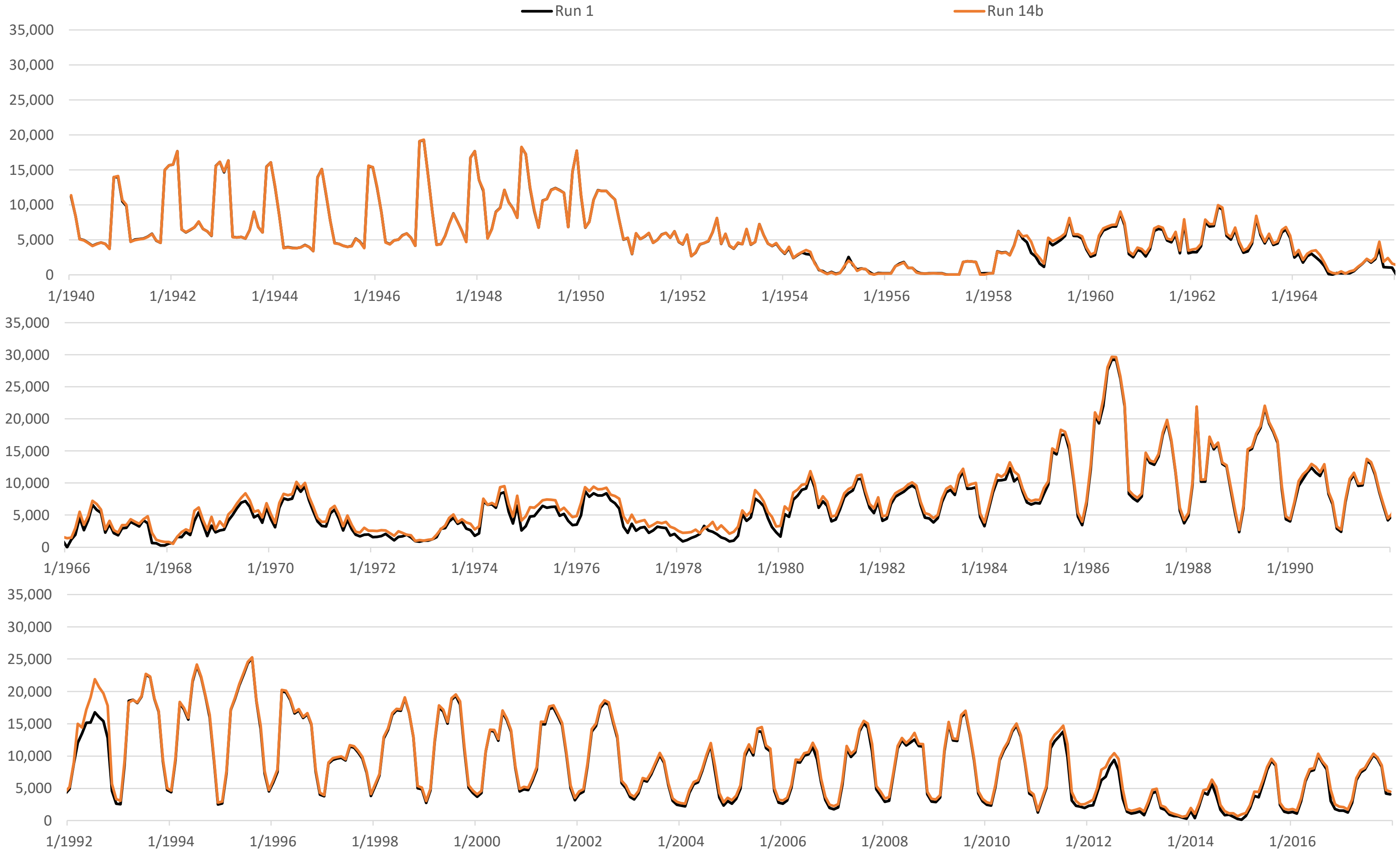
ILRG Model

1940 - 2017 (acre-feet)

EPCWID Total

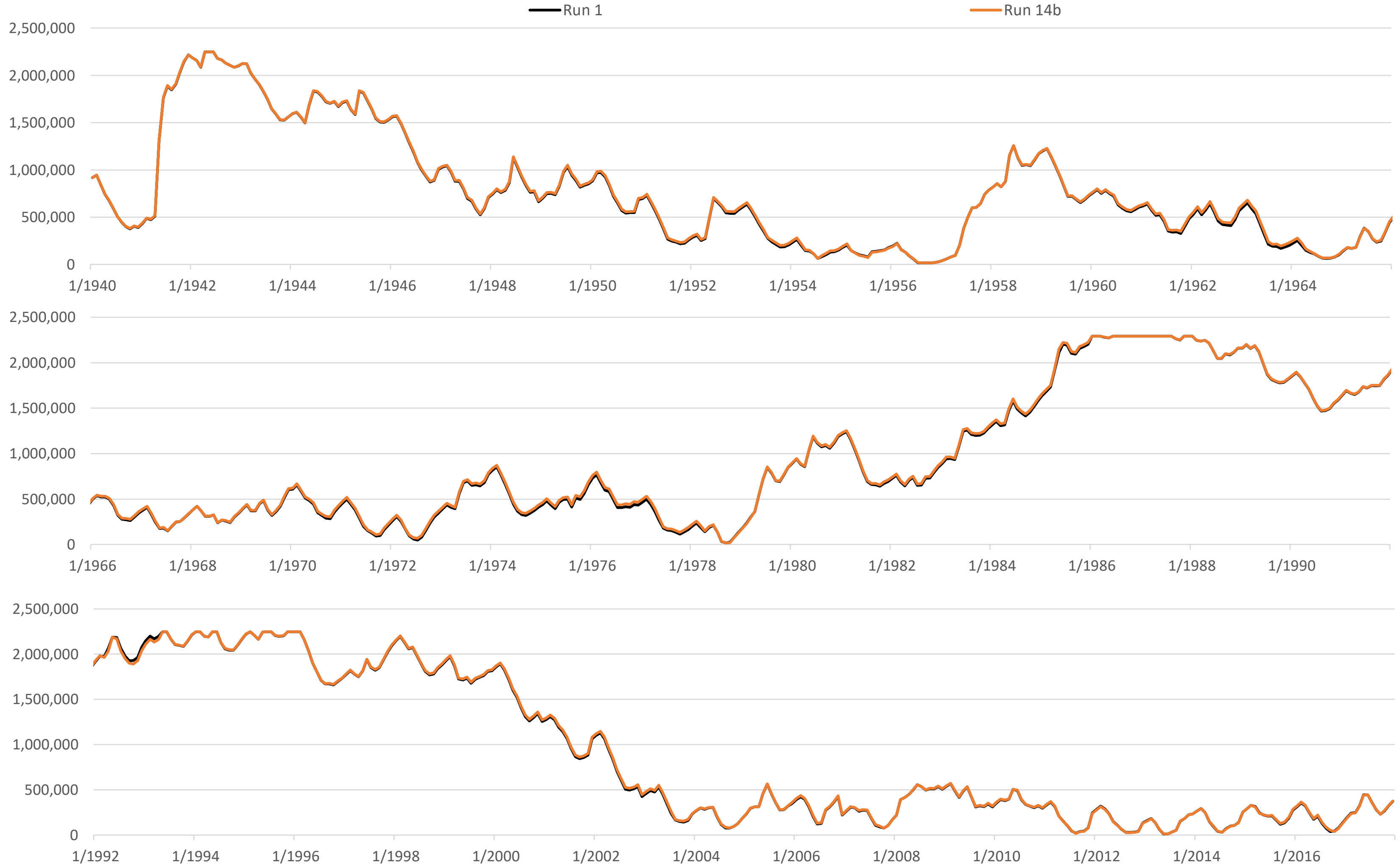
Note: EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

Run 14b - MX Hueco Pumping Off
Monthly Net RHG Diversions
Run 14b v. Run 1
ILRG Model
1940 - 2017 (acre-feet)
HCCRD Total



Note: HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

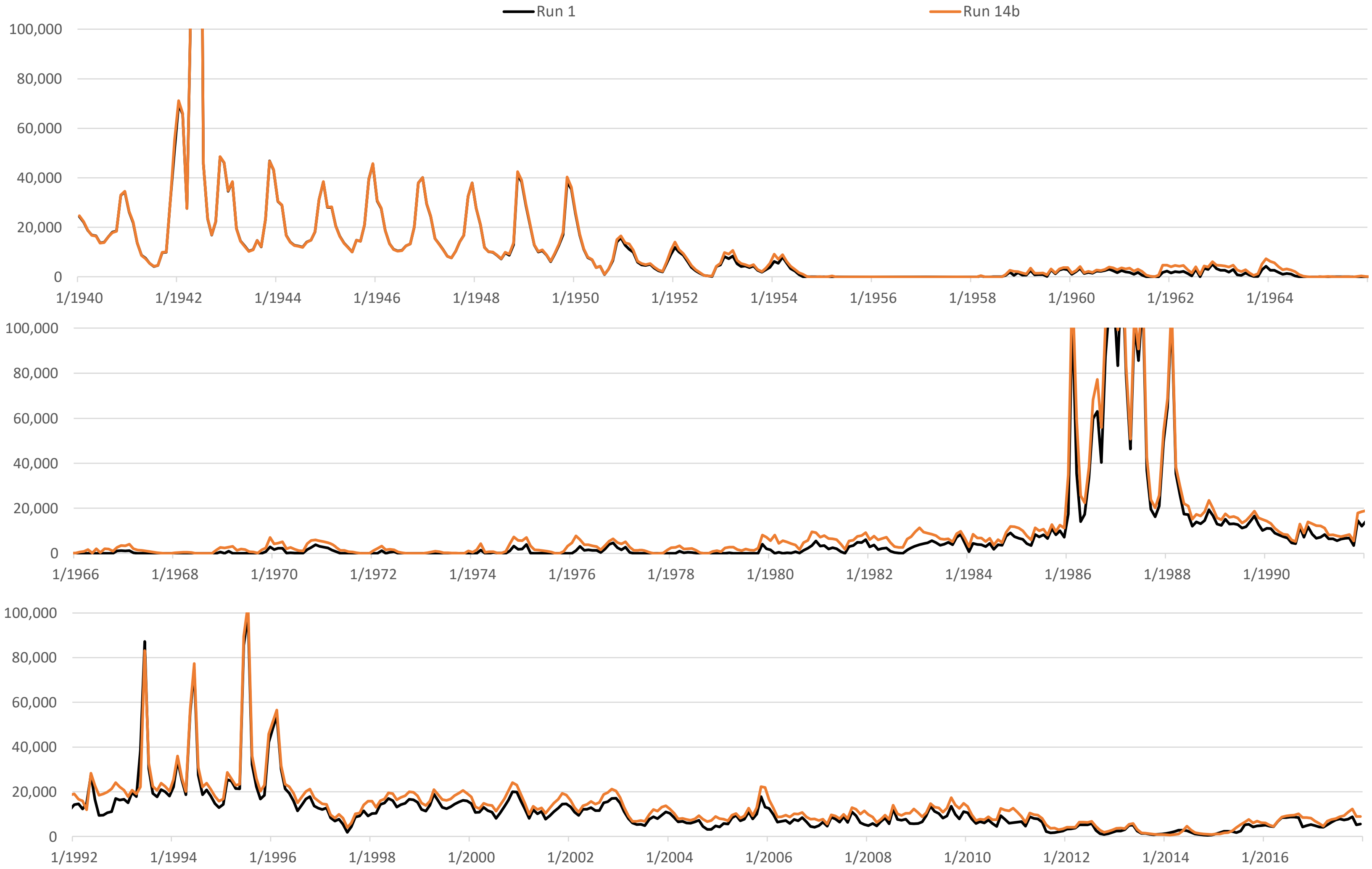
Run 14b - MX Hueco Pumping Off
End of Month Reservoir Storage (Elephant Butte + Caballo)
Run 14b v. Run 1
ILRG Model
1940 - 2017 (acre-feet)



Run 14b - MX Hueco Pumping Off
Monthly Caballo Releases
Run 14b v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

Run 14b - MX Hueco Pumping Off
Monthly Rio Grande at El Paso Flow
Run 14b v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

Run 14b - MX Hueco Pumping Off
Monthly Rio Grande at Fort Quitman Flow
Run 14b v. Run 1
ILRG Model
1940 - 2017 (acre-feet)



Appendix 30Q

Comparison of ILRG Model Runs

Run 14c v. Run 1

Model Run Specifications

Model Version:	LRG_v116

Name:	**Run 14c - TX WWTP Discharges Off**
Run ID:	LRG_v116_Operational_Run14c
Date:	8/25/2020
Name:	**Run 1 - Historical Base Run (All Pumping On)**
Run ID:	LRG_v116_Operational_Run1
Date:	8/23/2020

Selected Model Inputs

Pumping and Returns	**Run 14c**	**Run 1**
Irrigation Pumping	On	On
Irrigated Area	Hist	Hist
Non-Irrigation Pumping	On	On
Non-Irrigation Pumping Returns	TX Off	On
Las Cruces Jornada Pumping Returns	On	On

Project Allocation Rules		
1950-2005	D1/D2	D1/D2
2006-2007	D3	D3
2008-2017	D3 + CO	D3 + CO

EPCWID Operations		
Charge EPCWID for Use of WWTP Returns	Off	Off
ACE and Haskell Credits for EPCWID	On	On
Increased EPCWID Use of Fabens Drain Flows	Off	Off
Charge EPCWID for Fabens Drain Flow Use	Off	Off

Run 14c - TX WWTP Discharges Off
Comparison of ILRG Model Runs
Run 14c v. Run 1
1951 - 2017 Annual Average
(1,000 acre-feet)

Run No.	1	14c	14c - 1		
Simulated Input or Output	**Run 1**	**Run 14c**	**Run 14c minus Run 1**		
Pumping Stress					
WWTP Flows	58.0	29.5	-28.5		
Total Stress	-58.0	-29.5	28.5		
	Stress is Pumping minus WWTP and Urban Deep Perc				
Effects of Pumping Stress				***% Chg***	
FHG Deliveries (Mar - Oct)				***Stress***	***% Diff.***
EBID	167.6	161.0	-6.6	*-23%*	*-4%*
EPCWID (incl. EPW)	139.9	130.4	-9.5	*-33%*	*-7%*
HCCRD	32.8	32.4	-0.5	*-2%*	*-1%*
Total	340.3	323.8	-16.5	*-58%*	*-5%*
FHG Deliveries (Nov - Feb)					
EBID	0.0	0.0	0.0	*0%*	*5%*
EPCWID (incl. EPW)	0.2	0.1	-0.1	*0%*	*-48%*
HCCRD	2.4	1.9	-0.5	*-2%*	*-22%*
Total	2.6	2.0	-0.6	*-2%*	*-24%*
Irrigation Pumping					
EBID	140.4	146.7	6.3	*22%*	*4%*
EPCWID (Mesilla Valley)	7.4	7.9	0.5	*2%*	*7%*
EPCWID (El Paso Valley)	40.1	47.3	7.2	*25%*	*18%*
HCCRD	4.2	4.9	0.7	*2%*	*16%*
Total	192.1	206.7	14.6	*51%*	*8%*
	Pumping turned off.	*Other values are simulated responses and are totaled.*			
Other Inflows/Outflows					
Net Reservoir Evaporation	125.3	118.5	-6.8	*-24%*	*-5%*
Riparian ET	70.9	68.2	-2.7	*-9%*	*-4%*
River Evaporation + Incidental Canal Loss	30.3	29.2	-1.1	*-4%*	*-4%*
Total	226.6	216.0	-10.5	*-37%*	*-5%*
Rio Grande at Fort Quitman					
Reservoir Spills	33.3	21.8	-11.5	*-40%*	*-35%*
Nov-Feb Flows	21.4	14.1	-7.3	*-26%*	*-34%*
Mar - Oct Flows	41.1	35.4	-5.7	*-20%*	*-14%*
Underflow (GW Model)	0.2	0.2	0.0	*0%*	*-10%*
Total	96.0	71.4	-24.5	*-86%*	*-26%*

Run 14c - TX WWTP Discharges Off
Comparison of ILRG Model Runs
Run 14c v. Run 1
1951 - 2017 Annual Average
(1,000 acre-feet)

Run No.	1	14c	14c - 1		
Simulated Input or Output	**Run 1**	**Run 14c**	**Run 14c minus Run 1**		
Effects of Pumping Stress (continued)				*% Chg*	
Change in Storage				***Stress***	***% Diff.***
Reservoir Storage	-4.7	-4.6	0.1	*0%*	*-1%*
Alluvial GW Storage (RW Model)	-23.6	-26.1	-2.5	*-9%*	*11%*
Non-alluvial GW Storage (GW Models)	-96.4	-100.6	-4.3	*-15%*	*4%*
Soil Moisture Storage	0.6	0.5	-0.1	*0%*	*-17%*
Total	-124.0	-130.8	-6.8	*-24%*	*6%*
Summary of Effects					
FHG Deliveries (Mar-Oct)	340.3	323.8	-16.5	*-58%*	*-5%*
FHG Deliveries (Nov-Feb)	2.6	2.0	-0.6	*-2%*	*-24%*
Irrigation Pumping	192.1	206.7	14.6	*51%*	*8%*
Riparian ET + Evaporation	226.6	216.0	-10.5	*-37%*	*-5%*
Fort Quitman Flow	96.0	71.4	-24.5	*-86%*	*-26%*
Change in Storage	-124.0	-130.8	-6.8	*-24%*	*6%*
Total	733.6	689.1	-44.5	*-156%*	*-6%*
Other Effects of Pumping Stress				*% Chg*	
Rio Grande at El Paso				***Stress***	***% Diff.***
Reservoir Spills	49.4	36.1	-13.3	*-46%*	*-27%*
Nov-Feb Flows	22.8	23.2	0.4	*2%*	*2%*
Mar - Oct Flows	263.8	285.4	21.7	*76%*	*8%*
Total	336.0	344.8	8.8	*31%*	*3%*
Rio Grande below Caballo					
Reservoir Spills	65.9	46.8	-19.1	*-67%*	*-29%*
Nov-Feb Flows	0.5	0.9	0.4	*1%*	*84%*
Mar - Oct Flows	541.3	566.4	25.2	*88%*	*5%*
Total	607.6	614.1	6.5	*23%*	*1%*
Surface Water Diversions (Mar - Oct)					
EBID	366.5	351.9	-14.6	*-51%*	*-4%*
EPCWID (incl. EPW)	236.8	239.4	2.6	*9%*	*1%*
HCCRD	67.5	64.2	-3.4	*-12%*	*-5%*
Total	670.8	655.5	-15.4	*-54%*	*-2%*
Surface Water Diversions (Nov - Feb)					
EBID	0.0	0.0	0.0	*0%*	*0%*
EPCWID (incl. EPW)	14.3	11.2	-3.2	*-11%*	*-22%*
HCCRD	14.2	10.8	-3.4	*-12%*	*-24%*
Total	28.5	22.0	-6.6	*-23%*	*-23%*

Run 14c - TX WWTP Discharges Off

Annual Differences in ILRG Model Outputs

Run 14c minus Run 1

1940 - 2017 (acre-feet)

	Net River Headgate Diversions						Farm Headgate Deliveries						Annual Flows		
	EBID		EPCWID (incl. EPW)		HCCRD		EBID		EPCWID (incl. EPW)		HCCRD				
Year	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Caballo Releases	Rio Grande at El Paso	Rio Grande at Fort Quitman
1940	-50	-50	194	-829	406	-216	20	20	-808	-808	370	370	6,635	6,248	-505
1941	21	21	867	-791	253	-418	-2	-6	-4	-251	192	78	-24,426	-16,414	-17,465
1942	3	3	612	-865	-347	-417	-9	-11	514	-201	-345	-374	22,247	14,366	-3,098
1943	-35	-35	562	-1,191	-270	-676	-30	-30	434	191	-80	-532	8,940	8,503	-1,619
1944	20	20	776	-344	708	251	115	116	-906	-1,118	596	301	10,757	10,368	-912
1945	-97	-97	798	-832	764	126	41	41	-1,171	-1,572	696	595	10,773	10,525	-684
1946	-45	-45	1,217	-2,037	801	-170	60	61	-735	-2,113	726	642	10,262	10,125	46
1947	-72	-72	2,109	-546	775	-202	-4	-3	69	-744	658	719	11,010	10,795	455
1948	-9	-9	1,441	-64	936	366	78	78	-596	-1,072	421	199	10,114	9,962	310
1949	-100	-100	641	-1,704	695	-335	25	26	-1,262	-1,286	-63	-150	9,742	9,621	-591
1950	-11	-11	909	65	755	194	47	48	-961	-961	-47	-83	8,553	8,408	-1,988
1951	-37,046	-37,046	-650	-647	371	286	-21,655	-21,657	-2,050	-2,057	284	216	-9,990	4,928	-2,044
1952	-728	-728	-25	-997	-193	-782	-362	-357	-965	-963	-175	-272	23,174	13,772	-1,646
1953	-34,188	-34,188	-910	-905	220	138	-22,028	-22,028	-2,282	-2,285	122	78	-8,111	6,593	1,536
1954	-26,125	-26,125	-19,375	-22,941	-3,136	-4,237	-15,499	-15,499	-15,650	-15,656	-3,030	-3,965	-26,235	-18,163	-4,626
1955	-8,276	-8,276	-6,482	-11,427	-822	-1,299	-4,970	-4,970	-6,509	-6,737	-1,224	-1,646	4,238	-1,641	-1
1956	-10,015	-10,015	-12,551	-16,894	-720	-1,600	-5,197	-5,197	-7,895	-8,700	-615	-1,426	-15,535	-6,830	-100
1957	-38	-38	-1,036	-5,875	58	-626	-81	-81	-1,420	-1,866	630	-5	6,050	4,076	-1
1958	18	18	7,263	5,086	1,858	74	-171	-171	408	308	-857	-1,264	30,615	21,242	1,949
1959	5	5	2,273	1,139	-1,544	-3,247	-45	-45	-1,288	-1,289	328	533	18,600	15,664	-3,753
1960	0	0	1,613	257	-360	-1,762	-3	-3	-1,863	-1,863	0	0	21,678	20,060	-2,397
1961	3	3	1,465	-57	-8	-2,082	3	3	-2,319	-2,319	82	-198	18,204	17,190	-2,613
1962	-1,538	-1,538	-35,465	-36,870	-10,934	-12,577	10,396	10,397	-15,676	-15,668	1,783	2,546	-8,679	-19,502	-15,894
1963	-40,855	-40,855	3,500	2,009	-86	-1,625	-23,174	-23,174	-926	-926	248	420	-1,199	19,427	-1,572
1964	-32,204	-32,204	-24,316	-30,140	-1,927	-3,782	-18,705	-18,705	-20,189	-20,565	-1,738	-1,808	-24,525	-14,570	-5,467
1965	-16,682	-16,682	-9,676	-16,358	-5	-2,008	-4,833	-4,833	-4,680	-5,121	1,418	33	1,242	5,159	-34
1966	73	73	3,300	-539	-3,945	-5,678	-565	-565	-168	-172	-3,987	-3,508	31,887	20,565	-2,403
1967	-34,915	-34,915	-25,959	-31,062	-5,545	-8,501	-13,324	-13,324	-20,556	-20,885	-6,072	-5,578	-35,878	-16,077	-2,238
1968	-6,353	-6,353	12,308	8,431	-2,629	-4,873	-5,080	-5,080	-2,204	-2,405	-1,844	-3,014	43,397	26,236	-664
1969	-155	-155	9,236	7,711	169	-3,336	-3,210	-3,209	179	180	107	-1,348	34,330	25,665	-2,126
1970	-57	-57	9,009	6,934	1,007	-2,614	146	146	-1,118	-1,116	-680	-952	25,644	25,614	-1,620
1971	-61,509	-61,509	-30,235	-38,826	-2,177	-8,003	-36,463	-36,463	-29,564	-29,279	-727	-3,502	-69,997	-26,948	-2,844
1972	-4,623	-4,623	-3,693	-12,812	-5,313	-10,200	-4,116	-4,116	-12,382	-12,286	-5,047	-8,722	16,600	1,217	-1,751
1973	103	103	20,136	15,964	1,296	-5,365	-509	-509	-1,398	-1,560	2,012	-3,946	53,960	39,514	117
1974	35	35	17,691	15,832	5,082	1,669	-140	-140	-755	-757	3,258	-101	46,029	40,051	1,346
1975	-1,388	-1,388	16,203	14,384	2,265	163	-8,520	-8,516	204	211	2,140	2,070	47,680	34,566	-1,706
1976	-67	-67	18,080	16,950	4,213	940	147	148	-453	-453	-42	-138	32,646	38,665	1,768
1977	-112,651	-112,651	-55,845	-63,016	-5,621	-10,873	-54,465	-54,465	-44,989	-44,998	-3,974	-6,636	-150,337	-56,825	-1,651
1978	3,766	3,766	-16,186	-27,310	-4,608	-9,528	2,046	2,046	-23,175	-22,954	-2,456	-5,221	29,237	-8,976	-1,657

Run 14c - TX WWTP Discharges Off
Annual Differences in ILRG Model Outputs
Run 14c minus Run 1
1940 - 2017 (acre-feet)

	Net River Headgate Diversions						Farm Headgate Deliveries						Annual Flows		
	EBID		EPCWID (incl. EPW)		HCCRD		EBID		EPCWID (incl. EPW)		HCCRD				
Year	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Caballo Releases	Rio Grande at El Paso	Rio Grande at Fort Quitman
1979	-1,656	-1,656	10,543	5,216	-3,061	-5,523	-2,549	-2,547	-10,467	-10,475	-1,324	-2,866	59,724	35,460	-3,621
1980	28	28	23,797	21,567	1,389	-5,196	-297	-297	8	1	1,286	-2,339	62,012	52,711	-4,096
1981	25	25	23,696	21,982	-322	-8,169	-260	-260	-34	-36	0	0	57,536	52,481	-8,777
1982	-1	-1	23,084	21,211	-819	-7,184	-27	-27	-201	-202	96	298	56,364	53,032	-7,822
1983	-14	-14	23,187	21,210	-163	-6,257	36	36	-38	-39	0	0	56,515	53,818	-7,140
1984	44	44	24,806	22,888	2,831	-2,876	-164	-164	-14	-15	71	71	52,752	50,532	-5,929
1985	1,558	1,558	31,725	30,665	-18,091	-22,530	7,406	7,406	4,811	4,726	0	0	20,156	16,944	-26,390
1986	-89	-89	25,787	25,183	-8,859	-17,339	-1,125	-1,141	-404	-426	0	0	-273,089	-264,279	-235,939
1987	-45	-45	28,585	28,514	5,567	1,618	-143	-145	-4	-7	0	0	258	-1,494	-184,789
1988	-18	-18	29,631	29,561	6,354	2,335	97	97	3	2	0	0	48,393	41,238	-52,483
1989	-36	-36	32,704	32,333	7,505	4,080	230	231	353	-26	0	0	75,980	71,335	6,320
1990	-33	-33	30,874	29,234	6,084	2,121	279	279	317	-199	0	0	51,177	51,158	-7,490
1991	-114	-114	19,035	17,978	1,069	-1,947	-803	-802	17	-779	0	0	52,095	49,961	-15,589
1992	2,874	2,874	24,795	24,489	-16,414	-19,156	13,519	13,518	5,599	5,258	0	0	-20,156	-23,804	-76,604
1993	-4,360	-4,360	-76,454	-76,459	-42,179	-46,094	10,345	10,357	-41,644	-41,627	0	0	-118,319	-123,399	-167,945
1994	-1,384	-1,384	7,204	7,199	-1,107	-5,179	277	278	-3,747	-3,745	0	0	-26,045	-15,137	-77,581
1995	-790	-790	6,044	5,968	-1,333	-5,595	235	235	-2,269	-2,331	0	0	-4,698	-3,494	-72,264
1996	41	41	15,703	15,653	2,774	-77	-170	-170	-25	-26	0	0	58,274	51,084	-18,491
1997	119	119	30,499	27,186	3,231	-501	-783	-783	-690	-1,710	0	0	72,538	69,078	-5,976
1998	74	74	20,306	19,073	-24,759	-28,857	12,310	12,309	-4,269	-4,271	0	0	-12,032	-9,352	-60,817
1999	-15,445	-15,445	-11,202	-14,404	784	-1,516	8,954	8,957	-18,794	-18,806	0	0	0	-319	-43,854
2000	-20,572	-20,572	13,598	9,230	4,401	2,661	-3,583	-3,580	-13,992	-14,028	0	0	11,450	24,072	-32,501
2001	-774	-774	42,509	37,273	8,572	7,240	-52	-52	9,326	9,308	0	0	61,817	54,189	-16,180
2002	-1,214	-1,214	19,102	15,590	3,642	2,431	-201	-201	3,702	3,699	0	0	34,086	32,821	-29,897
2003	-188,305	-188,305	-92,535	-97,137	-16,577	-21,405	-107,496	-107,496	-74,909	-74,941	0	0	-195,008	-99,545	-48,119
2004	35,509	35,509	14,477	9,466	-3,230	-8,540	22,730	22,730	-7,171	-7,197	0	0	99,456	37,140	-42,229
2005	-56,707	-56,707	-17,429	-22,118	-18,579	-22,594	-28,839	-28,832	-32,076	-32,085	274	295	-684	1,121	-40,762
2006	-40,533	-40,533	-57,389	-62,537	-22,304	-27,418	-20,833	-20,833	-49,976	-49,993	-4	0	-80,528	-54,224	-47,743
2007	-28,056	-28,056	-13,151	-18,147	-15,772	-22,655	-12,140	-12,140	-28,253	-28,272	0	0	-5,704	-1,090	-42,495
2008	-27,517	-27,517	35,834	31,037	1,849	-845	-16,684	-16,684	-1,100	-1,117	0	0	63,164	51,090	-20,406
2009	-36,291	-36,291	23,087	17,872	3,996	2,628	-21,708	-21,708	-5,673	-5,688	0	0	37,550	38,016	-17,383
2010	-59,204	-59,204	19,316	13,810	3,597	2,740	-34,332	-34,332	-8,657	-8,676	0	0	19,625	30,061	-8,251
2011	-20,678	-20,678	-61,119	-65,450	-21,981	-26,808	-8,994	-8,994	-50,191	-50,201	-8,545	-8,710	-89,479	-56,010	-22,502
2012	-10,100	-10,100	4,267	-424	-13,495	-20,492	-4,638	-4,638	-11,406	-11,411	3,069	2,838	16,931	21,187	-27,109
2013	-8,550	-8,550	-12,048	-15,649	-7,001	-10,012	-3,844	-3,844	-18,854	-18,856	-4,781	-5,327	-4,692	2,126	-19,954
2014	-23,652	-23,652	7,212	3,034	-3,927	-6,633	-7,053	-7,053	-7,666	-7,668	-3,477	-5,068	3,476	21,276	-8,681
2015	-4,967	-4,967	-4,916	-8,898	-7,688	-11,130	3,415	3,415	-22,942	-22,945	121	8	3,043	10,550	-21,522
2016	-26,773	-26,773	-6,276	-10,585	-9,527	-14,946	-9,660	-9,660	-22,982	-22,988	724	746	-6,980	9,339	-46,820
2017	-14,154	-14,154	35,005	31,512	1,672	-1,801	-4,228	-4,228	-1,425	-1,429	635	58	61,116	51,973	-21,988
Averages															
1951-2017	-14,585	-14,585	2,590	-565	-3,357	-6,758	-6,584	-6,584	-9,484	-9,573	-476	-1,005	6,460	8,840	-24,536
1951-1978	-15,193	-15,193	-4,297	-7,928	-1,180	-3,619	-8,228	-8,227	-7,846	-7,935	-716	-1,691	4,812	7,524	-1,860
1979-2005	-9,307	-9,307	12,003	9,946	-3,751	-7,928	-2,595	-2,595	-6,912	-7,036	15	-168	10,391	9,531	-47,665
2006-2017	-25,040	-25,040	-2,515	-7,035	-7,548	-11,448	-11,725	-11,725	-19,094	-19,104	-1,021	-1,288	1,460	10,358	-25,404
1985-2017	-16,672	-16,672	4,993	2,123	-5,810	-9,582	-6,288	-6,288	-12,272	-12,378	-363	-459	-1,419	2,534	-47,104
1985-2005	-11,891	-11,891	9,284	7,356	-4,816	-8,516	-3,182	-3,181	-8,375	-8,534	13	14	-3,064	-1,937	-59,504

Notes:

EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).

EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

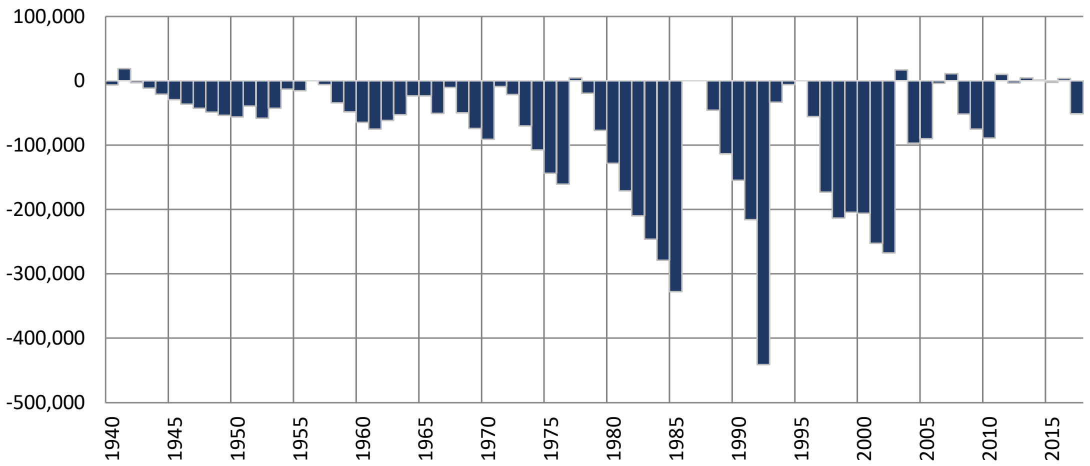
Run 14c - TX WWTP Discharges Off

Simulated Differences in ILRG Model Outputs

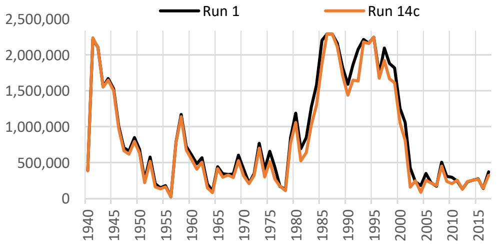
Run 14c minus Run 1

1940 - 2017 (acre-feet)

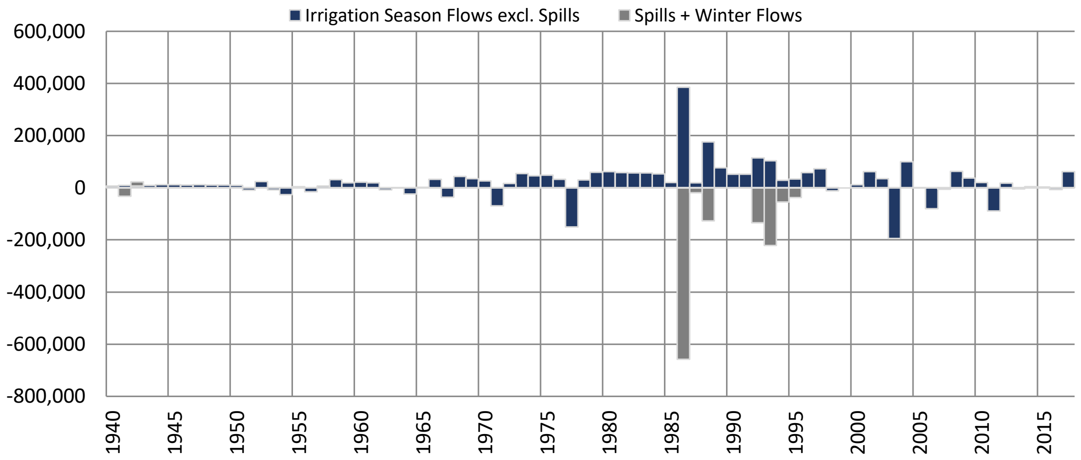
Total Project Storage (Year End)



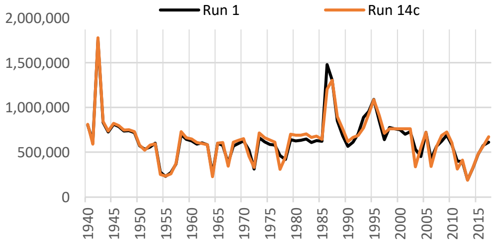
Period	Average Difference
1951-2017	69
1951-1978	1,312
1979-2005	-2,609
2006-2017	3,195
1985-2017	6,888
1985-2005	8,998



Caballo Reservoir Outflows (Annual)



	Average Difference		
Period	Irr Season (excl. Spills)	Nov-Feb and Spills	Annual
1951-2017	25,155	-18,695	6,460
1951-1978	4,812	0	4,812
1979-2005	56,782	-46,391	10,391
2006-2017	1,460	0	1,460
1985-2017	36,538	-37,957	-1,419
1985-2005	56,582	-59,646	-3,064



Notes:

Reservoir storage does not include storage attributed to SJC, CO, or NM credit waters.

Average differences calculated as (Final Storage - Initial Storage)/(no. years).

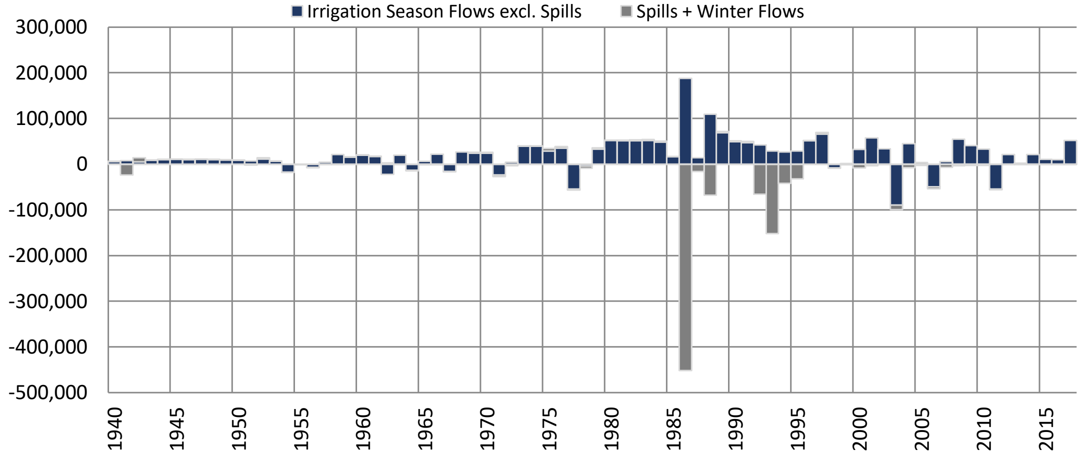
Run 14c - TX WWTP Discharges Off

Simulated Differences in ILRG Model Outputs

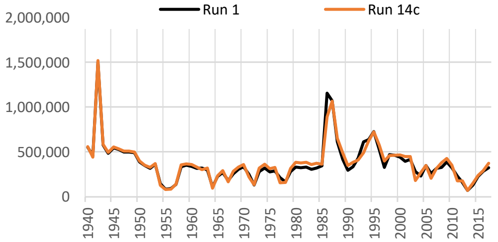
Run 14c minus Run 1

1940 - 2017 (acre-feet)

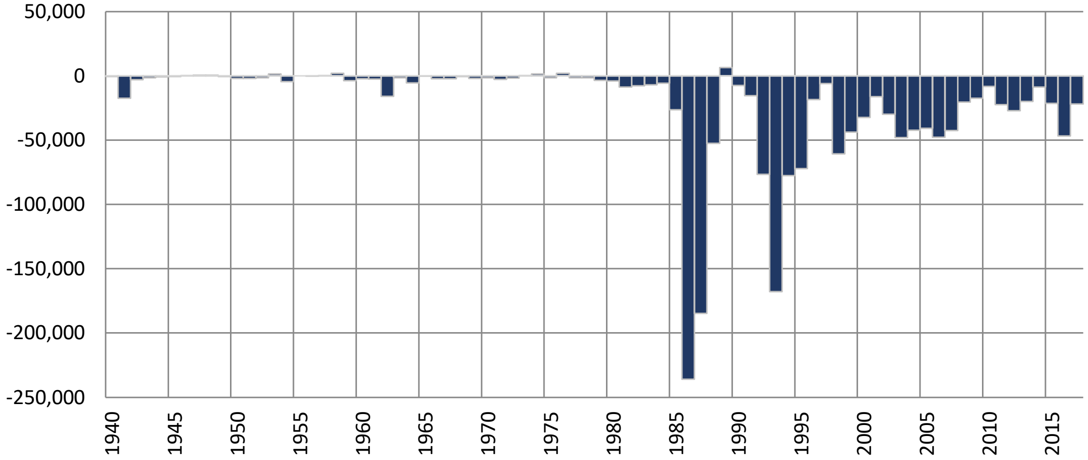
Rio Grande at El Paso (Annual)



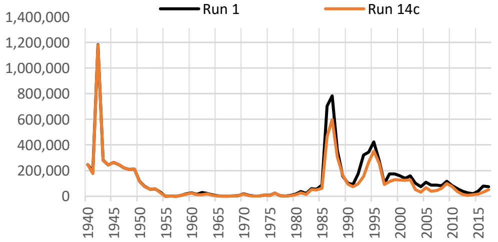
	Average Difference		
Period	Irr Season (excl. Spills)	Nov-Feb and Spills	Annual
1951-2017	21,653	-12,812	8,840
1951-1978	7,574	-50	7,524
1979-2005	40,433	-30,902	9,531
2006-2017	12,247	-1,889	10,358
1985-2017	28,828	-26,295	2,534
1985-2005	38,304	-40,241	-1,937



Rio Grande at Fort Quitman (Annual)



Period	Average Difference
1951-2017	-24,515
1951-1978	-1,845
1979-2005	-47,638
2006-2017	-25,387
1985-2017	-47,085
1985-2005	-59,484



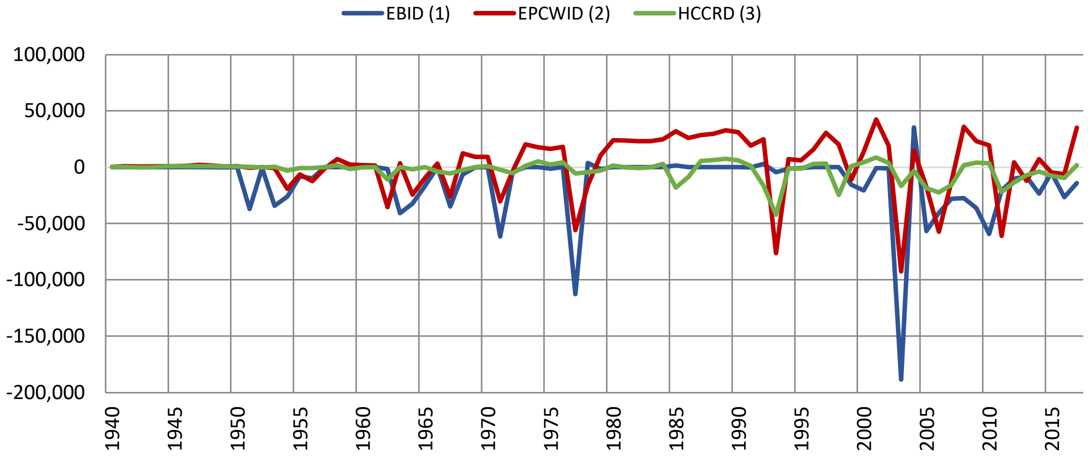
Run 14c - TX WWTP Discharges Off

Simulated Differences in ILRG Model Outputs

Run 14c minus Run 1

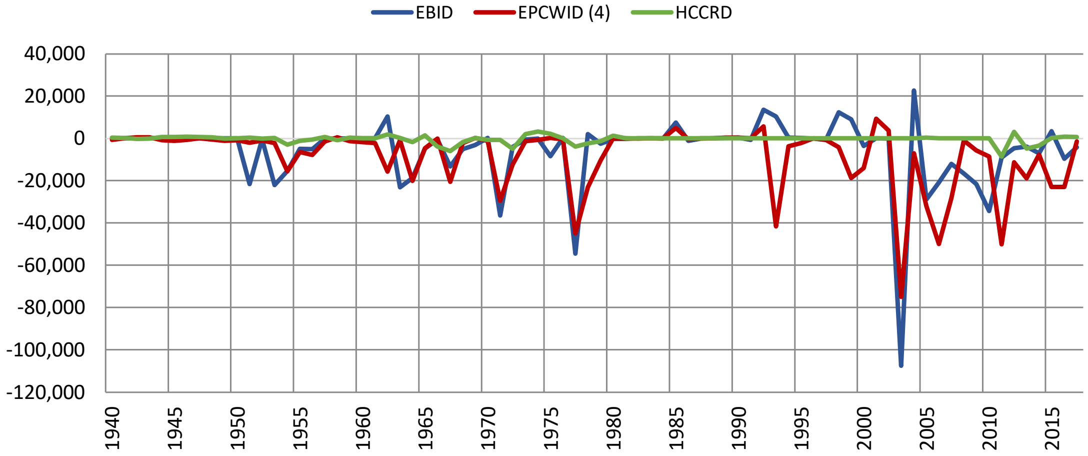
1940 - 2017 (acre-feet)

River Headgate (RHG) Diversions (Irrigation Season)



	Average Difference		
Period	EBID	EPCWID	HCCRD
1951-2017	-14,585	2,590	-3,357
1951-1978	-15,193	-4,297	-1,180
1979-2005	-9,307	12,003	-3,751
2006-2017	-25,040	-2,515	-7,548
1985-2017	-16,672	4,993	-5,810
1985-2005	-11,891	9,284	-4,816

Farm Headgate (FHG) Deliveries (Irrigation Season)



	Average Difference		
Period	EBID	EPCWID	HCCRD
1951-2017	-6,584	-9,484	-476
1951-1978	-8,228	-7,846	-716
1979-2005	-2,595	-6,912	15
2006-2017	-11,725	-19,094	-1,021
1985-2017	-6,288	-12,272	-363
1985-2005	-3,182	-8,375	13

Notes:

(1) EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).

(2) EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

(3) HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

(4) EPCWID FHG values include deliveries to Rogers WTP and R/U WTP.

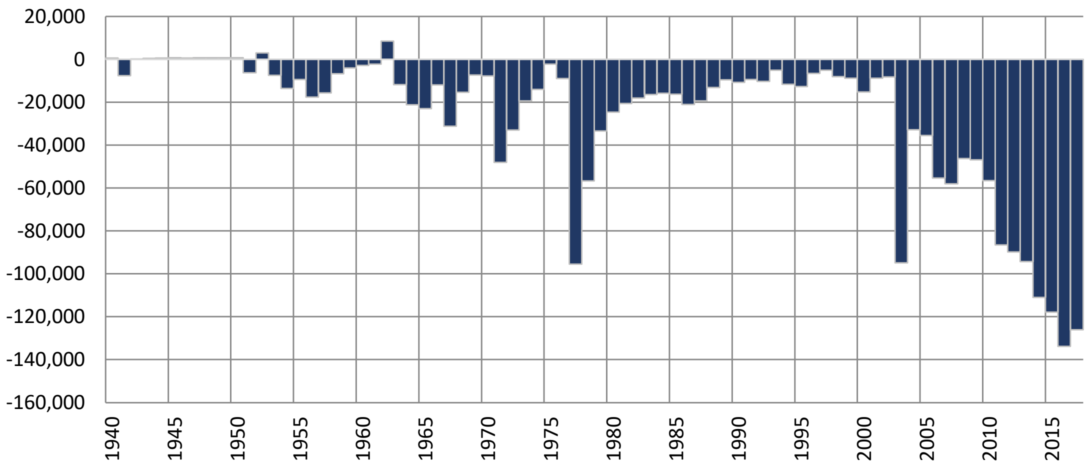
Run 14c - TX WWTP Discharges Off

Simulated Differences in ILRG Model Outputs

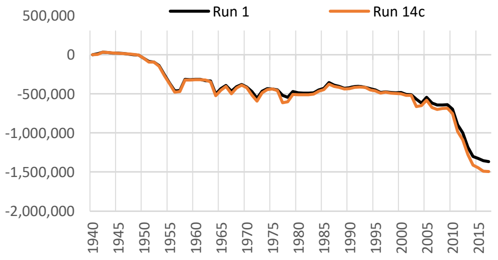
Run 14c minus Run 1

1940 - 2017 (acre-feet)

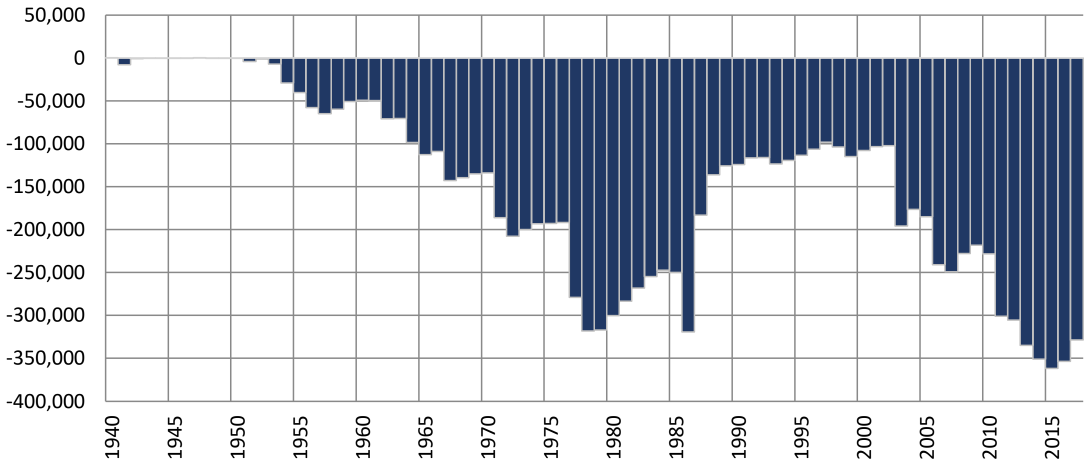
Cumulative Annual Rincon-Mesilla Groundwater Storage



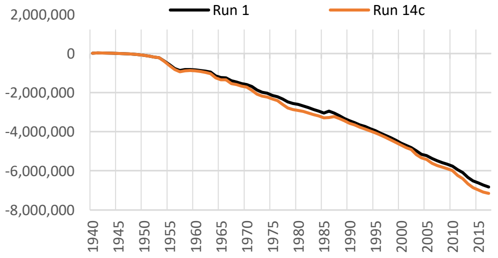
Period	Average Difference
1951-2017	-1,891
1951-1978	-2,049
1979-2005	782
2006-2017	-7,537
1985-2017	-3,336
1985-2005	-936



Cumulative Annual Hueco Groundwater Storage



Period	Average Difference
1951-2017	-4,896
1951-1978	-11,352
1979-2005	4,937
2006-2017	-11,956
1985-2017	-2,458
1985-2005	2,970

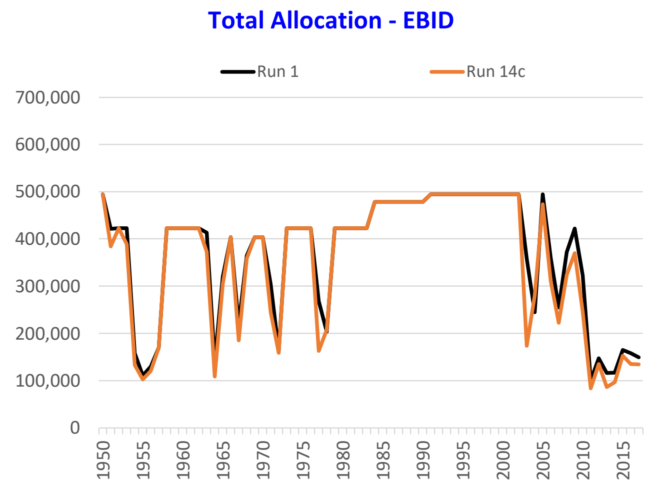


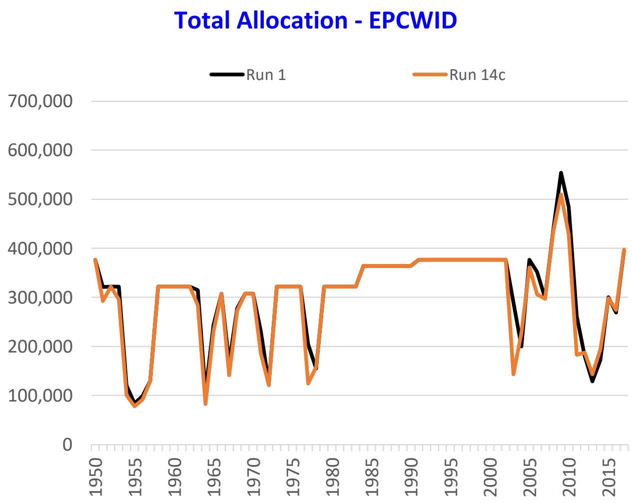
Notes:

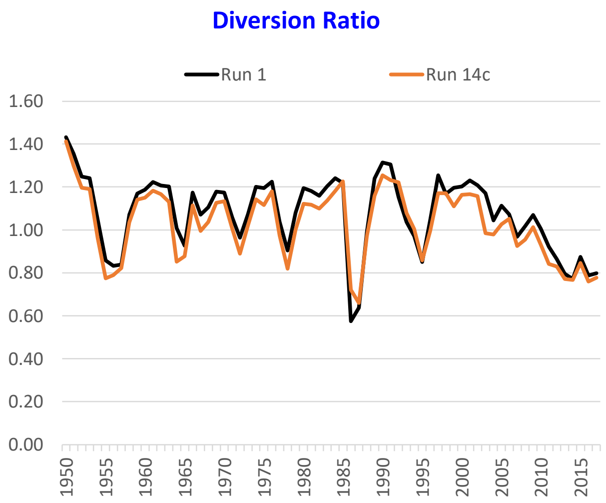
Cumulative storage change in alluvial and non-alluvial aquifers.

Average differences calculated as (Final Storage - Initial Storage)/(no. years).

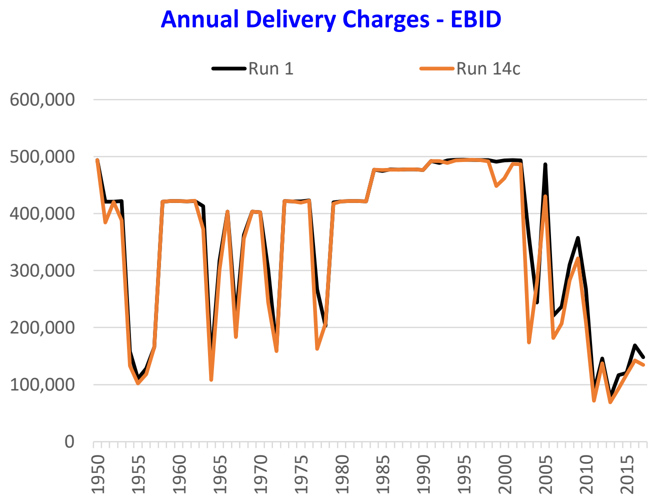
Run 14c - TX WWTP Discharges Off
Annual Allocation and Charges
Run 14c v. Run 1
ILRG Model
1950 - 2017 (acre-feet)

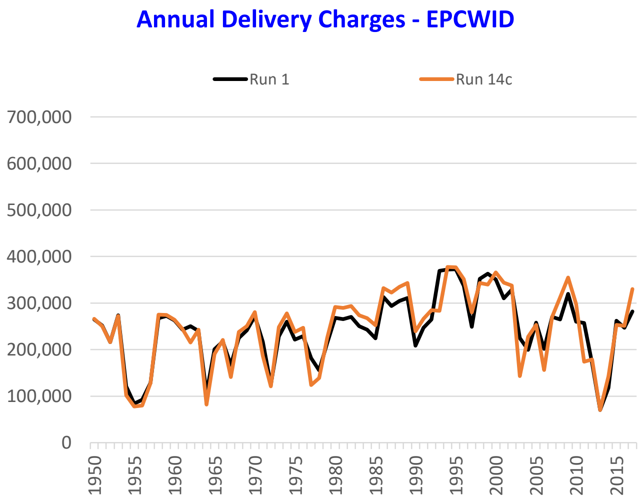

Total Allocation - EBID


Total Allocation - EPCWID

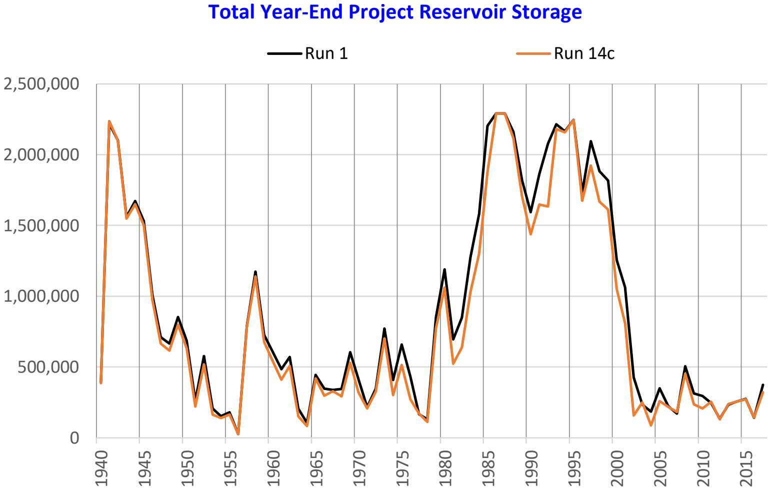

Diversion Ratio

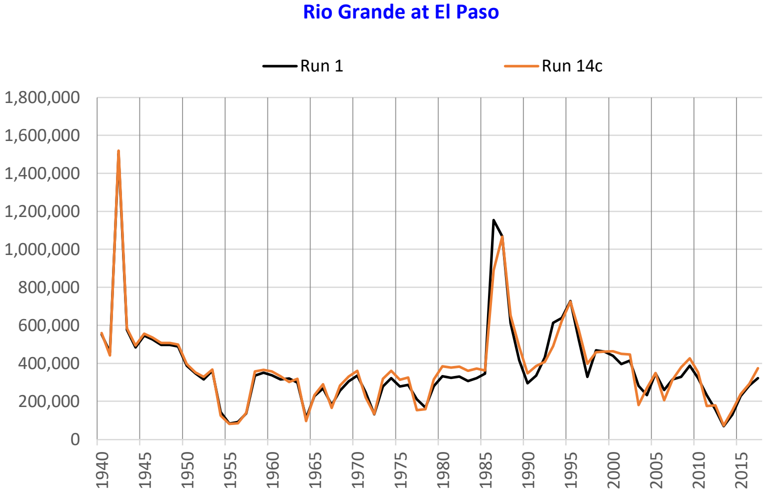
Note:
Computed as Total Charges/Caballo Release.

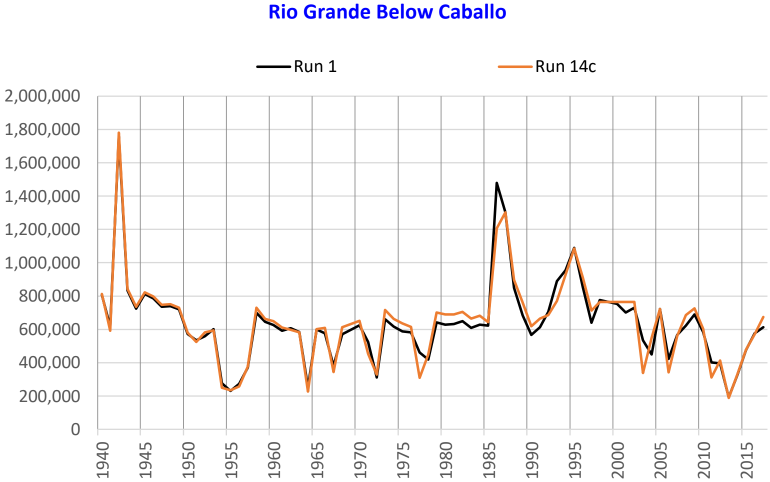

Annual Delivery Charges - EBID

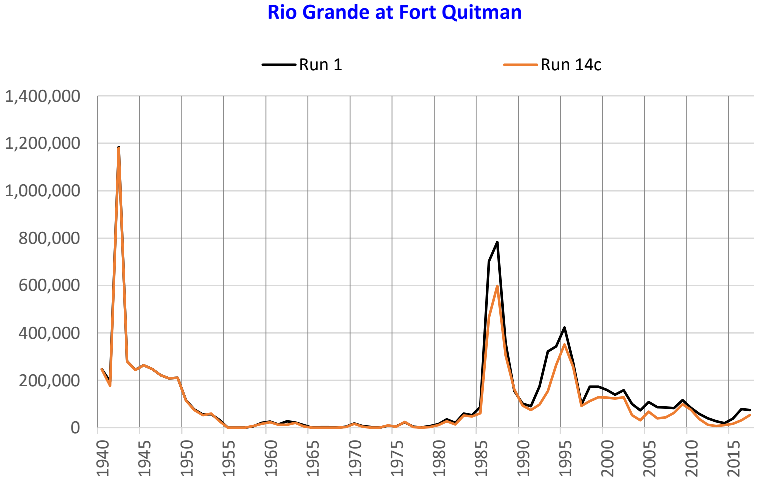

Annual Delivery Charges - EPCWID

Run 14c - TX WWTP Discharges Off
Annual Summary of Project Storage and Rio Grande Flows
Run 14c v. Run 1
ILRG Model
1940 - 2017 (acre-feet)







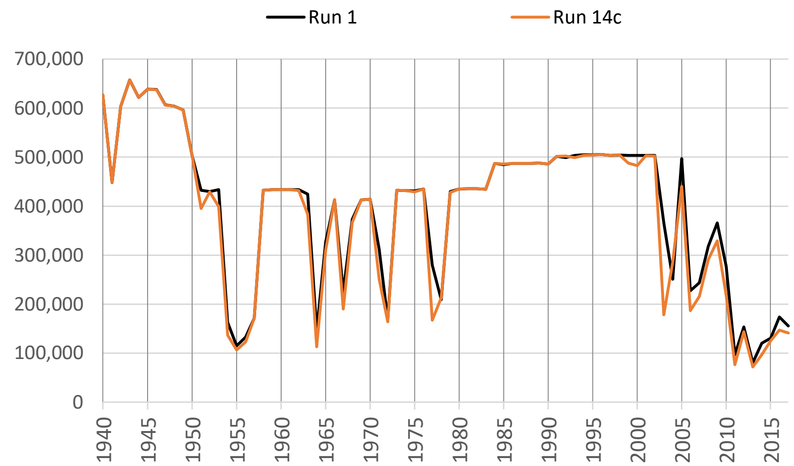


***Note different scales.**

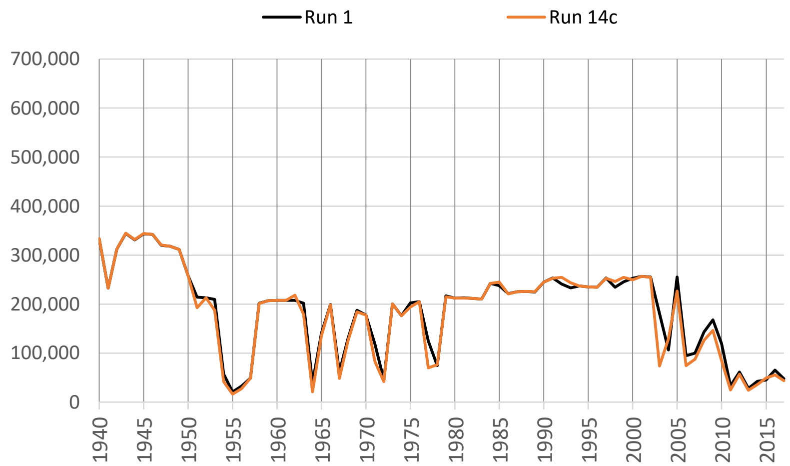
Run 14c - TX WWTP Discharges Off
Irrigation Season Summary of Irrigation Operations
Run 14c v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

EBID Total

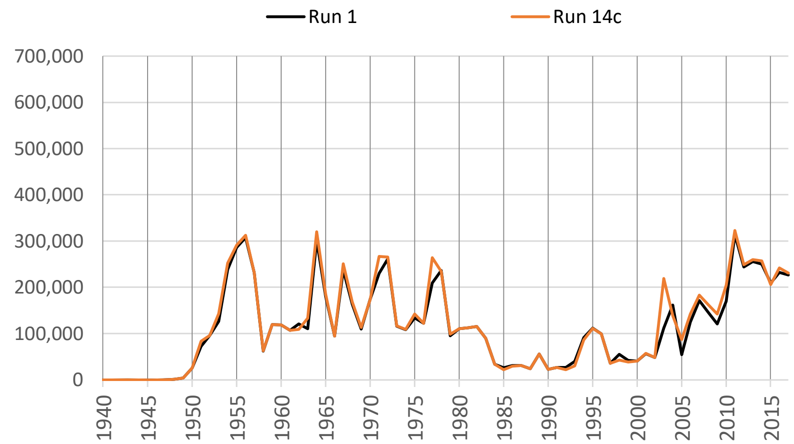
Net River Headgate Diversions



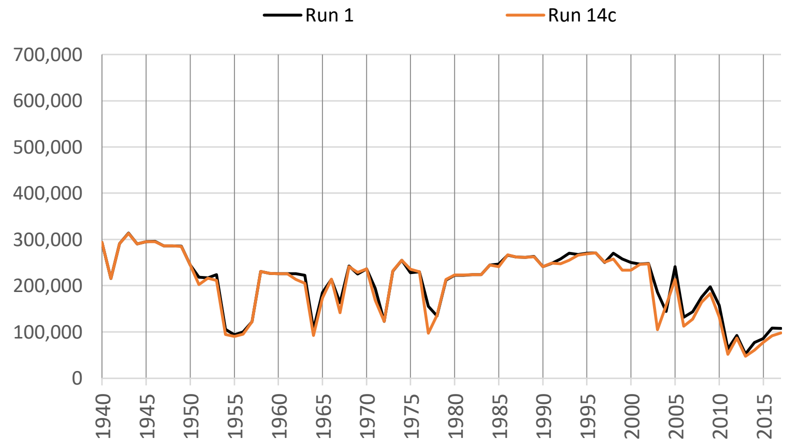
Farm Headgate Deliveries



Pumping



RHG Diversions - FHG Deliveries

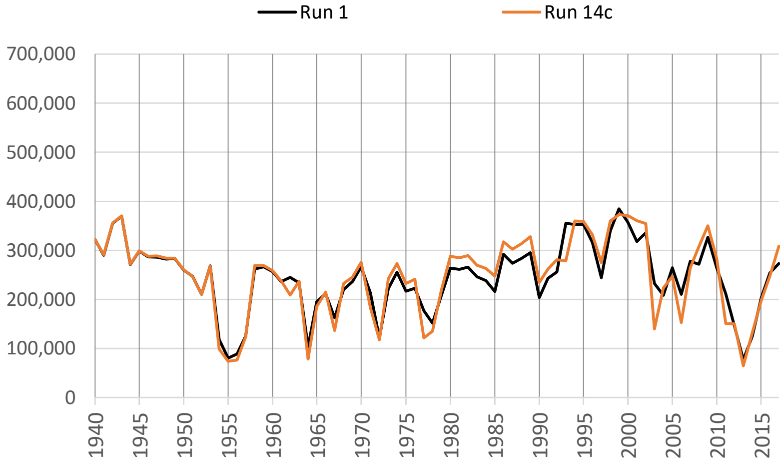


Notes: EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).
Pumping includes Supplemental and Primary groundwater pumping.

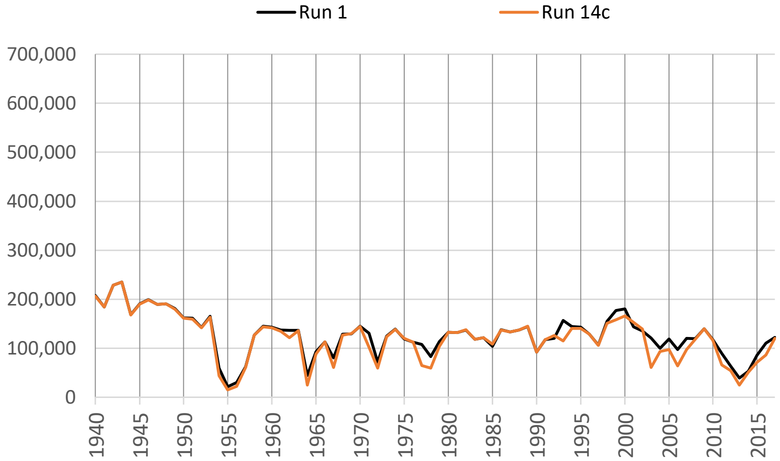
Run 14c - TX WWTP Discharges Off
Irrigation Season Summary of Irrigation Operations
Run 14c v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

EPCWID Total

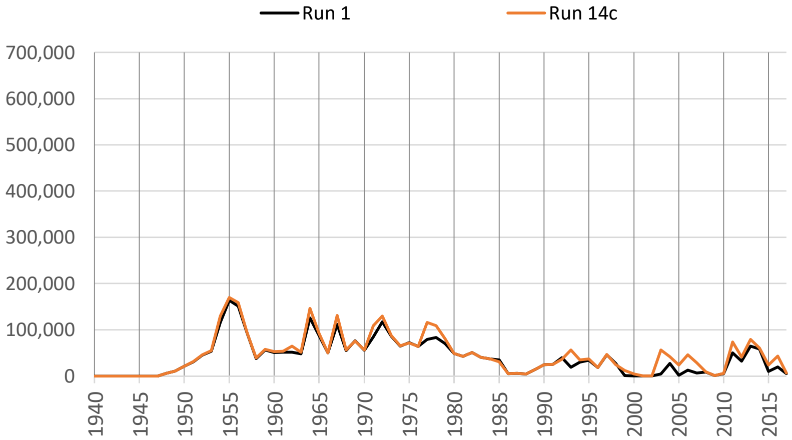
Net River Headgate Diversions



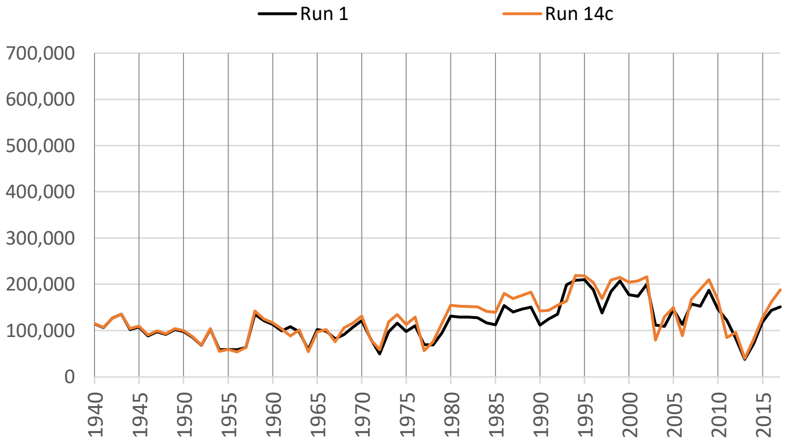
Farm Headgate Deliveries



Pumping



RHG Diversions - FHG Deliveries



Note: EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

Run 14c - TX WWTP Discharges Off

Irrigation Season Summary of Irrigation Operations

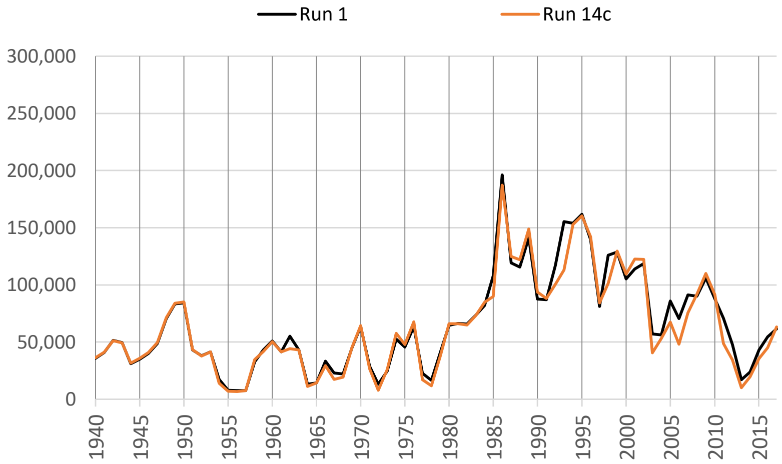
Run 14c v. Run 1

ILRG Model

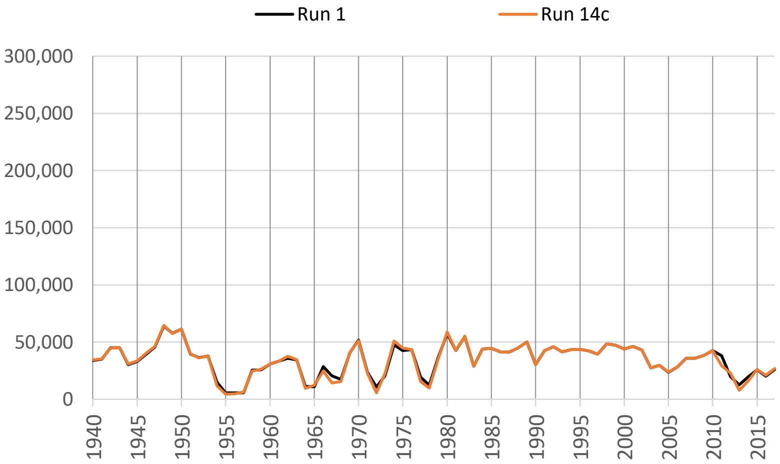
1940 - 2017 (acre-feet)

HCCRD Total

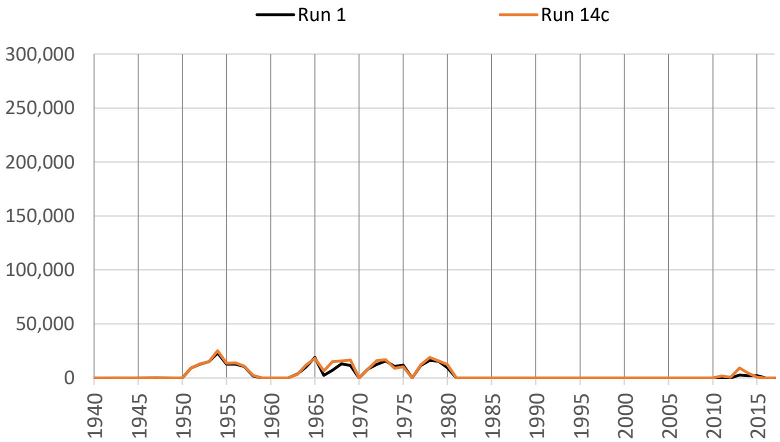
Net River Headgate Diversions



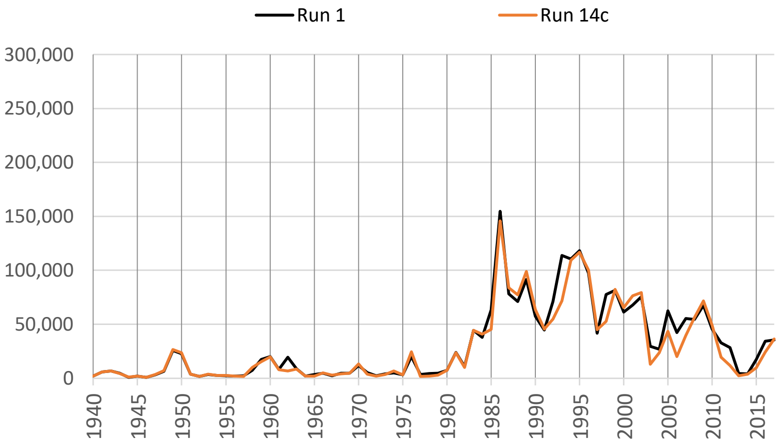
Farm Headgate Deliveries



Pumping



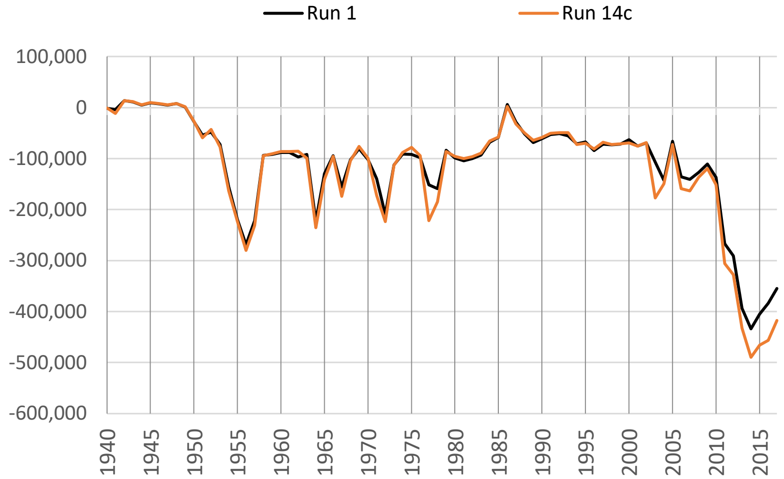
RHG Diversions - FHG Deliveries



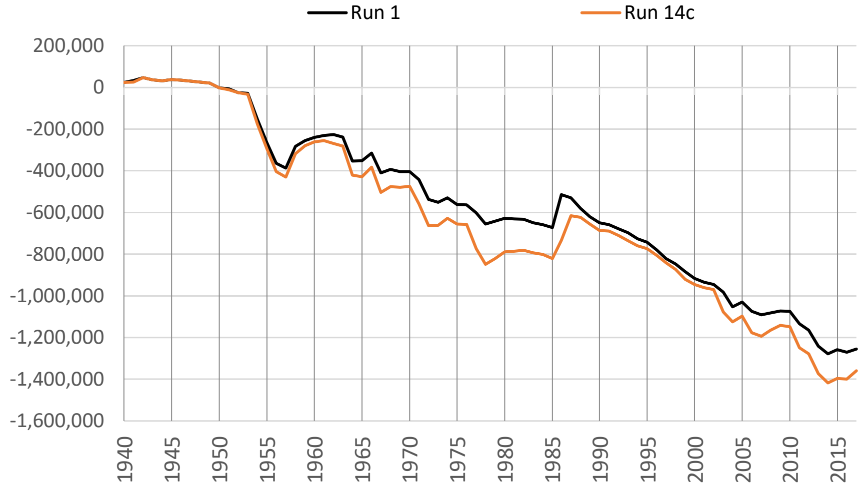
Note: HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

Run 14c - TX WWTP Discharges Off
Cumulative Change in Ground Water Storage
Run 14c v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

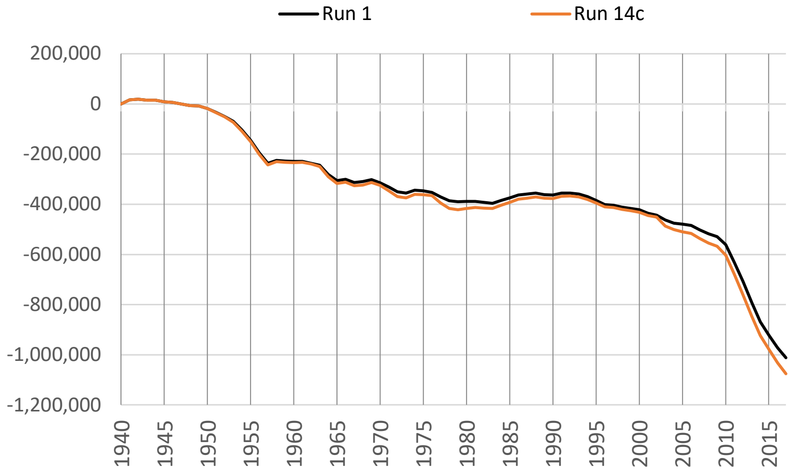
Rincon-Mesilla Alluvial Aquifer



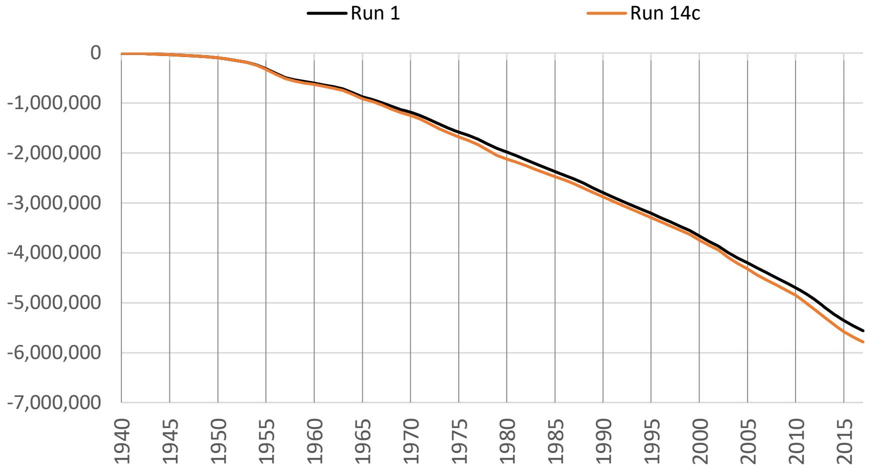
Hueco Alluvial Aquifer



Rincon-Mesilla Non-Alluvial Aquifer



Hueco Non-Alluvial Aquifer



***Note different scales.**

Run 14c - TX WWTP Discharges Off

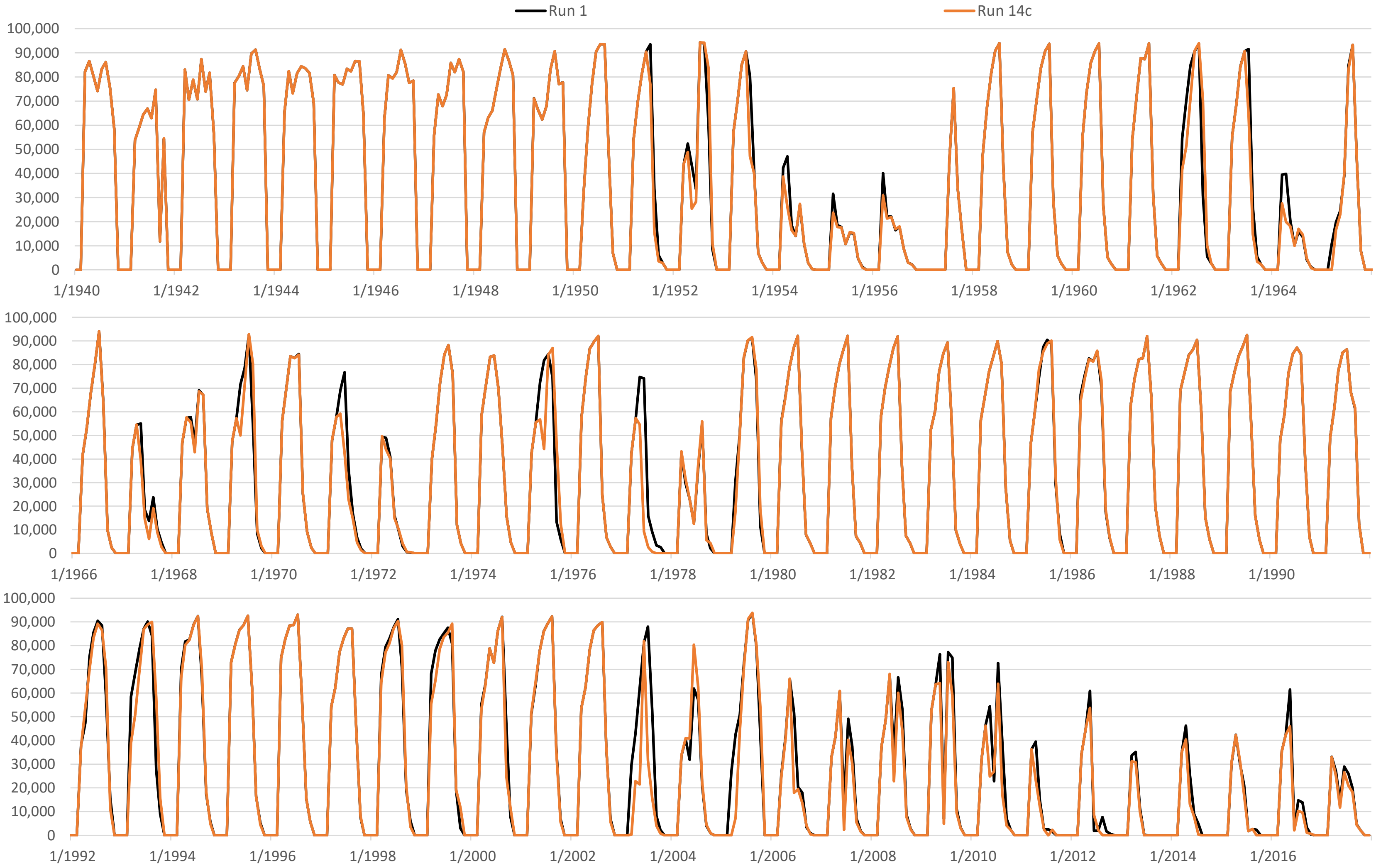
Monthly Net RHG Diversions

Run 14c v. Run 1

ILRG Model

1940 - 2017 (acre-feet)

EBID Total



Note: EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).

Run 14c - TX WWTP Discharges Off

Monthly Net RHG Diversions

Run 14c v. Run 1

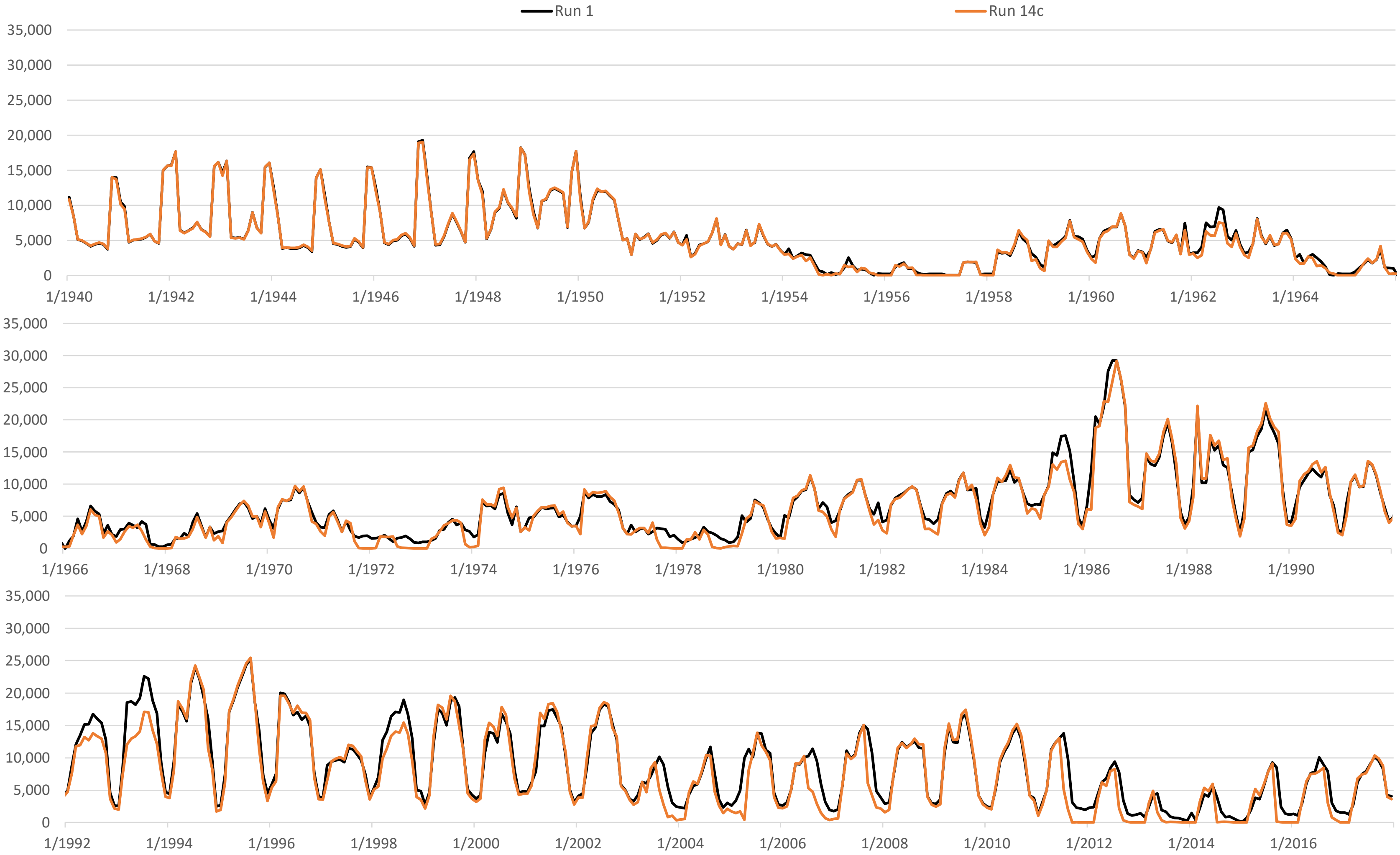
ILRG Model

1940 - 2017 (acre-feet)

EPCWID Total

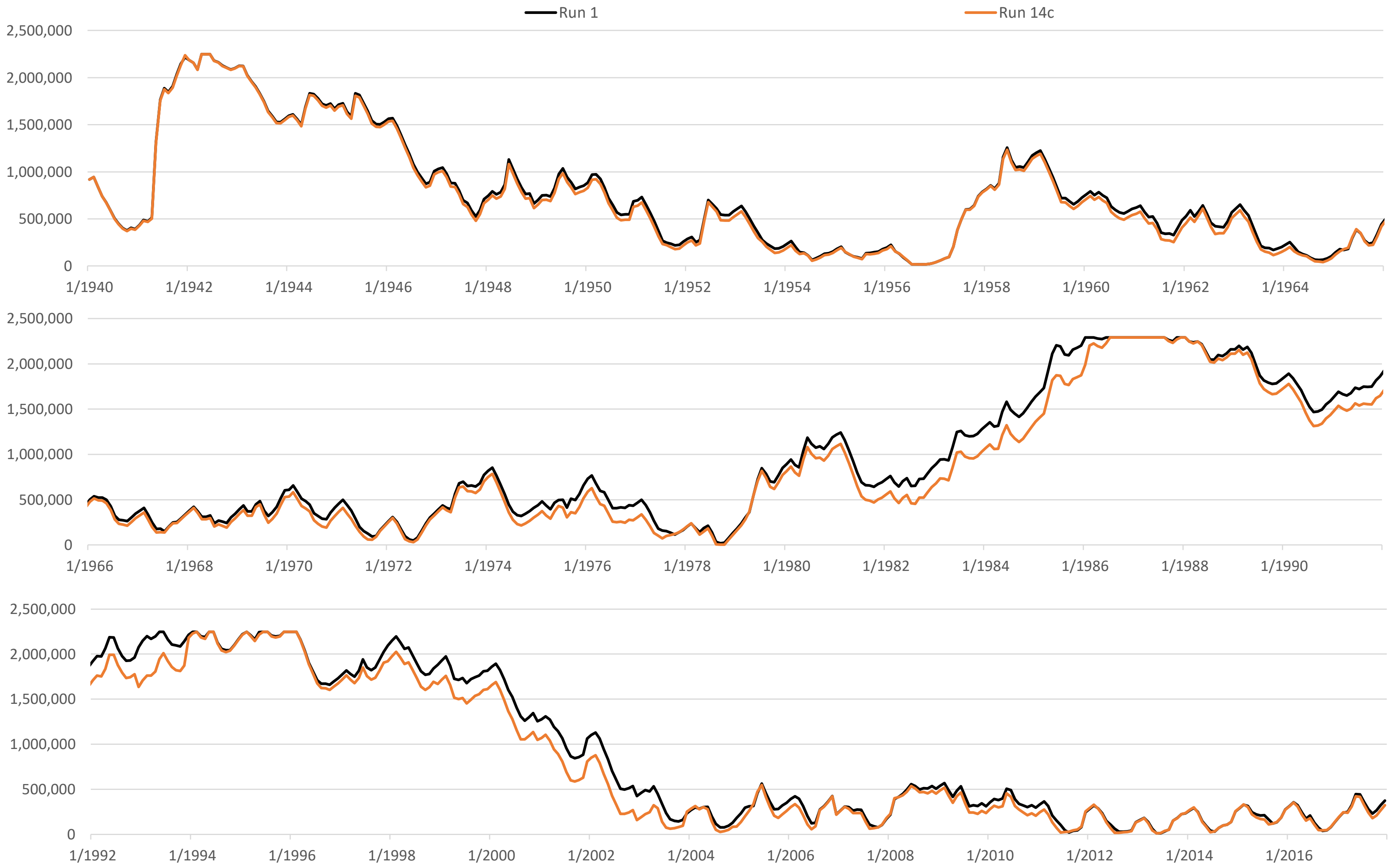
Note: EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

Run 14c - TX WWTP Discharges Off
Monthly Net RHG Diversions
Run 14c v. Run 1
ILRG Model
1940 - 2017 (acre-feet)
HCCRD Total



Note: HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

Run 14c - TX WWTP Discharges Off
End of Month Reservoir Storage (Elephant Butte + Caballo)
Run 14c v. Run 1
ILRG Model
1940 - 2017 (acre-feet)



Run 14c - TX WWTP Discharges Off
Monthly Caballo Releases
Run 14c v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

Run 14c - TX WWTP Discharges Off
Monthly Rio Grande at El Paso Flow
Run 14c v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

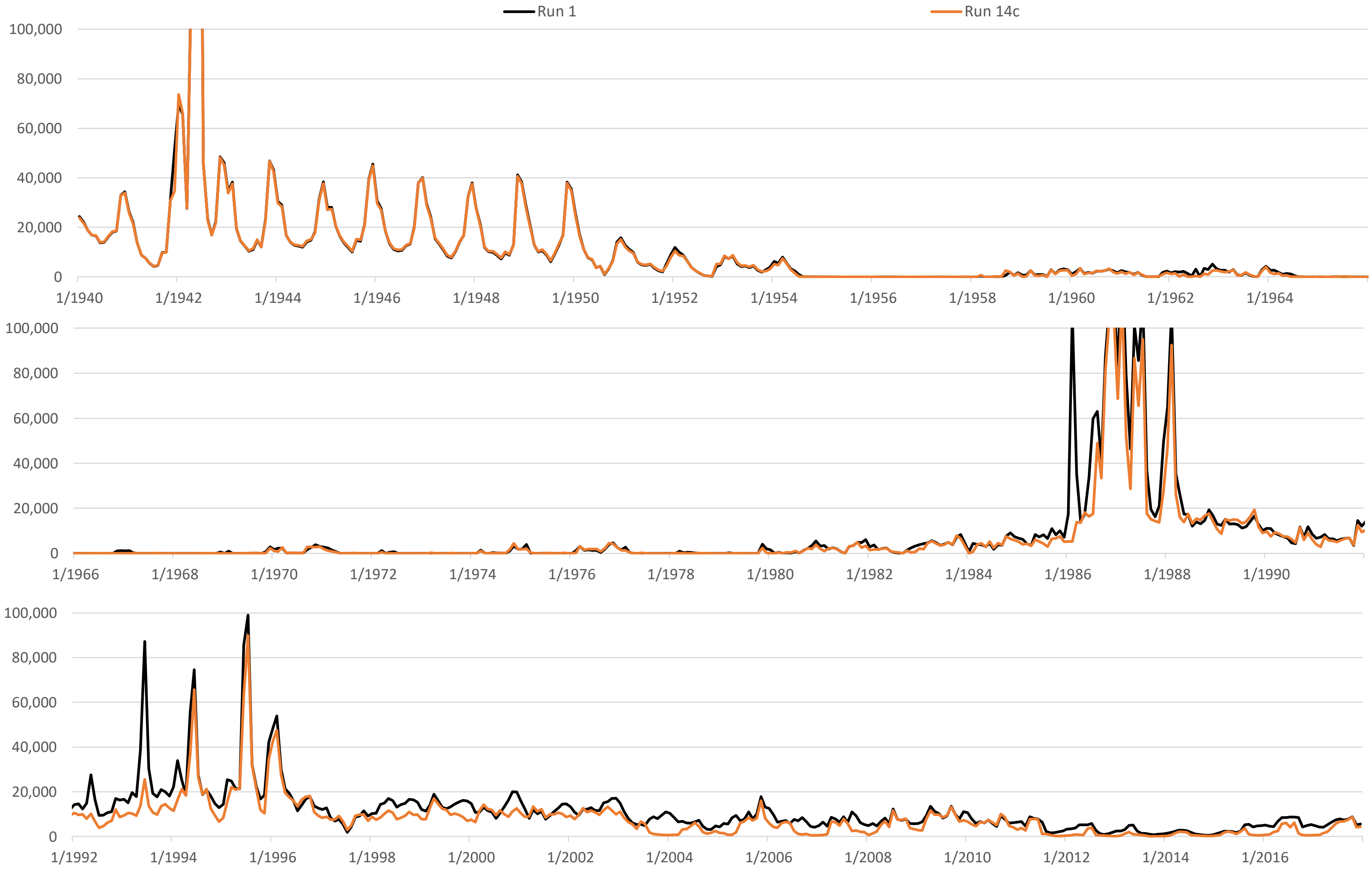
Run 14c - TX WWTP Discharges Off

Monthly Rio Grande at Fort Quitman Flow

Run 14c v. Run 1

ILRG Model

1940 - 2017 (acre-feet)



Appendix 30R

Comparison of ILRG Model Runs
Run 14d v. Run 1

Model Run Specifications

Model Version: LRG_v116

Name: **Run 14d - TX Hueco Pumping Off (Returns Left On)**

Run ID: LRG_v116_Operational_Run14d
Date: 8/27/2020

Name: **Run 1 - Historical Base Run (All Pumping On)**

Run ID: LRG_v116_Operational_Run1
Date: 8/23/2020

Selected Model Inputs

Pumping and Returns	**Run 14d**	**Run 1**
Irrigation Pumping	TX Hueco Off	On
Irrigated Area	Hist	Hist
Non-Irrigation Pumping	TX Hueco Off	On
Non-Irrigation Pumping Returns	On	On
Las Cruces Jornada Pumping Returns	On	On

Project Allocation Rules		
1950-2005	D1/D2	D1/D2
2006-2007	D3	D3
2008-2017	D3 + CO	D3 + CO

EPCWID Operations		
Charge EPCWID for Use of WWTP Returns	Off	Off
ACE and Haskell Credits for EPCWID	On	On
Increased EPCWID Use of Fabens Drain Flows	Off	Off
Charge EPCWID for Fabens Drain Flow Use	Off	Off

Run 14d - TX Hueco Pumping Off (Returns Left On)

Comparison of ILRG Model Runs

Run 14d v. Run 1

1951 - 2017 Annual Average

(1,000 acre-feet)

Run No.	1	14d	14d - 1		
Simulated Input or Output	**Run 1**	**Run 14d**	**Run 14d minus Run 1**		
Pumping Stress					
Irrigation Pumping	44.3	0.0	-44.3		
Non-Irrigation Pumping	181.0	118.4	-62.6		
WWTP Flows	58.0	58.0	0.0		
Urban Deep Percolation	13.1	13.1	0.0		
Total Stress	154.2	47.3	-106.9		
		Stress is Pumping minus WWTP and Urban Deep Perc			
Effects of Pumping Stress				***% Chg***	
FHG Deliveries (Mar - Oct)				***Stress***	***% Diff.***
EBID	167.6	170.2	2.5	*-2%*	*2%*
EPCWID (incl. EPW)	139.9	142.7	2.9	*-3%*	*2%*
HCCRD	32.8	34.6	1.7	*-2%*	*5%*
Total	340.3	347.5	7.1	*-7%*	*2%*
FHG Deliveries (Nov - Feb)					
EBID	0.0	0.0	0.0	*0%*	*-3%*
EPCWID (incl. EPW)	0.2	0.2	0.0	*0%*	*5%*
HCCRD	2.4	2.3	-0.1	*0%*	*-3%*
Total	2.6	2.5	-0.1	*0%*	*-2%*
Irrigation Pumping					
EBID	140.4	138.0	-2.5	*2%*	*-2%*
EPCWID (Mesilla Valley)	7.4	7.1	-0.2	*0%*	*-3%*
EPCWID (El Paso Valley)	40.1	0.0			
HCCRD	4.2	0.0			
Total	147.8	145.1	-2.7	*3%*	*-2%*
	Pumping turned off.	*Other values are simulated responses and are totaled.*			
Other Inflows/Outflows					
Net Reservoir Evaporation	125.3	128.1	2.8	*-3%*	*2%*
Riparian ET	70.9	76.4	5.6	*-5%*	*8%*
River Evaporation + Incidental Canal Loss	30.3	30.3	-0.1	*0%*	*0%*
Total	226.6	234.8	8.3	*-8%*	*4%*
Rio Grande at Fort Quitman					
Reservoir Spills	33.3	36.4	3.1	*-3%*	*9%*
Nov-Feb Flows	21.4	31.6	10.2	*-10%*	*48%*
Mar - Oct Flows	41.1	54.6	13.6	*-13%*	*33%*
Underflow (GW Model)	0.2	0.3	0.1	*0%*	*24%*
Total	96.0	122.9	26.9	*-25%*	*28%*

Run 14d - TX Hueco Pumping Off (Returns Left On)
Comparison of ILRG Model Runs
Run 14d v. Run 1
1951 - 2017 Annual Average
(1,000 acre-feet)

Run No.	1	14d	14d - 1		
Simulated Input or Output	**Run 1**	**Run 14d**	**Run 14d minus Run 1**		
Effects of Pumping Stress (continued)				***% Chg***	
Change in Storage				***Stress***	***% Diff.***
Reservoir Storage	-4.7	-5.1	-0.5	*0%*	*10%*
Alluvial GW Storage (RW Model)	-23.6	-16.1	7.5	*-7%*	*-32%*
Non-alluvial GW Storage (GW Models)	-96.4	-47.6	48.8	*-46%*	*-51%*
Soil Moisture Storage	0.6	0.6	0.0	*0%*	*5%*
Total	-124.0	-68.2	55.8	*-52%*	*-45%*
Summary of Effects					
FHG Deliveries (Mar-Oct)	340.3	347.5	7.1	*-7%*	*2%*
FHG Deliveries (Nov-Feb)	2.6	2.5	-0.1	*0%*	*-2%*
Irrigation Pumping	147.8	145.1	-2.7	*3%*	*-2%*
Riparian ET + Evaporation	226.6	234.8	8.3	*-8%*	*4%*
Fort Quitman Flow	96.0	122.9	26.9	*-25%*	*28%*
Change in Storage	-124.0	-68.2	55.8	*-52%*	*-45%*
Total	689.2	784.7	95.5	*-89%*	*14%*
Other Effects of Pumping Stress				***% Chg***	
Rio Grande at El Paso				***Stress***	***% Diff.***
Reservoir Spills	49.4	49.3	-0.1	*0%*	*0%*
Nov-Feb Flows	22.8	22.8	0.0	*0%*	*0%*
Mar - Oct Flows	263.8	261.3	-2.4	*2%*	*-1%*
Total	336.0	333.5	-2.5	*2%*	*-1%*
Rio Grande below Caballo					
Reservoir Spills	65.9	64.8	-1.1	*1%*	*-2%*
Nov-Feb Flows	0.5	0.5	0.0	*0%*	*-4%*
Mar - Oct Flows	541.3	540.1	-1.1	*1%*	*0%*
Total	607.6	605.4	-2.2	*2%*	*0%*
Surface Water Diversions (Mar - Oct)					
EBID	366.5	370.9	4.4	*-4%*	*1%*
EPCWID (incl. EPW)	236.8	233.7	-3.1	*3%*	*-1%*
HCCRD	67.5	72.4	4.9	*-5%*	*7%*
Total	670.8	677.0	6.2	*-6%*	*1%*
Surface Water Diversions (Nov - Feb)					
EBID	0.0	0.0	0.0	*0%*	*0%*
EPCWID (incl. EPW)	14.3	14.4	0.1	*0%*	*0%*
HCCRD	14.2	16.5	2.3	*-2%*	*16%*
Total	28.5	30.9	2.4	*-2%*	*8%*

Run 14d - TX Hueco Pumping Off (Returns Left On)

Annual Differences in ILRG Model Outputs

Run 14d minus Run 1

1940 - 2017 (acre-feet)

	Net River Headgate Diversions						Farm Headgate Deliveries						Annual Flows		
	EBID		EPCWID (incl. EPW)		HCCRD		EBID		EPCWID (incl. EPW)		HCCRD				
Year	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Caballo Releases	Rio Grande at El Paso	Rio Grande at Fort Quitman
1940	-52	-52	-996	1,239	-595	790	-37	-38	1,198	1,432	-496	-496	-10,994	-10,492	7,603
1941	-194	-194	-1,744	-531	-357	180	1	3	-170	241	-314	-223	9,572	6,548	13,619
1942	-19	-19	-1,416	-585	259	186	8	9	-706	134	134	157	-1,564	1,203	12,130
1943	9	9	-1,390	-654	82	352	-26	-26	-469	-225	147	478	-4,537	-4,387	4,071
1944	26	26	-1,218	-1,057	-295	-159	-16	-16	252	475	-235	-12	-4,811	-4,659	4,180
1945	19	19	-1,274	-816	-370	-186	-19	-19	195	583	-339	-169	-4,706	-4,626	3,671
1946	11	11	-1,537	-869	-285	-212	-28	-29	32	730	-266	-303	-4,936	-4,842	3,266
1947	22	22	-1,963	-1,369	-362	-517	-21	-21	-280	514	-308	-327	-5,356	-5,262	3,059
1948	30	30	-2,601	-1,961	161	442	-25	-26	-31	527	282	105	-6,591	-6,421	5,103
1949	35	35	-2,996	-2,419	1,191	2,191	-16	-16	236	520	-115	-232	-6,253	-6,184	8,410
1950	2	2	-4,409	-4,465	1,377	2,071	-56	-56	14	72	-13	-22	-6,381	-6,221	8,690
1951	1,020	1,020	-4,745	-5,292	1,368	1,968	609	609	373	383	1,524	1,120	-6,357	-6,285	17,938
1952	402	402	-6,032	-6,597	1,744	2,586	1,507	1,504	47	42	1,567	905	-17,218	-13,142	16,824
1953	346	346	-8,284	-8,871	2,815	4,200	2,536	2,535	153	149	3,247	3,674	-7,518	-9,703	27,063
1954	-341	-341	302	251	2,764	4,949	5,454	5,454	6,790	6,788	3,317	5,153	-5,343	3,261	20,679
1955	29,567	29,567	21,954	22,140	8,299	11,291	15,081	15,081	22,401	22,444	7,826	10,480	52,340	23,908	18,235
1956	-2,641	-2,641	-128	193	7,219	9,550	-4,267	-4,267	3,956	3,789	6,669	8,335	-7,036	-2,574	8,336
1957	31	31	-8,792	-8,299	1,138	4,581	54	54	1,774	1,620	1,806	3,451	-10,680	-8,418	5,320
1958	-17	-17	-22,237	-21,901	6,040	11,098	-20	-20	-1,449	-1,546	-1,522	-91	-32,538	-25,883	34,009
1959	0	0	-13,508	-13,730	4,881	8,131	-15	-15	-313	-312	403	682	-19,553	-17,850	36,981
1960	3	3	-11,581	-11,852	3,406	5,419	-28	-28	-447	-447	0	0	-16,337	-15,722	31,073
1961	7	7	-10,743	-11,003	3,658	5,528	-31	-31	1,116	1,116	1,402	-703	-15,416	-14,842	34,125
1962	9	9	-9,576	-9,833	3,364	5,257	-17	-17	201	201	702	1,047	-14,581	-13,765	31,050
1963	8,879	8,879	-9,037	-9,306	3,217	4,799	4,814	4,815	118	120	1,971	1,878	-1,358	-5,109	31,773
1964	17,399	17,399	10,909	11,251	4,304	6,467	20,705	20,705	14,065	13,883	4,983	6,333	12,652	17,413	25,063
1965	35,664	35,664	10,617	10,428	7,888	11,200	18,071	18,071	19,889	19,648	8,417	10,758	34,892	15,957	28,458
1966	-82	-82	-11,352	-10,748	7,446	10,827	263	263	-118	40	-3,930	-6,341	-20,791	-11,119	37,547
1967	21,861	21,861	16,002	17,987	7,233	13,201	13,530	13,530	20,154	19,640	6,184	9,836	29,869	18,367	23,458
1968	-515	-515	-15,877	-14,426	10,276	16,206	-95	-95	520	122	8,693	8,690	-23,955	-12,719	25,817
1969	-4	-4	-14,775	-14,945	11,854	15,627	480	480	-270	-269	3,104	-1,268	-21,320	-17,523	36,217
1970	4	4	-12,455	-12,791	4,434	6,794	-9	-8	66	66	-1,274	-2,725	-17,327	-15,964	30,809
1971	33,445	33,445	-13,201	-12,596	5,715	9,219	20,592	20,592	76	79	5,200	7,909	878	-11,491	24,578
1972	7,404	7,404	5,199	5,841	11,387	15,478	-119	-119	5,812	5,658	7,841	7,583	16,792	6,838	27,677
1973	-323	-323	-17,178	-17,308	16,618	21,287	1,208	1,208	525	458	16,982	16,158	-33,152	-19,657	17,323
1974	-74	-74	-15,080	-15,225	14,449	19,815	407	407	558	560	-2,592	-4,322	-20,493	-17,771	44,849
1975	-253	-253	-12,738	-12,931	14,341	19,582	1,132	1,132	32	33	11,534	8,792	-17,398	-14,334	25,116
1976	-17	-17	-11,070	-11,307	10,954	16,918	708	708	16	16	-1,658	-5,532	-14,503	-13,903	34,717
1977	58,620	58,620	26,108	27,514	15,614	20,894	26,127	26,127	16,201	16,203	13,994	13,612	50,277	35,165	35,968
1978	19,319	19,319	8,312	10,652	5,628	11,868	10,376	10,376	16,431	16,435	7,399	7,593	25,996	16,106	29,436

Run 14d - TX Hueco Pumping Off (Returns Left On)

Annual Differences in ILRG Model Outputs

Run 14d minus Run 1

1940 - 2017 (acre-feet)

	Net River Headgate Diversions						Farm Headgate Deliveries						Annual Flows		
	EBID		EPCWID (incl. EPW)		HCCRD		EBID		EPCWID (incl. EPW)		HCCRD				
Year	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Caballo Releases	Rio Grande at El Paso	Rio Grande at Fort Quitman
1979	-220	-220	-12,479	-12,048	6,190	11,315	899	900	801	821	4,319	1,934	-22,046	-10,642	38,530
1980	-82	-82	-12,549	-12,367	3,936	7,636	151	151	-7	151	-3,214	-6,867	-18,326	-13,877	54,196
1981	-43	-43	-10,791	-10,960	2,235	4,098	501	501	33	34	-56	-251	-13,841	-11,965	34,685
1982	-14	-14	-11,840	-11,891	1,936	3,711	59	59	-4	165	-403	-1,356	-14,588	-12,998	43,912
1983	-13	-13	-9,489	-9,621	4,401	6,238	42	42	-164	-72	0	0	-11,053	-10,246	33,839
1984	-13	-13	-9,546	-9,593	8,207	9,916	19	19	-5	229	0	0	-8,351	-8,075	29,315
1985	-60	-60	-8,472	-8,506	3,659	5,256	28	28	-207	56	0	0	-10,531	-9,622	27,085
1986	-32	-32	-4,005	-4,153	1,907	3,166	216	225	-37	-25	0	0	70,333	68,942	199,296
1987	-34	-34	-3,319	-3,471	426	1,218	13	14	-6	-4	0	0	-28	494	42,214
1988	-9	-9	-2,697	-2,850	477	1,213	54	54	0	1	0	0	-3,498	-2,377	18,065
1989	-8	-8	-4,043	-4,144	544	1,292	17	17	-74	9	0	0	-5,474	-4,831	14,034
1990	-42	-42	-5,429	-5,338	4,830	5,645	143	143	-70	305	0	0	-4,710	-4,092	17,383
1991	-24	-24	-7,080	-7,134	1,771	2,875	26	26	-248	-25	0	0	-6,944	-6,353	31,361
1992	2,639	2,639	69,785	69,633	34,315	36,215	-10,090	-10,102	33,107	33,182	0	0	33,627	39,824	53,137
1993	567	567	-10,585	-10,788	-551	945	775	770	-2,956	-2,963	0	0	-21,522	-24,620	9,905
1994	301	301	-1,135	-1,321	2,107	3,464	-172	-172	3,474	3,474	0	0	9,963	6,905	30,601
1995	490	490	-1,985	-2,001	1,413	2,988	13	12	2,385	2,667	0	0	-3,330	-2,359	24,745
1996	-50	-50	-5,656	-5,813	161	1,190	207	207	19	20	0	0	-7,859	-7,032	18,271
1997	-10	-10	-9,543	-9,549	2,997	4,024	-48	-48	-1,032	-744	0	0	-8,150	-7,905	24,360
1998	-8	-8	-6,852	-7,045	373	1,477	-1	-1	-180	-138	0	0	-9,032	-8,554	25,667
1999	111	111	-229	-347	604	1,084	9	9	1,642	1,645	0	0	0	-614	14,145
2000	-14	-14	-4,336	-4,404	-200	69	-1	-1	-1,541	-1,541	0	0	-4,486	-4,170	8,916
2001	-26	-26	-1,789	-1,868	252	494	-8	-8	2	2	0	0	-1,601	-1,532	8,842
2002	-17	-17	-1,770	-1,849	215	430	-4	-4	2	2	0	0	-1,528	-1,450	9,271
2003	18,515	18,515	-211	-233	430	798	11,529	11,529	1,315	1,320	0	0	10,713	3,607	9,387
2004	3,721	3,721	2,777	2,849	1,519	2,825	2,485	2,485	3,168	3,173	0	0	3,141	4,817	15,142
2005	115	115	-2,873	-2,927	1,325	2,100	234	233	163	164	0	0	-5,108	-2,233	14,707
2006	5,677	5,677	8,580	8,550	2,094	3,113	3,711	3,711	6,076	6,078	0	0	8,524	6,223	12,150
2007	3,364	3,364	2,181	2,216	2,156	3,130	1,652	1,652	3,928	3,930	0	0	5,047	3,878	13,377
2008	6,470	6,470	-4,337	-4,352	1,486	1,990	4,122	4,122	-782	-780	0	0	-4,376	-3,761	12,355
2009	6,009	6,009	-2,448	-2,518	213	509	2,681	2,681	-155	-153	0	0	-1,473	-1,888	10,515
2010	11,405	11,405	-2,033	-2,102	531	902	6,580	6,580	139	142	0	0	292	-1,648	10,015
2011	7,012	7,012	441	377	8,434	12,611	3,699	3,699	2,247	2,249	0	0	4,285	1,052	20,278
2012	-211	-211	51	-31	9,576	13,616	348	348	2,784	2,785	0	0	-947	-30	23,295
2013	-2,109	-2,109	-664	-735	6,210	8,863	-1,137	-1,137	2,090	2,090	5,149	6,831	-2,229	-618	17,427
2014	453	453	-699	-773	8,308	13,123	316	316	3,158	3,159	902	2,228	-1,185	-1,524	25,084
2015	-537	-537	-5,607	-5,674	3,078	5,306	-171	-171	54	54	-4,255	-3,626	-7,969	-5,706	30,366
2016	-574	-574	4,165	4,078	1,777	2,955	-25	-25	5,384	5,385	0	0	9,570	5,409	11,314
2017	3,816	3,816	-4,668	-4,770	518	1,189	1,914	1,914	-408	-407	0	0	-4,097	-4,883	7,654
Averages															
1951-2017	4,421	4,421	-3,137	-3,077	4,894	7,220	2,535	2,535	2,877	2,886	1,735	1,670	-2,208	-2,466	26,944
1951-1978	8,204	8,204	-4,607	-4,382	7,073	10,526	4,966	4,966	4,596	4,533	4,064	4,036	-3,542	-4,670	27,159
1979-2005	953	953	-2,820	-2,879	3,166	4,507	263	263	1,466	1,552	24	-242	-2,008	-1,147	31,519
2006-2017	3,398	3,398	-420	-478	3,698	5,609	1,974	1,974	2,043	2,044	150	453	454	-291	16,152
1985-2017	2,027	2,027	-439	-515	3,120	4,427	882	882	1,922	1,973	54	165	1,195	1,011	24,556
1985-2005	1,244	1,244	-450	-536	2,789	3,751	258	258	1,854	1,932	0	0	1,618	1,755	29,359

Notes:

EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).

EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

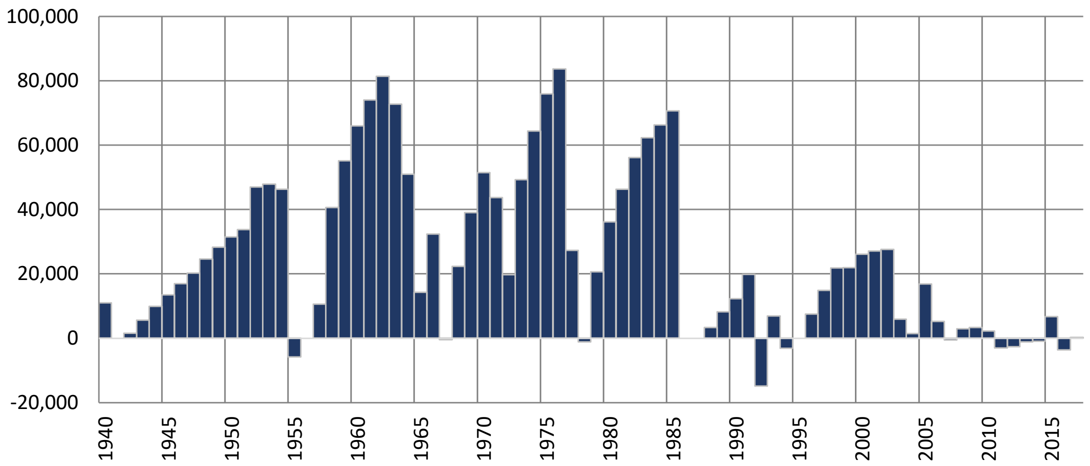
Run 14d - TX Hueco Pumping Off (Returns Left On)

Simulated Differences in ILRG Model Outputs

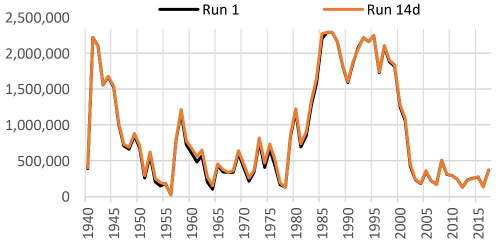
Run 14d minus Run 1

1940 - 2017 (acre-feet)

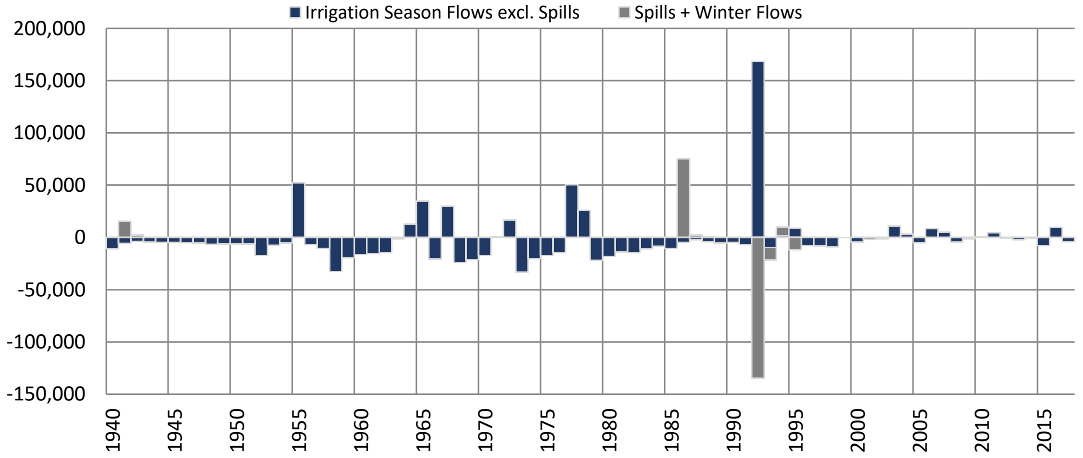
Total Project Storage (Year End)



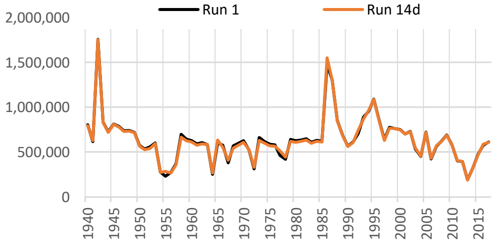
Period	Average Difference
1951-2017	-466
1951-1978	-1,167
1979-2005	668
2006-2017	-1,382
1985-2017	-1,999
1985-2005	-2,352



Caballo Reservoir Outflows (Annual)



	Average Difference		
Period	Irr Season (excl. Spills)	Nov-Feb and Spills	Annual
1951-2017	-1,131	-1,077	-2,208
1951-1978	-3,542	0	-3,542
1979-2005	665	-2,673	-2,008
2006-2017	454	0	454
1985-2017	3,381	-2,187	1,195
1985-2005	5,055	-3,437	1,618



Notes:

Reservoir storage does not include storage attributed to SJC, CO, or NM credit waters.

Average differences calculated as (Final Storage - Initial Storage)/(no. years).

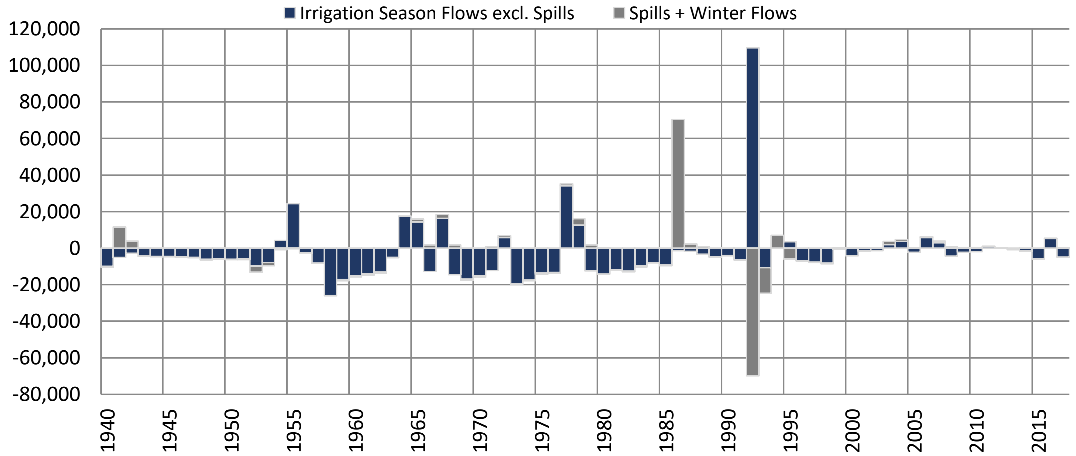
Run 14d - TX Hueco Pumping Off (Returns Left On)

Simulated Differences in ILRG Model Outputs

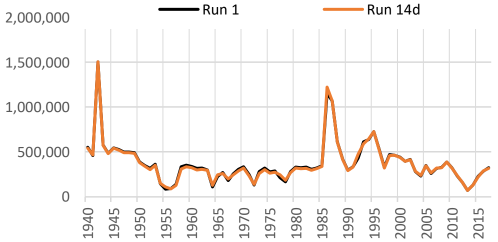
Run 14d minus Run 1

1940 - 2017 (acre-feet)

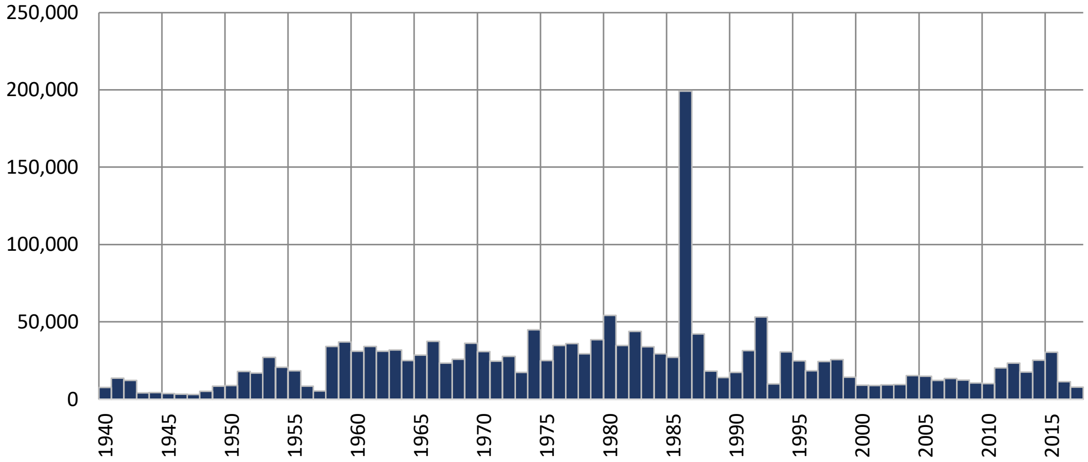
Rio Grande at El Paso (Annual)



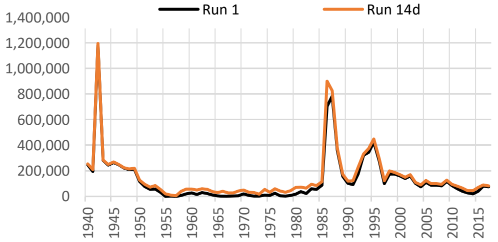
	Average Difference		
Period	Irr Season (excl. Spills)	Nov-Feb and Spills	Annual
1951-2017	-2,432	-34	-2,466
1951-1978	-4,715	46	-4,670
1979-2005	-897	-250	-1,147
2006-2017	-560	268	-291
1985-2017	1,137	-127	1,011
1985-2005	2,107	-352	1,755



Rio Grande at Fort Quitman (Annual)



Period	Average Difference
1951-2017	26,892
1951-1978	27,084
1979-2005	31,472
2006-2017	16,140
1985-2017	24,532
1985-2005	29,328



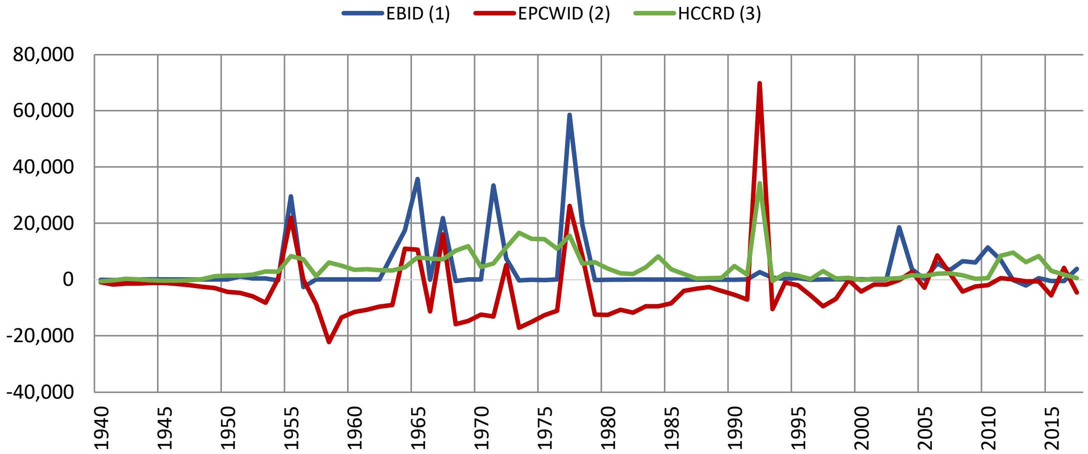
Run 14d - TX Hueco Pumping Off (Returns Left On)

Simulated Differences in ILRG Model Outputs

Run 14d minus Run 1

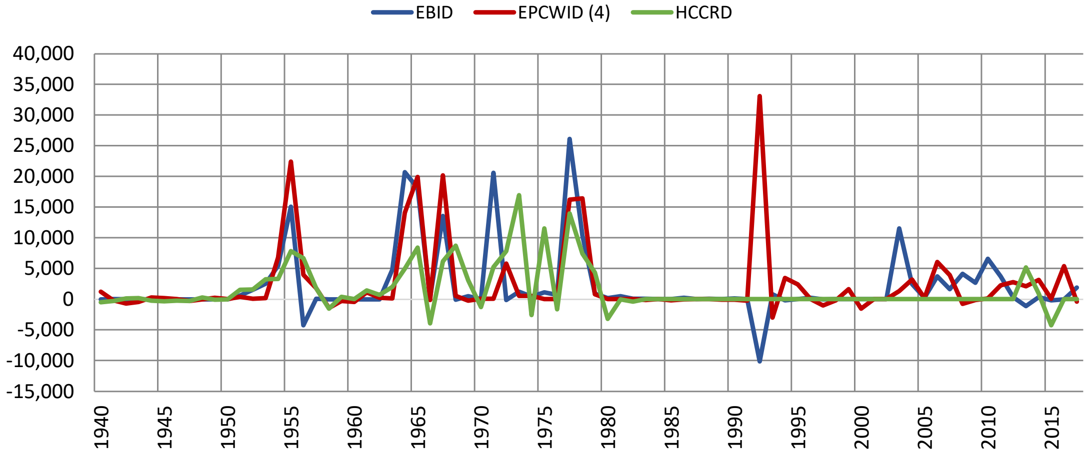
1940 - 2017 (acre-feet)

River Headgate (RHG) Diversions (Irrigation Season)



	Average Difference		
Period	EBID	EPCWID	HCCRD
1951-2017	4,421	-3,137	4,894
1951-1978	8,204	-4,607	7,073
1979-2005	953	-2,820	3,166
2006-2017	3,398	-420	3,698
1985-2017	2,027	-439	3,120
1985-2005	1,244	-450	2,789

Farm Headgate (FHG) Deliveries (Irrigation Season)



	Average Difference		
Period	EBID	EPCWID	HCCRD
1951-2017	2,535	2,877	1,735
1951-1978	4,966	4,596	4,064
1979-2005	263	1,466	24
2006-2017	1,974	2,043	150
1985-2017	882	1,922	54
1985-2005	258	1,854	0

Notes:

(1) EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).

(2) EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

(3) HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

(4) EPCWID FHG values include deliveries to Rogers WTP and R/U WTP.

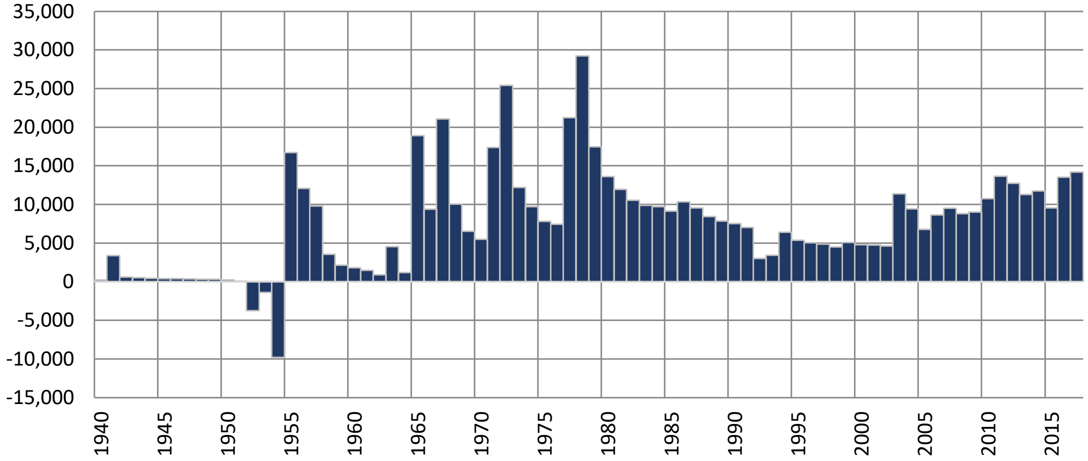
Run 14d - TX Hueco Pumping Off (Returns Left On)

Simulated Differences in ILRG Model Outputs

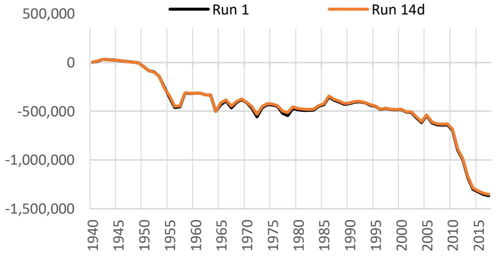
Run 14d minus Run 1

1940 - 2017 (acre-feet)

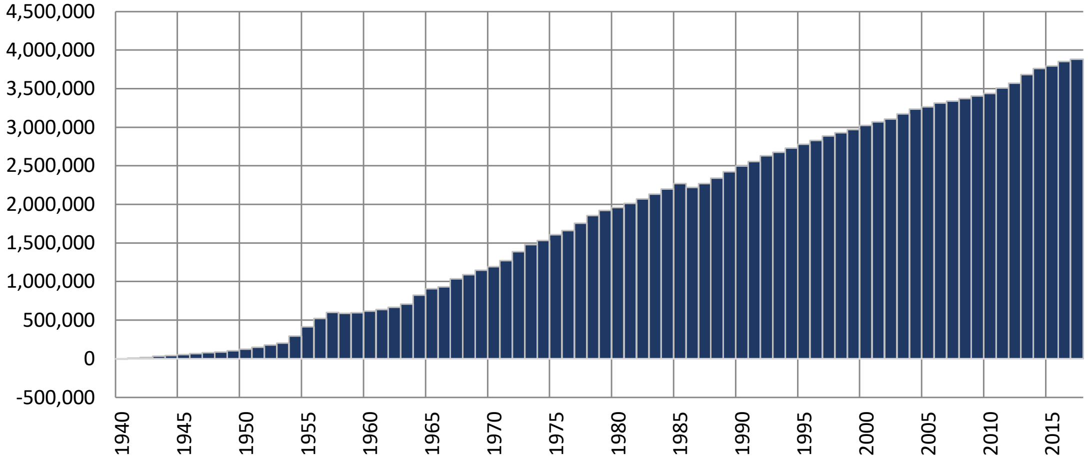
Cumulative Annual Rincon-Mesilla Groundwater Storage



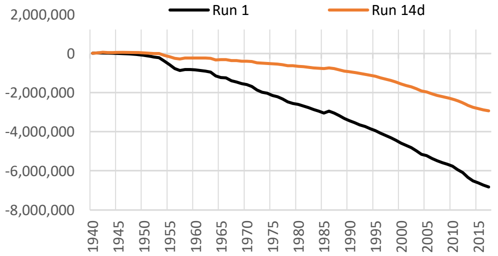
Period	Average Difference
1951-2017	208
1951-1978	1,035
1979-2005	-831
2006-2017	617
1985-2017	136
1985-2005	-139



Cumulative Annual Hueco Groundwater Storage



Period	Average Difference
1951-2017	56,075
1951-1978	61,814
1979-2005	52,185
2006-2017	51,440
1985-2017	50,989
1985-2005	50,731

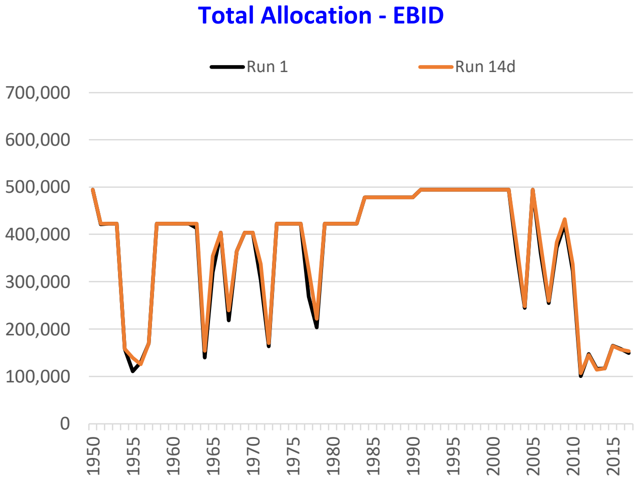


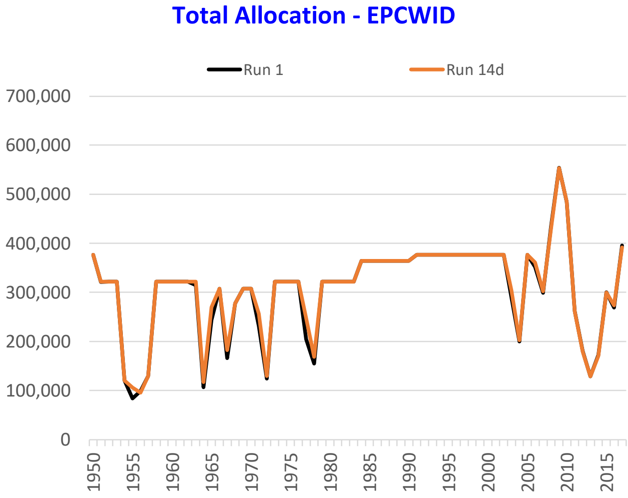
Notes:

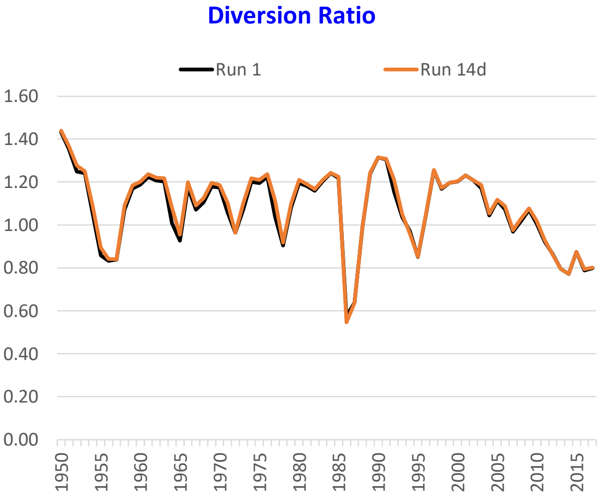
Cumulative storage change in alluvial and non-alluvial aquifers.

Average differences calculated as (Final Storage - Initial Storage)/(no. years).

Run 14d - TX Hueco Pumping Off (Returns Left On)
Annual Allocation and Charges
Run 14d v. Run 1
ILRG Model
1950 - 2017 (acre-feet)

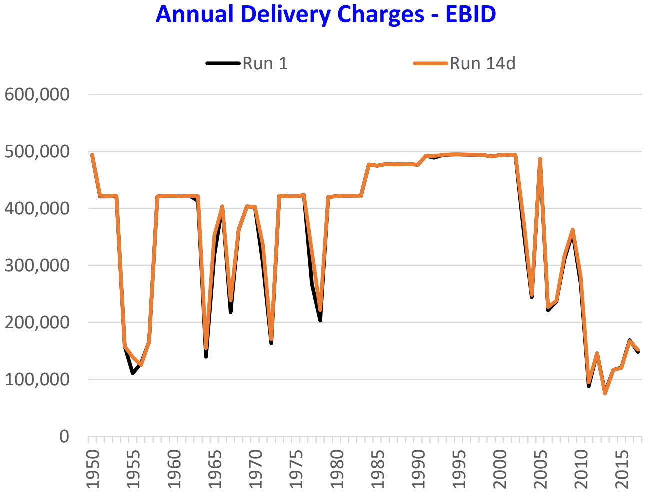


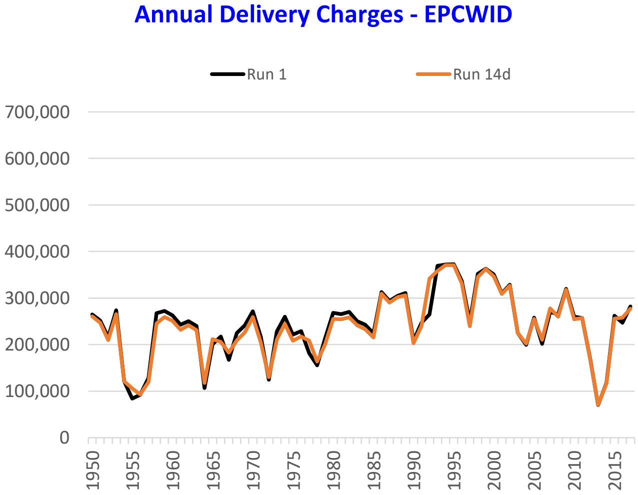




Note:

Computed as Total Charges/Caballo Release.





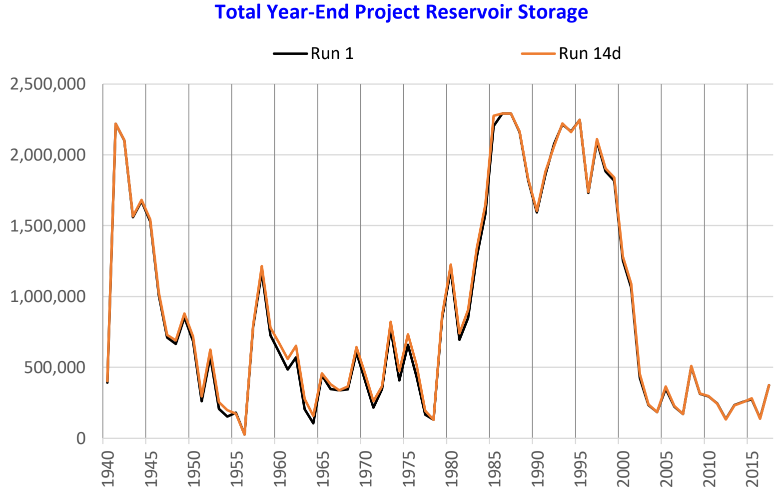
Run 14d - TX Hueco Pumping Off (Returns Left On)

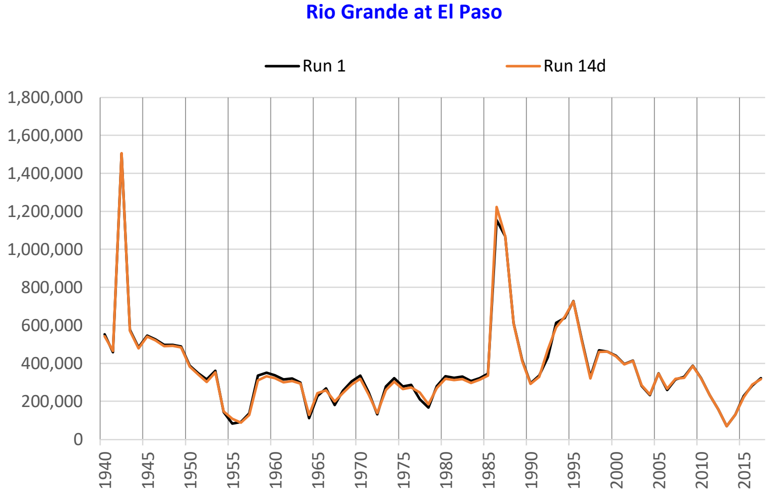
Annual Summary of Project Storage and Rio Grande Flows

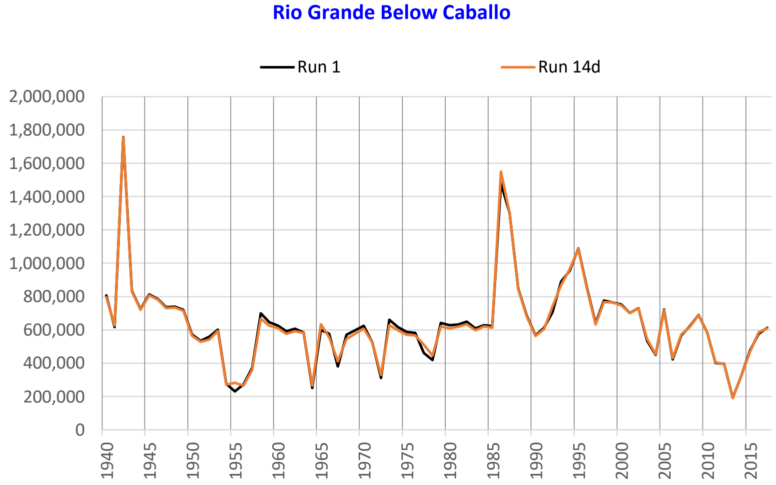
Run 14d v. Run 1

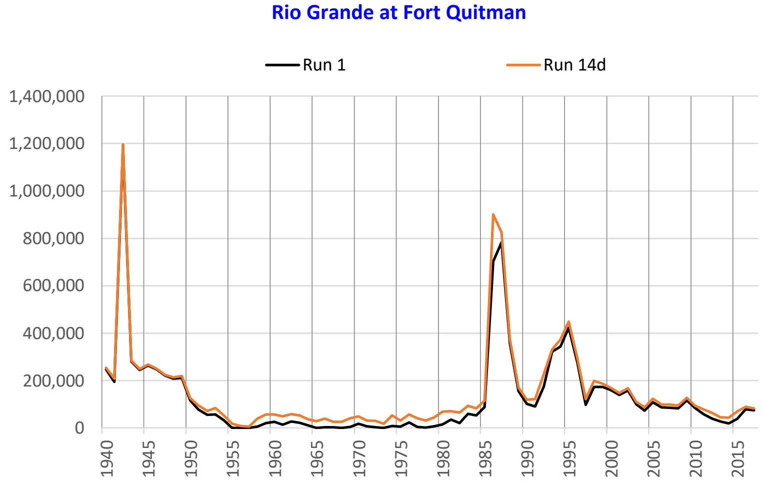
ILRG Model

1940 - 2017 (acre-feet)









***Note different scales.**

Run 14d - TX Hueco Pumping Off (Returns Left On)

Irrigation Season Summary of Irrigation Operations

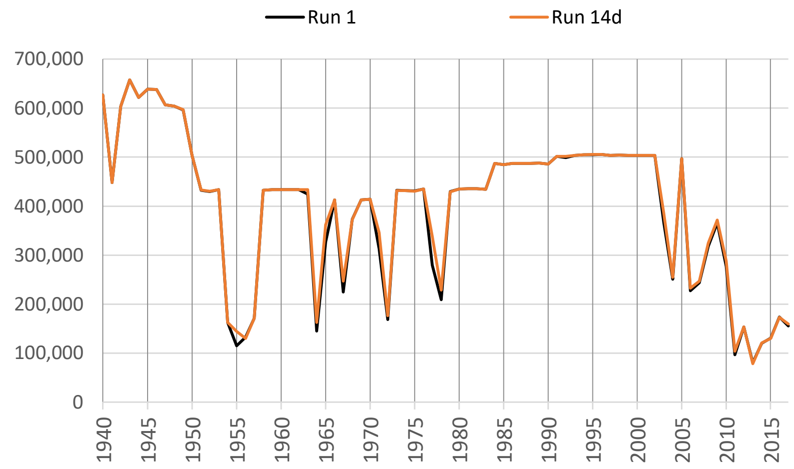
Run 14d v. Run 1

ILRG Model

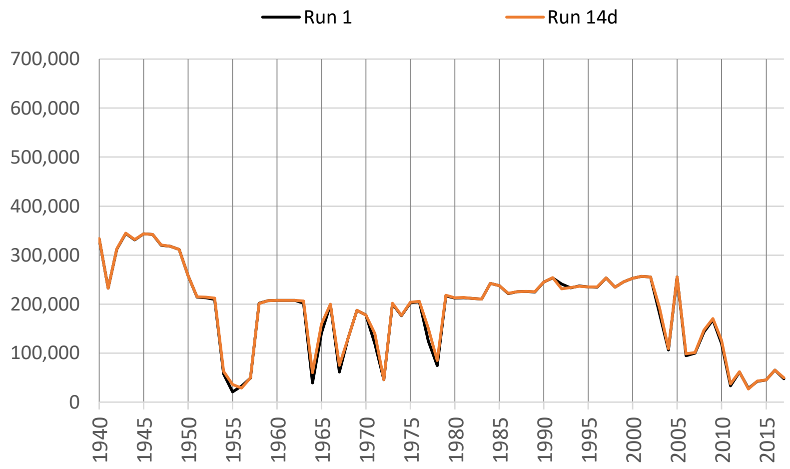
1940 - 2017 (acre-feet)

EBID Total

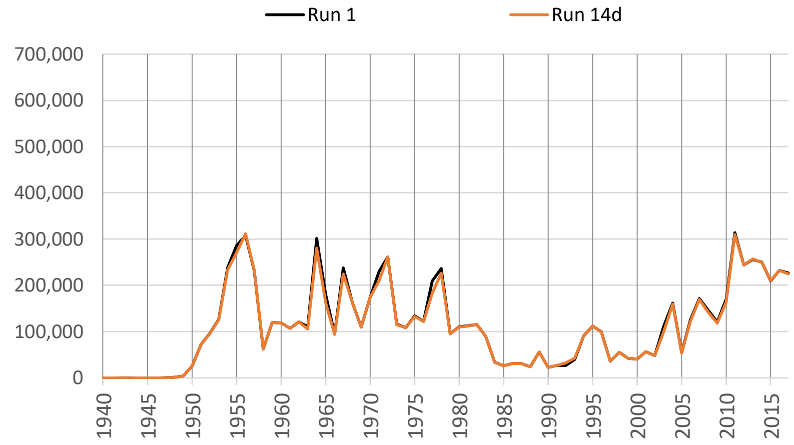
Net River Headgate Diversions



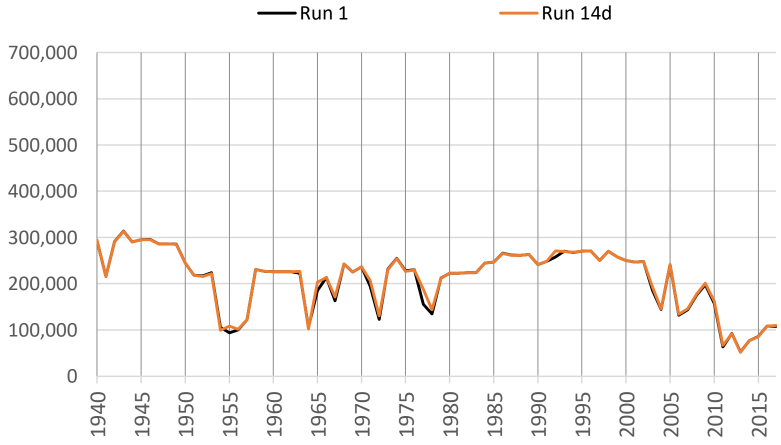
Farm Headgate Deliveries



Pumping



RHG Diversions - FHG Deliveries

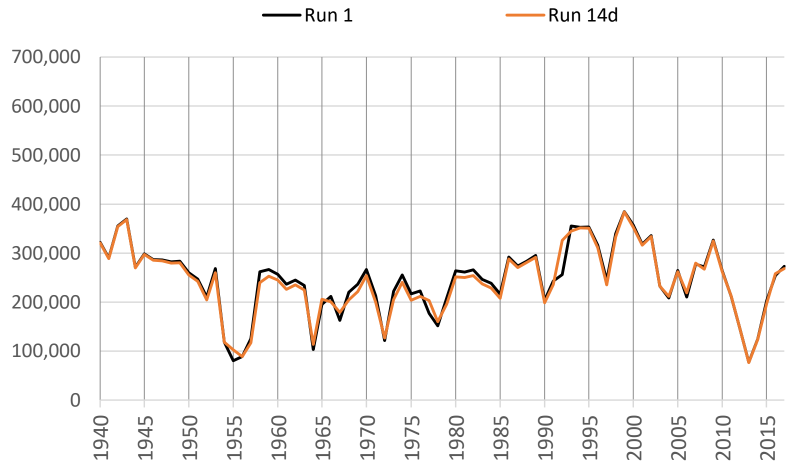


Notes: EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).
Pumping includes Supplemental and Primary groundwater pumping.

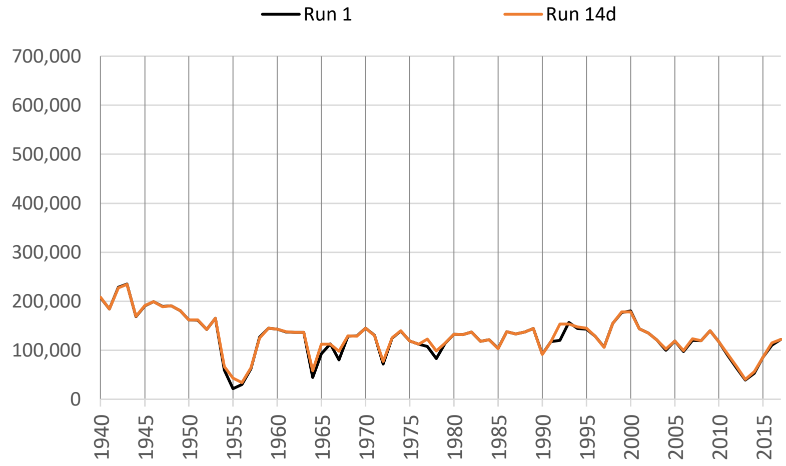
Run 14d - TX Hueco Pumping Off (Returns Left On)
Irrigation Season Summary of Irrigation Operations
Run 14d v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

EPCWID Total

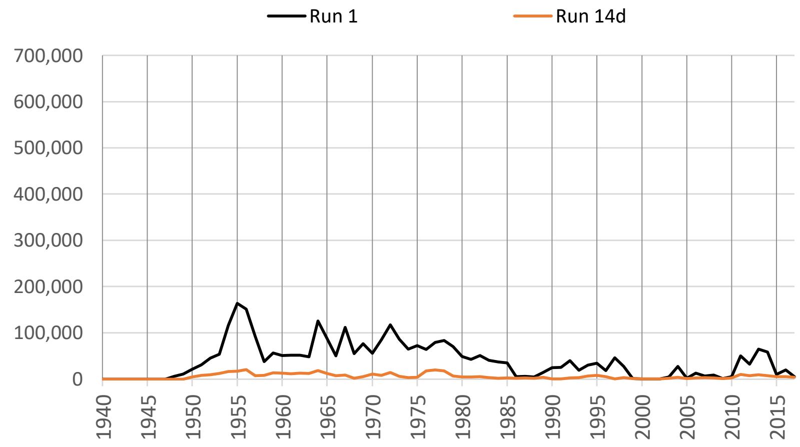
Net River Headgate Diversions



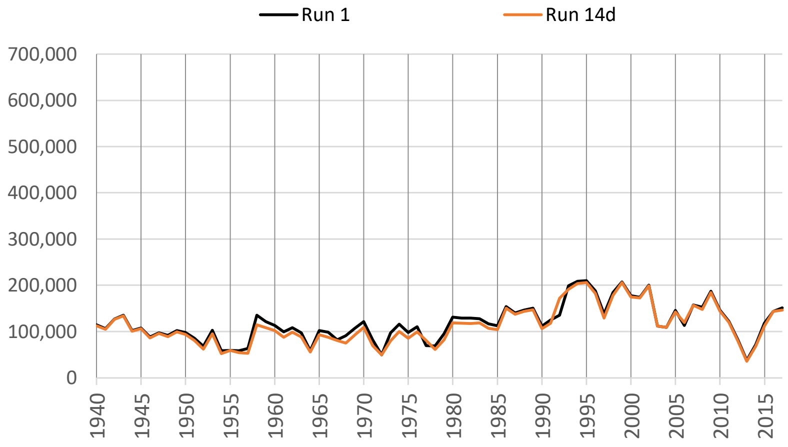
Farm Headgate Deliveries



Pumping



RHG Diversions - FHG Deliveries

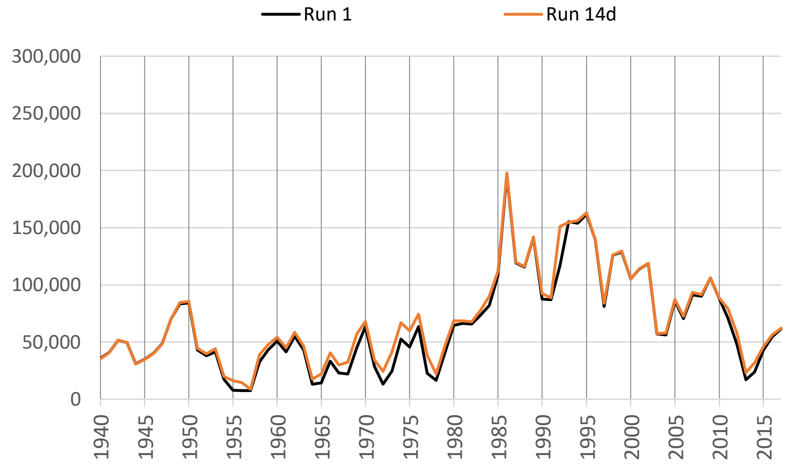


Note: EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

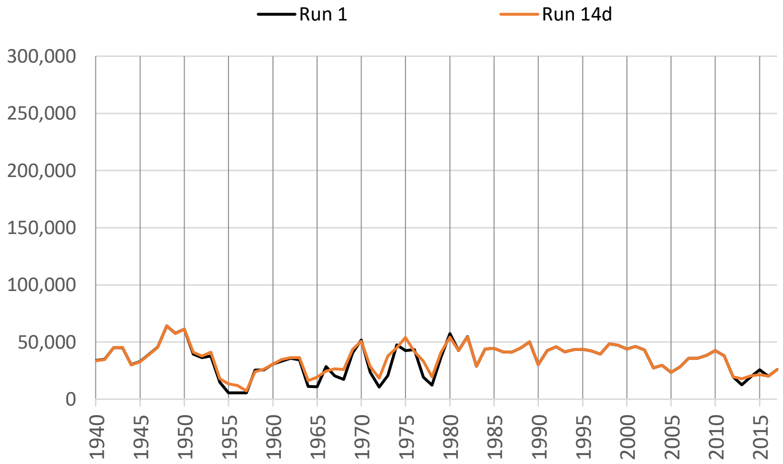
Run 14d - TX Hueco Pumping Off (Returns Left On)
Irrigation Season Summary of Irrigation Operations
Run 14d v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

HCCRD Total

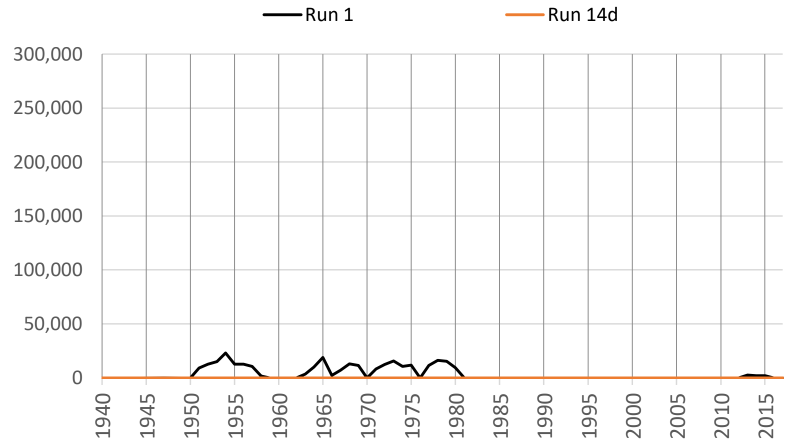
Net River Headgate Diversions



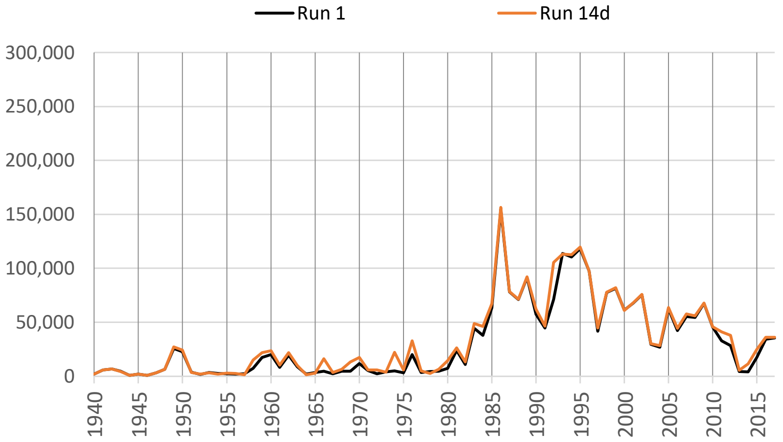
Farm Headgate Deliveries



Pumping



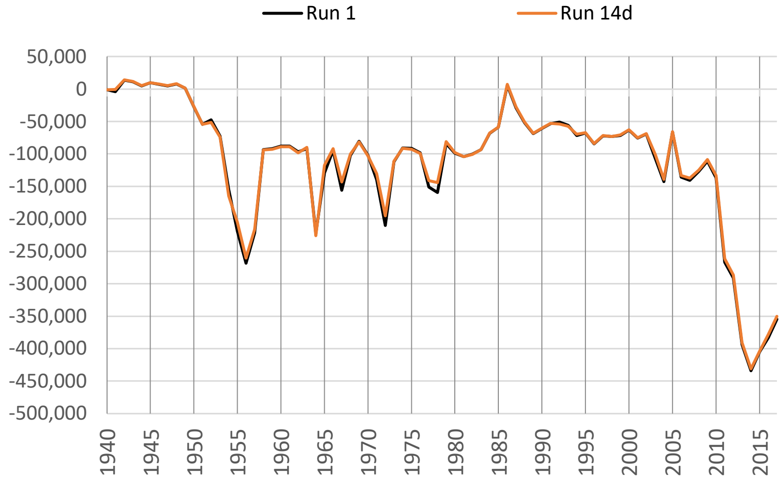
RHG Diversions - FHG Deliveries



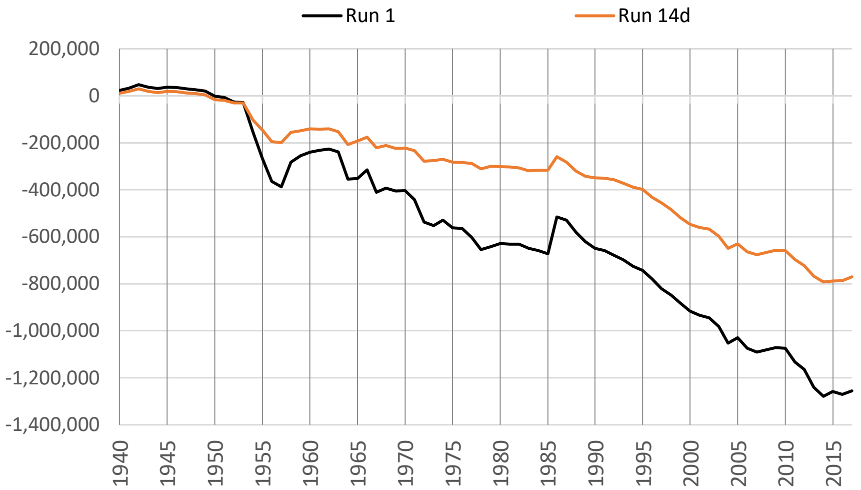
Note: HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

Run 14d - TX Hueco Pumping Off (Returns Left On)
Cumulative Change in Ground Water Storage
Run 14d v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

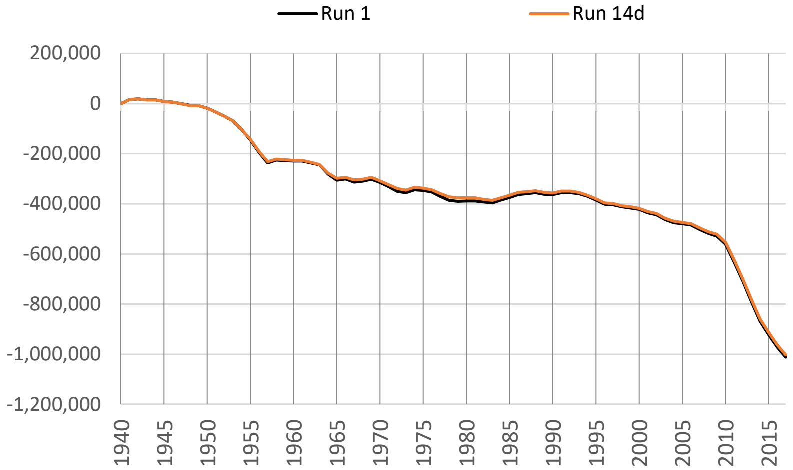
Rincon-Mesilla Alluvial Aquifer



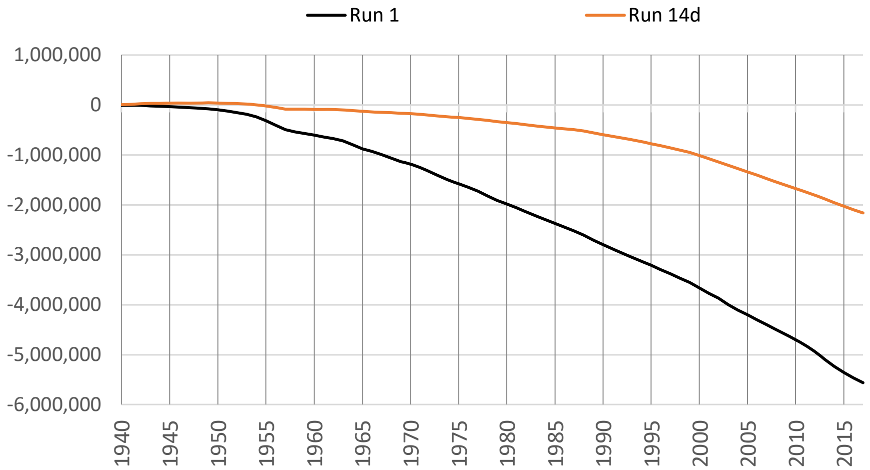
Hueco Alluvial Aquifer



Rincon-Mesilla Non-Alluvial Aquifer



Hueco Non-Alluvial Aquifer



***Note different scales.**

Run 14d - TX Hueco Pumping Off (Returns Left On)

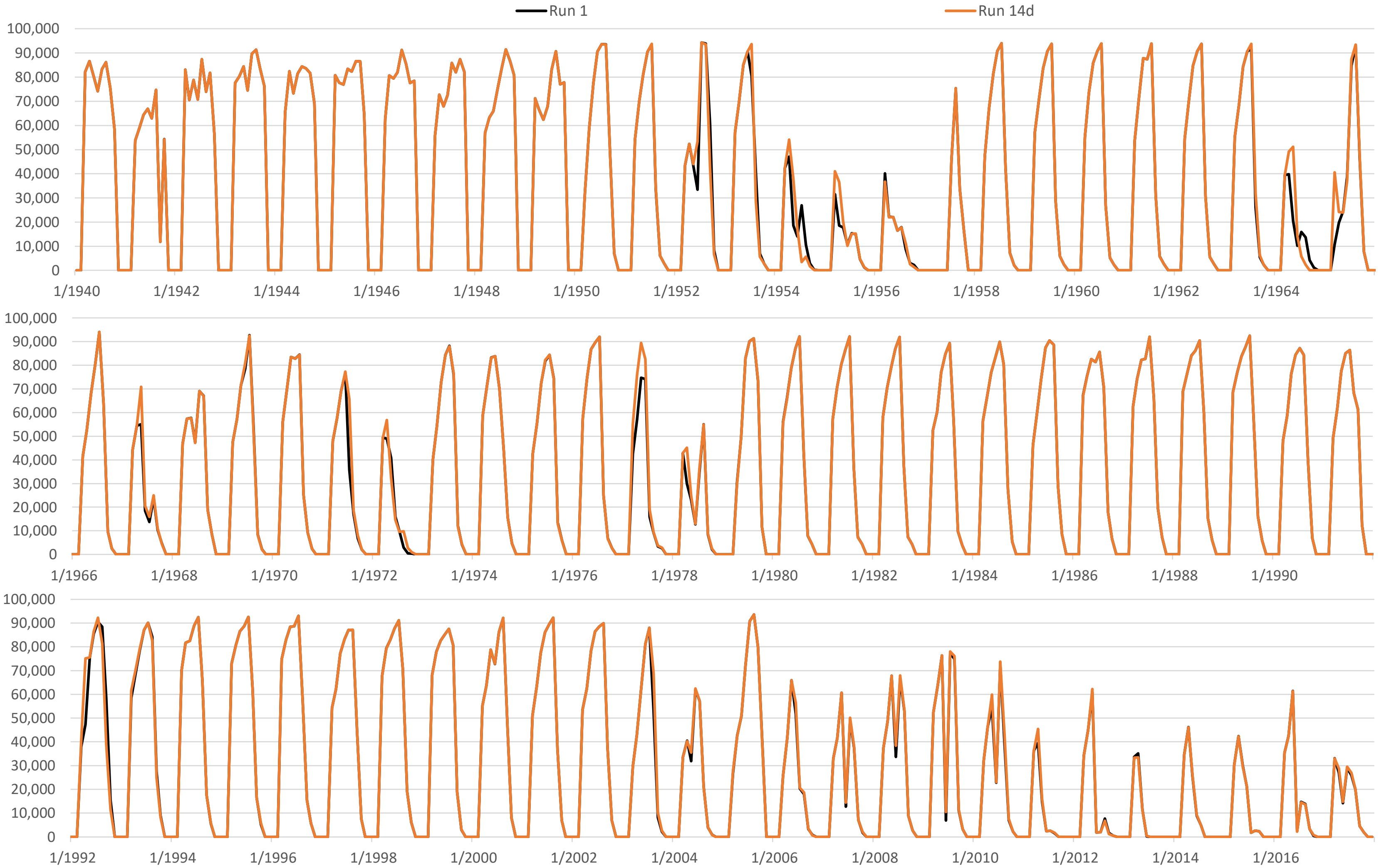
Monthly Net RHG Diversions

Run 14d v. Run 1

ILRG Model

1940 - 2017 (acre-feet)

EBID Total



Note: EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).

Run 14d - TX Hueco Pumping Off (Returns Left On)

Monthly Net RHG Diversions

Run 14d v. Run 1

ILRG Model

1940 - 2017 (acre-feet)

EPCWID Total

Note: EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

Run 14d - TX Hueco Pumping Off (Returns Left On)

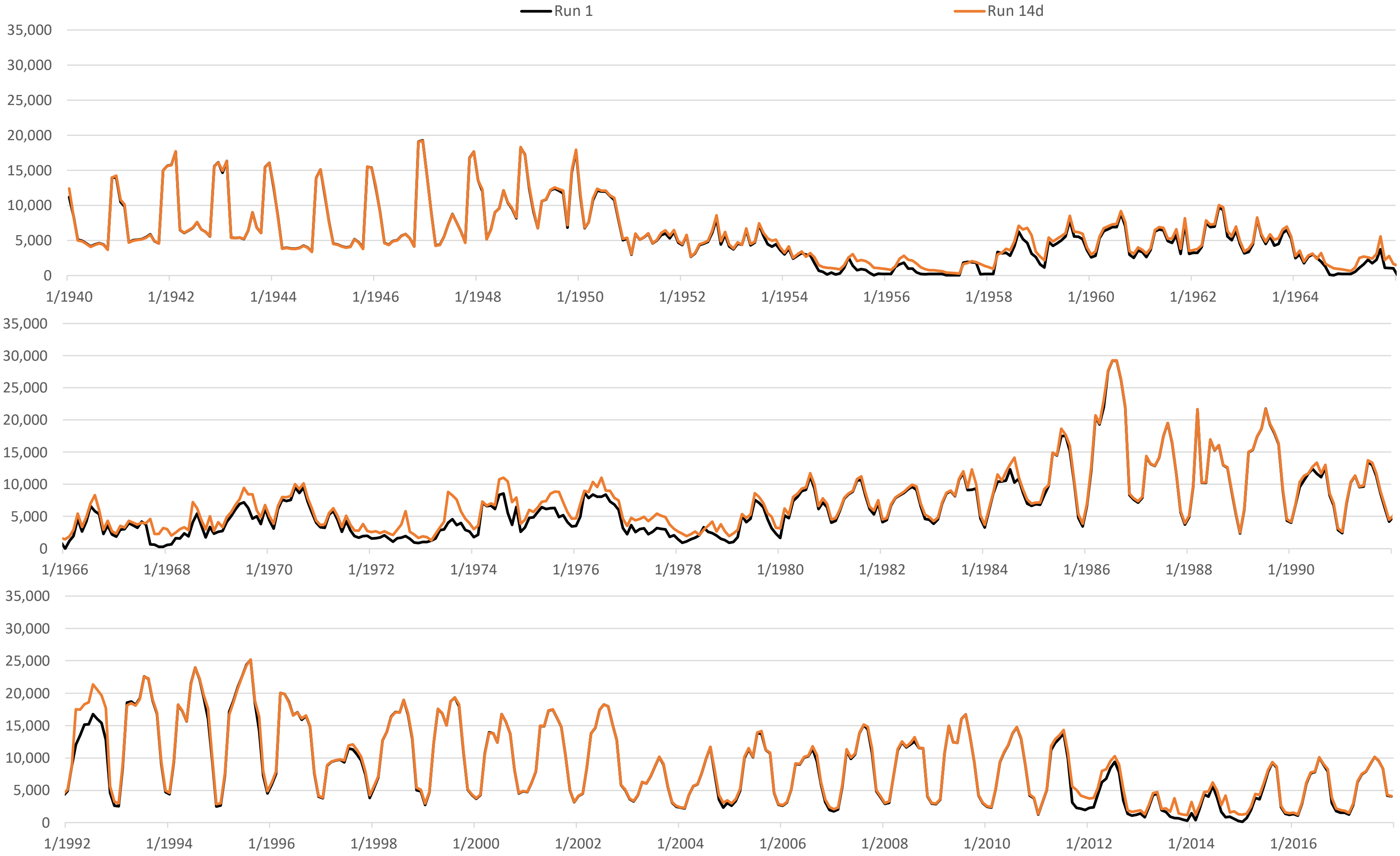
Monthly Net RHG Diversions

Run 14d v. Run 1

ILRG Model

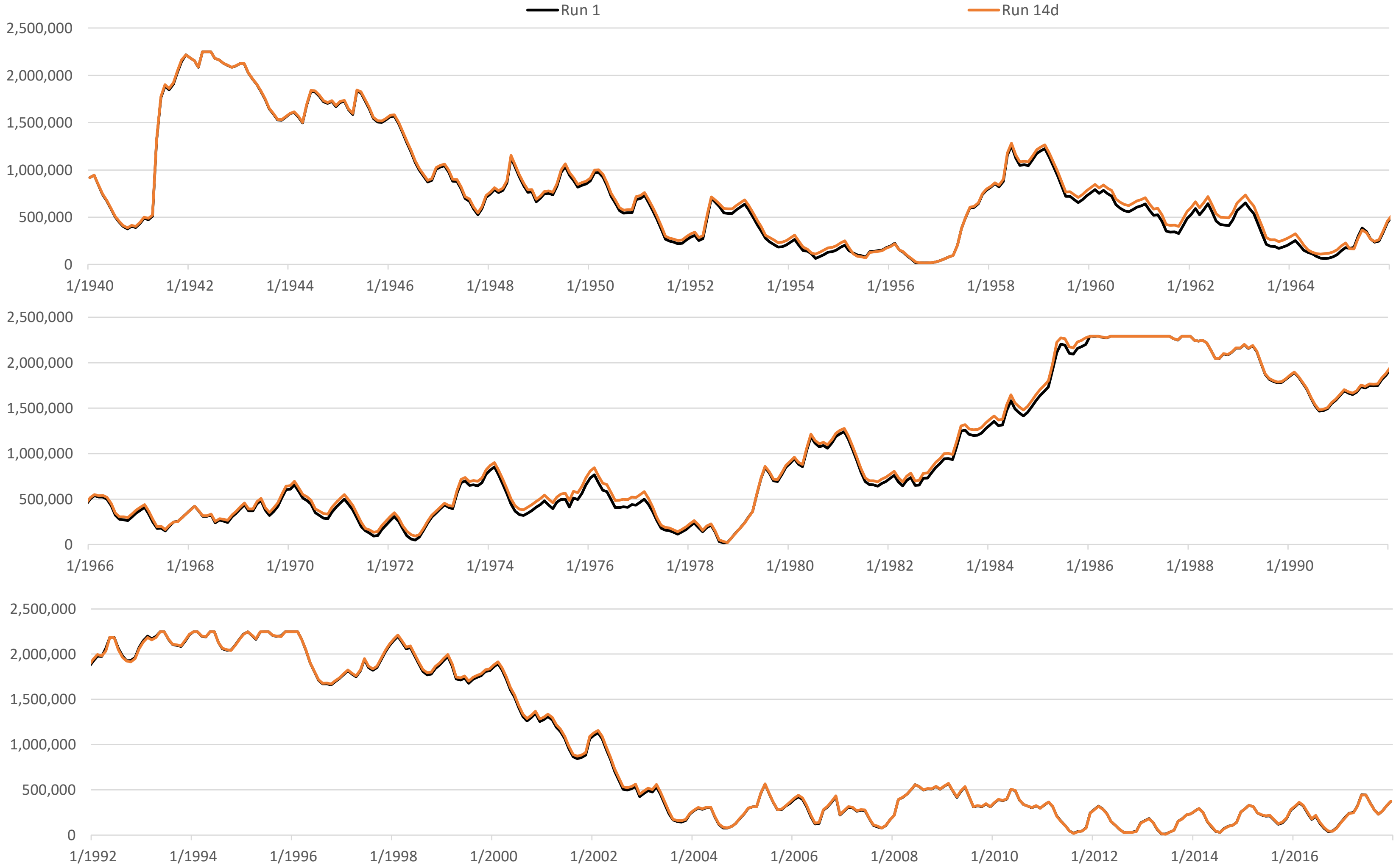
1940 - 2017 (acre-feet)

HCCRD Total



Note: HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

Run 14d - TX Hueco Pumping Off (Returns Left On)
End of Month Reservoir Storage (Elephant Butte + Caballo)
Run 14d v. Run 1
ILRG Model
1940 - 2017 (acre-feet)



Run 14d - TX Hueco Pumping Off (Returns Left On)
Monthly Caballo Releases
Run 14d v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

Run 14d - TX Hueco Pumping Off (Returns Left On)

Monthly Rio Grande at El Paso Flow

Run 14d v. Run 1

ILRG Model

1940 - 2017 (acre-feet)

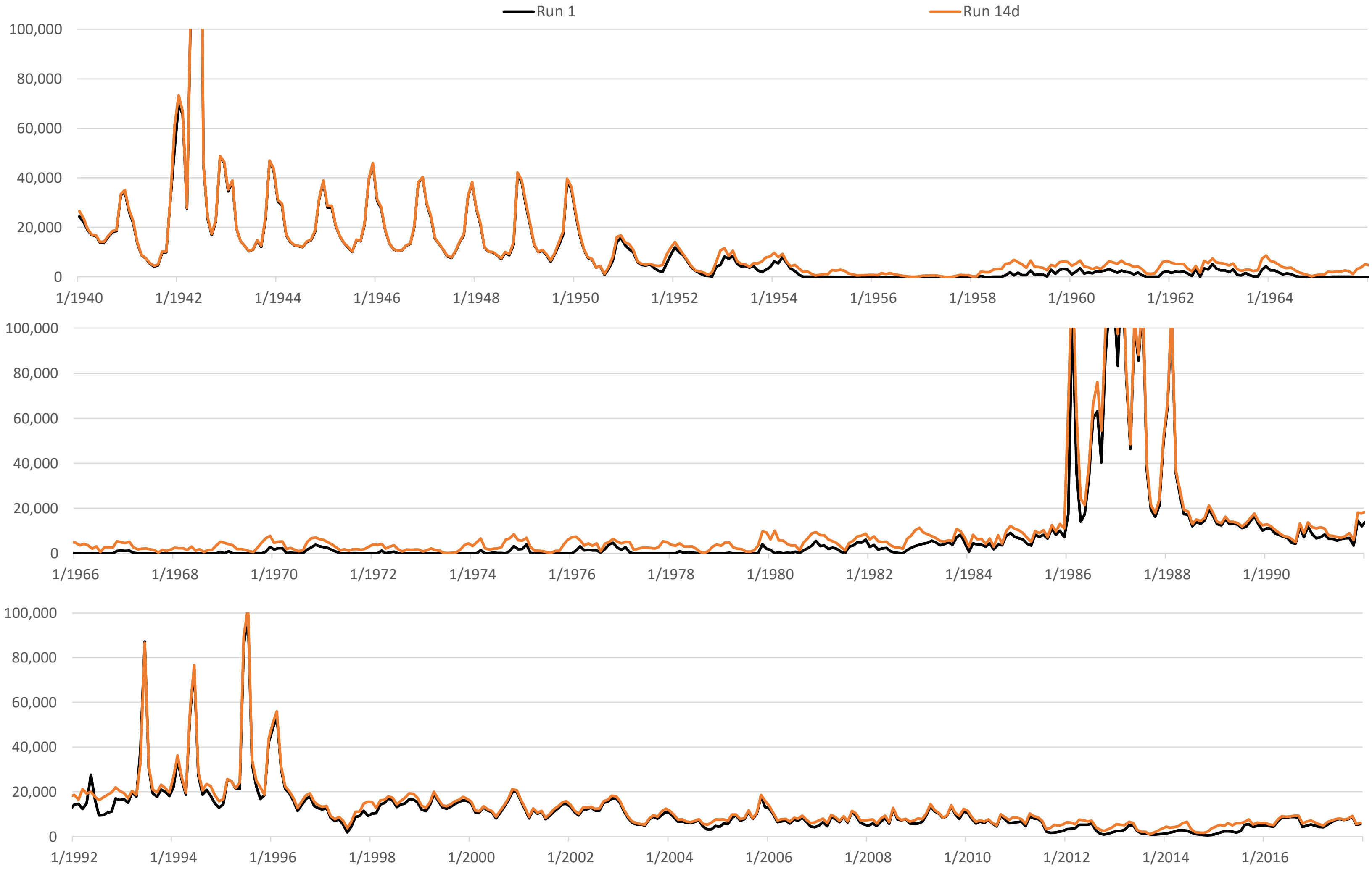
Run 14d - TX Hueco Pumping Off (Returns Left On)

Monthly Rio Grande at Fort Quitman Flow

Run 14d v. Run 1

ILRG Model

1940 - 2017 (acre-feet)



Appendix 30S

Comparison of ILRG Model Runs
Run 15 v. Run 1

Model Run Specifications

Model Version: LRG_v116

Name: **Run 15 - Early EPCWID Ops (WWTP & Fabens Drain)**

Run ID: LRG_v116_Operational_Run15
Date: 8/27/2020

Name: **Run 1 - Historical Base Run (All Pumping On)**

Run ID: LRG_v116_Operational_Run1
Date: 8/23/2020

Selected Model Inputs

Pumping and Returns	**Run 15**	**Run 1**
Irrigation Pumping	On	On
Irrigated Area	Hist	Hist
Non-Irrigation Pumping	On	On
Non-Irrigation Pumping Returns	On	On
Las Cruces Jornada Pumping Returns	On	On

Project Allocation Rules		
1950-2005	D1/D2	D1/D2
2006-2007	D3	D3
2008-2017	D3 + CO	D3 + CO

EPCWID Operations		
Charge EPCWID for Use of WWTP Returns	On	Off
ACE and Haskell Credits for EPCWID	Off	On
(1) Increased EPCWID Use of Fabens Drain Flows	On	Off
Charge EPCWID for Fabens Drain Flow Use	On	Off

Notes:
(1) Starting in July 1945, use 70% of simulated Fabens drain flow up to 6,000 af/month.

Run 15 - Early EPCWID Ops (WWTP & Fabens Drain)

Comparison of ILRG Model Runs

Run 15 v. Run 1

1951 - 2017 Annual Average

(1,000 acre-feet)

Run No.	1	15	15 - 1	
Simulated Input or Output	**Run 1**	**Run 15**	**Run 15 minus Run 1**	
Effects of Alternate Scenario				
FHG Deliveries (Mar - Oct)				***% Diff.***
EBID	167.6	177.9	10.3	*6%*
EPCWID (incl. EPW)	139.9	141.2	1.4	*1%*
HCCRD	32.8	32.4	-0.5	*-1%*
Total	340.3	351.5	11.2	*3%*
FHG Deliveries (Nov - Feb)				
EBID	0.0	0.0	0.0	*-3%*
EPCWID (incl. EPW)	0.2	1.9	1.7	*894%*
HCCRD	2.4	2.7	0.3	*14%*
Total	2.6	4.6	2.0	*78%*
Irrigation Pumping				
EBID	140.4	130.4	-10.0	*-7%*
EPCWID (Mesilla Valley)	7.4	7.0	-0.4	*-5%*
EPCWID (El Paso Valley)	40.1	37.5	-2.6	*-6%*
HCCRD	4.2	4.7	0.5	*11%*
Total	192.1	179.6	-12.5	*-7%*
Other Inflows/Outflows				
Net Reservoir Evaporation	125.3	129.6	4.3	*3%*
Riparian ET	70.9	70.5	-0.4	*-1%*
River Evaporation + Incidental Canal Loss	30.3	30.7	0.3	*1%*
Total	226.6	230.8	4.3	*2%*
Rio Grande at Fort Quitman				
Reservoir Spills	33.3	38.6	5.3	*16%*
Nov-Feb Flows	21.4	18.2	-3.2	*-15%*
Mar - Oct Flows	41.1	32.4	-8.6	*-21%*
Underflow (GW Model)	0.2	0.2	0.0	*-5%*
Total	96.0	89.4	-6.6	*-7%*

Run 15 - Early EPCWID Ops (WWTP & Fabens Drain)

Comparison of ILRG Model Runs

Run 15 v. Run 1

1951 - 2017 Annual Average

(1,000 acre-feet)

Run No.	1	15	15 - 1	
Simulated Input or Output	**Run 1**	**Run 15**	**Run 15 minus Run 1**	
Effects of Alternate Scenario (continued)				
Change in Storage				***% Diff.***
Reservoir Storage	-4.7	-6.0	-1.4	*29%*
Alluvial GW Storage (RW Model)	-23.6	-21.9	1.7	*-7%*
Non-alluvial GW Storage (GW Models)	-96.4	-94.6	1.8	*-2%*
Soil Moisture Storage	0.6	0.6	0.0	*-2%*
Total	-124.0	-121.9	2.1	*-2%*
Summary of Effects				
FHG Deliveries (Mar-Oct)	340.3	351.5	11.2	*3%*
FHG Deliveries (Nov-Feb)	2.6	4.6	2.0	*78%*
Irrigation Pumping	192.1	179.6	-12.5	*-7%*
Riparian ET + Evaporation	226.6	230.8	4.3	*2%*
Fort Quitman Flow	96.0	89.4	-6.6	*-7%*
Change in Storage	-124.0	-121.9	2.1	*-2%*
Total	733.6	734.0	0.5	*0%*
Other Effects of Alternate Scenario				
Rio Grande at El Paso				***% Diff.***
Reservoir Spills	49.4	59.4	10.0	*20%*
Nov-Feb Flows	22.8	22.7	-0.1	*0%*
Mar - Oct Flows	263.8	247.4	-16.3	*-6%*
Total	336.0	329.5	-6.4	*-2%*
Rio Grande below Caballo				
Reservoir Spills	65.9	79.3	13.5	*20%*
Nov-Feb Flows	0.5	0.3	-0.2	*-39%*
Mar - Oct Flows	541.3	525.0	-16.3	*-3%*
Total	607.6	604.6	-3.0	*0%*
Surface Water Diversions (Mar - Oct)				
EBID	366.5	384.8	18.4	*5%*
EPCWID (incl. EPW)	236.8	221.7	-15.1	*-6%*
HCCRD	67.5	64.4	-3.1	*-5%*
Total	670.8	671.0	0.2	*0%*
Surface Water Diversions (Nov - Feb)				
EBID	0.0	0.0	0.0	*0%*
EPCWID (incl. EPW)	14.3	15.7	1.4	*10%*
HCCRD	14.2	14.3	0.1	*1%*
Total	28.5	30.0	1.5	*5%*

Run 15 - Early EPCWID Ops (WWTP & Fabens Drain)
Annual Differences in ILRG Model Outputs
Run 15 minus Run 1
1940 - 2017 (acre-feet)

	Net River Headgate Diversions						Farm Headgate Deliveries						Annual Flows		
	EBID		EPCWID (incl. EPW)		HCCRD		EBID		EPCWID (incl. EPW)		HCCRD				
Year	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Caballo Releases	Rio Grande at El Paso	Rio Grande at Fort Quitman
1940	-53	-53	3	-5	1	-4	-2	-2	1	1	1	1	-52	-27	-51
1941	-165	-165	-6	-10	-2	-4	-4	-4	-1	0	-2	-4	44	71	10
1942	-33	-33	-1	-6	-1	-1	0	0	2	7	0	-1	28	9	-45
1943	-64	-64	-4	-7	2	3	-14	-14	-12	-12	2	-1	-22	-11	-113
1944	-82	-82	-144	-137	-73	-71	-5	-5	16	-2	-62	-63	-164	-156	-59
1945	2	2	-17,007	-5,527	1,397	918	-53	-53	-308	6,373	1,081	988	-10,929	-10,412	-16,329
1946	36	36	-10,388	-11,149	-392	-7,349	-110	-111	-717	3,359	-75	-239	-18,238	-17,652	-18,288
1947	56	56	-12,881	-6,763	699	-5,757	-15	-15	3,974	11,138	923	1,019	-10,314	-10,390	-19,242
1948	10	10	-10,680	-6,705	136	-4,668	-15	-16	-1,976	4,581	410	237	-8,508	-8,535	-10,866
1949	46	46	-20,056	-15,361	1,553	3,235	-52	-53	622	6,491	-293	-545	-18,657	-18,082	-19,561
1950	29	29	-22,080	-18,138	-9,742	-11,071	-10	-11	-2,678	2,556	238	420	-20,459	-20,089	-17,835
1951	1,031	1,031	-11,245	-5,716	-641	-2,838	547	546	-3,508	1,706	-204	-2,191	-8,349	-8,207	-12,040
1952	990	990	-10,230	-6,917	-852	-2,128	3,848	3,843	-3,031	-53	-2,244	545	-24,631	-18,186	-11,150
1953	374	374	-15,022	-11,707	-843	-1,988	2,382	2,381	-2,558	344	-1,247	625	-5,823	-11,206	-16,020
1954	19,737	19,737	5,461	6,461	-608	369	15,858	15,858	16,864	17,821	-80	877	15,476	12,025	-11,775
1955	32,948	32,948	21,327	21,393	1,978	3,108	17,384	17,384	21,132	21,075	1,916	2,969	52,052	26,213	387
1956	521	521	1,018	1,024	621	593	-2,354	-2,354	416	307	444	300	-1,818	812	-25
1957	10	10	-584	-750	511	466	70	70	546	503	680	590	-1,763	-567	-3
1958	-2	-2	-3,303	-3,501	725	1,763	283	283	-180	-162	75	57	-13,440	-3,251	1,334
1959	5	5	-10,170	-9,846	537	1,432	96	96	-543	-340	6	23	-14,382	-10,295	1,117
1960	8	8	-10,551	-10,102	-549	-807	50	50	-1,427	-893	0	0	-13,090	-11,464	-1,317
1961	15	15	232	1,210	665	823	54	54	1,142	2,162	647	-428	713	-73	1,652
1962	10	10	-13,595	-12,220	-2,153	-2,313	-12	-12	-1,499	-320	19	-303	-17,703	-15,417	-1,863
1963	8,891	8,891	-5,579	-3,709	-1,278	-1,594	4,851	4,851	-911	785	-512	-514	1,784	-2,062	-1,637
1964	23,205	23,205	8,235	9,173	123	793	11,908	11,908	18,888	19,529	1,038	969	23,726	12,129	-4,022
1965	7,409	7,409	258	252	1,736	1,733	3,904	3,904	3,401	3,377	594	585	-2,303	1,783	191
1966	-32	-32	-10,691	-10,007	-3,129	-3,345	248	248	-216	146	-3,069	-1,086	-14,380	-8,987	-1,154
1967	15,337	15,337	3,524	4,296	1,284	1,703	8,631	8,631	3,819	3,587	582	1,688	10,590	5,925	-648
1968	7,801	7,801	4,888	5,719	1,768	1,255	6,287	6,287	1,298	1,009	1,704	1,366	7,992	7,786	173
1969	-16	-16	-15,894	-15,390	-9,696	-9,407	240	240	71	402	-9,314	-7,737	-21,223	-16,229	-1,587
1970	3	3	-21,538	-20,836	-7,851	-7,431	41	41	-1,263	-577	-322	4,348	-25,952	-23,128	-10,297
1971	28,846	28,846	-7,523	-6,074	-1,589	-3,323	17,598	17,598	-682	249	-297	-1,642	8,379	-4,291	-1,433
1972	-1,898	-1,898	-8,574	-7,858	-1,434	-1,584	-3,800	-3,800	-6,355	-6,343	-1,651	-1,789	-12,245	-6,506	-1,224
1973	-88	-88	2,895	2,897	673	833	715	715	607	423	585	838	514	2,778	6
1974	-5	-5	-9,063	-8,751	-4,117	-4,195	246	246	398	672	-3,588	-2,517	-9,589	-9,128	-1,922
1975	-235	-235	-17,873	-17,244	-12,941	-12,503	1,178	1,178	-323	220	-12,707	-12,582	-22,060	-17,960	384
1976	7	7	-18,342	-17,514	-17,236	-17,463	722	722	-858	-139	-2,753	3,540	-21,564	-20,125	-19,603
1977	51,142	51,142	23,618	25,238	9,140	9,553	21,699	21,699	14,206	16,535	8,479	9,420	44,578	32,383	1,611
1978	15,205	15,205	-1,303	444	-3,121	-3,420	7,924	7,924	9,342	10,771	-2,852	-3,213	9,167	4,134	-1,212

Run 15 - Early EPCWID Ops (WWTP & Fabens Drain)

Annual Differences in ILRG Model Outputs

Run 15 minus Run 1

1940 - 2017 (acre-feet)

	Net River Headgate Diversions						Farm Headgate Deliveries						Annual Flows		
	EBID		EPCWID (incl. EPW)		HCCRD		EBID		EPCWID (incl. EPW)		HCCRD				
Year	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Caballo Releases	Rio Grande at El Paso	Rio Grande at Fort Quitman
1979	253	253	-10,377	-8,624	-3,606	-2,620	1,079	1,079	3,320	4,818	-3,489	-2,644	-16,702	-8,342	-228
1980	11	11	-22,674	-20,834	-4,707	-4,195	159	159	-394	1,444	-1,795	-843	-27,114	-24,352	-5,028
1981	-53	-53	-26,925	-24,375	-6,320	-7,234	657	657	-1,235	1,748	964	1,298	-31,299	-29,363	-8,489
1982	-8	-8	-28,591	-25,816	-4,306	-4,952	-11	-11	-1,802	1,698	-1,222	840	-32,831	-31,337	-7,001
1983	-13	-13	-28,620	-26,278	-11,457	-11,853	-57	-57	-2,488	511	0	0	-32,938	-31,875	-12,753
1984	-46	-46	-26,481	-24,447	-17,022	-17,717	-1	-1	-1,502	1,776	377	377	-23,244	-23,579	-18,354
1985	-225	-225	-27,784	-25,505	-12,900	-12,637	458	460	-1,858	1,014	0	0	38,669	33,590	19,304
1986	-80	-80	-40,660	-39,311	-7,856	-6,639	345	356	-1,790	-32	0	0	87,164	89,553	69,341
1987	-194	-194	-52,069	-49,311	-7,544	-6,810	1,311	1,315	-879	3,230	0	0	-233	-729	-67,914
1988	-15	-15	-50,023	-46,674	-7,294	-6,895	128	128	-4,800	-97	0	0	-50,042	-43,698	-36,915
1989	9	9	-43,364	-38,789	-12,650	-13,149	-187	-188	-5,889	363	0	0	-52,018	-50,077	-36,657
1990	1,051	1,051	14,165	18,028	-2,570	-2,863	-7,635	-7,639	18,214	24,085	0	0	-20,240	-11,618	-19,924
1991	888	888	-39,567	-35,475	-15,468	-15,815	954	950	-7,965	-1,571	0	0	-38,656	-41,873	-31,558
1992	3,403	3,403	36,137	38,980	28,845	29,495	-10,156	-10,170	30,536	35,119	0	0	105,864	109,404	80,995
1993	591	591	-51,458	-47,315	-8,621	-8,841	729	723	-8,830	-2,284	0	0	-9,220	-13,448	-2,718
1994	419	419	-36,180	-32,959	-3,095	-3,119	-178	-175	27	5,072	0	0	17,113	13,291	9,011
1995	917	917	-31,911	-28,023	-722	-946	9	9	1,845	8,155	0	0	11,381	9,918	2,318
1996	-66	-66	-45,779	-43,137	-5,767	-5,071	120	120	-5,771	-1,639	0	0	-59,657	-54,301	-40,418
1997	-19	-19	-32,326	-29,971	-10,300	-11,792	-233	-233	-7,293	-2,217	0	0	-31,274	-32,198	-24,924
1998	-18	-18	-31,214	-29,092	-565	-1,507	41	42	-2,062	1,399	0	0	-19,924	-19,658	-24,533
1999	-299	-299	-46,311	-45,372	-735	-1,358	-296	-296	-8,090	-6,644	0	0	-39,106	-38,286	-29,025
2000	-410	-410	-22,677	-22,758	4,190	3,943	-8,914	-8,914	-5,757	-5,772	0	0	-24,407	-15,524	-11,196
2001	289	289	-21,542	-21,834	-4,646	-4,357	-362	-362	5,178	5,169	0	0	-18,646	-24,813	-25,825
2002	-9	-9	-28,214	-28,290	-2,044	-1,232	-266	-266	-40	-42	0	0	-28,180	-29,060	-30,520
2003	104,684	104,684	15,689	15,830	10,491	11,530	55,835	55,836	18,137	18,156	0	0	77,099	43,035	8,017
2004	36,680	36,680	-24,635	-23,896	-1,167	670	25,385	25,385	208	225	0	0	-20,644	-13,065	-10,748
2005	3,019	3,019	-13,484	-13,243	-6,336	-5,539	5,480	5,467	6,321	6,323	0	0	-30,347	-13,905	-15,419
2006	89,189	89,189	20,732	21,024	12,472	13,842	49,031	49,031	17,090	17,102	0	0	68,427	39,326	10,730
2007	70,547	70,547	-14,508	-14,011	-8,157	-6,780	43,568	43,568	5,963	5,985	0	0	-1,322	-8,275	-8,183
2008	121,041	121,041	-24,237	-23,578	-13,652	-12,353	76,791	76,793	-1,257	-1,216	0	0	21,645	-12,698	-11,250
2009	154,564	154,564	-30,342	-29,368	-3,004	-2,074	97,071	97,084	-3,739	-3,681	0	0	24,467	-973	-274
2010	129,946	129,946	-24,930	-23,113	-10,388	-9,848	86,115	86,116	-2,230	-2,181	0	0	-9,689	-10,302	-1,227
2011	78,768	78,768	-20,548	-19,675	-14,764	-14,519	40,483	40,483	-1,460	-1,431	0	0	4,052	-16,945	-14,042
2012	21,367	21,367	-3,236	-3,128	-6,274	-6,726	6,198	6,198	9,014	9,731	0	0	-1,904	-3,497	-3,784
2013	12,578	12,578	-11,693	-11,687	959	1,256	6,914	6,914	-2,803	-2,716	1,378	1,086	-9,724	-11,507	-2,944
2014	41,026	41,026	-26,778	-26,773	-4,886	-5,067	25,060	25,060	-13,253	-13,251	-4,631	-4,647	-1,140	-27,625	-6,221
2015	47,320	47,320	1,387	1,455	2,566	2,746	22,428	22,428	3,760	5,143	966	862	40,907	-692	-9,453
2016	486	486	-28,778	-28,693	-1,681	-1,848	-6,379	-6,379	-5,703	-4,800	0	0	-52,839	-32,180	-18,081
2017	101,668	101,668	-12,047	-11,741	1,194	747	56,084	56,084	3,097	3,791	0	0	39,662	-12,233	-14,095
Averages															
1951-2017	18,365	18,365	-15,097	-13,699	-3,105	-3,016	10,274	10,274	1,382	3,064	-471	-133	-3,018	-6,433	-6,598
1951-1978	7,544	7,544	-4,272	-3,215	-1,724	-1,783	4,307	4,307	2,456	3,314	-860	-188	-1,977	-2,897	-3,288
1979-2005	5,584	5,584	-26,551	-24,389	-4,229	-4,130	2,385	2,384	568	3,704	-191	-36	-9,979	-9,345	-10,043
2006-2017	72,375	72,375	-14,581	-14,107	-3,801	-3,385	41,947	41,948	707	1,040	-191	-225	10,212	-8,133	-6,569
1985-2017	30,882	30,882	-22,672	-21,134	-3,405	-3,138	17,149	17,149	846	3,045	-69	-82	522	-6,093	-9,034
1985-2005	7,172	7,172	-27,296	-25,148	-3,179	-2,997	2,979	2,978	926	4,191	0	0	-5,014	-4,927	-10,443

Notes:

EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).

EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

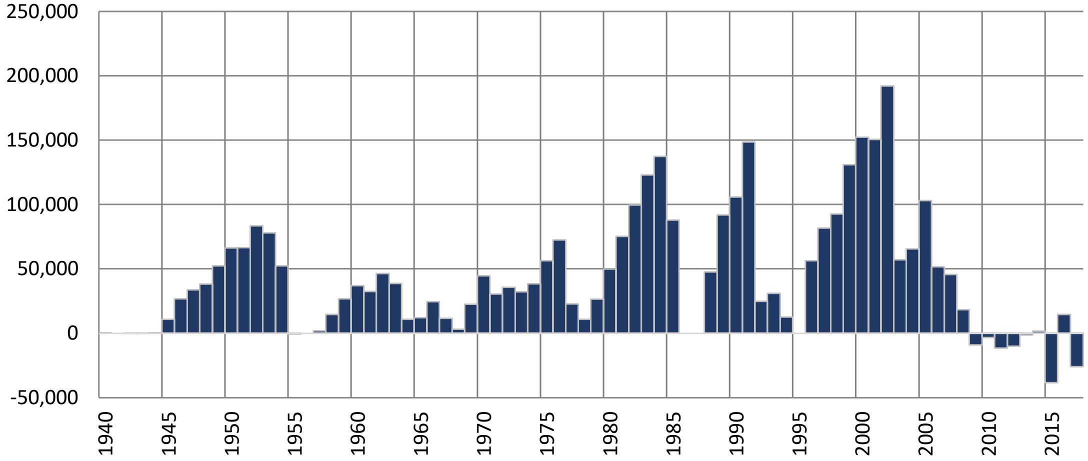
Run 15 - Early EPCWID Ops (WWTP & Fabens Drain)

Simulated Differences in ILRG Model Outputs

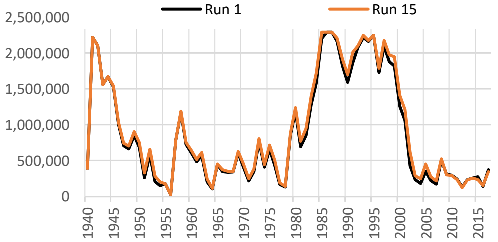
Run 15 minus Run 1

1940 - 2017 (acre-feet)

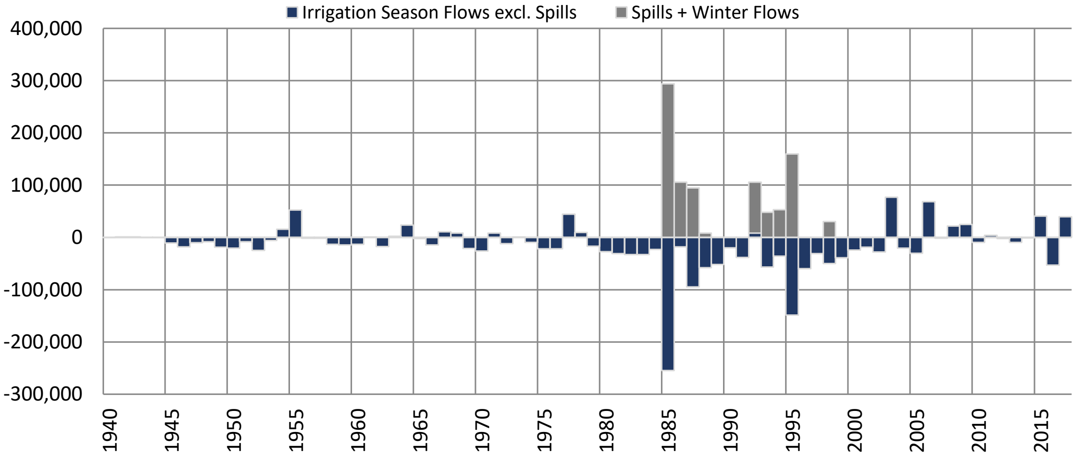
Total Project Storage (Year End)



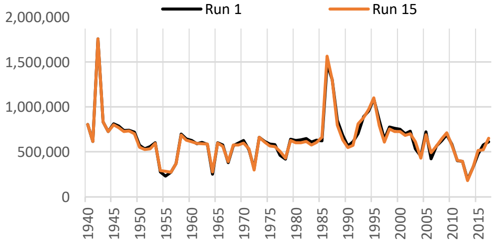
Period	Average Difference
1951-2017	-1,374
1951-1978	-1,980
1979-2005	3,418
2006-2017	-10,743
1985-2017	-4,944
1985-2005	-1,631



Caballo Reservoir Outflows (Annual)



	Average Difference		
Period	Irr Season (excl. Spills)	Nov-Feb and Spills	Annual
1951-2017	-16,303	13,285	-3,018
1951-1978	-1,977	0	-1,977
1979-2005	-42,945	32,966	-9,979
2006-2017	10,212	0	10,212
1985-2017	-26,450	26,972	522
1985-2005	-47,399	42,385	-5,014



Notes:

Reservoir storage does not include storage attributed to SJC, CO, or NM credit waters.

Average differences calculated as (Final Storage - Initial Storage)/(no. years).

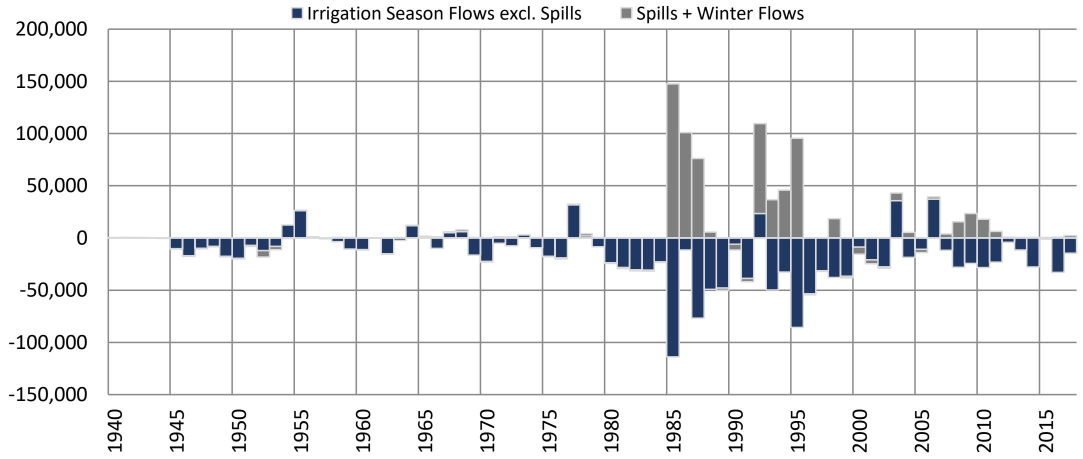
Run 15 - Early EPCWID Ops (WWTP & Fabens Drain)

Simulated Differences in ILRG Model Outputs

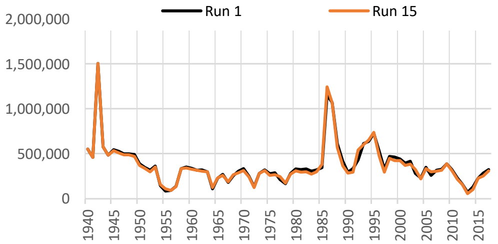
Run 15 minus Run 1

1940 - 2017 (acre-feet)

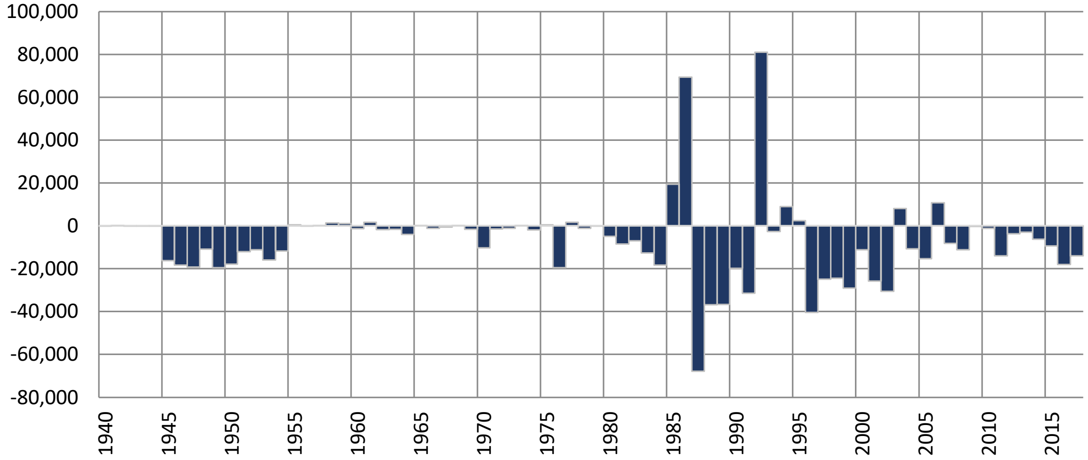
Rio Grande at El Paso (Annual)



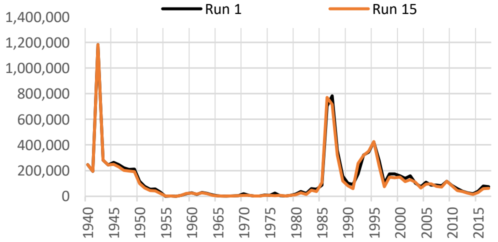
	Average Difference		
	Irr Season	Nov-Feb	
Period	(excl. Spills)	and Spills	Annual
1951-2017	-16,337	9,904	-6,433
1951-1978	-2,825	-72	-2,897
1979-2005	-31,287	21,942	-9,345
2006-2017	-14,229	6,096	-8,133
1985-2017	-26,393	20,300	-6,093
1985-2005	-33,344	28,417	-4,927



Rio Grande at Fort Quitman (Annual)



Period	Average Difference
1951-2017	-6,586
1951-1978	-3,280
1979-2005	-10,025
2006-2017	-6,564
1985-2017	-9,024
1985-2005	-10,430



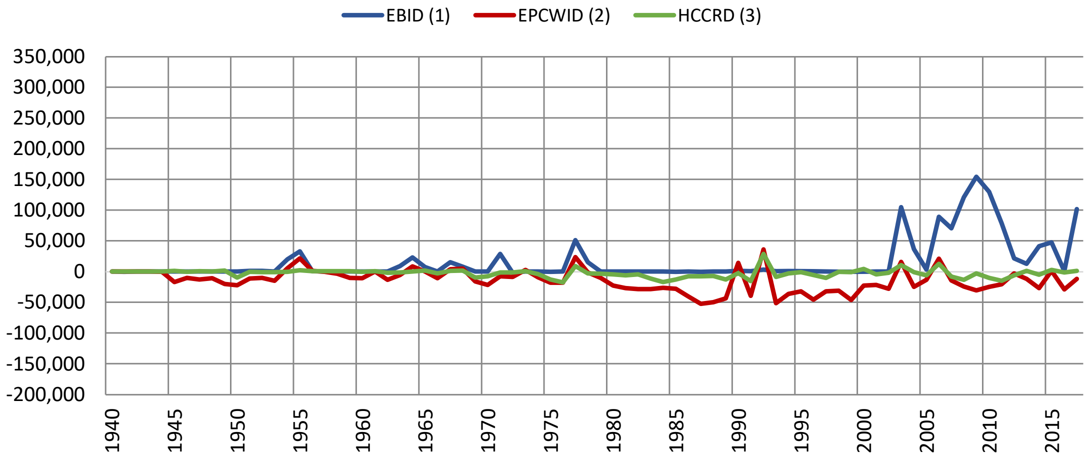
Run 15 - Early EPCWID Ops (WWTP & Fabens Drain)

Simulated Differences in ILRG Model Outputs

Run 15 minus Run 1

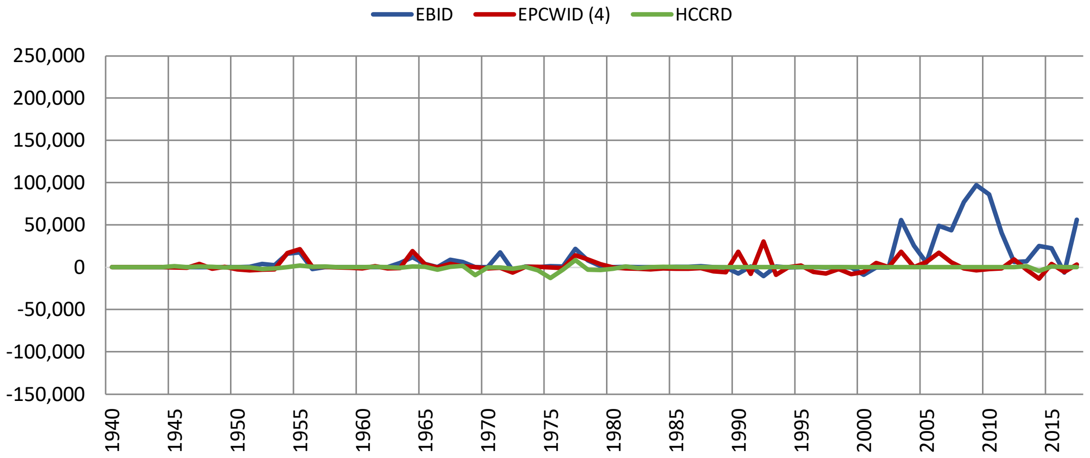
1940 - 2017 (acre-feet)

River Headgate (RHG) Diversions (Irrigation Season)



	Average Difference		
Period	EBID	EPCWID	HCCRD
1951-2017	18,365	-15,097	-3,105
1951-1978	7,544	-4,272	-1,724
1979-2005	5,584	-26,551	-4,229
2006-2017	72,375	-14,581	-3,801
1985-2017	30,882	-22,672	-3,405
1985-2005	7,172	-27,296	-3,179

Farm Headgate (FHG) Deliveries (Irrigation Season)



	Average Difference		
Period	EBID	EPCWID	HCCRD
1951-2017	10,274	1,382	-471
1951-1978	4,307	2,456	-860
1979-2005	2,385	568	-191
2006-2017	41,947	707	-191
1985-2017	17,149	846	-69
1985-2005	2,979	926	0

Notes:

(1) EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).

(2) EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

(3) HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

(4) EPCWID FHG values include deliveries to Rogers WTP and R/U WTP.

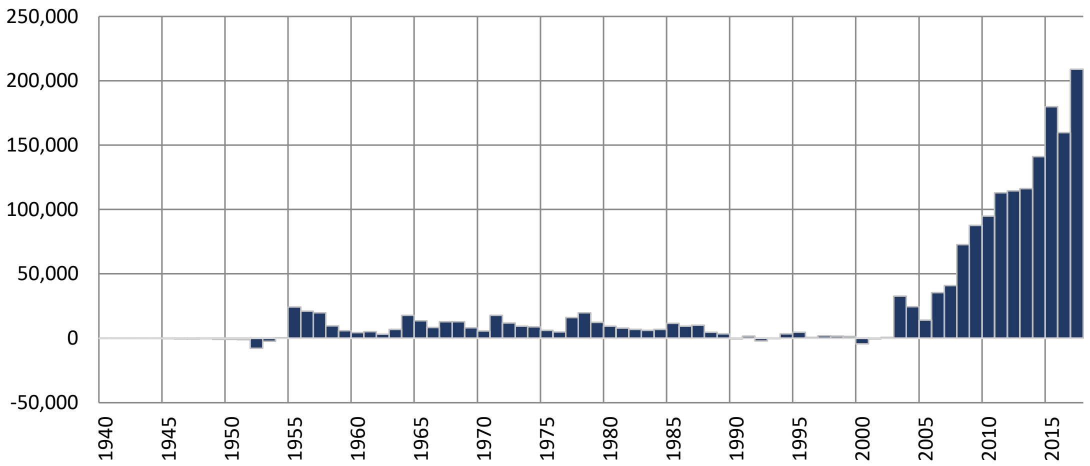
Run 15 - Early EPCWID Ops (WWTP & Fabens Drain)

Simulated Differences in ILRG Model Outputs

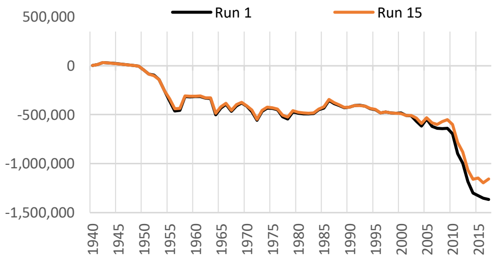
Run 15 minus Run 1

1940 - 2017 (acre-feet)

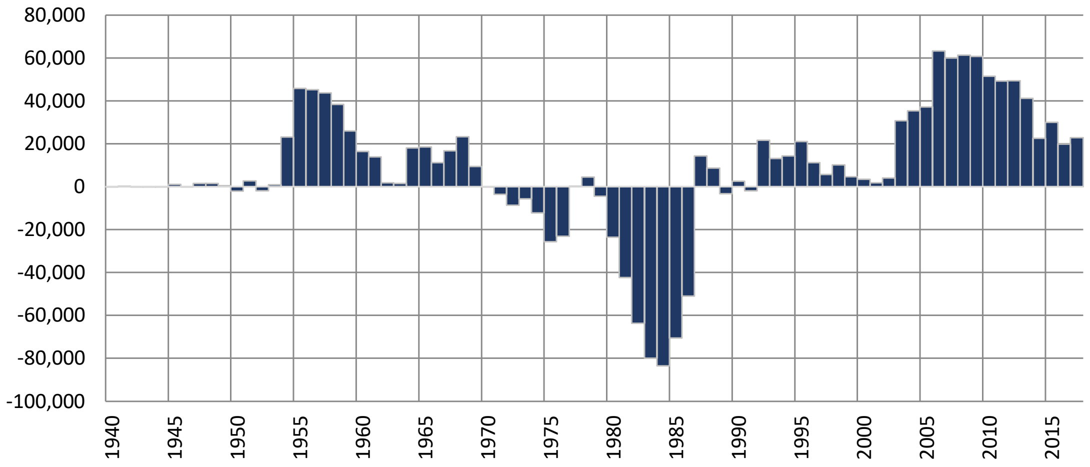
Cumulative Annual Rincon-Mesilla Groundwater Storage



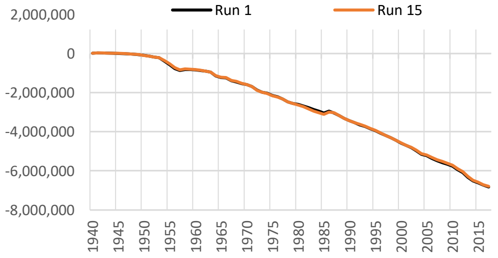
Period	Average Difference
1951-2017	3,131
1951-1978	733
1979-2005	-206
2006-2017	16,235
1985-2017	6,126
1985-2005	349



Cumulative Annual Hueco Groundwater Storage



Period	Average Difference
1951-2017	371
1951-1978	236
1979-2005	1,208
2006-2017	-1,196
1985-2017	3,221
1985-2005	5,744

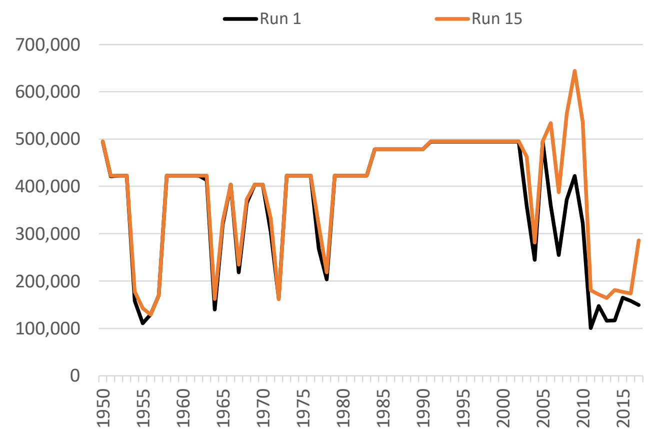


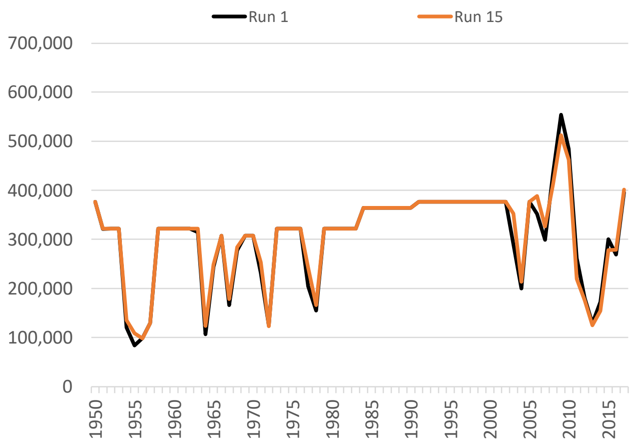
Notes:

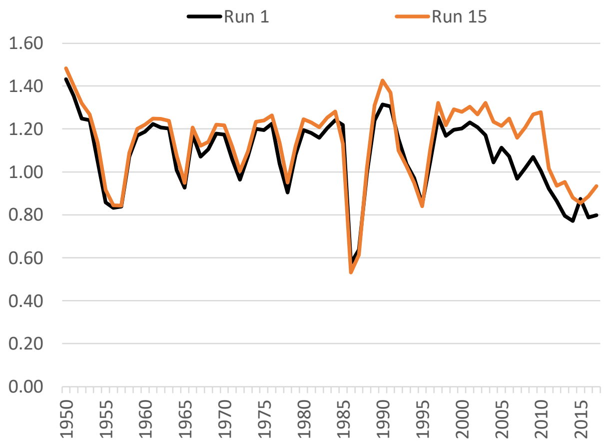
Cumulative storage change in alluvial and non-alluvial aquifers.

Average differences calculated as (Final Storage - Initial Storage)/(no. years).

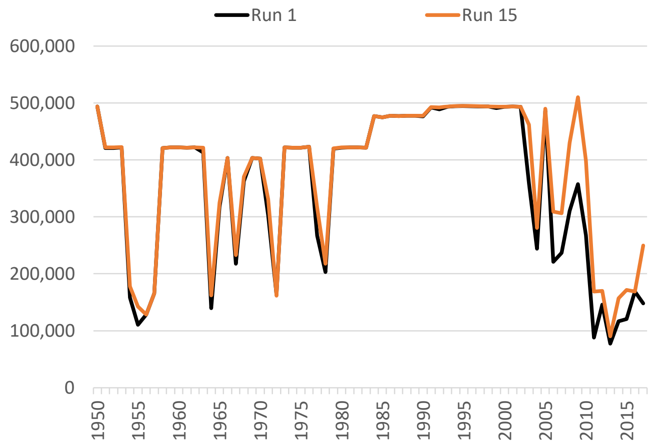
Run 15 - Early EPCWID Ops (WWTP & Fabens Drain)
Annual Allocation and Charges
Run 15 v. Run 1
ILRG Model
1950 - 2017 (acre-feet)

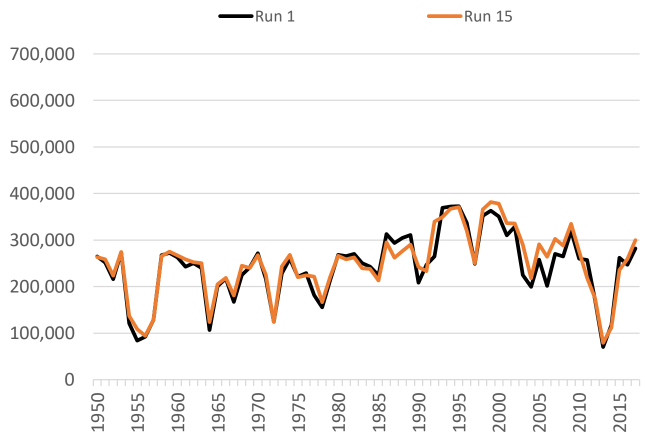

Total Allocation - EBID


Total Allocation - EPCWID


Diversion Ratio

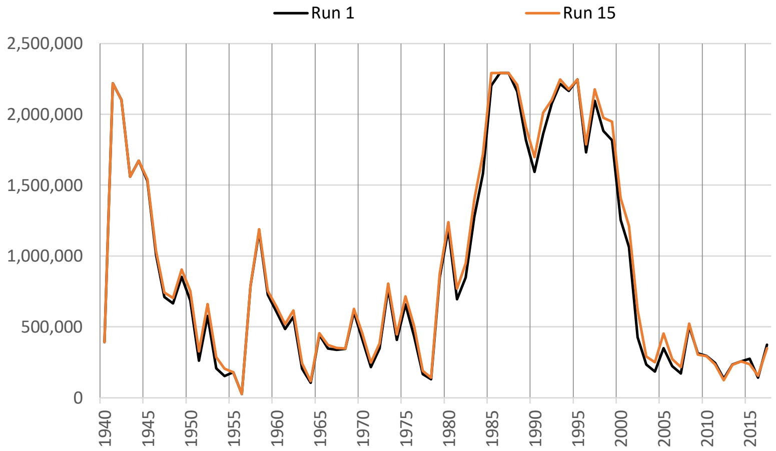
Note:
Computed as Total Charges/Caballo Release.


Annual Delivery Charges - EBID

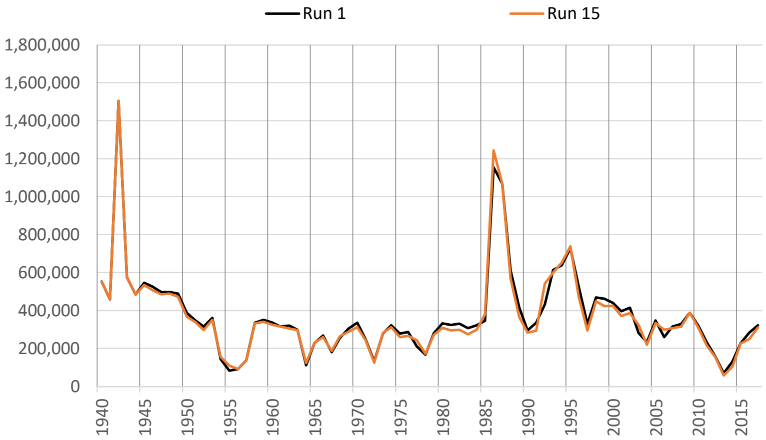

Annual Delivery Charges - EPCWID

Run 15 - Early EPCWID Ops (WWTP & Fabens Drain)
Annual Summary of Project Storage and Rio Grande Flows
Run 15 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

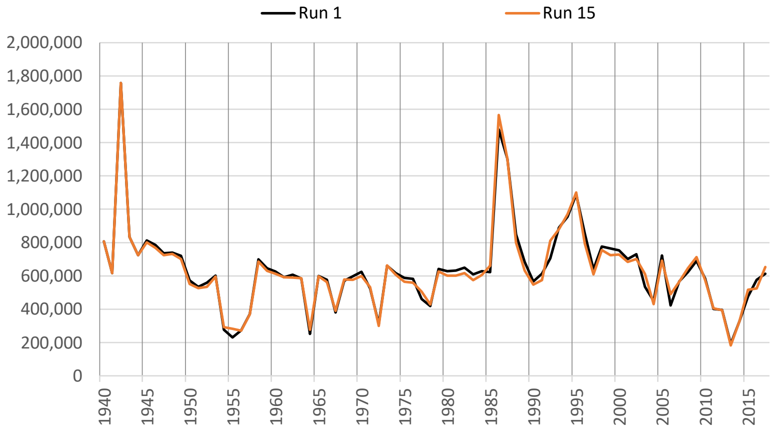
Total Year-End Project Reservoir Storage



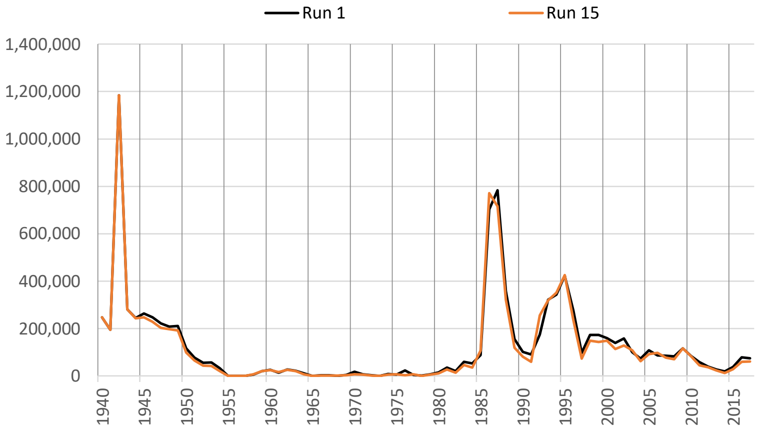
Rio Grande at El Paso



Rio Grande Below Caballo



Rio Grande at Fort Quitman

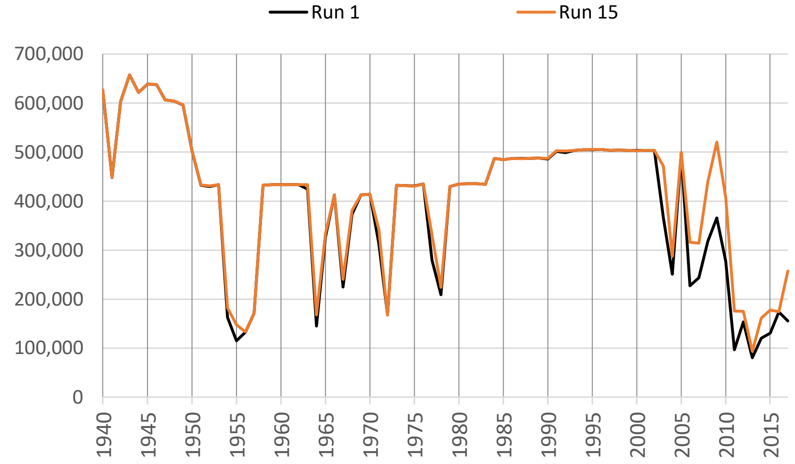


***Note different scales.**

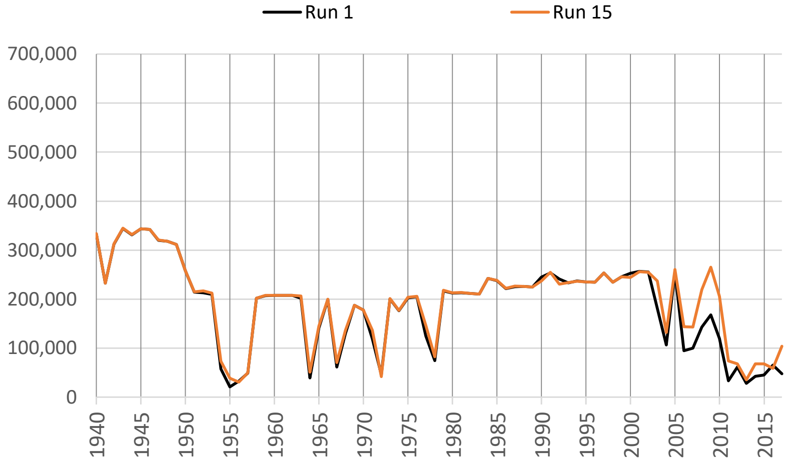
Run 15 - Early EPCWID Ops (WWTP & Fabens Drain)
Irrigation Season Summary of Irrigation Operations
Run 15 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

EBID Total

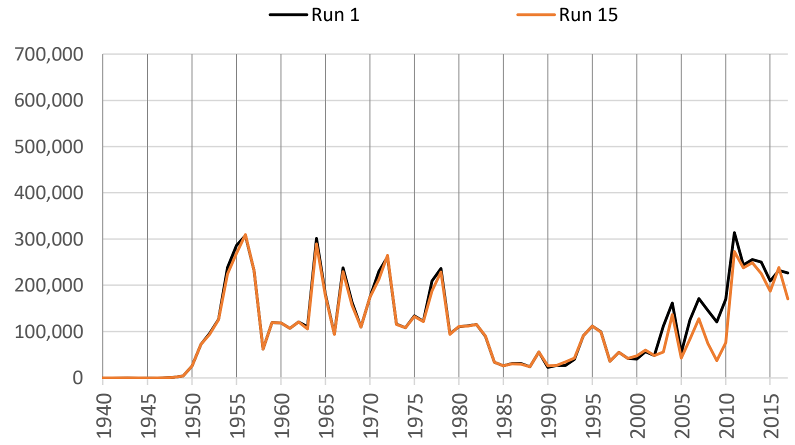
Net River Headgate Diversions



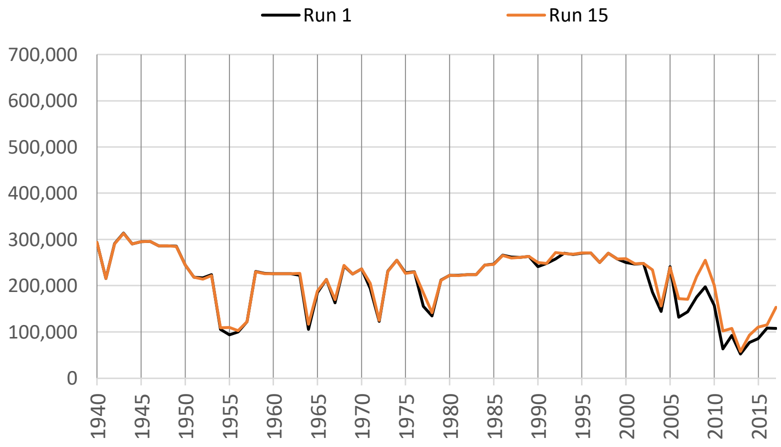
Farm Headgate Deliveries



Pumping



RHG Diversions - FHG Deliveries

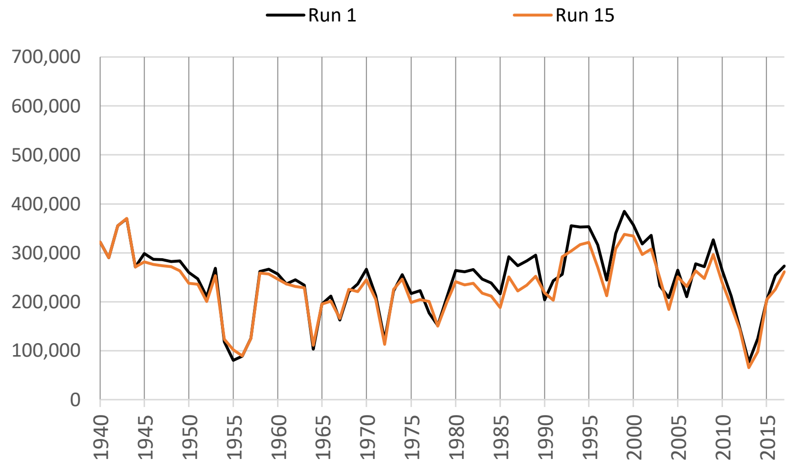


Notes: EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).
Pumping includes Supplemental and Primary groundwater pumping.

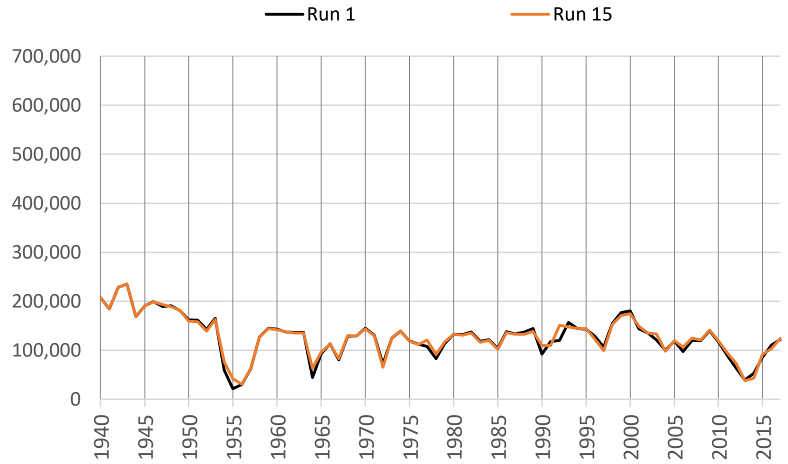
Run 15 - Early EPCWID Ops (WWTP & Fabens Drain)
Irrigation Season Summary of Irrigation Operations
Run 15 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

EPCWID Total

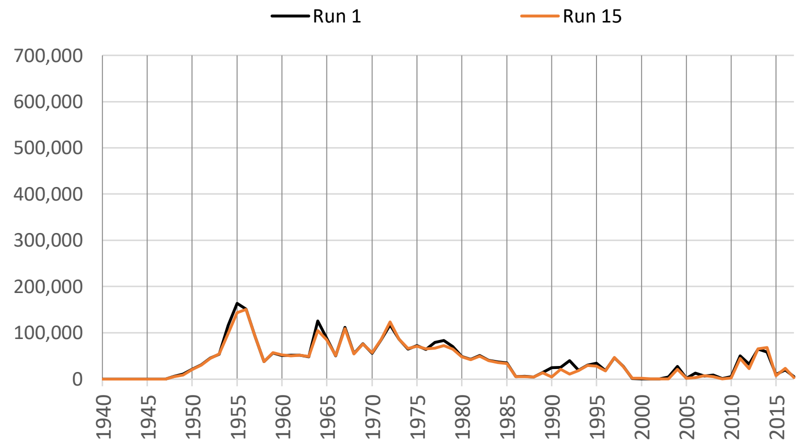
Net River Headgate Diversions



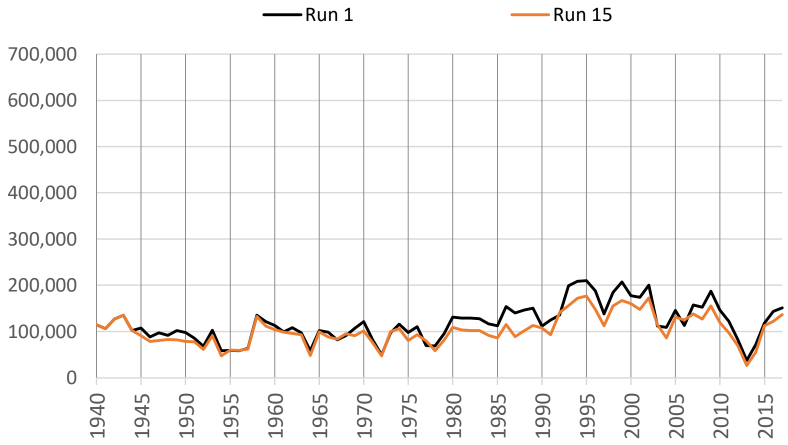
Farm Headgate Deliveries



Pumping



RHG Diversions - FHG Deliveries



Note: EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

Run 15 - Early EPCWID Ops (WWTP & Fabens Drain)

Irrigation Season Summary of Irrigation Operations

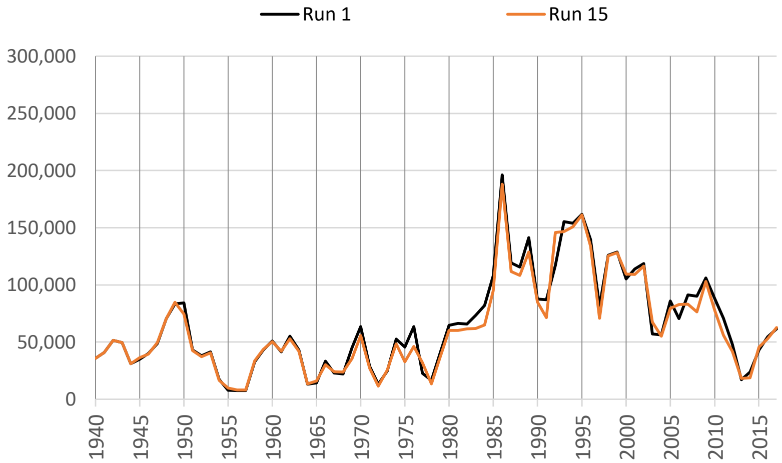
Run 15 v. Run 1

ILRG Model

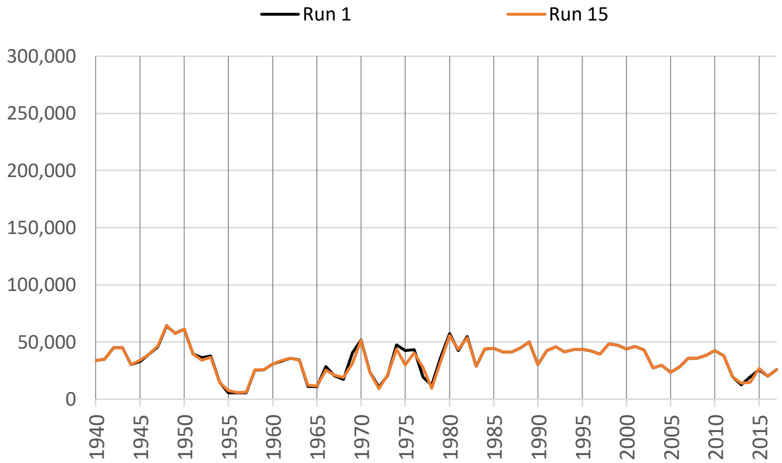
1940 - 2017 (acre-feet)

HCCRD Total

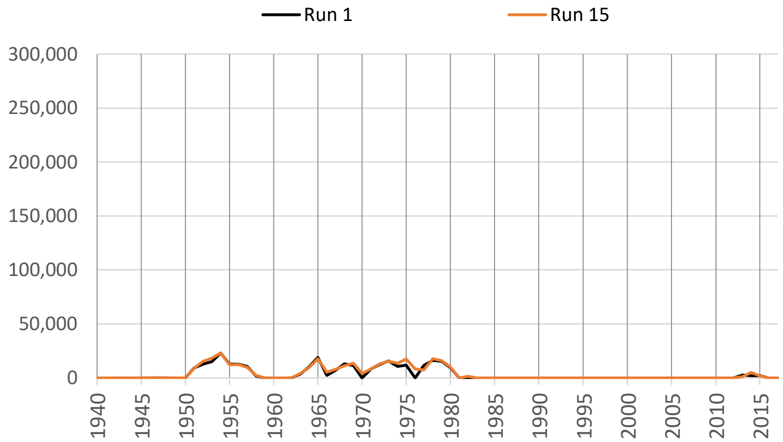
Net River Headgate Diversions



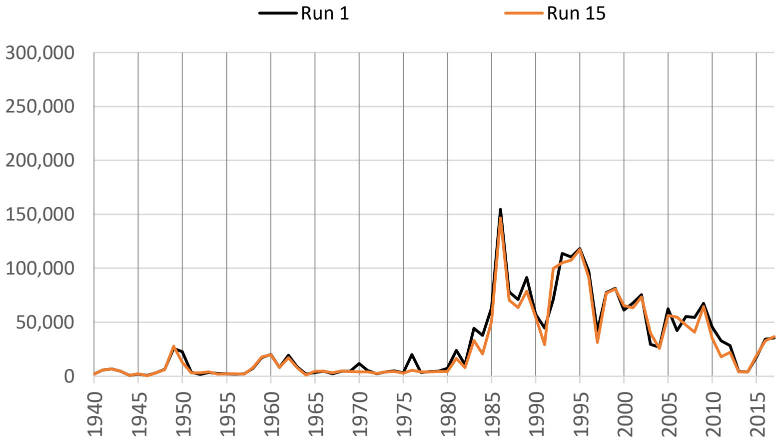
Farm Headgate Deliveries



Pumping



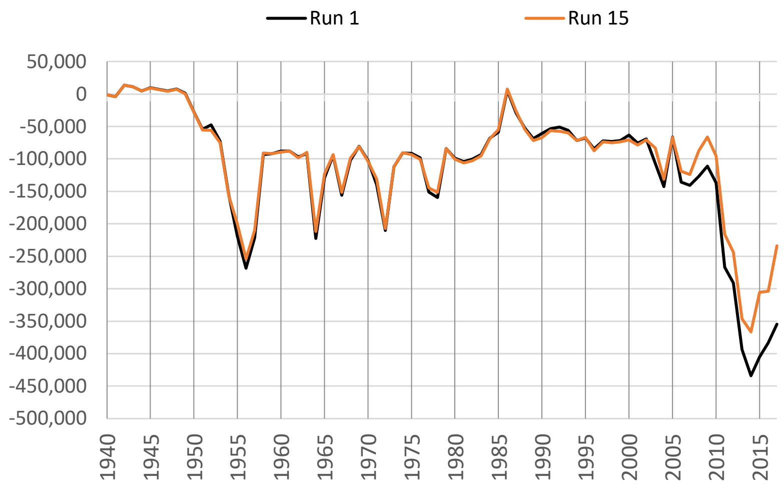
RHG Diversions - FHG Deliveries



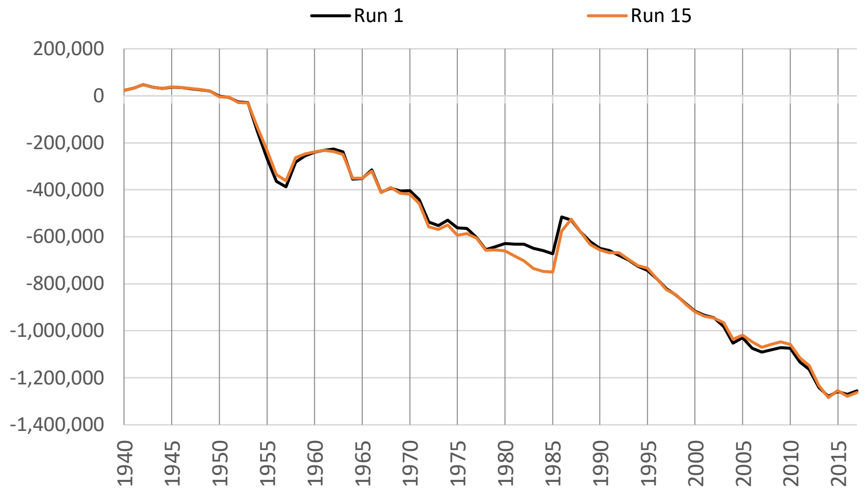
Note: HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

Run 15 - Early EPCWID Ops (WWTP & Fabens Drain)
Cumulative Change in Ground Water Storage
Run 15 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

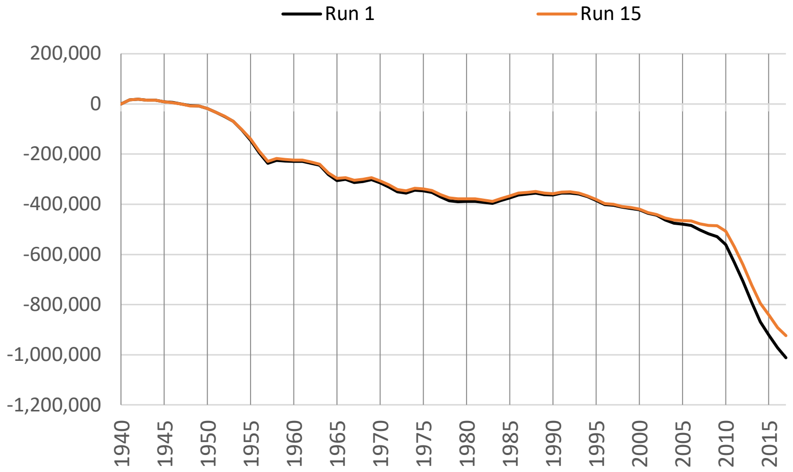
Rincon-Mesilla Alluvial Aquifer



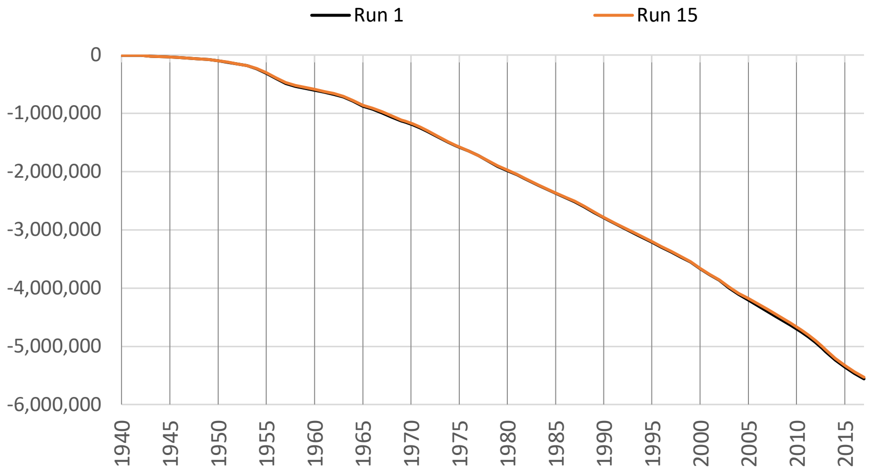
Hueco Alluvial Aquifer



Rincon-Mesilla Non-Alluvial Aquifer



Hueco Non-Alluvial Aquifer



***Note different scales.**

Run 15 - Early EPCWID Ops (WWTP & Fabens Drain)

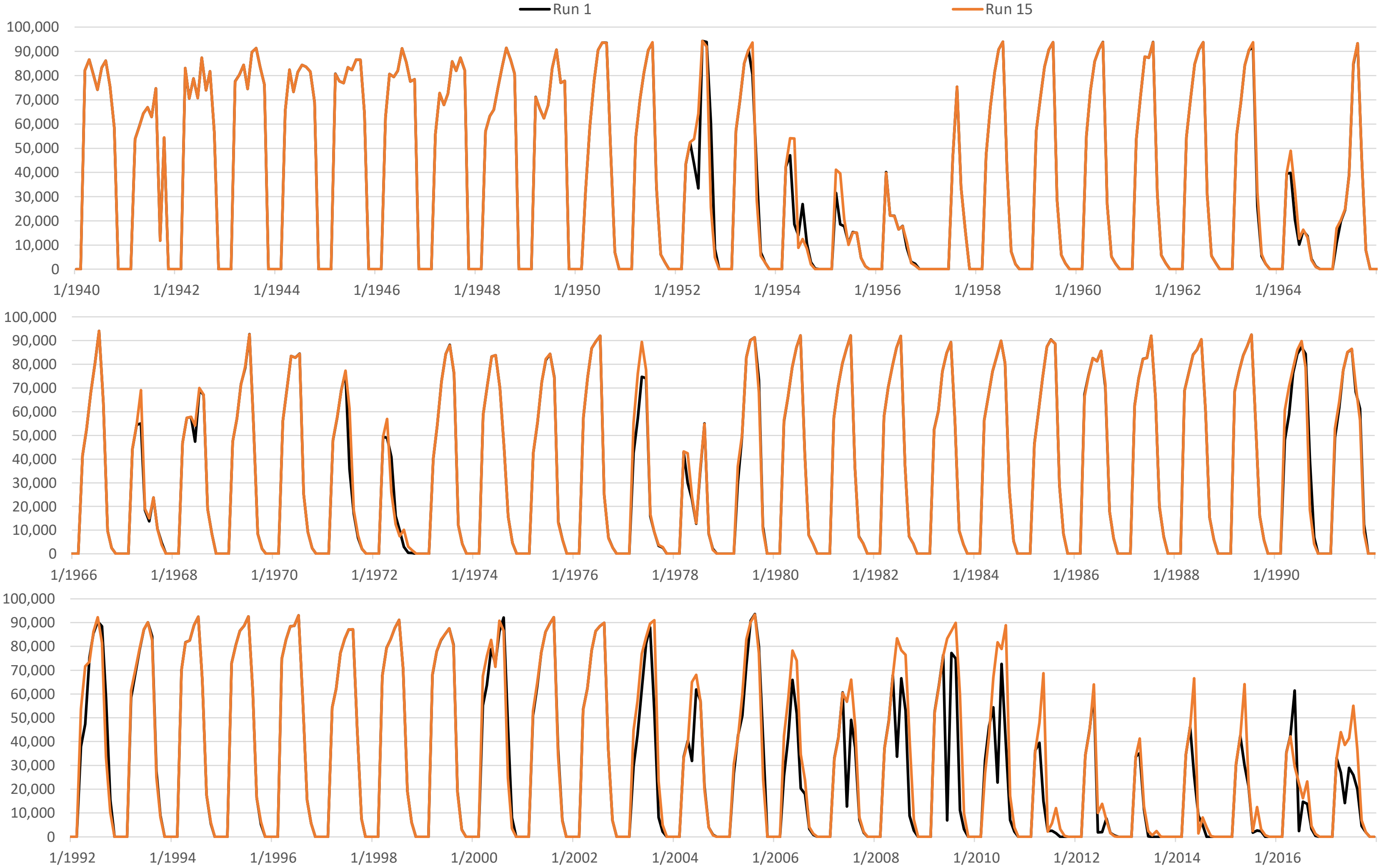
Monthly Net RHG Diversions

Run 15 v. Run 1

ILRG Model

1940 - 2017 (acre-feet)

EBID Total



Note: EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).

Run 15 - Early EPCWID Ops (WWTP & Fabens Drain)

Monthly Net RHG Diversions

Run 15 v. Run 1

ILRG Model

1940 - 2017 (acre-feet)

EPCWID Total

Note: EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

Run 15 - Early EPCWID Ops (WWTP & Fabens Drain)

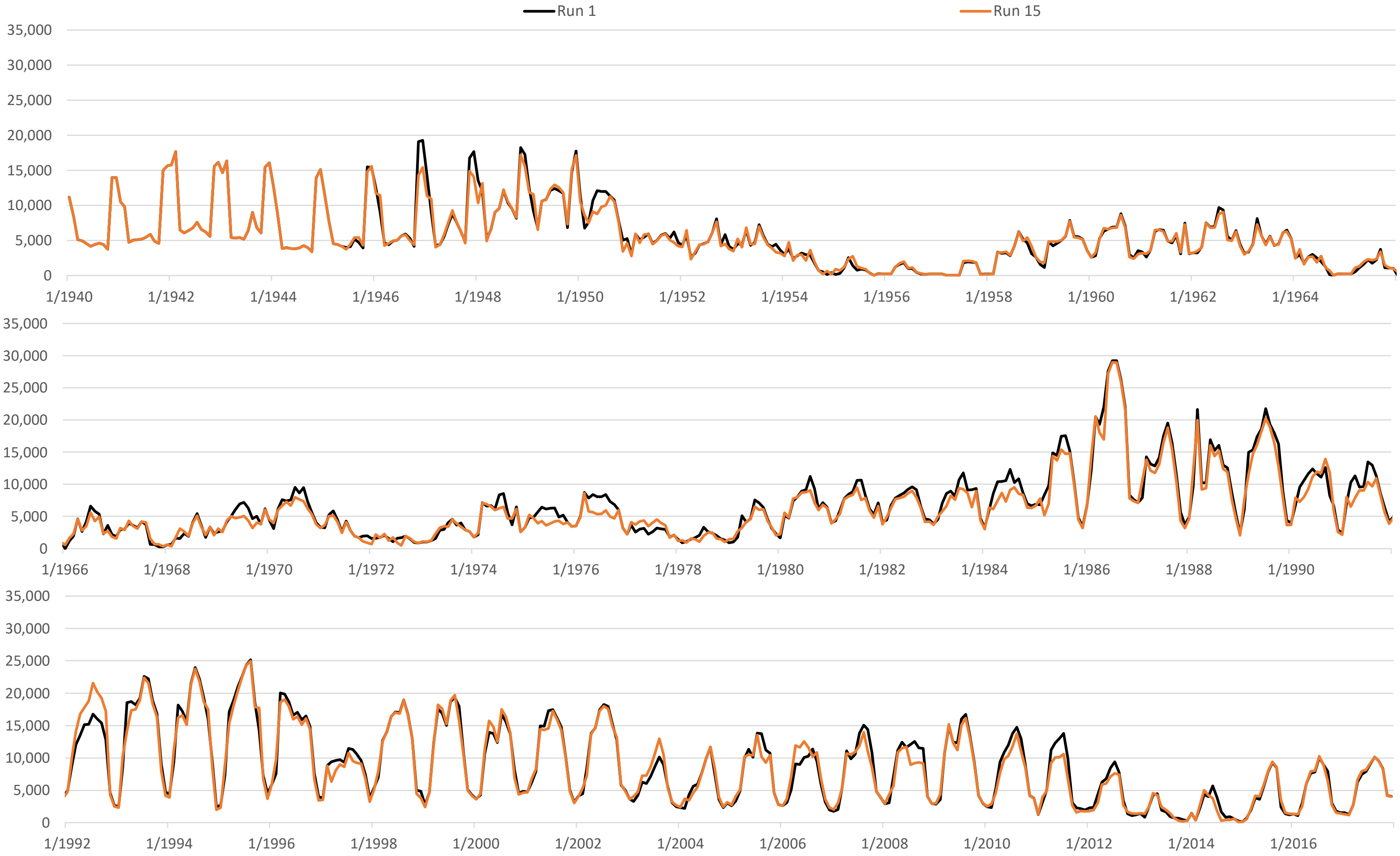
Monthly Net RHG Diversions

Run 15 v. Run 1

ILRG Model

1940 - 2017 (acre-feet)

HCCRD Total



Note: HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

Run 15 - Early EPCWID Ops (WWTP & Fabens Drain)

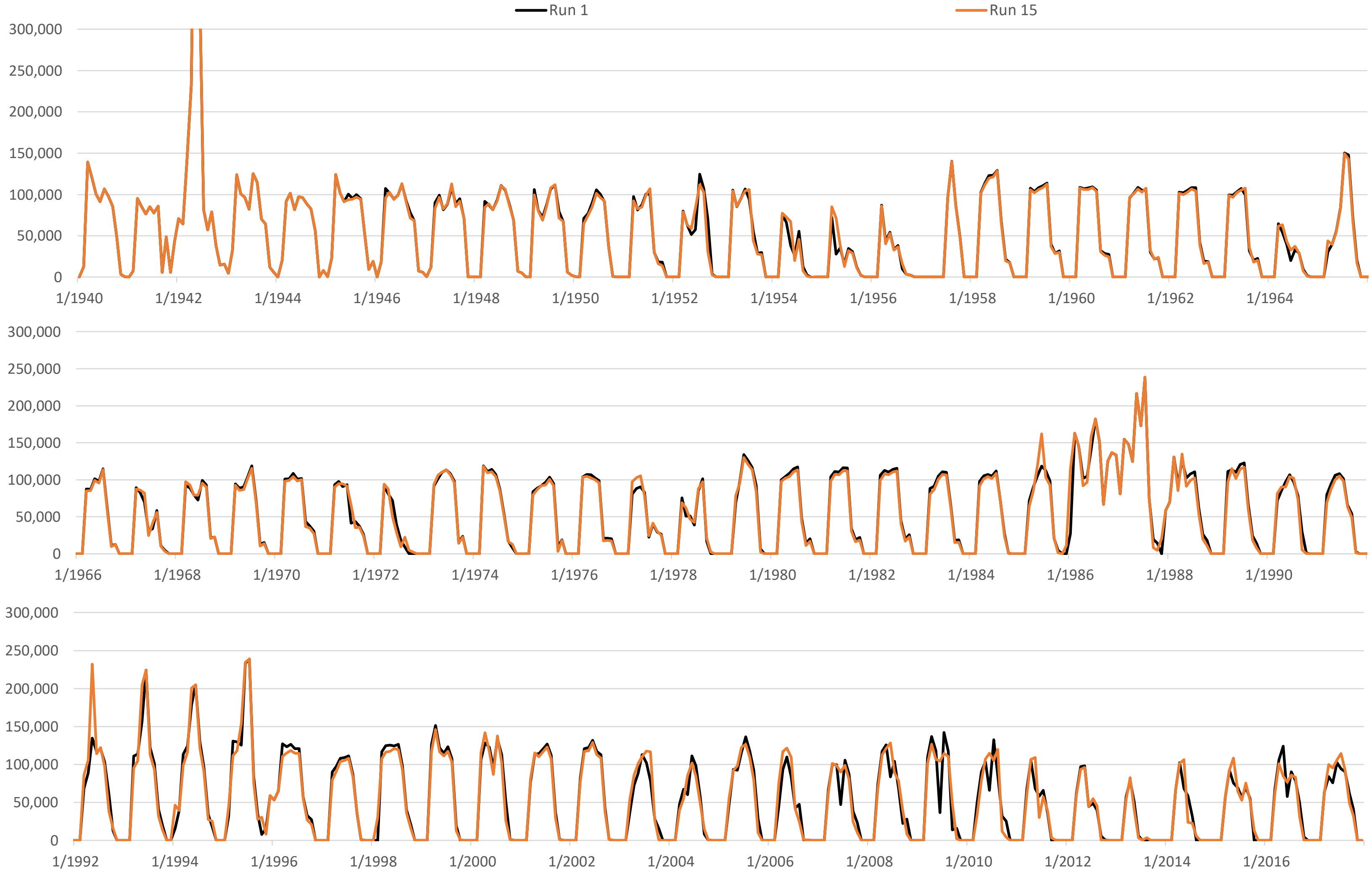
End of Month Reservoir Storage (Elephant Butte + Caballo)

Run 15 v. Run 1

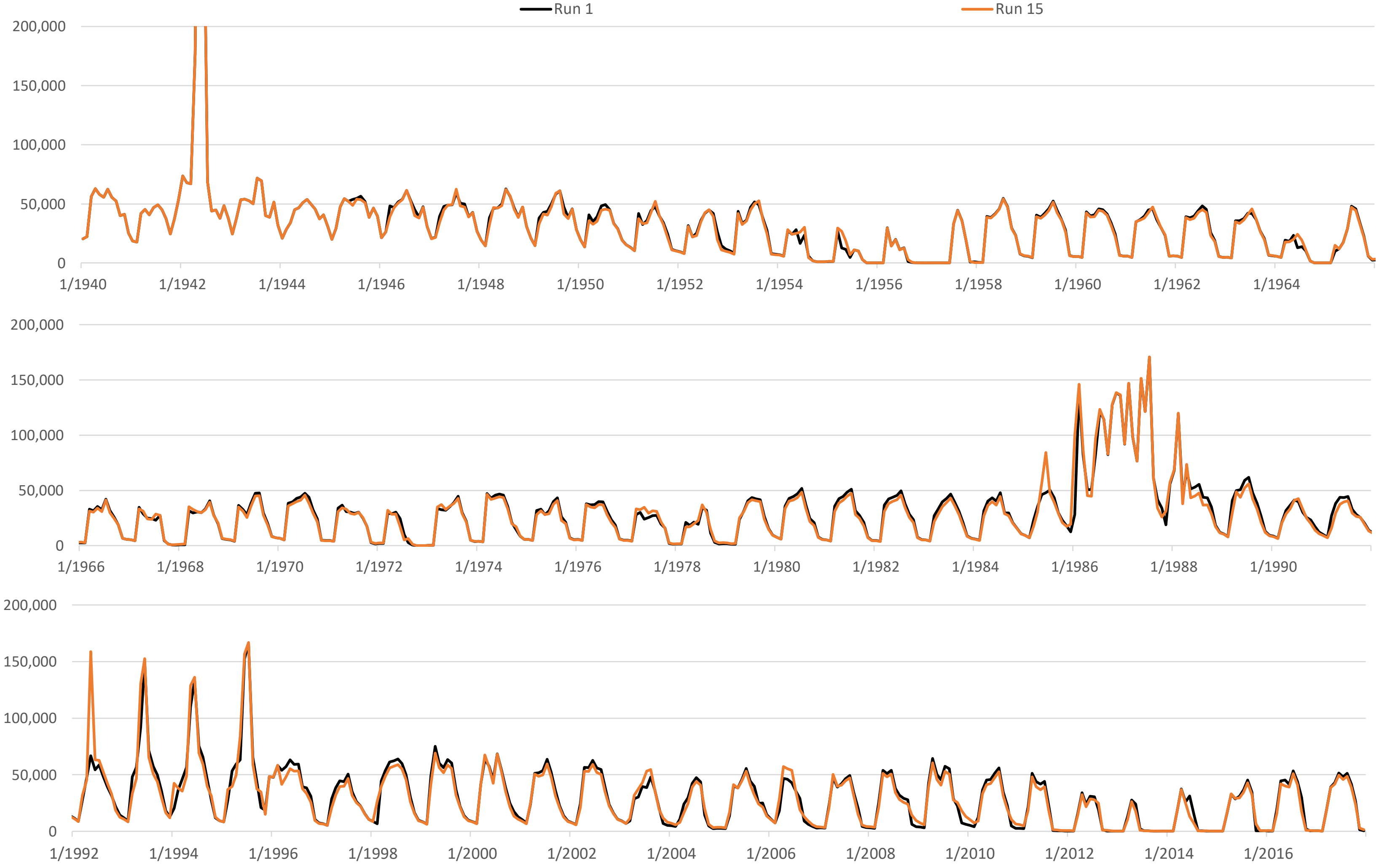
ILRG Model

1940 - 2017 (acre-feet)

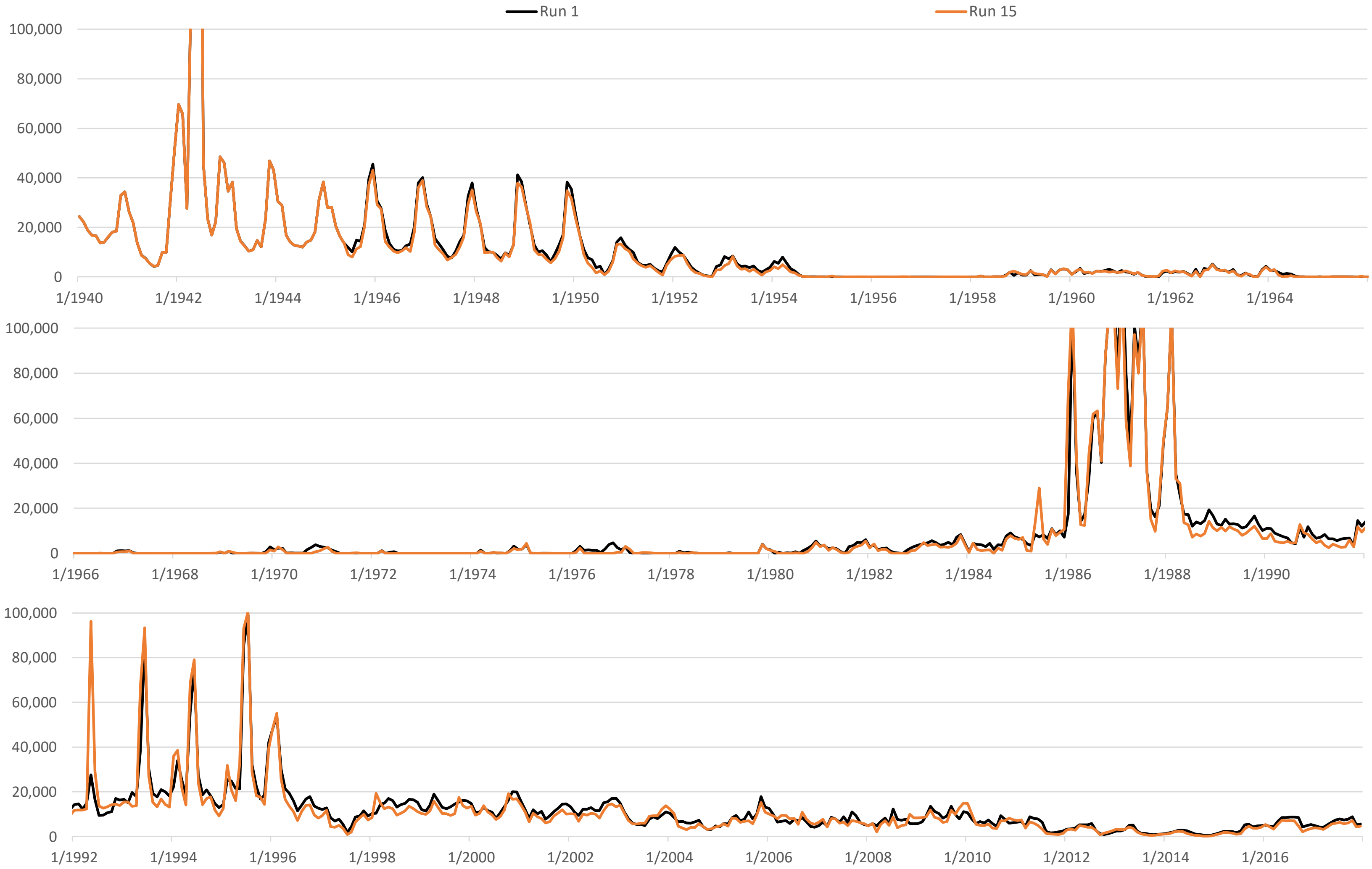
Run 15 - Early EPCWID Ops (WWTP & Fabens Drain)
Monthly Caballo Releases
Run 15 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)



Run 15 - Early EPCWID Ops (WWTP & Fabens Drain)
Monthly Rio Grande at El Paso Flow
Run 15 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)



Run 15 - Early EPCWID Ops (WWTP & Fabens Drain)
Monthly Rio Grande at Fort Quitman Flow
Run 15 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)



Appendix 30T

Comparison of ILRG Model Runs
Run 15a v. Run 1

Model Run Specifications

Model Version: LRG_v116

Name: **Run 15a - Early EPCWID Ops (WWTP)**

Run ID: LRG_v116_Operational_Run15a
Date: 8/28/2020

Name: **Run 1 - Historical Base Run (All Pumping On)**

Run ID: LRG_v116_Operational_Run1
Date: 8/23/2020

Selected Model Inputs

Pumping and Returns	**Run 15a**	**Run 1**
Irrigation Pumping	On	On
Irrigated Area	Hist	Hist
Non-Irrigation Pumping	On	On
Non-Irrigation Pumping Returns	On	On
Las Cruces Jornada Pumping Returns	On	On

Project Allocation Rules		
1950-2005	D1/D2	D1/D2
2006-2007	D3	D3
2008-2017	D3 + CO	D3 + CO

EPCWID Operations		
Charge EPCWID for Use of WWTP Returns	On	Off
ACE and Haskell Credits for EPCWID	Off	On
Increased EPCWID Use of Fabens Drain Flows	Off	Off
Charge EPCWID for Fabens Drain Flow Use	Off	Off

Run 15a - Early EPCWID Ops (WWTP)
Comparison of ILRG Model Runs
Run 15a v. Run 1
1951 - 2017 Annual Average
(1,000 acre-feet)

Run No.	1	15a	15a - 1	
Simulated Input or Output	**Run 1**	**Run 15a**	**Run 15a minus Run 1**	
Effects of Alternate Scenario				
FHG Deliveries (Mar - Oct)				***% Diff.***
EBID	167.6	172.6	5.0	*3%*
EPCWID (incl. EPW)	139.9	138.0	-1.9	*-1%*
HCCRD	32.8	32.8	-0.1	*0%*
Total	340.3	343.4	3.0	*1%*
FHG Deliveries (Nov - Feb)				
EBID	0.0	0.0	0.0	*-4%*
EPCWID (incl. EPW)	0.2	0.2	0.0	*1%*
HCCRD	2.4	2.4	0.0	*1%*
Total	2.6	2.6	0.0	*1%*
Irrigation Pumping				
EBID	140.4	135.5	-4.9	*-4%*
EPCWID (Mesilla Valley)	7.4	7.3	0.0	*-1%*
EPCWID (El Paso Valley)	40.1	41.2	1.1	*3%*
HCCRD	4.2	4.3	0.1	*2%*
Total	192.1	188.3	-3.8	*-2%*
Other Inflows/Outflows				
Net Reservoir Evaporation	125.3	125.2	-0.1	*0%*
Riparian ET	70.9	70.8	-0.1	*0%*
River Evaporation + Incidental Canal Loss	30.3	30.4	0.1	*0%*
Total	226.6	226.4	-0.1	*0%*
Rio Grande at Fort Quitman				
Reservoir Spills	33.3	34.1	0.8	*2%*
Nov-Feb Flows	21.4	20.5	-0.9	*-4%*
Mar - Oct Flows	41.1	40.8	-0.2	*-1%*
Underflow (GW Model)	0.2	0.2	0.0	*0%*
Total	96.0	95.6	-0.4	*0%*

Run 15a - Early EPCWID Ops (WWTP)

Comparison of ILRG Model Runs

Run 15a v. Run 1
1951 - 2017 Annual Average
(1,000 acre-feet)

Run No.	1	15a	15a - 1	
Simulated Input or Output	**Run 1**	**Run 15a**	**Run 15a minus Run 1**	
Effects of Alternate Scenario (continued)				
Change in Storage				***% Diff.***
Reservoir Storage	-4.7	-5.2	-0.6	*12%*
Alluvial GW Storage (RW Model)	-23.6	-22.6	1.0	*-4%*
Non-alluvial GW Storage (GW Models)	-96.4	-96.3	0.0	*0%*
Soil Moisture Storage	0.6	0.6	0.0	*-6%*
Total	-124.0	-123.6	0.5	*0%*
Summary of Effects				
FHG Deliveries (Mar-Oct)	340.3	343.4	3.0	*1%*
FHG Deliveries (Nov-Feb)	2.6	2.6	0.0	*1%*
Irrigation Pumping	192.1	188.3	-3.8	*-2%*
Riparian ET + Evaporation	226.6	226.4	-0.1	*0%*
Fort Quitman Flow	96.0	95.6	-0.4	*0%*
Change in Storage	-124.0	-123.6	0.5	*0%*
Total	733.6	732.7	-0.8	*0%*
Other Effects of Alternate Scenario				
Rio Grande at El Paso				***% Diff.***
Reservoir Spills	49.4	50.3	0.9	*2%*
Nov-Feb Flows	22.8	22.4	-0.4	*-2%*
Mar - Oct Flows	263.8	261.7	-2.1	*-1%*
Total	336.0	334.4	-1.5	*0%*
Rio Grande below Caballo				
Reservoir Spills	65.9	66.8	0.9	*1%*
Nov-Feb Flows	0.5	0.0	-0.5	*-100%*
Mar - Oct Flows	541.3	541.4	0.1	*0%*
Total	607.6	608.2	0.6	*0%*
Surface Water Diversions (Mar - Oct)				
EBID	366.5	374.6	8.1	*2%*
EPCWID (incl. EPW)	236.8	233.9	-2.9	*-1%*
HCCRD	67.5	66.9	-0.7	*-1%*
Total	670.8	675.4	4.6	*1%*
Surface Water Diversions (Nov - Feb)				
EBID	0.0	0.0	0.0	*0%*
EPCWID (incl. EPW)	14.3	14.4	0.0	*0%*
HCCRD	14.2	14.0	-0.2	*-2%*
Total	28.5	28.4	-0.2	*-1%*

Run 15a - Early EPCWID Ops (WWTP)

Annual Differences in ILRG Model Outputs

Run 15a minus Run 1

1940 - 2017 (acre-feet)

	Net River Headgate Diversions						Farm Headgate Deliveries						Annual Flows		
	EBID		EPCWID (incl. EPW)		HCCRD		EBID		EPCWID (incl. EPW)		HCCRD				
Year	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Caballo Releases	Rio Grande at El Paso	Rio Grande at Fort Quitman
1940	-12	-12	2	0	1	0	0	0	2	1	0	0	-9	-4	-28
1941	-56	-56	0	0	0	0	-1	-1	0	1	0	-1	8	25	-27
1942	-1	-1	-1	0	0	1	1	1	-2	-4	0	0	13	-1	-70
1943	-15	-15	1	6	0	2	-3	-3	2	-12	-1	-1	-2	0	-70
1944	-15	-15	-134	-128	-69	-68	-1	-1	11	-1	-59	-59	-144	-140	-61
1945	-15	-15	11	19	2	6	-1	-1	9	1	2	2	10	10	-1
1946	-6	-6	6	6	1	1	-1	-1	4	3	1	1	8	7	-5
1947	-13	-13	5	8	-34	-20	-1	-1	3	-20	-34	-34	4	3	5
1948	-11	-11	12	11	4	7	-1	-1	14	8	1	1	12	13	22
1949	-15	-15	1	1	-1	0	0	0	2	1	0	0	1	1	60
1950	-3	-3	-3	-3	0	0	-11	-11	-2	-2	0	0	-3	-6	-21
1951	33	33	4	4	1	1	-25	-25	2	2	0	1	5	4	-41
1952	0	0	13	14	5	7	-17	-17	0	0	5	6	-6	9	-77
1953	4	4	1	1	2	2	16	16	1	1	2	-2	-2	-2	-44
1954	26	26	133	139	123	63	57	57	12	12	305	234	56	25	10
1955	-7	-7	-19	-14	-60	-89	-56	-56	-125	-125	-90	-132	-87	-39	0
1956	28	28	5	5	-1	-2	129	129	69	69	8	7	50	5	0
1957	-1	-1	-1	-2	0	-1	-2	-2	1	1	34	32	-3	-1	0
1958	4	4	-45	-44	-5	-14	0	0	3	-4	14	19	-20	-47	-55
1959	3	3	-15	-16	-21	-43	10	10	3	3	0	2	-26	-25	2
1960	2	2	-6	-7	0	0	5	5	2	2	0	0	-10	-13	16
1961	5	5	-2	-3	-1	-1	4	4	0	0	-2	2	-14	-9	-6
1962	-6	-6	-33	-33	-2	-2	-41	-41	-22	-22	0	1	24	-10	-175
1963	23	23	-7	-6	1	1	10	10	-6	-6	0	0	1	5	2
1964	12	12	19	20	1	0	23	23	9	10	2	1	-16	17	-57
1965	29	29	-26	-26	10	-90	-2	-2	533	533	109	9	-16	-50	15
1966	-6	-6	-12	-12	-124	-197	-10	-10	6	6	-150	127	-71	-26	-122
1967	357	357	-1,668	-1,690	-117	-142	675	675	-1,143	-1,094	-378	-274	-1,856	-2,269	-46
1968	1,322	1,322	447	956	9	-50	808	808	-35	104	17	47	991	1,224	4
1969	-1	-1	23	41	-23	-16	14	14	-4	-4	-23	-22	-200	74	4
1970	1	1	14	15	-4	-8	6	6	3	3	5	7	-4	8	-16
1971	521	521	-168	-168	-13	-33	377	377	4	4	16	1	28	-127	-11
1972	-5,700	-5,700	-6,757	-6,761	-1,025	-1,049	553	553	-2,870	-2,864	-778	-760	-13,370	-3,997	0
1973	10	10	770	760	-632	-619	-262	-262	-31	-27	-585	-432	5,421	473	-1
1974	15	15	153	101	80	38	-71	-71	-7	-8	25	-71	1,036	-33	176
1975	-4	-4	55	35	-113	-130	91	91	-3	-4	-194	-208	265	-50	-17
1976	8	8	44	29	-50	-81	-18	-18	0	0	0	0	309	-10	-73
1977	2,640	2,640	40	122	1	7	1,392	1,392	73	73	10	22	1,535	372	-16
1978	1,306	1,306	-7,081	-7,099	-842	-688	615	615	-3,996	-3,997	-889	-645	-6,798	-5,484	66

Run 15a - Early EPCWID Ops (WWTP)
Annual Differences in ILRG Model Outputs
Run 15a minus Run 1
1940 - 2017 (acre-feet)

	Net River Headgate Diversions						Farm Headgate Deliveries						Annual Flows		
	EBID		EPCWID (incl. EPW)		HCCRD		EBID		EPCWID (incl. EPW)		HCCRD				
Year	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Caballo Releases	Rio Grande at El Paso	Rio Grande at Fort Quitman
1979	364	364	1,521	1,509	-869	-1,079	235	234	2,800	2,799	-910	-1,125	2,144	2,823	-450
1980	61	61	-27	-128	-299	-529	72	71	-64	-65	-289	-511	975	-311	-5
1981	-3	-3	14	-5	-74	-109	-5	-5	-5	-5	0	0	273	-37	-141
1982	-7	-7	8	5	-30	-49	5	5	-3	-3	8	25	75	4	-120
1983	-8	-8	4	4	-25	-38	3	3	-4	-4	0	0	62	14	-43
1984	-10	-10	6	7	-34	-44	4	4	1	1	0	0	56	26	-45
1985	-21	-21	-9	-7	-6	-13	-7	-7	-11	-12	0	0	80	60	-3
1986	-11	-11	6	7	15	17	56	57	7	7	0	0	2,367	2,288	781
1987	-20	-20	-19	-19	-9	-15	-18	-18	-12	-12	0	0	1	26	-890
1988	-5	-5	0	0	-7	-11	18	18	-2	-1	0	0	84	67	40
1989	-7	-7	0	2	-6	-9	5	5	0	-1	0	0	177	44	4
1990	-11	-11	3	5	-3	-6	6	6	2	2	0	0	19	74	-6
1991	-49	-49	-16	-15	-13	-12	-64	-64	-13	-12	0	0	53	79	-38
1992	-117	-117	-139	-130	-71	-80	432	431	18	16	0	0	527	242	220
1993	-359	-359	-6,125	-6,114	-1,320	-1,498	188	187	-3,924	-3,927	0	0	-11,179	-9,138	-4,819
1994	-687	-687	-4,228	-4,212	-624	-1,273	20	21	-2,150	-2,153	0	0	-6,604	-4,214	-2,576
1995	-583	-583	-3,831	-3,855	-1,477	-1,974	171	172	-1,488	-1,548	0	0	16,579	13,840	9,630
1996	13	13	330	334	77	-7	-2	-2	0	-1	0	0	618	444	-617
1997	-10	-10	69	69	17	16	-5	-5	7	2	0	0	145	94	-5
1998	-10	-10	29	27	12	7	27	27	2	2	0	0	97	49	18
1999	-671	-671	-27,414	-27,420	-4,198	-4,841	1,799	1,799	-14,025	-14,030	0	0	-13,161	-11,327	1,514
2000	-2,511	-2,511	-3,169	-3,208	-401	-905	-503	-503	-589	-594	0	0	11,450	12,359	8,876
2001	57	57	11,315	11,271	2,003	1,909	-175	-175	7,475	7,473	0	0	12,428	10,633	3,071
2002	-13	-13	38	34	37	51	-27	-27	0	-1	0	0	145	54	304
2003	-8,312	-8,312	-2,145	-2,220	-248	-271	-5,029	-5,029	-1,659	-1,661	0	0	-6,963	-3,777	-311
2004	-1,367	-1,367	-36,958	-37,115	-6,192	-7,360	557	557	-22,083	-22,088	0	0	-36,577	-30,318	-9,046
2005	3,101	3,101	6,052	5,972	-865	-1,775	4,296	4,281	3,315	3,308	0	0	812	1,523	-9,210
2006	48,251	48,251	-2,028	-2,073	3,731	3,423	23,446	23,446	-9,543	-9,544	0	0	26,355	11,546	10,664
2007	29,118	29,118	-22,247	-22,335	-4,528	-6,009	17,081	17,081	-12,916	-12,912	0	0	-16,640	-16,343	-6,893
2008	60,581	60,581	-1,251	-1,014	-1,275	-2,038	40,851	40,851	-2,076	-2,066	0	0	20,134	1,442	-3,576
2009	99,699	99,699	-8,633	-8,289	-1,737	-1,640	61,522	61,522	-6,369	-6,345	0	0	21,213	-714	3,510
2010	99,846	99,846	-7,237	-6,094	-1,078	-786	65,702	65,702	-5,657	-5,629	0	0	10,979	629	6,281
2011	60,012	60,012	-40,451	-39,976	-11,869	-14,677	36,801	36,801	-26,251	-26,235	-685	-224	-41,716	-43,081	-6,283
2012	18,009	18,009	2,683	2,690	-1,291	-3,261	8,856	8,856	1,992	1,996	992	1,824	13,290	4,218	-7,950
2013	19,749	19,749	-12,601	-12,599	-2,322	-2,603	10,753	10,753	-8,968	-8,967	-788	-1,080	-1,763	-11,756	-2,659
2014	25,941	25,941	-13,193	-13,191	-2,503	-2,684	17,390	17,390	-8,111	-8,111	-2,091	-2,149	2,607	-12,783	-3,298
2015	47,924	47,924	3,465	3,539	-343	-336	23,114	23,114	1,367	1,371	-61	-154	44,811	1,610	-2,486
2016	-21,628	-21,628	-16,833	-16,782	-2,528	-3,334	-15,408	-15,408	-10,108	-10,105	0	0	-53,411	-19,428	-4,966
2017	66,268	66,268	4,891	5,079	-521	-1,005	35,888	35,888	2,486	2,490	0	0	49,546	5,360	-3,442
Averages															
1951-2017	8,107	8,107	-2,869	-2,834	-652	-865	4,960	4,960	-1,852	-1,849	-95	-81	557	-1,547	-379
1951-1978	22	22	-504	-487	-100	-112	153	153	-269	-262	-91	-72	-456	-356	-16
1979-2005	-415	-415	-2,396	-2,415	-541	-737	76	76	-1,200	-1,204	-44	-60	-938	-532	-143
2006-2017	46,147	46,147	-9,453	-9,254	-2,189	-2,912	27,166	27,166	-7,013	-7,005	-219	-149	6,284	-6,608	-1,758
1985-2017	16,430	16,430	-5,444	-5,383	-1,198	-1,606	9,932	9,931	-3,615	-3,615	-80	-54	1,409	-2,915	-732
1985-2005	-552	-552	-3,153	-3,171	-632	-859	83	83	-1,673	-1,678	0	0	-1,376	-805	-146

Notes:

EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).

EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

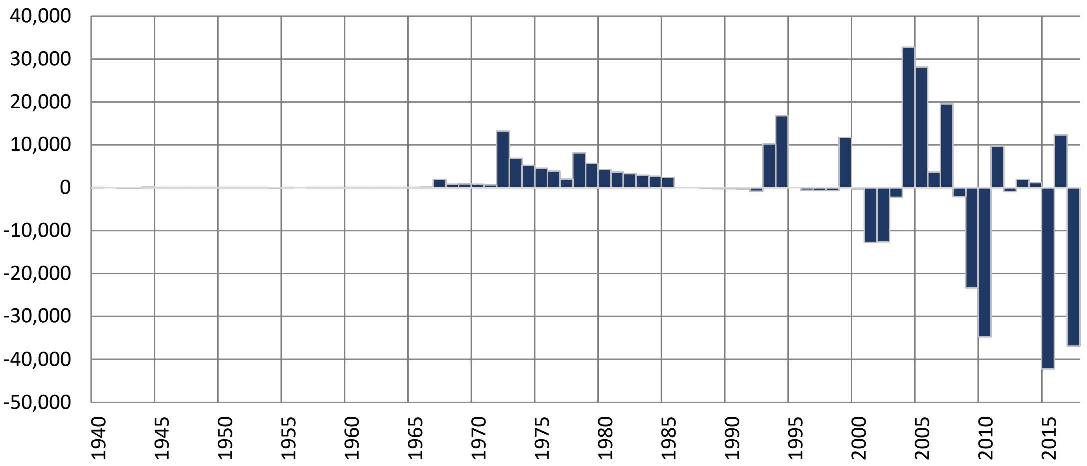
Run 15a - Early EPCWID Ops (WWTP)

Simulated Differences in ILRG Model Outputs

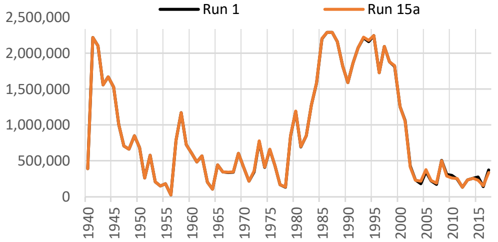
Run 15a minus Run 1

1940 - 2017 (acre-feet)

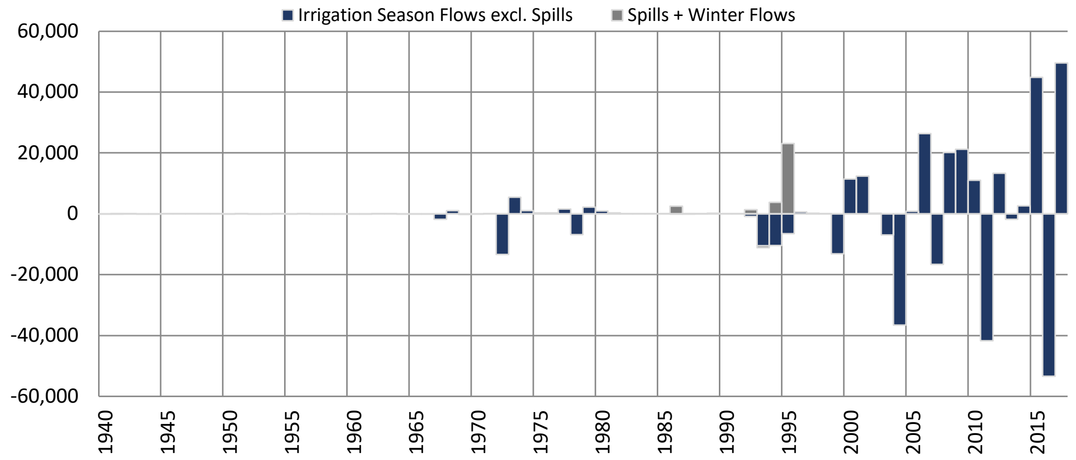
Total Project Storage (Year End)



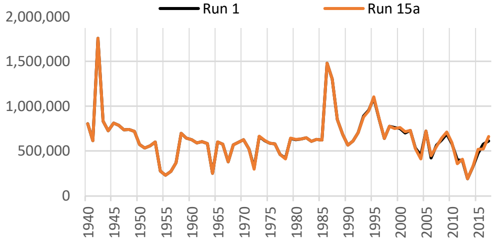
Period	Average Difference
1951-2017	-551
1951-1978	289
1979-2005	738
2006-2017	-5,415
1985-2017	-1,199
1985-2005	1,210



Caballo Reservoir Outflows (Annual)



	Average Difference		
Period	Irr Season (excl. Spills)	Nov-Feb and Spills	Annual
1951-2017	108	449	557
1951-1978	-456	0	-456
1979-2005	-2,051	1,113	-938
2006-2017	6,284	0	6,284
1985-2017	498	911	1,409
1985-2005	-2,808	1,431	-1,376



Notes:

Reservoir storage does not include storage attributed to SJC, CO, or NM credit waters.

Average differences calculated as (Final Storage - Initial Storage)/(no. years).

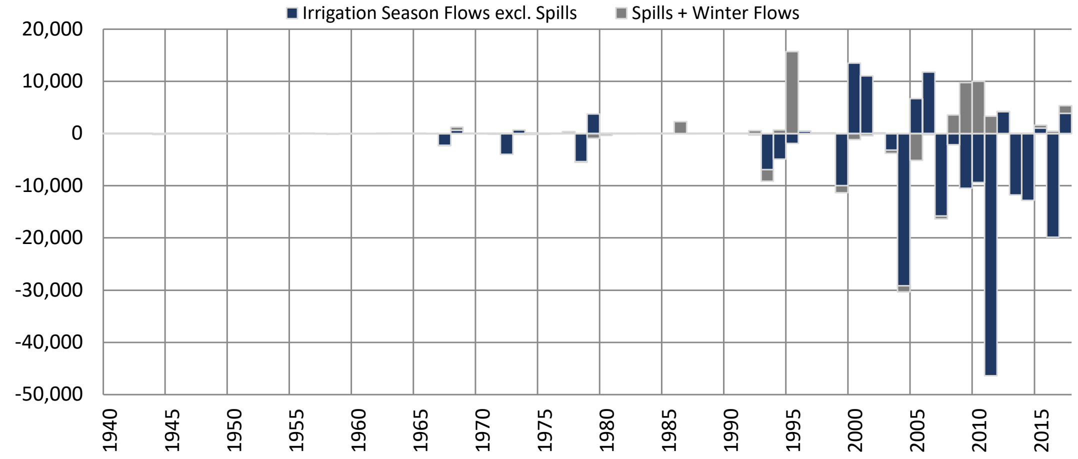
Run 15a - Early EPCWID Ops (WWTP)

Simulated Differences in ILRG Model Outputs

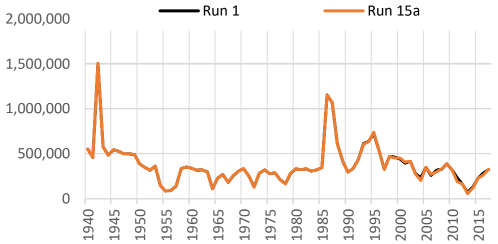
Run 15a minus Run 1

1940 - 2017 (acre-feet)

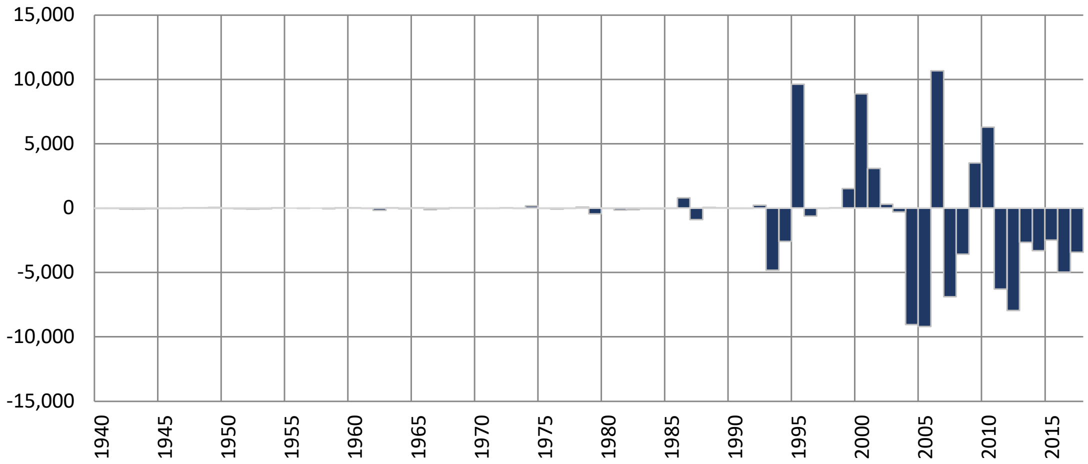
Rio Grande at El Paso (Annual)



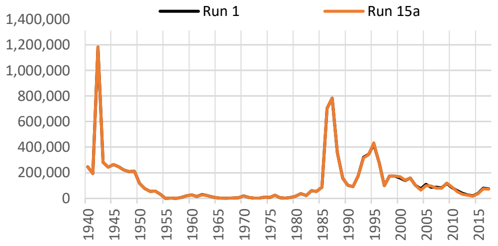
	Average Difference		
Period	Irr Season (excl. Spills)	Nov-Feb and Spills	Annual
1951-2017	-2,065	518	-1,547
1951-1978	-357	1	-356
1979-2005	-766	234	-532
2006-2017	-8,971	2,363	-6,608
1985-2017	-4,005	1,090	-2,915
1985-2005	-1,168	363	-805



Rio Grande at Fort Quitman (Annual)



Period	Average Difference
1951-2017	-379
1951-1978	-16
1979-2005	-142
2006-2017	-1,757
1985-2017	-731
1985-2005	-145



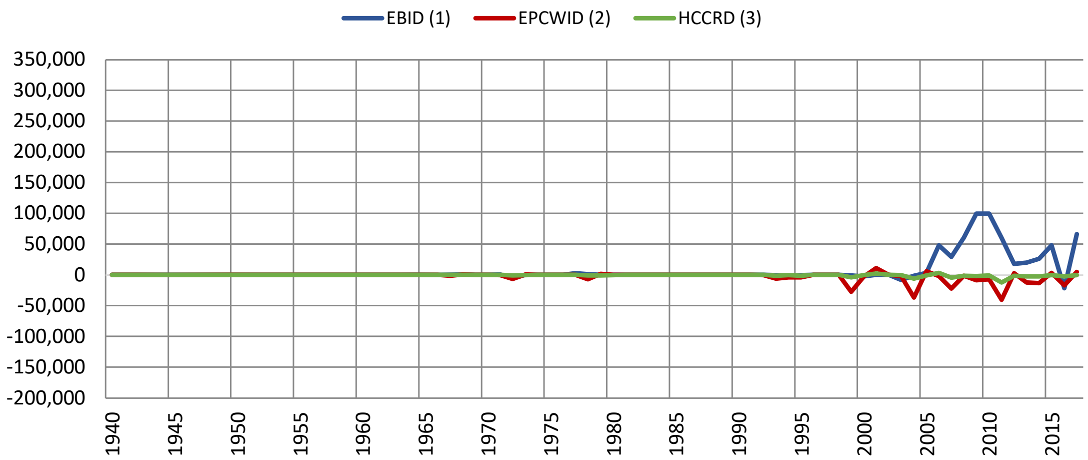
Run 15a - Early EPCWID Ops (WWTP)

Simulated Differences in ILRG Model Outputs

Run 15a minus Run 1

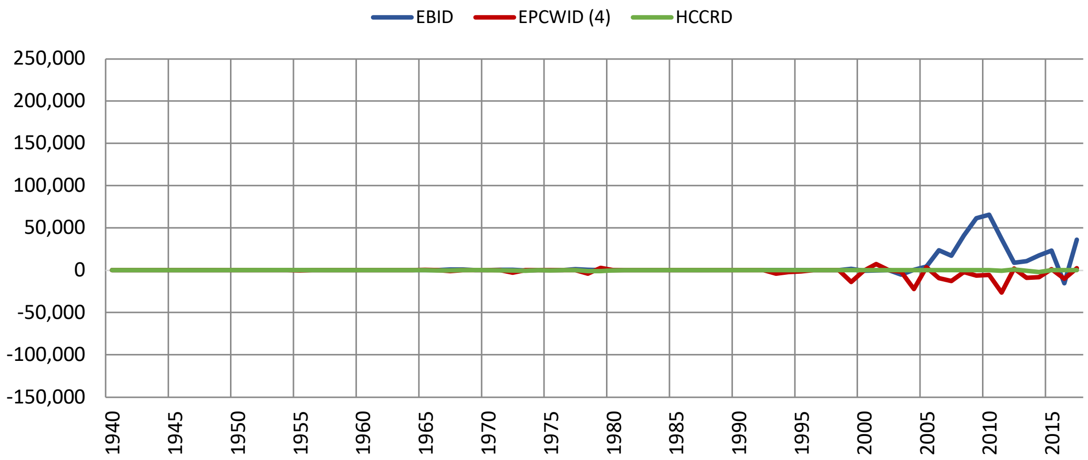
1940 - 2017 (acre-feet)

River Headgate (RHG) Diversions (Irrigation Season)



	Average Difference		
Period	EBID	EPCWID	HCCRD
1951-2017	8,107	-2,869	-652
1951-1978	22	-504	-100
1979-2005	-415	-2,396	-541
2006-2017	46,147	-9,453	-2,189
1985-2017	16,430	-5,444	-1,198
1985-2005	-552	-3,153	-632

Farm Headgate (FHG) Deliveries (Irrigation Season)



	Average Difference		
Period	EBID	EPCWID	HCCRD
1951-2017	4,960	-1,852	-95
1951-1978	153	-269	-91
1979-2005	76	-1,200	-44
2006-2017	27,166	-7,013	-219
1985-2017	9,932	-3,615	-80
1985-2005	83	-1,673	0

Notes:

(1) EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).

(2) EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

(3) HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

(4) EPCWID FHG values include deliveries to Rogers WTP and R/U WTP.

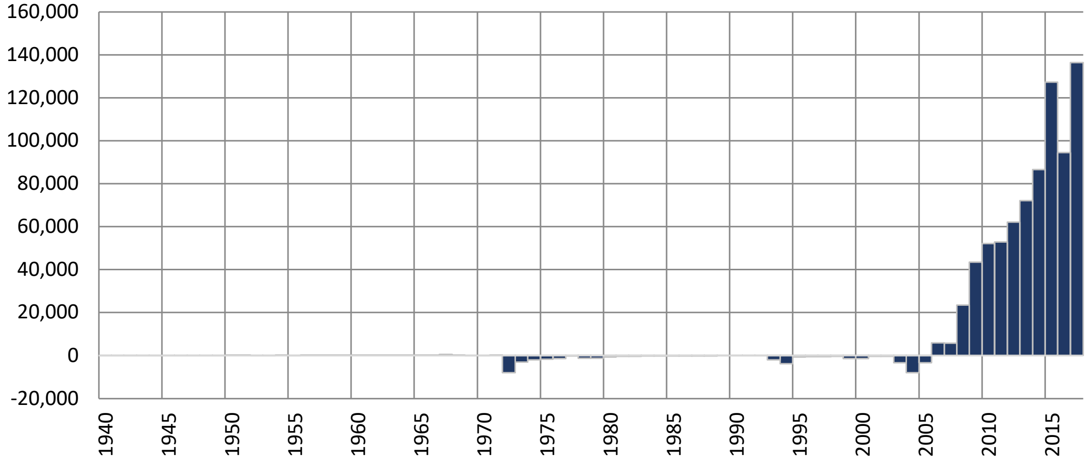
Run 15a - Early EPCWID Ops (WWTP)

Simulated Differences in ILRG Model Outputs

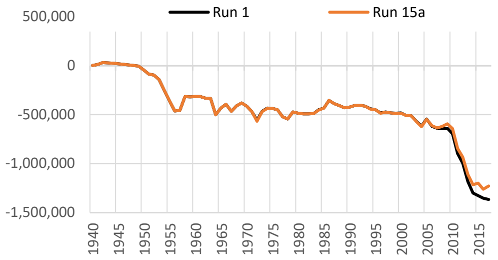
Run 15a minus Run 1

1940 - 2017 (acre-feet)

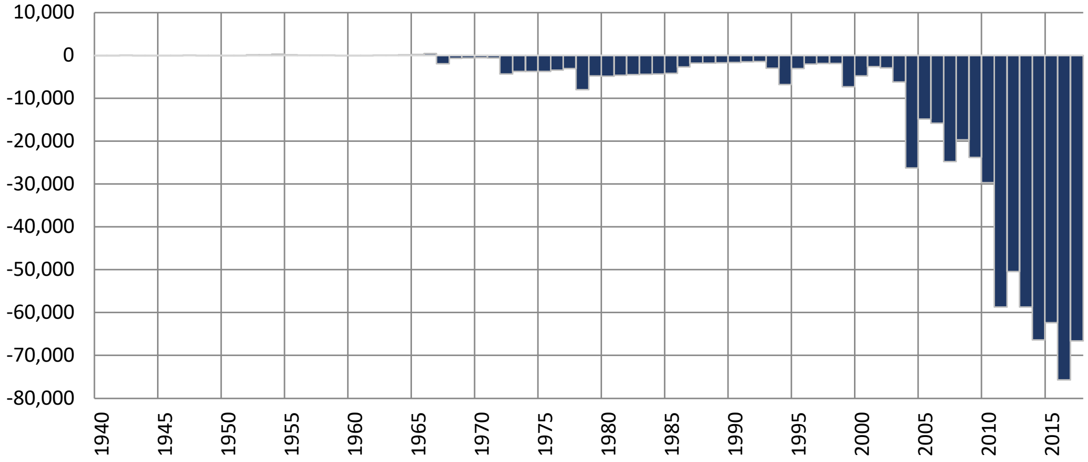
Cumulative Annual Rincon-Mesilla Groundwater Storage



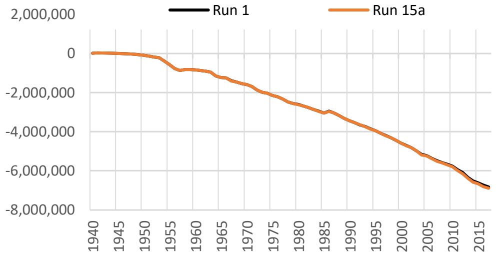
Period	Average Difference
1951-2017	2,036
1951-1978	-47
1979-2005	-77
2006-2017	11,650
1985-2017	4,143
1985-2005	-147



Cumulative Annual Hueco Groundwater Storage



Period	Average Difference
1951-2017	-994
1951-1978	-285
1979-2005	-252
2006-2017	-4,315
1985-2017	-1,888
1985-2005	-501



Notes:

Cumulative storage change in alluvial and non-alluvial aquifers.

Average differences calculated as (Final Storage - Initial Storage)/(no. years).

Run 15a - Early EPCWID Ops (WWTP)

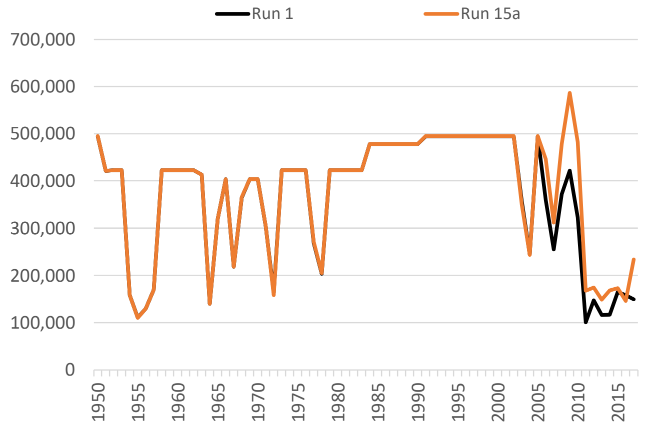
Annual Allocation and Charges

Run 15a v. Run 1

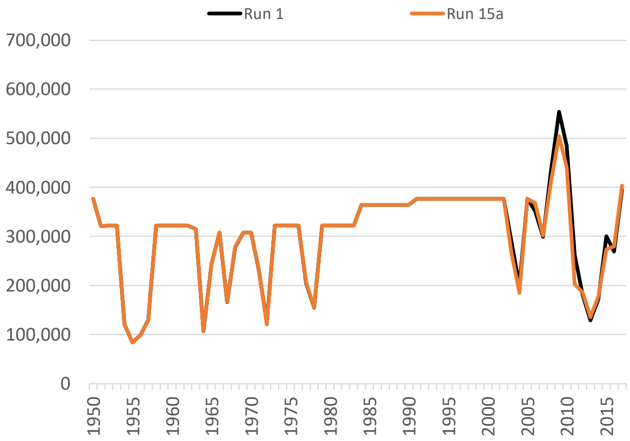
ILRG Model

1950 - 2017 (acre-feet)

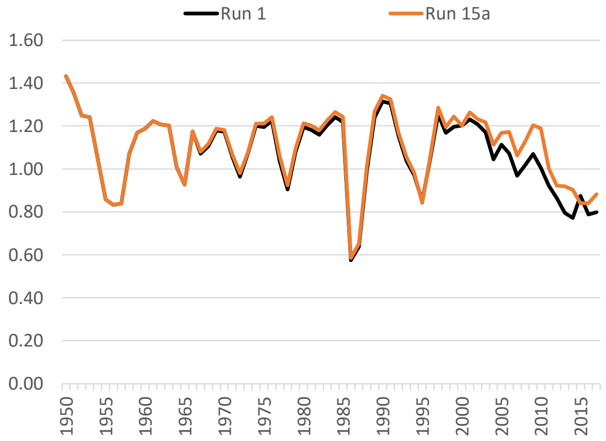
Total Allocation - EBID



Total Allocation - EPCWID



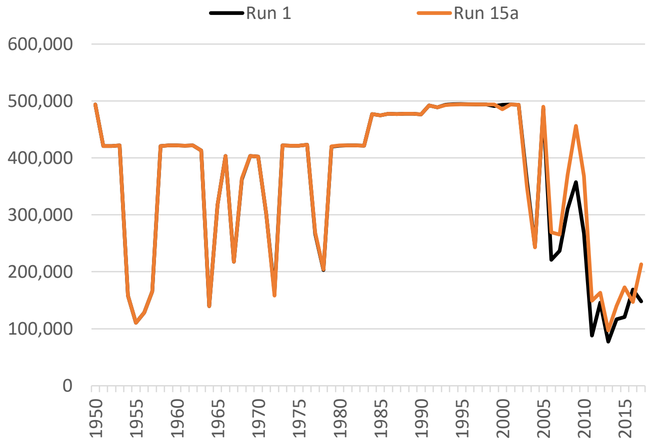
Diversion Ratio



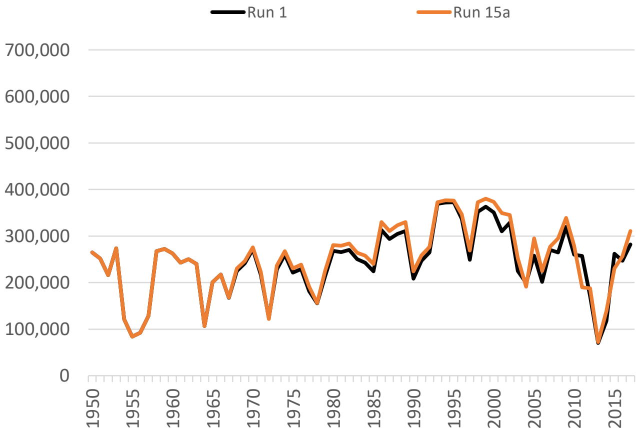
Note:

Computed as Total Charges/Caballo Release.

Annual Delivery Charges - EBID



Annual Delivery Charges - EPCWID



Run 15a - Early EPCWID Ops (WWTP)

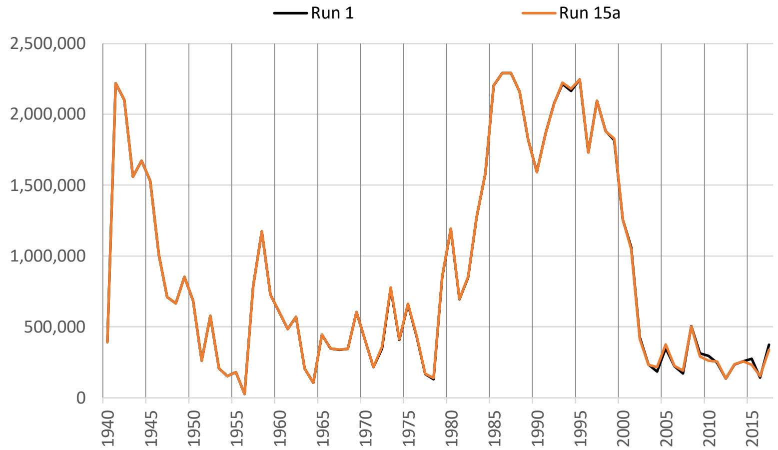
Annual Summary of Project Storage and Rio Grande Flows

Run 15a v. Run 1

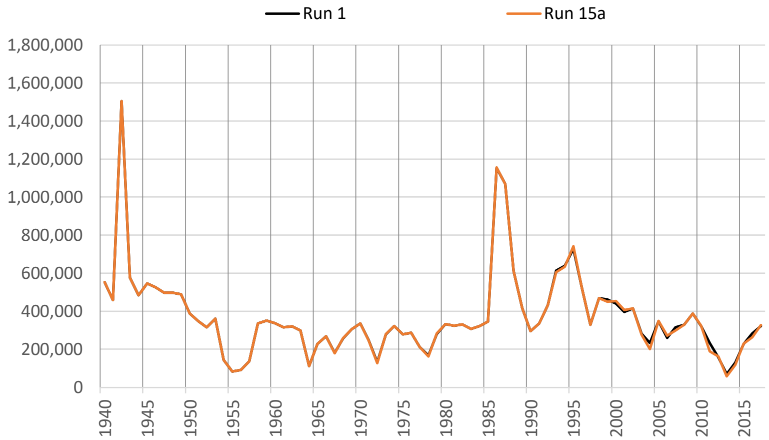
ILRG Model

1940 - 2017 (acre-feet)

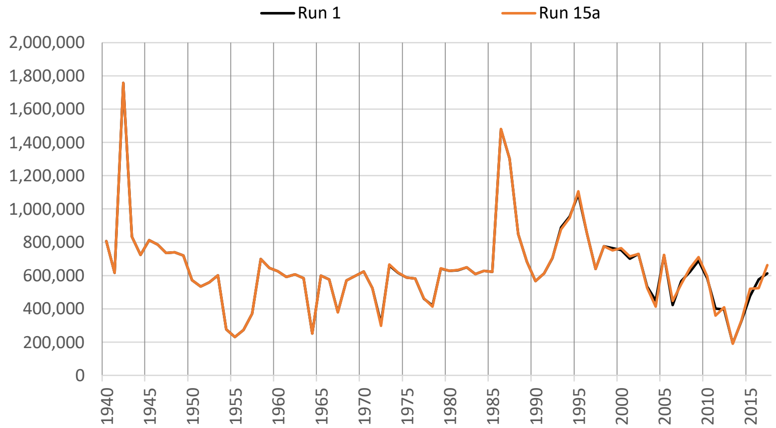
Total Year-End Project Reservoir Storage



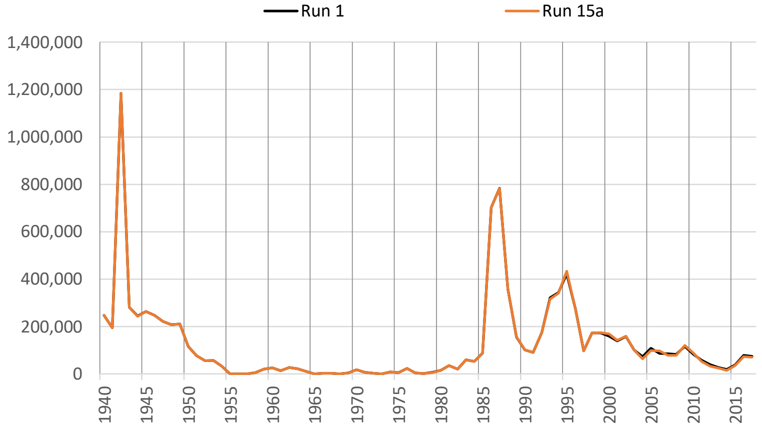
Rio Grande at El Paso



Rio Grande Below Caballo



Rio Grande at Fort Quitman

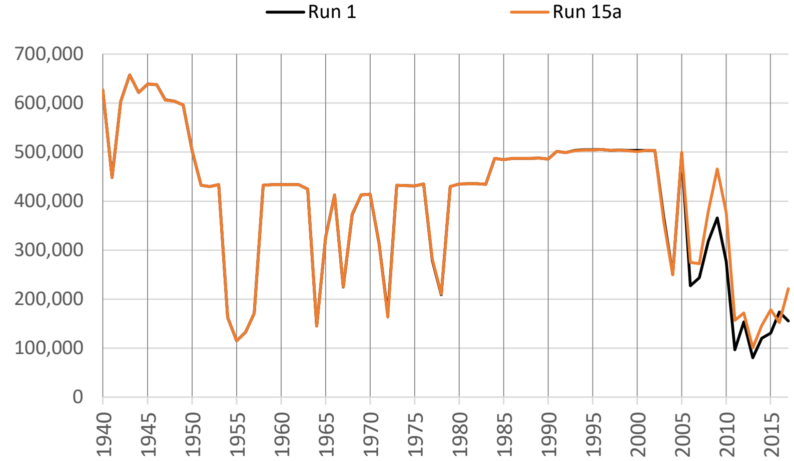


***Note different scales.**

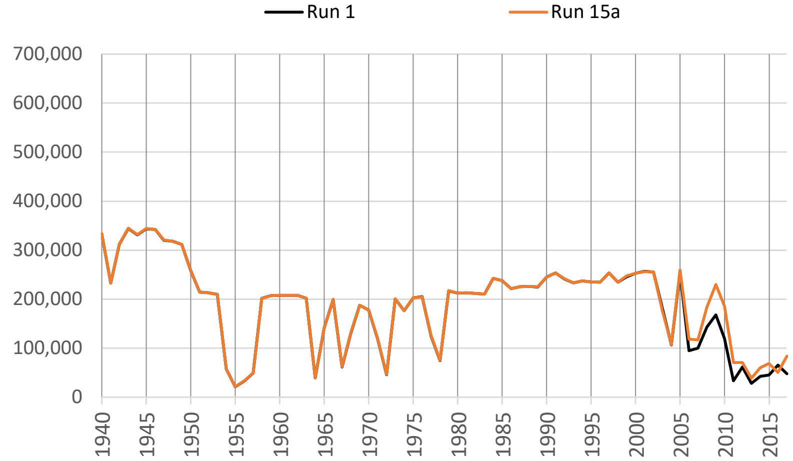
Run 15a - Early EPCWID Ops (WWTP)
Irrigation Season Summary of Irrigation Operations
Run 15a v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

EBID Total

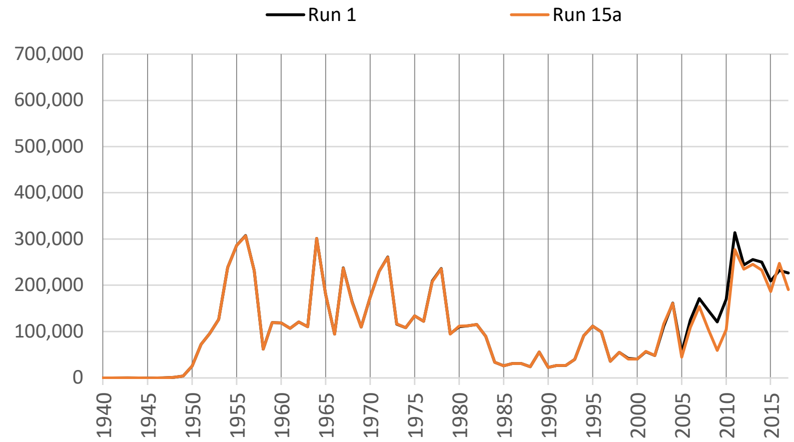
Net River Headgate Diversions



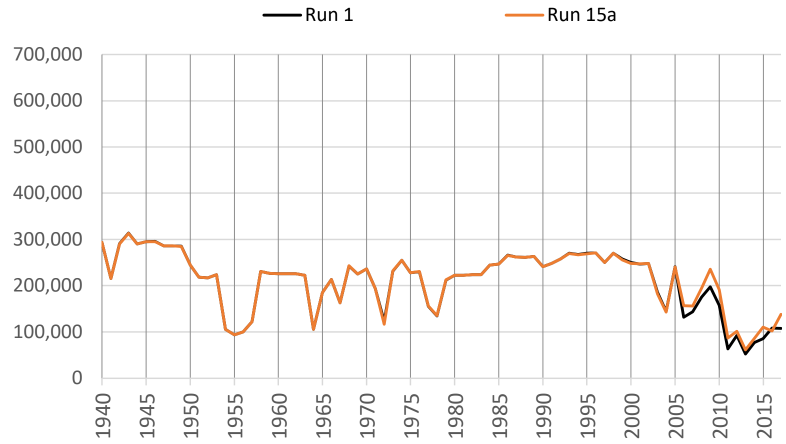
Farm Headgate Deliveries



Pumping



RHG Diversions - FHG Deliveries



Notes: EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).
Pumping includes Supplemental and Primary groundwater pumping.

Run 15a - Early EPCWID Ops (WWTP)

Irrigation Season Summary of Irrigation Operations

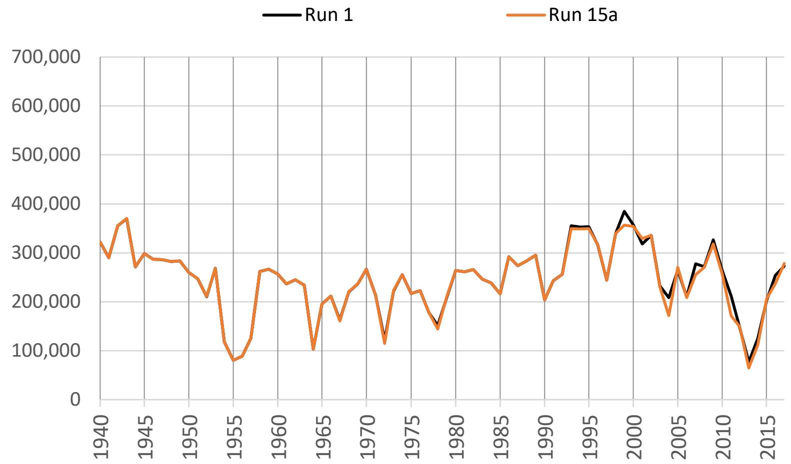
Run 15a v. Run 1

ILRG Model

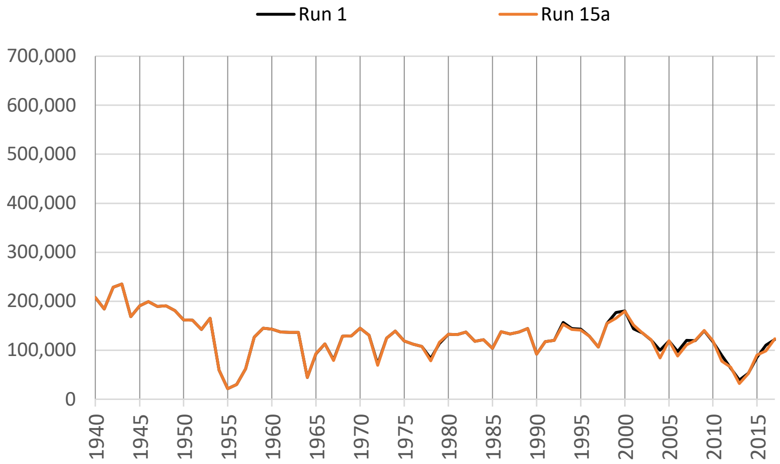
1940 - 2017 (acre-feet)

EPCWID Total

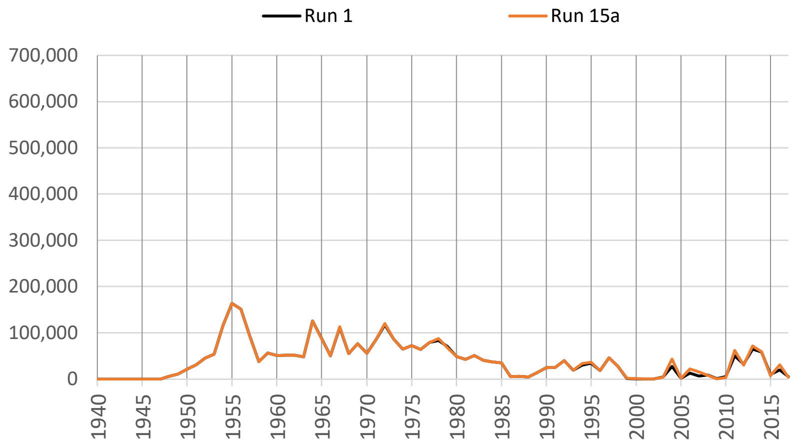
Net River Headgate Diversions



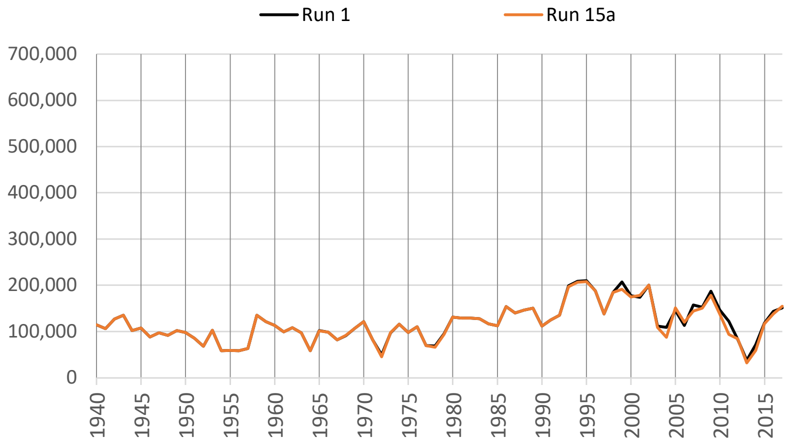
Farm Headgate Deliveries



Pumping



RHG Diversions - FHG Deliveries



Note: EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

Run 15a - Early EPCWID Ops (WWTP)

Irrigation Season Summary of Irrigation Operations

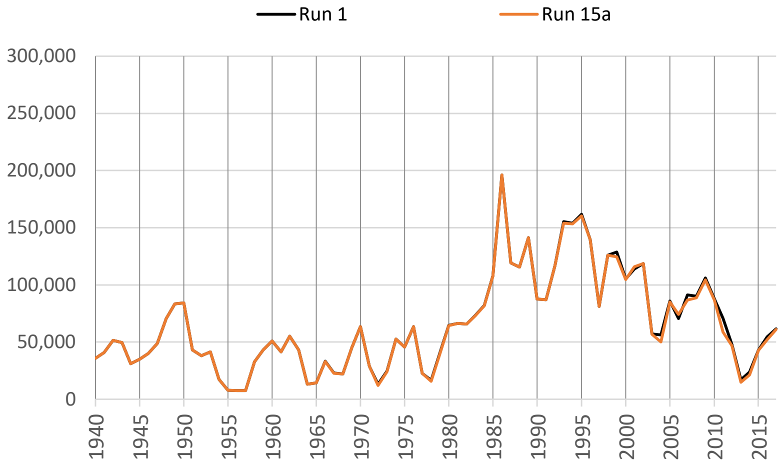
Run 15a v. Run 1

ILRG Model

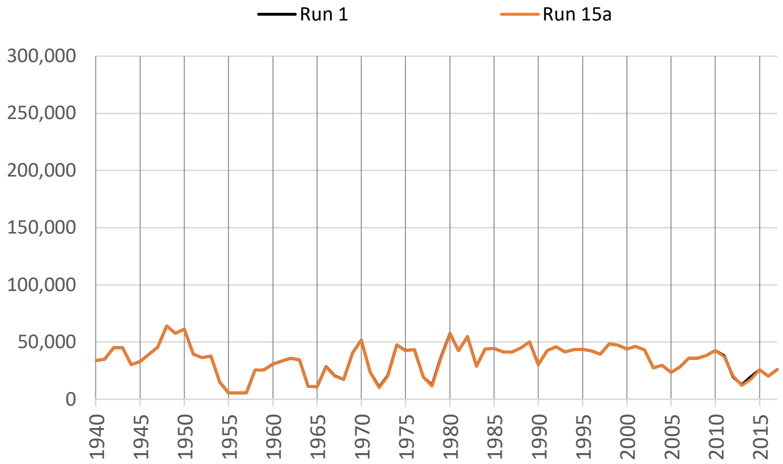
1940 - 2017 (acre-feet)

HCCRD Total

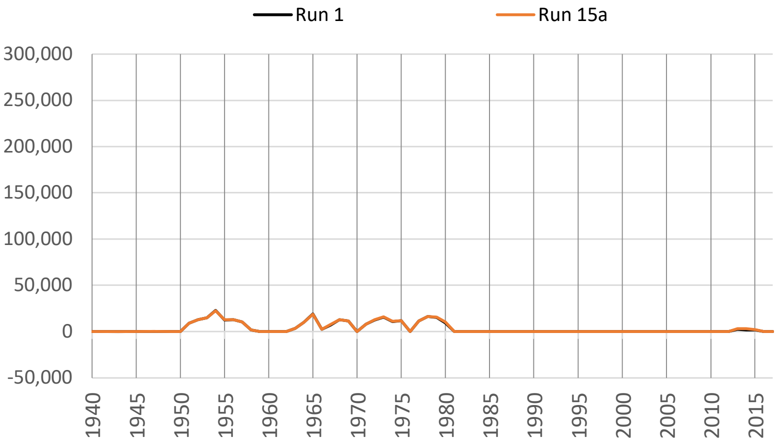
Net River Headgate Diversions



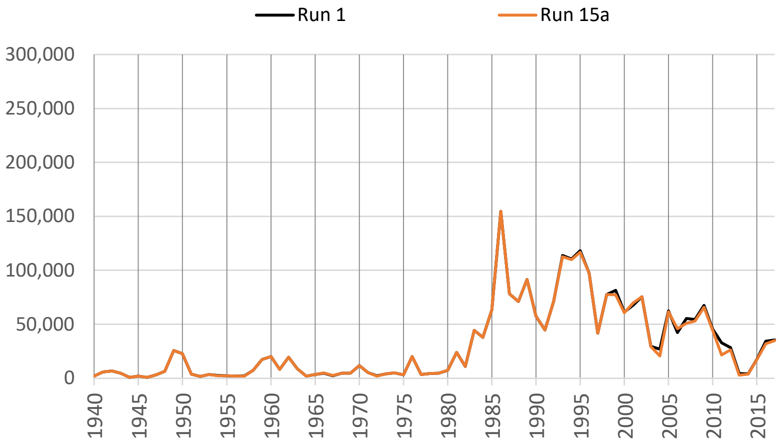
Farm Headgate Deliveries



Pumping



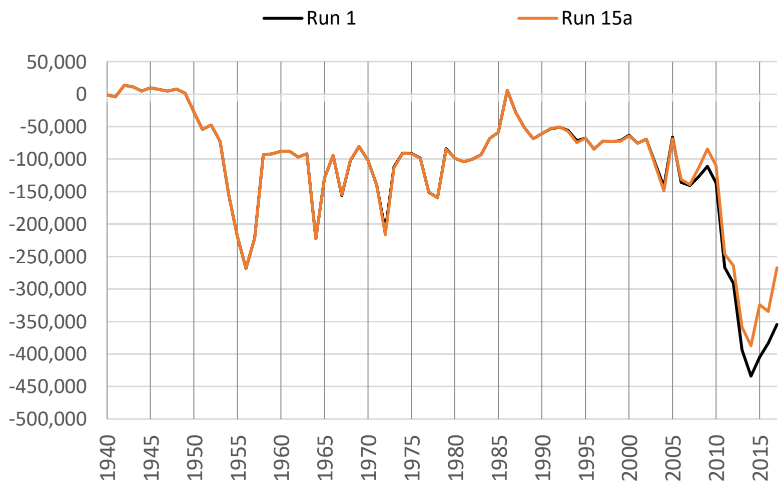
RHG Diversions - FHG Deliveries



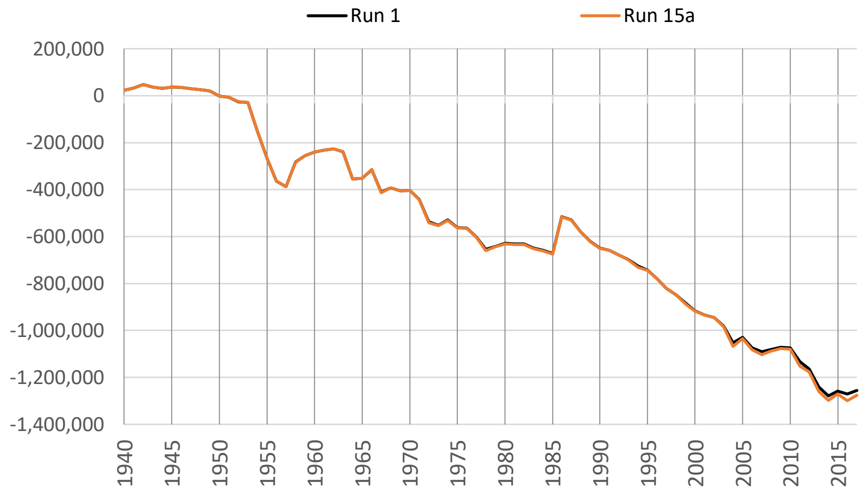
Note: HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

Run 15a - Early EPCWID Ops (WWTP)
Cumulative Change in Ground Water Storage
Run 15a v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

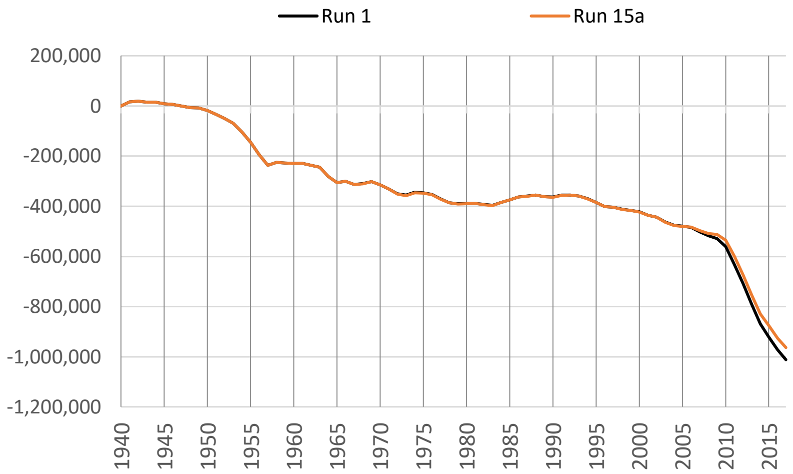
Rincon-Mesilla Alluvial Aquifer



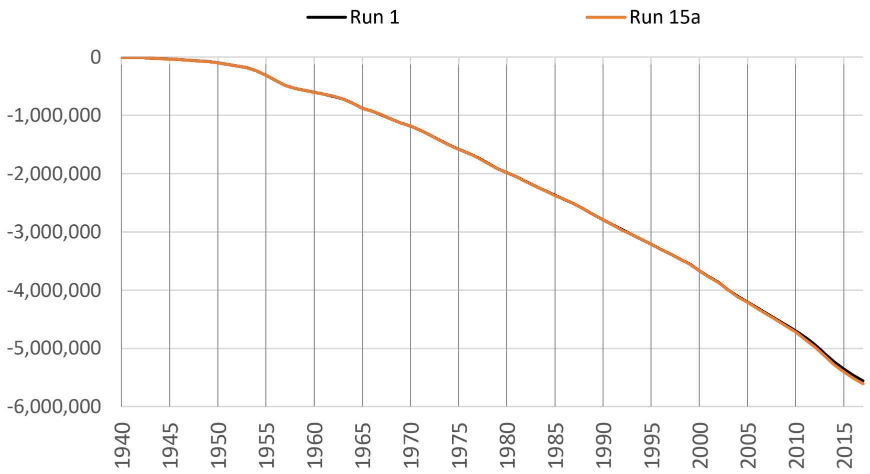
Hueco Alluvial Aquifer



Rincon-Mesilla Non-Alluvial Aquifer



Hueco Non-Alluvial Aquifer



***Note different scales.**

Run 15a - Early EPCWID Ops (WWTP)

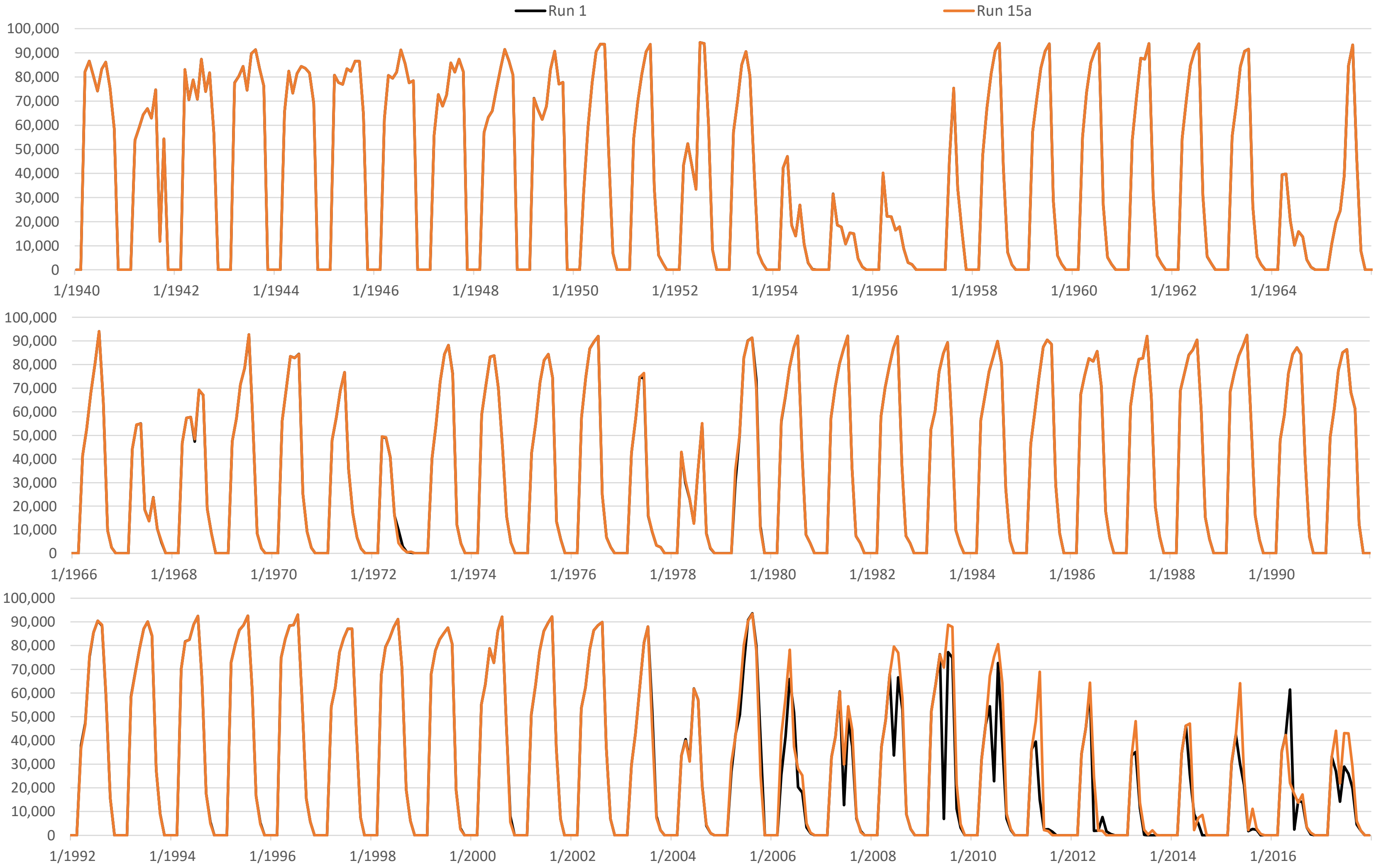
Monthly Net RHG Diversions

Run 15a v. Run 1

ILRG Model

1940 - 2017 (acre-feet)

EBID Total

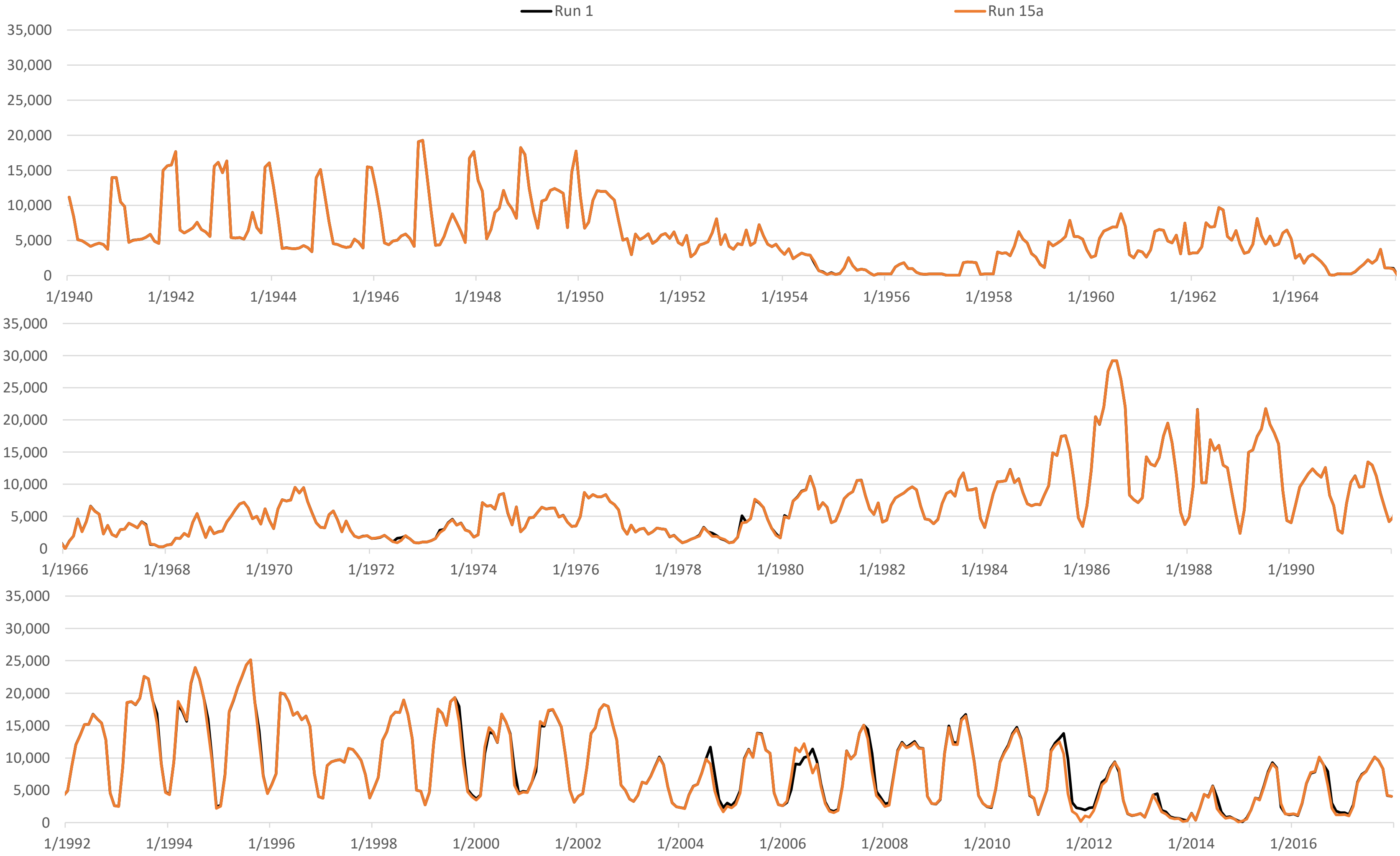


Note: EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).

Run 15a - Early EPCWID Ops (WWTP)
Monthly Net RHG Diversions
Run 15a v. Run 1
ILRG Model
1940 - 2017 (acre-feet)
EPCWID Total

Note: EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

Run 15a - Early EPCWID Ops (WWTP)
Monthly Net RHG Diversions
Run 15a v. Run 1
ILRG Model
1940 - 2017 (acre-feet)
HCCRD Total



Note: HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

Run 15a - Early EPCWID Ops (WWTP)

End of Month Reservoir Storage (Elephant Butte + Caballo)

Run 15a v. Run 1

ILRG Model

1940 - 2017 (acre-feet)

Run 15a - Early EPCWID Ops (WWTP)
Monthly Caballo Releases
Run 15a v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

Run 15a - Early EPCWID Ops (WWTP)

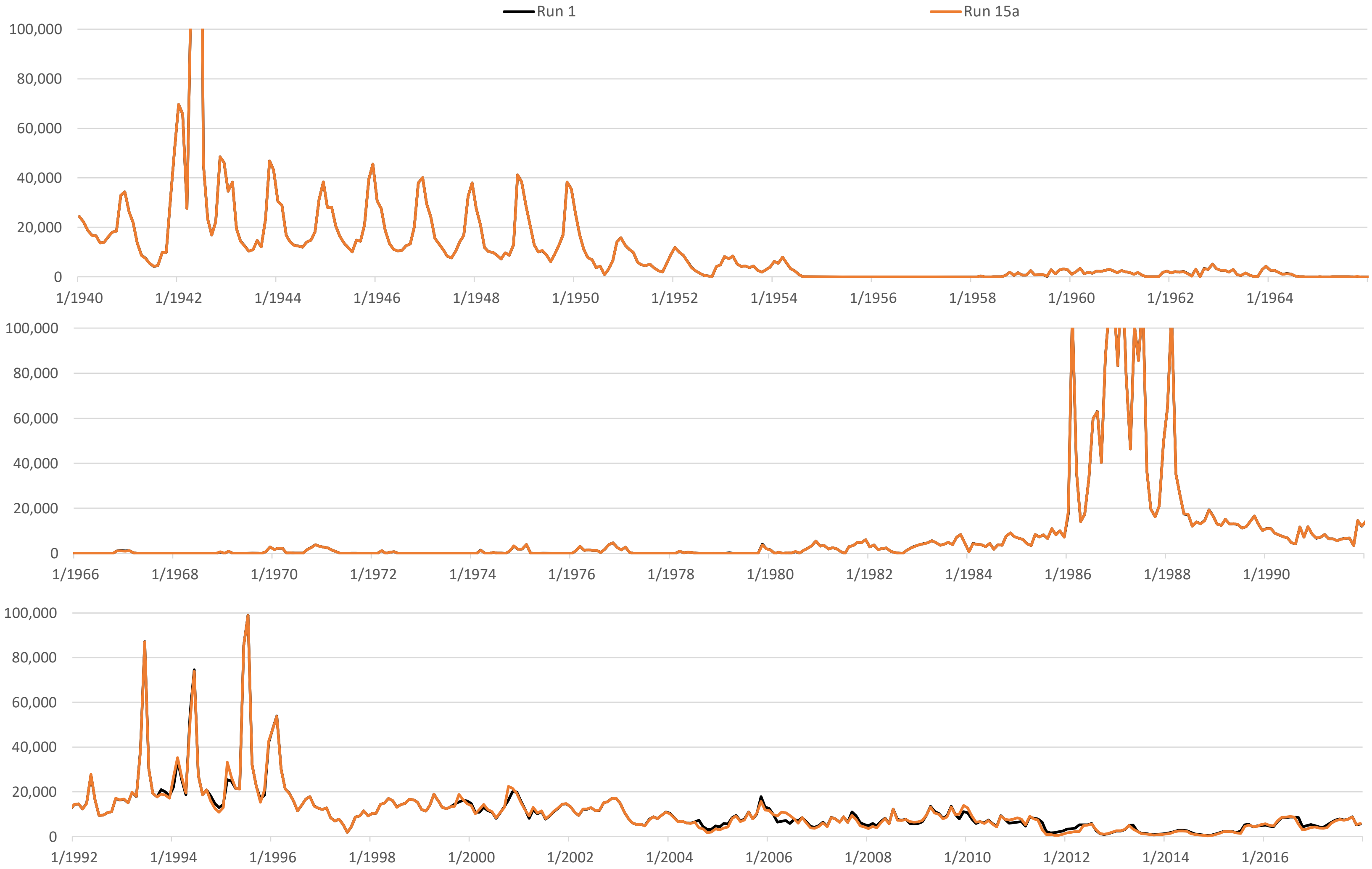
Monthly Rio Grande at El Paso Flow

Run 15a v. Run 1

ILRG Model

1940 - 2017 (acre-feet)

Run 15a - Early EPCWID Ops (WWTP)
Monthly Rio Grande at Fort Quitman Flow
Run 15a v. Run 1
ILRG Model
1940 - 2017 (acre-feet)



Appendix 30U

Comparison of ILRG Model Runs
Run 15b v. Run 1

Model Run Specifications

Model Version: LRG_v116

Name: **Run 15b - Early EPCWID Ops (Fabens Drain)**

Run ID: LRG_v116_Operational_Run15b
Date: 8/28/2020

Name: **Run 1 - Historical Base Run (All Pumping On)**

Run ID: LRG_v116_Operational_Run1
Date: 8/23/2020

Selected Model Inputs

Pumping and Returns	**Run 15b**	**Run 1**
Irrigation Pumping	On	On
Irrigated Area	Hist	Hist
Non-Irrigation Pumping	On	On
Non-Irrigation Pumping Returns	On	On
Las Cruces Jornada Pumping Returns	On	On

Project Allocation Rules		
1950-2005	D1/D2	D1/D2
2006-2007	D3	D3
2008-2017	D3 + CO	D3 + CO

EPCWID Operations		
Charge EPCWID for Use of WWTP Returns	Off	Off
ACE and Haskell Credits for EPCWID	On	On
(1) Increased EPCWID Use of Fabens Drain Flows	On	Off
Charge EPCWID for Fabens Drain Flow Use	On	Off

Notes:
(1) Starting in July 1945, use 70% of simulated Fabens drain flow up to 6,000 af/month.

Run 15b - Early EPCWID Ops (Fabens Drain)

Comparison of ILRG Model Runs

Run 15b v. Run 1

1951 - 2017 Annual Average

(1,000 acre-feet)

Run No.	1	15b	15b - 1	
Simulated Input or Output	**Run 1**	**Run 15b**	**Run 15b minus Run 1**	
Effects of Alternate Scenario				
FHG Deliveries (Mar - Oct)				***% Diff.***
EBID	167.6	174.4	6.7	*4%*
EPCWID (incl. EPW)	139.9	143.0	3.1	*2%*
HCCRD	32.8	32.4	-0.4	*-1%*
Total	340.3	349.8	9.4	*3%*
FHG Deliveries (Nov - Feb)				
EBID	0.0	0.0	0.0	*-6%*
EPCWID (incl. EPW)	0.2	1.9	1.7	*912%*
HCCRD	2.4	2.8	0.4	*15%*
Total	2.6	4.7	2.1	*80%*
Irrigation Pumping				
EBID	140.4	133.9	-6.6	*-5%*
EPCWID (Mesilla Valley)	7.4	7.0	-0.3	*-4%*
EPCWID (El Paso Valley)	40.1	36.2	-3.9	*-10%*
HCCRD	4.2	4.6	0.3	*8%*
Total	192.1	181.7	-10.4	*-5%*
Other Inflows/Outflows				
Net Reservoir Evaporation	125.3	130.0	4.7	*4%*
Riparian ET	70.9	70.6	-0.2	*0%*
River Evaporation + Incidental Canal Loss	30.3	30.6	0.2	*1%*
Total	226.6	231.2	4.6	*2%*
Rio Grande at Fort Quitman				
Reservoir Spills	33.3	38.5	5.3	*16%*
Nov-Feb Flows	21.4	18.2	-3.2	*-15%*
Mar - Oct Flows	41.1	32.7	-8.4	*-20%*
Underflow (GW Model)	0.2	0.2	0.0	*-5%*
Total	96.0	89.7	-6.3	*-7%*

Run 15b - Early EPCWID Ops (Fabens Drain)

Comparison of ILRG Model Runs

Run 15b v. Run 1

1951 - 2017 Annual Average

(1,000 acre-feet)

Run No.	1	15b	15b - 1	
Simulated Input or Output	**Run 1**	**Run 15b**	**Run 15b minus Run 1**	
Effects of Alternate Scenario (continued)				
Change in Storage				***% Diff.***
Reservoir Storage	-4.7	-5.7	-1.0	*22%*
Alluvial GW Storage (RW Model)	-23.6	-22.6	1.0	*-4%*
Non-alluvial GW Storage (GW Models)	-96.4	-94.8	1.6	*-2%*
Soil Moisture Storage	0.6	0.6	0.0	*2%*
Total	-124.0	-122.5	1.5	*-1%*
Summary of Effects				
FHG Deliveries (Mar-Oct)	340.3	349.8	9.4	*3%*
FHG Deliveries (Nov-Feb)	2.6	4.7	2.1	*80%*
Irrigation Pumping	192.1	181.7	-10.4	*-5%*
Riparian ET + Evaporation	226.6	231.2	4.6	*2%*
Fort Quitman Flow	96.0	89.7	-6.3	*-7%*
Change in Storage	-124.0	-122.5	1.5	*-1%*
Total	733.6	734.5	0.9	*0%*
Other Effects of Alternate Scenario				
Rio Grande at El Paso				***% Diff.***
Reservoir Spills	49.4	59.4	10.0	*20%*
Nov-Feb Flows	22.8	22.3	-0.5	*-2%*
Mar - Oct Flows	263.8	249.1	-14.7	*-6%*
Total	336.0	330.7	-5.2	*-2%*
Rio Grande below Caballo				
Reservoir Spills	65.9	79.3	13.5	*20%*
Nov-Feb Flows	0.5	0.3	-0.2	*-40%*
Mar - Oct Flows	541.3	524.4	-16.9	*-3%*
Total	607.6	604.0	-3.6	*-1%*
Surface Water Diversions (Mar - Oct)				
EBID	366.5	378.6	12.2	*3%*
EPCWID (incl. EPW)	236.8	223.9	-12.9	*-5%*
HCCRD	67.5	65.0	-2.6	*-4%*
Total	670.8	667.6	-3.2	*0%*
Surface Water Diversions (Nov - Feb)				
EBID	0.0	0.0	0.0	*0%*
EPCWID (incl. EPW)	14.3	15.7	1.4	*10%*
HCCRD	14.2	14.4	0.2	*2%*
Total	28.5	30.2	1.6	*6%*

Run 15b - Early EPCWID Ops (Fabens Drain)

Annual Differences in ILRG Model Outputs

Run 15b minus Run 1

1940 - 2017 (acre-feet)

	Net River Headgate Diversions						Farm Headgate Deliveries						Annual Flows		
	EBID		EPCWID (incl. EPW)		HCCRD		EBID		EPCWID (incl. EPW)		HCCRD				
Year	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Caballo Releases	Rio Grande at El Paso	Rio Grande at Fort Quitman
1940	-53	-53	6	-1	1	-3	-2	-2	3	2	1	1	-47	-23	-48
1941	-165	-165	-5	-9	-2	-4	-4	-4	-1	0	-2	-4	40	68	12
1942	-33	-33	1	-4	-1	0	0	0	2	8	0	-1	28	8	-57
1943	-64	-64	-8	-11	1	1	-14	-14	-13	-13	1	-1	-27	-15	-88
1944	-81	-81	-144	-137	-110	-92	-5	-5	16	-2	-99	-100	-162	-155	-65
1945	2	2	-17,006	-5,526	1,400	925	-53	-53	-308	6,374	1,084	991	-10,928	-10,411	-16,322
1946	36	36	-10,389	-11,150	-392	-7,349	-110	-111	-717	3,359	-75	-239	-18,240	-17,653	-18,285
1947	56	56	-12,881	-6,763	699	-5,757	-15	-15	3,974	11,138	922	1,018	-10,314	-10,390	-19,236
1948	10	10	-10,680	-6,705	136	-4,668	-15	-16	-1,977	4,581	410	237	-8,507	-8,534	-10,885
1949	46	46	-20,056	-15,361	1,554	3,235	-52	-53	622	6,491	-293	-545	-18,657	-18,081	-19,553
1950	29	29	-22,082	-18,140	-9,742	-11,072	-10	-11	-2,678	2,555	239	421	-20,460	-20,089	-17,853
1951	1,031	1,031	-11,245	-5,716	-641	-2,838	547	546	-3,508	1,705	-204	-2,191	-8,348	-8,206	-12,029
1952	990	990	-10,233	-6,921	-853	-2,129	3,848	3,843	-3,031	-55	-2,244	544	-24,633	-18,189	-11,119
1953	374	374	-15,020	-11,706	-841	-1,984	2,382	2,381	-2,557	343	-1,245	629	-5,820	-11,203	-15,941
1954	19,737	19,737	5,461	6,461	-606	373	15,855	15,855	16,862	17,818	-77	881	15,476	12,024	-11,847
1955	33,004	33,004	21,928	21,994	2,038	3,168	17,426	17,426	20,346	20,290	1,944	2,995	52,752	26,837	313
1956	177	177	800	807	628	600	-2,670	-2,670	199	89	451	307	-2,375	566	-25
1957	10	10	-584	-751	511	465	70	70	546	503	680	589	-1,748	-569	-3
1958	-2	-2	-3,302	-3,501	802	1,820	283	283	-180	-162	75	57	-13,274	-3,257	1,392
1959	5	5	-10,246	-9,922	512	1,404	96	96	-549	-344	6	23	-14,442	-10,381	1,094
1960	8	8	-10,577	-10,131	-542	-805	50	50	-1,436	-903	0	0	-13,113	-11,494	-1,323
1961	15	15	250	1,225	663	817	54	55	1,147	2,163	647	-428	736	-54	1,643
1962	10	10	-13,589	-12,215	-2,154	-2,315	-12	-12	-1,497	-319	18	-304	-17,696	-15,410	-1,866
1963	8,891	8,891	-5,576	-3,706	-1,279	-1,595	4,851	4,851	-911	785	-512	-514	1,780	-2,066	-1,639
1964	23,165	23,165	8,207	9,146	118	788	11,871	11,871	18,866	19,507	1,095	1,026	23,673	12,098	-4,022
1965	7,402	7,402	262	256	1,736	1,733	3,897	3,897	3,395	3,371	595	586	-2,288	1,785	191
1966	-32	-32	-10,691	-10,008	-3,130	-3,346	247	247	-216	145	-3,073	-1,092	-14,379	-8,990	-1,154
1967	15,337	15,337	4,232	5,011	1,431	1,871	8,637	8,637	4,100	3,867	667	1,796	11,091	6,360	-644
1968	7,453	7,453	4,725	5,559	1,742	1,220	6,057	6,057	1,296	1,008	1,683	1,333	7,623	7,603	172
1969	-12	-12	-15,911	-15,412	-9,708	-9,419	233	233	65	395	-9,331	-7,757	-21,188	-16,251	-1,584
1970	3	3	-21,538	-20,837	-7,856	-7,436	41	41	-1,262	-576	-327	4,344	-25,942	-23,129	-10,298
1971	28,767	28,767	-7,447	-6,004	-1,586	-3,319	17,499	17,499	-680	235	-301	-1,643	8,456	-4,217	-1,434
1972	-1,857	-1,857	-7,035	-6,333	-1,458	-1,599	-3,722	-3,722	-5,203	-5,206	-1,691	-1,821	-11,164	-6,091	-1,223
1973	-106	-106	2,690	2,690	723	889	697	697	591	408	638	868	-43	2,562	6
1974	-9	-9	-9,109	-8,794	-4,113	-4,187	244	244	392	667	-3,584	-2,510	-9,687	-9,173	-1,930
1975	-236	-236	-17,895	-17,262	-12,930	-12,490	1,182	1,181	-323	223	-12,682	-12,557	-22,108	-17,970	386
1976	7	7	-18,353	-17,524	-17,238	-17,462	722	722	-858	-140	-2,751	3,542	-21,595	-20,135	-19,603
1977	50,960	50,960	23,636	25,251	9,141	9,599	21,791	21,791	14,213	16,550	8,478	9,465	44,512	32,365	1,612
1978	15,214	15,214	102	1,940	-2,800	-3,054	7,991	7,991	10,136	11,559	-2,527	-2,843	11,462	5,197	-1,212

Run 15b - Early EPCWID Ops (Fabens Drain)
Annual Differences in ILRG Model Outputs
Run 15b minus Run 1
1940 - 2017 (acre-feet)

	Net River Headgate Diversions						Farm Headgate Deliveries						Annual Flows		
	EBID		EPCWID (incl. EPW)		HCCRD		EBID		EPCWID (incl. EPW)		HCCRD				
Year	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Caballo Releases	Rio Grande at El Paso	Rio Grande at Fort Quitman
1979	185	185	-10,680	-8,919	-3,506	-2,444	1,084	1,084	3,320	4,864	-3,383	-2,450	-17,429	-8,540	-97
1980	-13	-13	-22,726	-20,842	-4,667	-4,114	138	138	-380	1,474	-1,755	-804	-27,458	-24,318	-4,974
1981	-54	-54	-26,970	-24,410	-6,312	-7,212	663	663	-1,241	1,750	963	1,296	-31,441	-29,390	-8,462
1982	-8	-8	-28,615	-25,840	-4,301	-4,944	-11	-11	-1,805	1,697	-1,220	841	-32,875	-31,360	-6,989
1983	-14	-14	-28,634	-26,291	-11,452	-11,845	-58	-58	-2,490	512	0	0	-32,959	-31,890	-12,740
1984	-46	-46	-26,493	-24,457	-17,016	-17,708	-1	-1	-1,503	1,777	376	376	-23,256	-23,590	-18,342
1985	-225	-225	-27,784	-25,506	-12,908	-12,645	453	455	-1,858	1,015	0	0	38,073	33,029	18,957
1986	-79	-79	-40,662	-39,314	-7,858	-6,640	345	356	-1,790	-32	0	0	87,164	89,533	69,288
1987	-195	-195	-52,072	-49,313	-7,542	-6,808	1,311	1,315	-879	3,230	0	0	-233	-735	-67,975
1988	-15	-15	-50,025	-46,675	-7,293	-6,893	128	128	-4,800	-96	0	0	-50,044	-43,702	-36,924
1989	9	9	-43,358	-38,785	-12,654	-13,134	-188	-188	-5,882	362	0	0	-52,011	-50,073	-36,571
1990	1,051	1,051	14,163	18,026	-2,570	-2,864	-7,635	-7,639	18,214	24,084	0	0	-20,241	-11,620	-19,956
1991	888	888	-39,570	-35,478	-15,470	-15,817	953	950	-7,966	-1,571	0	0	-38,659	-41,877	-31,554
1992	3,403	3,403	36,136	38,978	28,839	29,486	-10,156	-10,171	30,536	35,119	0	0	105,863	109,402	80,986
1993	585	585	-51,453	-47,309	-8,630	-8,855	730	724	-8,828	-2,282	0	0	-9,222	-13,449	-2,780
1994	420	420	-36,169	-32,951	-3,099	-3,125	-178	-175	35	5,072	0	0	17,120	13,296	9,074
1995	917	917	-31,910	-28,020	-727	-952	9	10	1,846	8,156	0	0	11,377	9,913	2,352
1996	-66	-66	-45,785	-43,144	-5,776	-5,084	120	120	-5,770	-1,638	0	0	-59,664	-54,310	-40,523
1997	-19	-19	-32,329	-29,974	-10,310	-11,807	-233	-233	-7,293	-2,217	0	0	-31,276	-32,201	-24,859
1998	-18	-18	-31,213	-29,092	-573	-1,519	42	43	-2,061	1,399	0	0	-19,917	-19,652	-24,520
1999	1,199	1,199	-21,612	-20,670	3,380	2,952	-2	-3	7,076	8,524	0	0	-29,641	-30,541	-33,411
2000	1,300	1,300	-25,409	-25,435	2,416	2,582	-8,884	-8,884	-9,559	-9,569	0	0	-43,856	-33,996	-25,280
2001	227	227	-29,773	-30,051	-6,946	-6,600	-335	-335	-96	-102	0	0	-27,438	-33,000	-27,844
2002	-11	-11	-28,245	-28,323	-2,131	-1,350	-271	-271	-40	-42	0	0	-28,066	-29,050	-31,125
2003	114,024	114,024	18,968	19,113	10,933	12,002	61,044	61,044	20,565	20,588	0	0	90,501	51,468	11,711
2004	38,938	38,938	11,291	12,629	4,342	7,771	25,575	25,575	24,790	24,815	0	0	23,590	21,608	1,238
2005	2,125	2,125	-30,980	-30,551	-9,345	-7,352	3,888	3,879	-3,501	-3,492	0	0	-54,018	-27,695	-9,400
2006	66,685	66,685	30,353	30,678	14,518	16,284	33,977	33,977	24,922	24,934	0	0	68,901	46,128	14,913
2007	40,156	40,156	-10,767	-10,273	-6,159	-4,344	23,697	23,697	9,727	9,746	0	0	-3,245	-5,761	-4,016
2008	60,837	60,837	-24,037	-23,565	-12,698	-11,296	40,672	40,672	86	105	0	0	-12,262	-20,643	-14,626
2009	69,879	69,879	-23,416	-23,031	-1,996	-1,461	42,037	42,037	1,154	1,177	0	0	-12,719	-19,688	-18,434
2010	99,018	99,018	-19,805	-18,946	-9,630	-9,621	64,821	64,821	973	998	0	0	-398	-15,102	-11,780
2011	63,693	63,693	10,686	11,165	-7,729	-5,619	36,839	36,839	22,091	22,608	0	0	40,762	13,474	-8,084
2012	5,094	5,094	14,763	14,861	-1,142	393	2,685	2,685	22,821	24,178	0	0	18,915	15,458	5,391
2013	-13,590	-13,590	-15,843	-15,757	814	1,493	-6,606	-6,606	-4,275	-3,743	1,696	1,404	-41,249	-17,160	348
2014	-7,039	-7,039	10,200	10,200	6,467	6,917	-2,911	-2,911	11,401	11,401	3,243	3,565	9,472	12,042	-1,702
2015	1,156	1,156	-10,596	-10,603	2,445	3,382	746	746	1,006	2,300	-4,184	-3,453	-12,971	-11,417	1,241
2016	11,964	11,964	-6,885	-6,852	1,580	2,126	3,067	3,067	9,002	10,079	0	0	3,667	-7,048	-11,963
2017	43,010	43,010	-18,317	-18,112	1,307	1,464	22,704	22,704	1,461	2,780	0	0	6,333	-19,372	-11,379
Averages															
1951-2017	12,174	12,174	-12,860	-11,481	-2,554	-2,305	6,723	6,722	3,119	4,834	-416	-58	-3,628	-5,242	-6,312
1951-1978	7,511	7,511	-4,145	-3,086	-1,703	-1,758	4,292	4,292	2,498	3,355	-842	-167	-1,867	-2,835	-3,289
1979-2005	6,093	6,093	-25,256	-23,059	-4,118	-3,886	2,538	2,538	1,431	4,570	-186	-27	-9,482	-8,990	-10,027
2006-2017	36,739	36,739	-5,305	-5,019	-1,019	-24	21,811	21,811	8,364	8,880	63	126	5,434	-2,424	-5,008
1985-2017	18,343	18,343	-18,226	-16,730	-2,307	-1,725	9,953	9,952	4,337	6,603	23	46	-770	-3,719	-8,461
1985-2005	7,831	7,831	-25,609	-23,421	-3,044	-2,698	3,177	3,176	2,035	5,301	0	0	-4,314	-4,460	-10,434

Notes:

EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).

EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

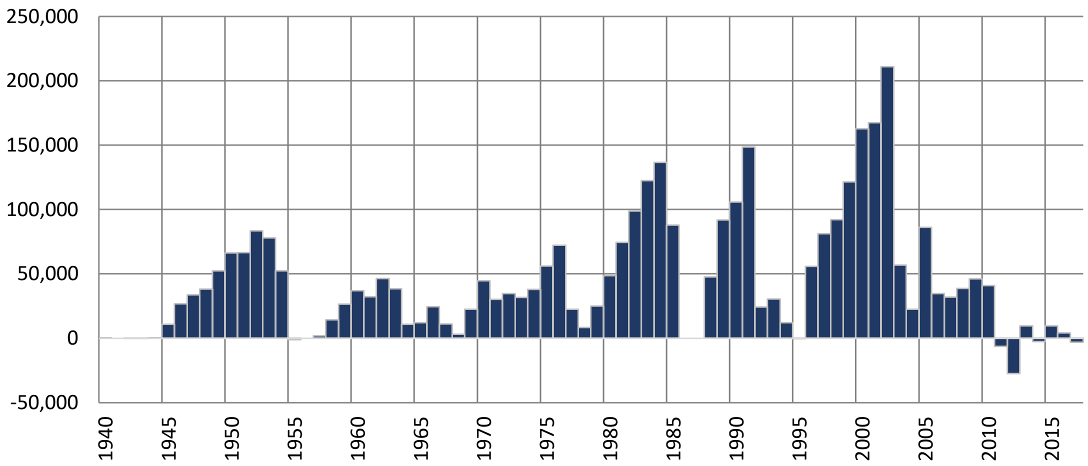
Run 15b - Early EPCWID Ops (Fabens Drain)

Simulated Differences in ILRG Model Outputs

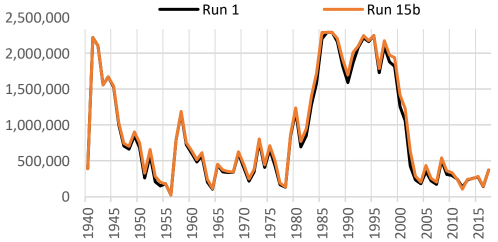
Run 15b minus Run 1

1940 - 2017 (acre-feet)

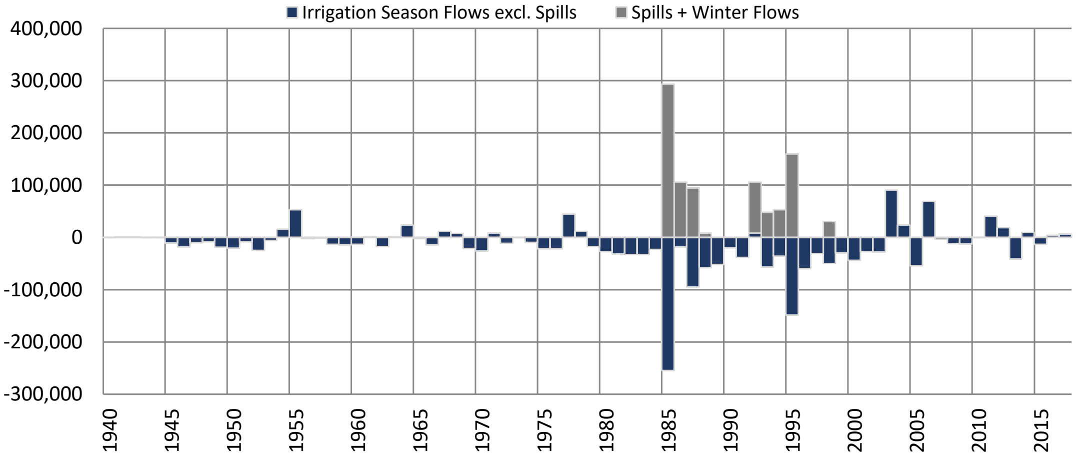
Total Project Storage (Year End)



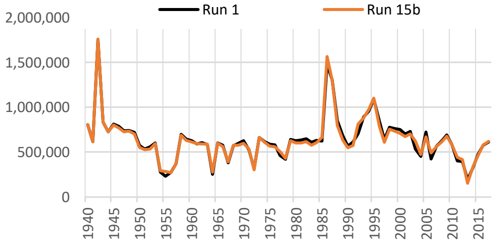
Period	Average Difference
1951-2017	-1,032
1951-1978	-2,067
1979-2005	2,881
2006-2017	-7,421
1985-2017	-4,231
1985-2005	-2,408



Caballo Reservoir Outflows (Annual)



Period	Average Difference Irr Season (excl. Spills)	Nov-Feb and Spills	Annual
1951-2017	-16,904	13,275	-3,628
1951-1978	-1,867	0	-1,867
1979-2005	-42,425	32,943	-9,482
2006-2017	5,434	0	5,434
1985-2017	-27,723	26,953	-770
1985-2005	-46,669	42,355	-4,314



Notes:

Reservoir storage does not include storage attributed to SJC, CO, or NM credit waters.

Average differences calculated as (Final Storage - Initial Storage)/(no. years).

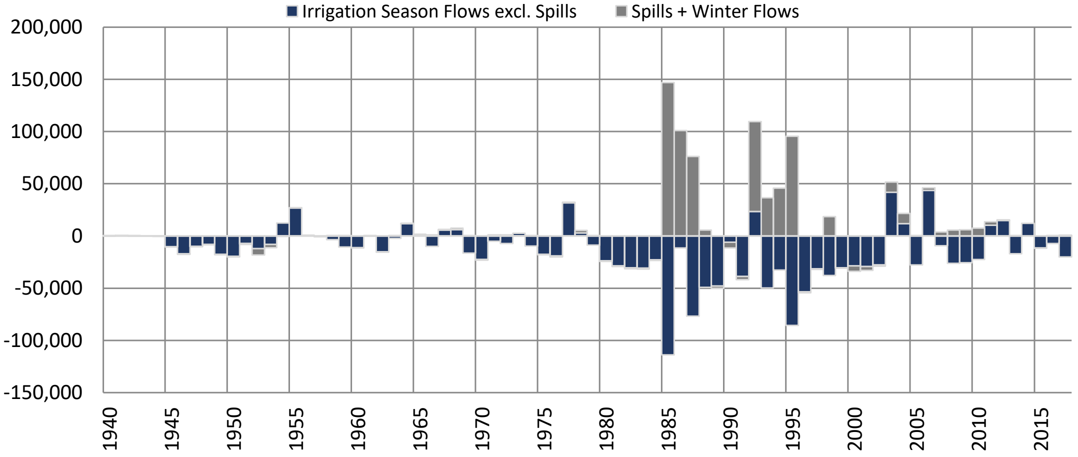
Run 15b - Early EPCWID Ops (Fabens Drain)

Simulated Differences in ILRG Model Outputs

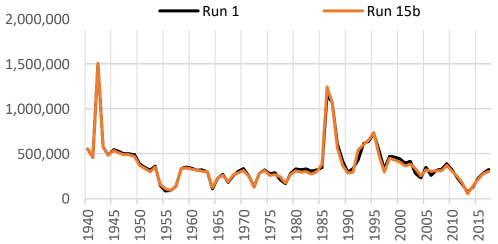
Run 15b minus Run 1

1940 - 2017 (acre-feet)

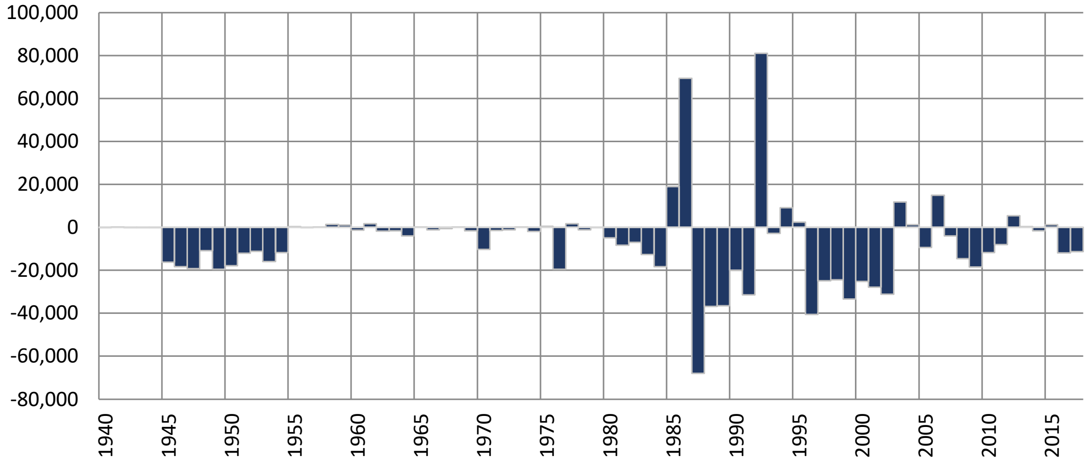
Rio Grande at El Paso (Annual)



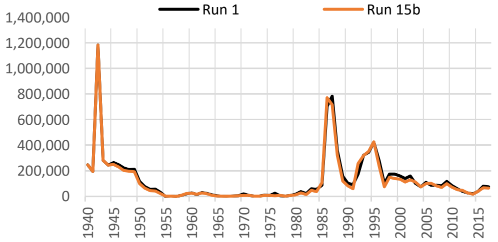
	Average Difference		
Period	Irr Season (excl. Spills)	Nov-Feb and Spills	Annual
1951-2017	-14,685	9,443	-5,242
1951-1978	-2,761	-74	-2,835
1979-2005	-31,383	22,393	-8,990
2006-2017	-4,933	2,509	-2,424
1985-2017	-23,076	19,357	-3,719
1985-2005	-33,443	28,984	-4,460



Rio Grande at Fort Quitman (Annual)



Period	Average Difference
1951-2017	-6,301
1951-1978	-3,281
1979-2005	-10,009
2006-2017	-5,005
1985-2017	-8,452
1985-2005	-10,421



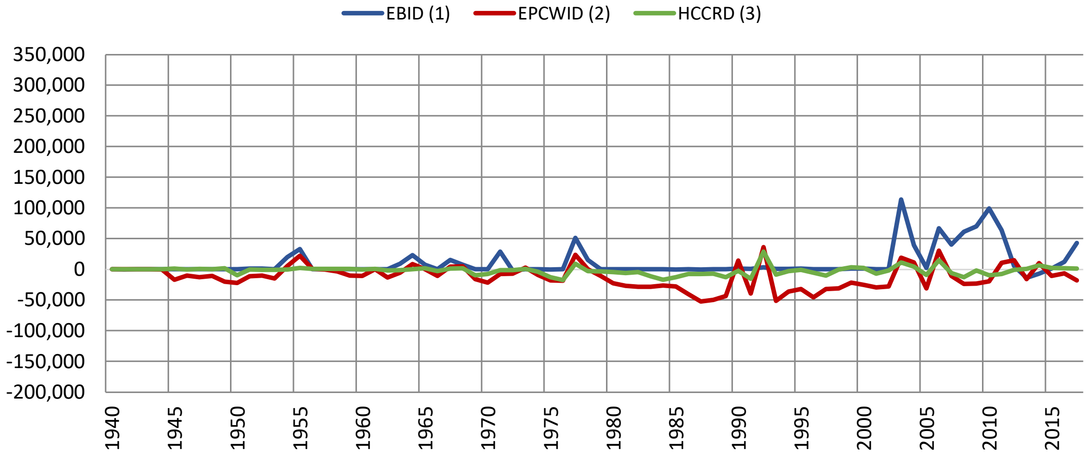
Run 15b - Early EPCWID Ops (Fabens Drain)

Simulated Differences in ILRG Model Outputs

Run 15b minus Run 1

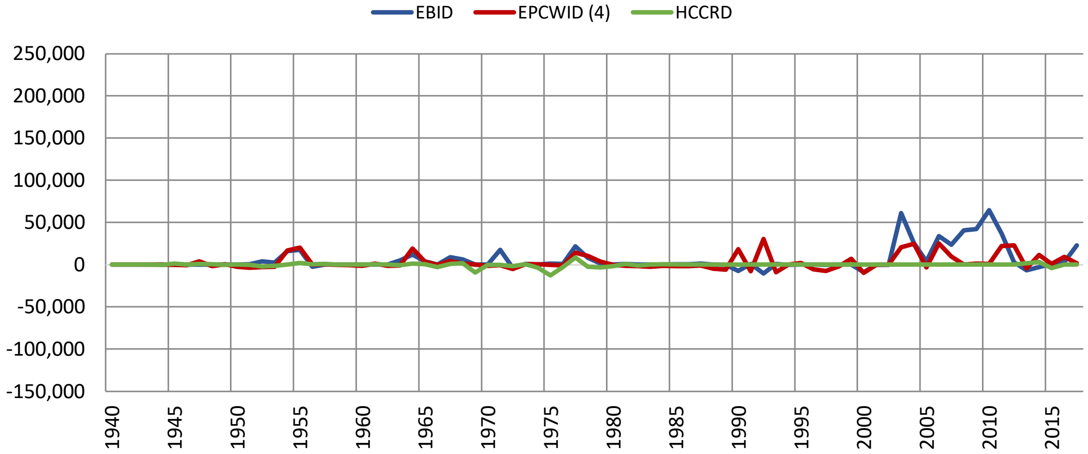
1940 - 2017 (acre-feet)

River Headgate (RHG) Diversions (Irrigation Season)



	Average Difference		
Period	EBID	EPCWID	HCCRD
1951-2017	12,174	-12,860	-2,554
1951-1978	7,511	-4,145	-1,703
1979-2005	6,093	-25,256	-4,118
2006-2017	36,739	-5,305	-1,019
1985-2017	18,343	-18,226	-2,307
1985-2005	7,831	-25,609	-3,044

Farm Headgate (FHG) Deliveries (Irrigation Season)



	Average Difference		
Period	EBID	EPCWID	HCCRD
1951-2017	6,723	3,119	-416
1951-1978	4,292	2,498	-842
1979-2005	2,538	1,431	-186
2006-2017	21,811	8,364	63
1985-2017	9,953	4,337	23
1985-2005	3,177	2,035	0

Notes:

(1) EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).

(2) EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

(3) HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

(4) EPCWID FHG values include deliveries to Rogers WTP and R/U WTP.

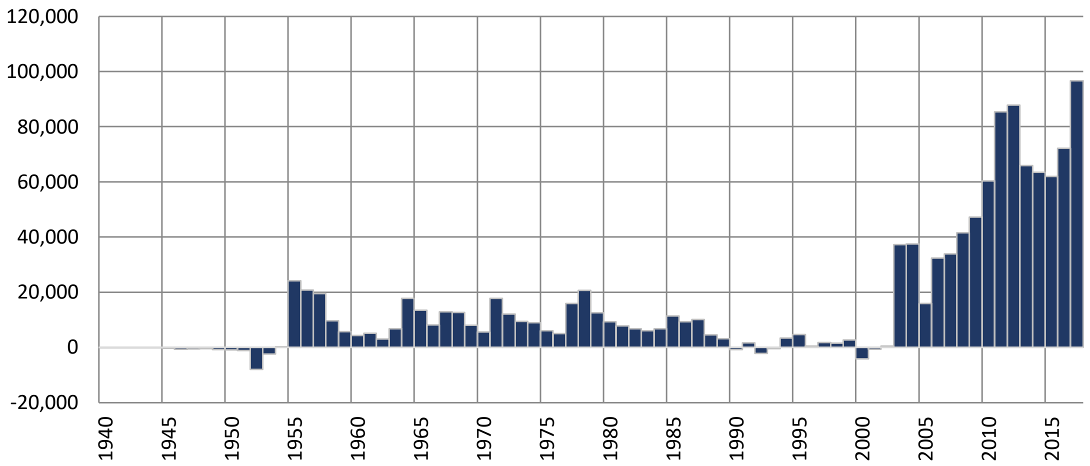
Run 15b - Early EPCWID Ops (Fabens Drain)

Simulated Differences in ILRG Model Outputs

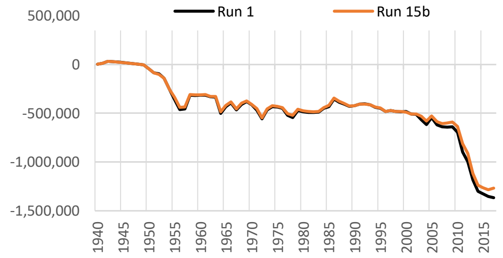
Run 15b minus Run 1

1940 - 2017 (acre-feet)

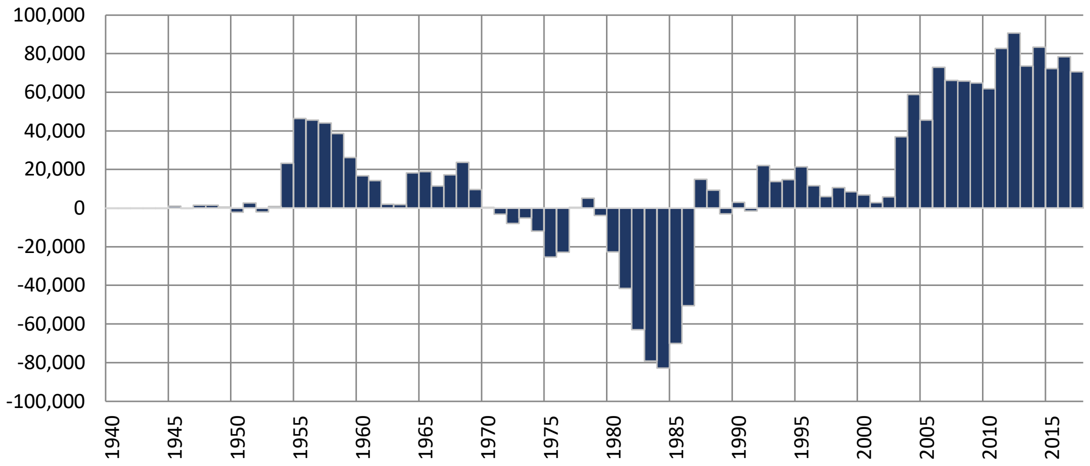
Cumulative Annual Rincon-Mesilla Groundwater Storage



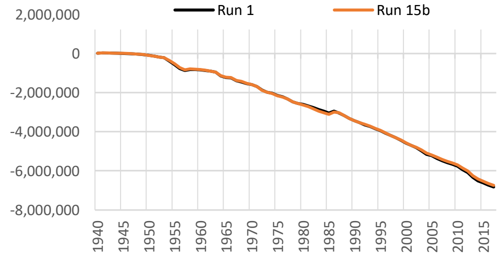
Period	Average Difference
1951-2017	1,456
1951-1978	770
1979-2005	-178
2006-2017	6,732
1985-2017	2,725
1985-2005	436



Cumulative Annual Hueco Groundwater Storage



Period	Average Difference
1951-2017	1,085
1951-1978	259
1979-2005	1,496
2006-2017	2,087
1985-2017	4,651
1985-2005	6,116



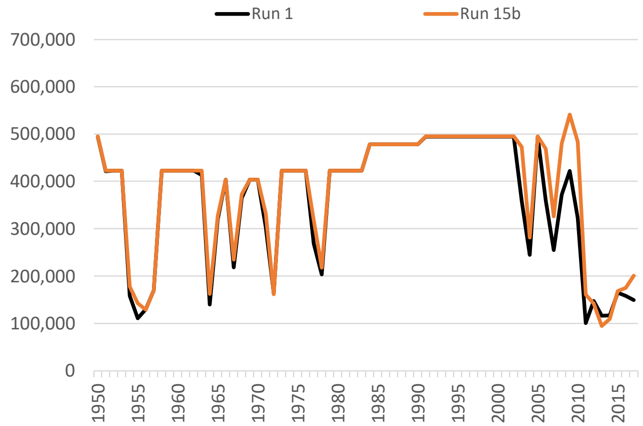
Notes:

Cumulative storage change in alluvial and non-alluvial aquifers.

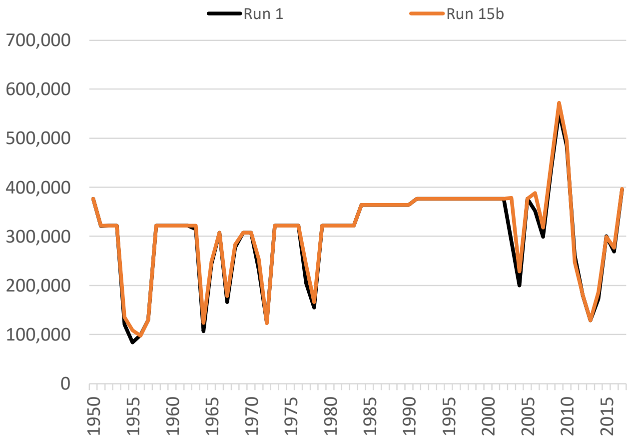
Average differences calculated as (Final Storage - Initial Storage)/(no. years).

Run 15b - Early EPCWID Ops (Fabens Drain)
Annual Allocation and Charges
Run 15b v. Run 1
ILRG Model
1950 - 2017 (acre-feet)

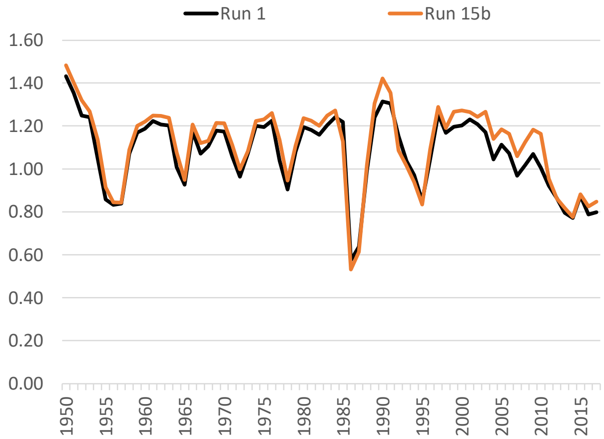
Total Allocation - EBID



Total Allocation - EPCWID

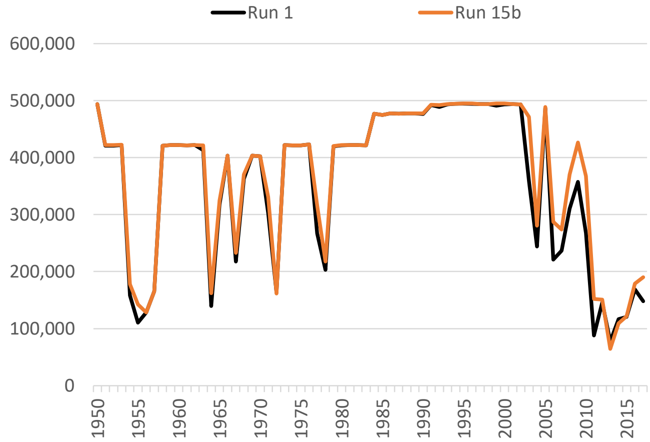


Diversion Ratio

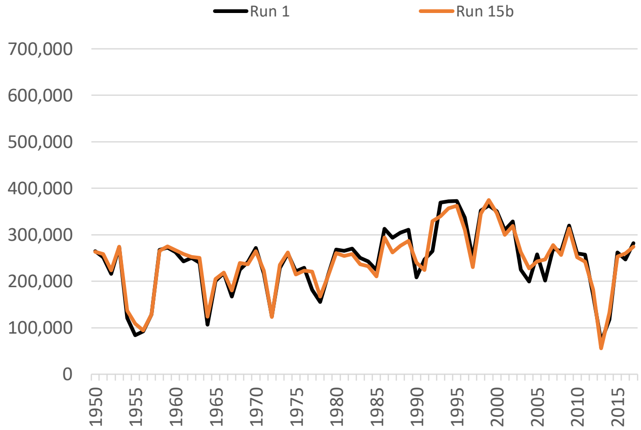


Note:
Computed as Total Charges/Caballo Release.

Annual Delivery Charges - EBID



Annual Delivery Charges - EPCWID



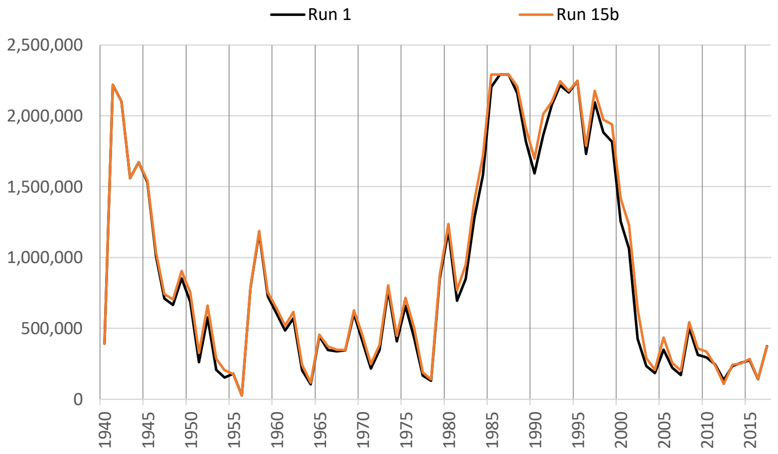
Run 15b - Early EPCWID Ops (Fabens Drain)

Annual Summary of Project Storage and Rio Grande Flows

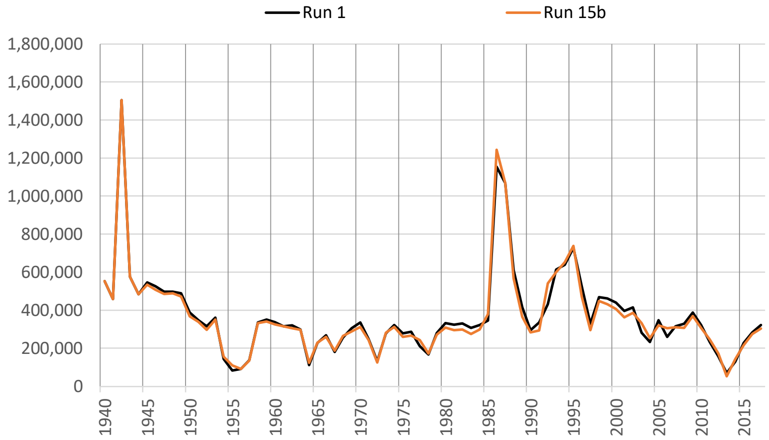
Run 15b v. Run 1

ILRG Model

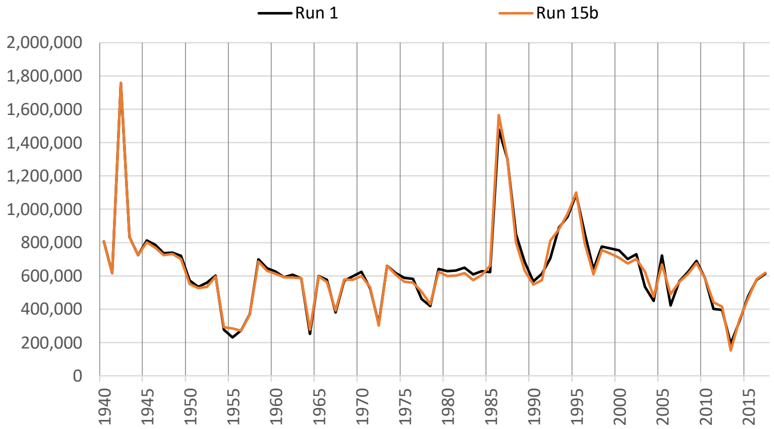
1940 - 2017 (acre-feet)



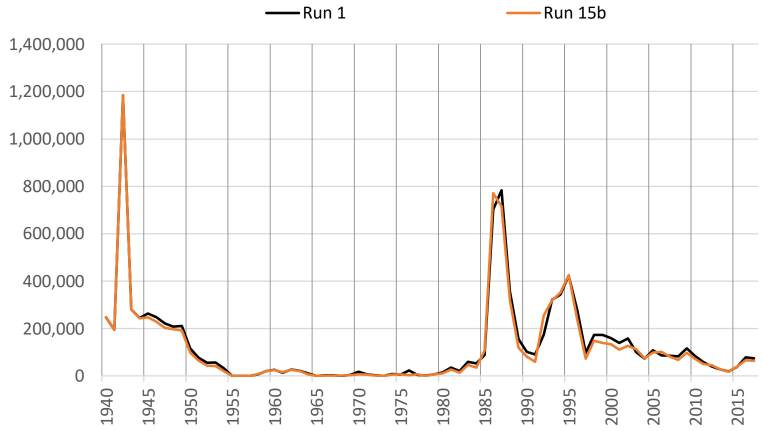
Total Year-End Project Reservoir Storage



Rio Grande at El Paso



Rio Grande Below Caballo



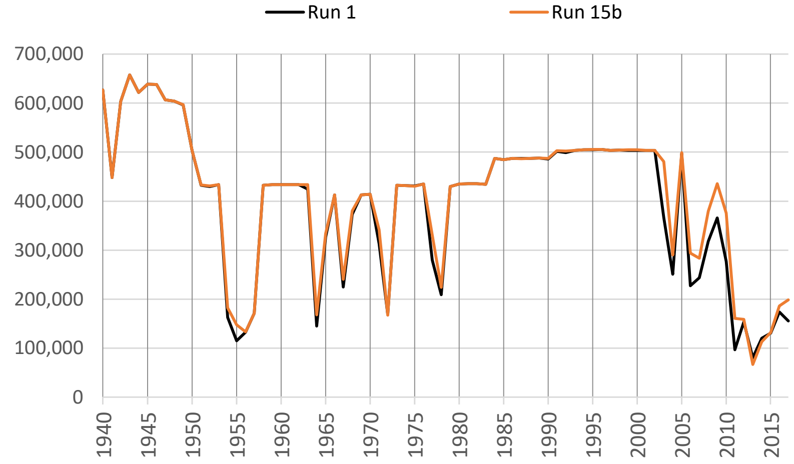
Rio Grande at Fort Quitman

***Note different scales.**

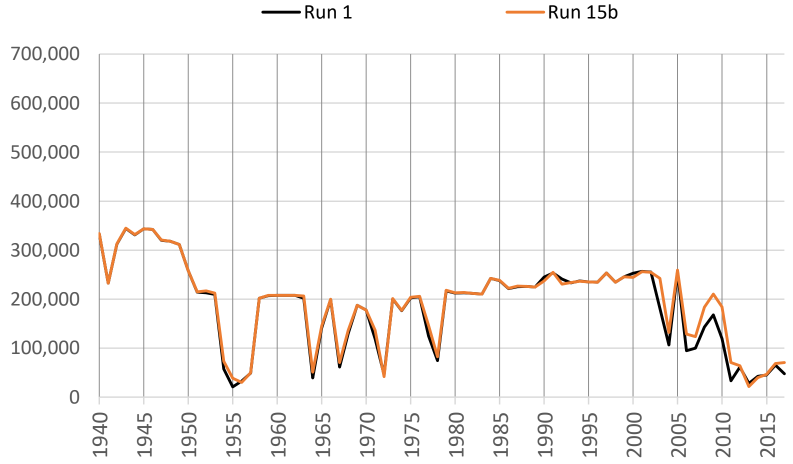
Run 15b - Early EPCWID Ops (Fabens Drain)
Irrigation Season Summary of Irrigation Operations
Run 15b v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

EBID Total

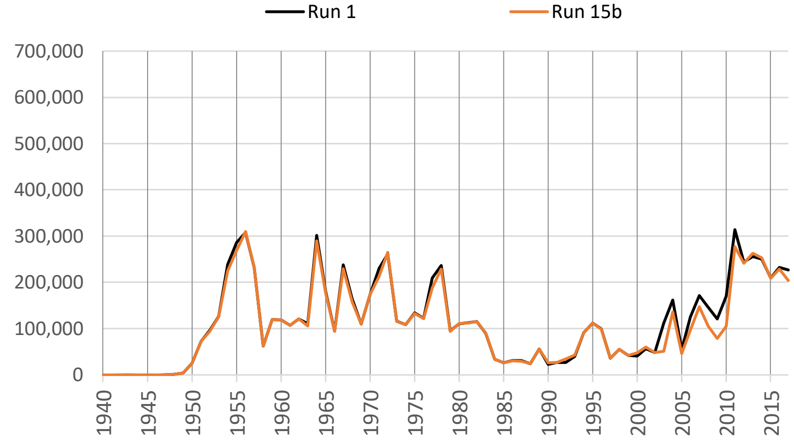
Net River Headgate Diversions



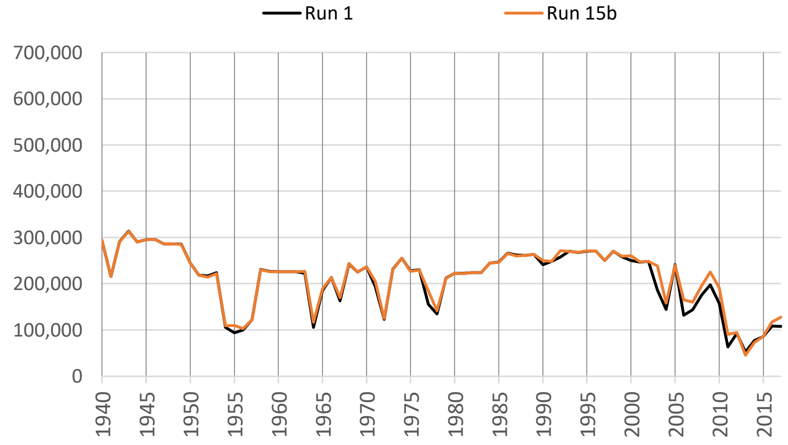
Farm Headgate Deliveries



Pumping



RHG Diversions - FHG Deliveries

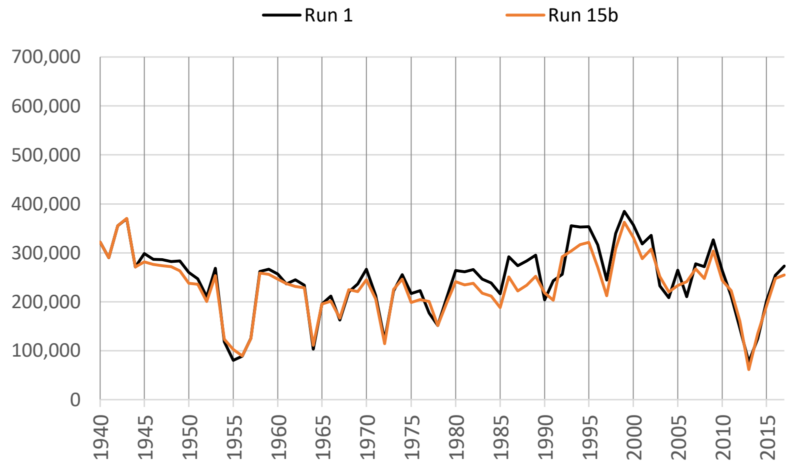


Notes: EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).
Pumping includes Supplemental and Primary groundwater pumping.

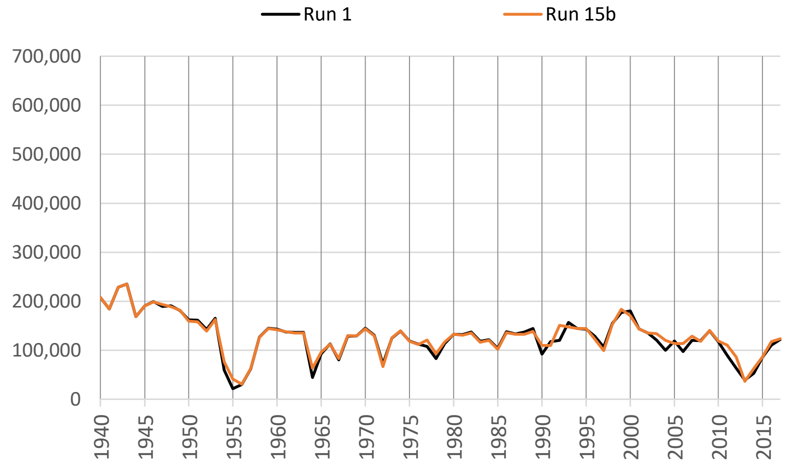
Run 15b - Early EPCWID Ops (Fabens Drain)
Irrigation Season Summary of Irrigation Operations
Run 15b v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

EPCWID Total

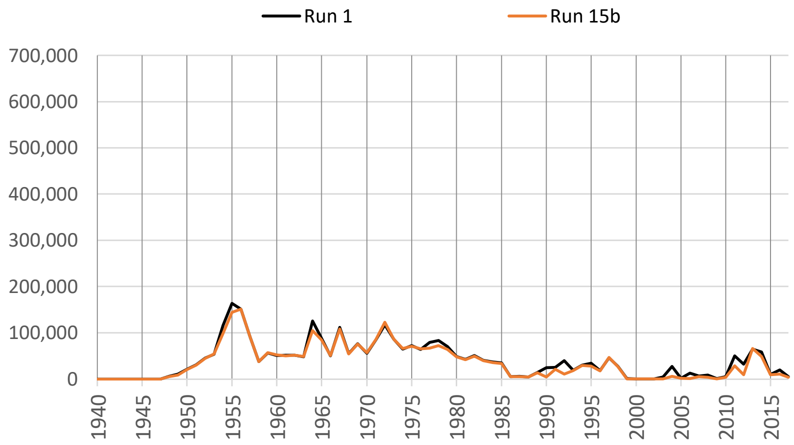
Net River Headgate Diversions



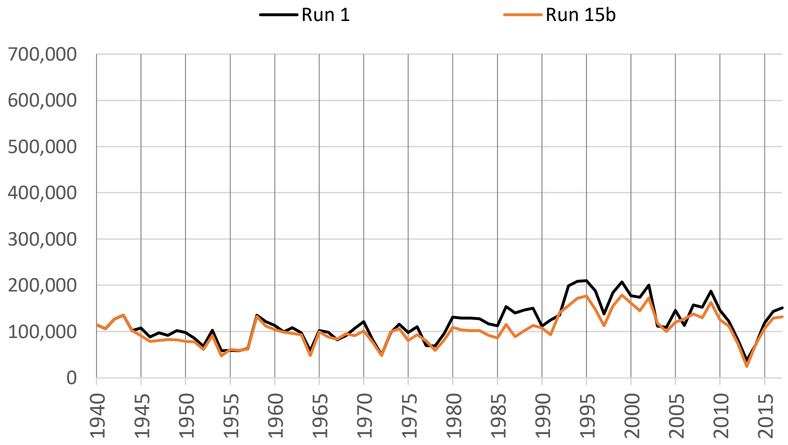
Farm Headgate Deliveries



Pumping



RHG Diversions - FHG Deliveries



Note: EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

Run 15b - Early EPCWID Ops (Fabens Drain)

Irrigation Season Summary of Irrigation Operations

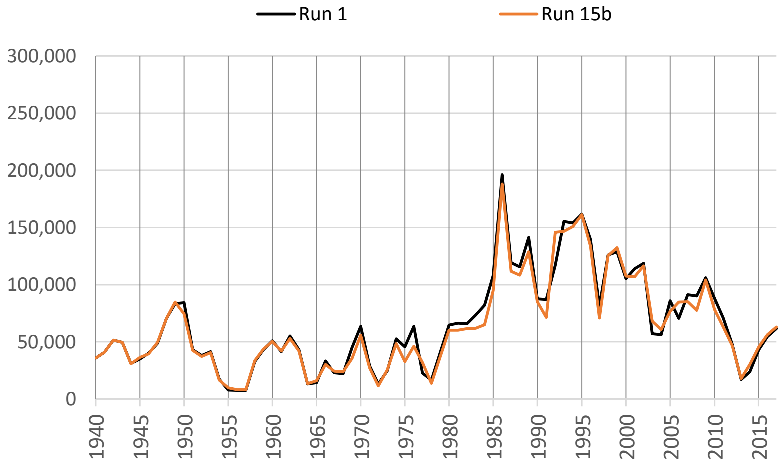
Run 15b v. Run 1

ILRG Model

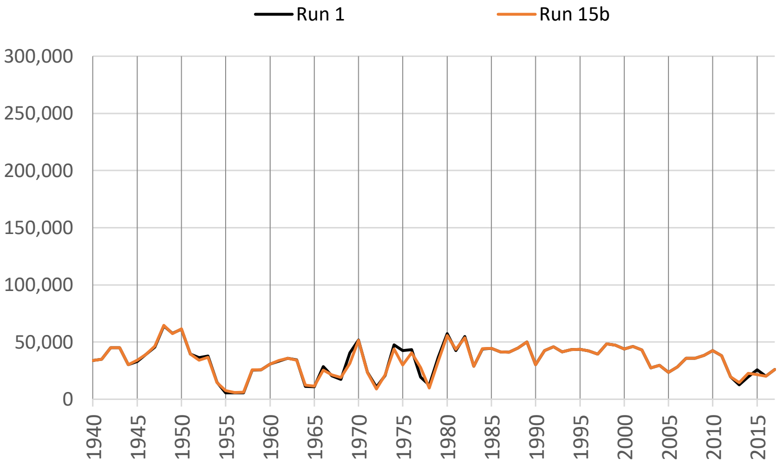
1940 - 2017 (acre-feet)

HCCRD Total

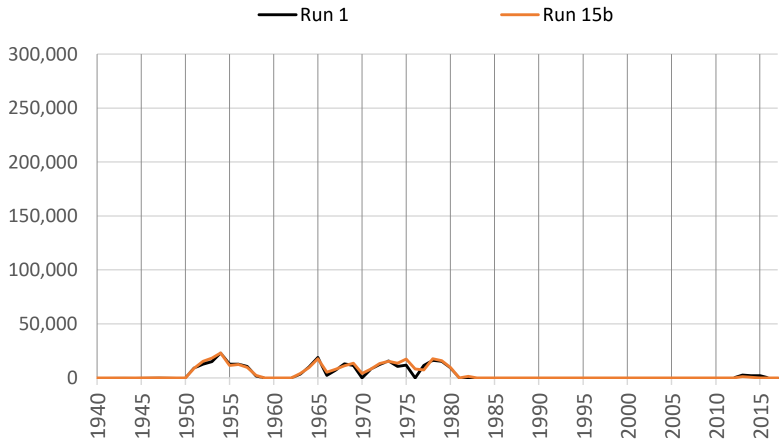
Net River Headgate Diversions



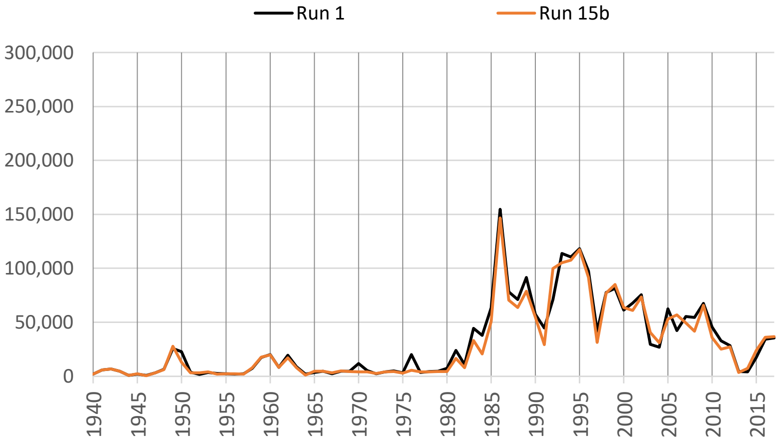
Farm Headgate Deliveries



Pumping



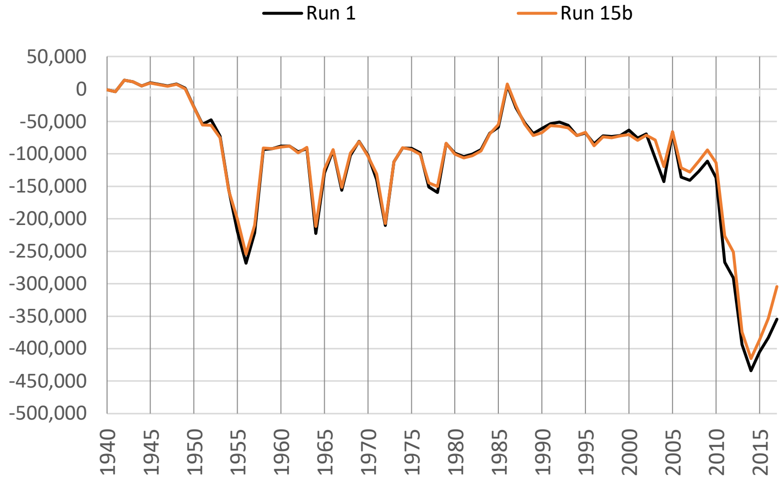
RHG Diversions - FHG Deliveries



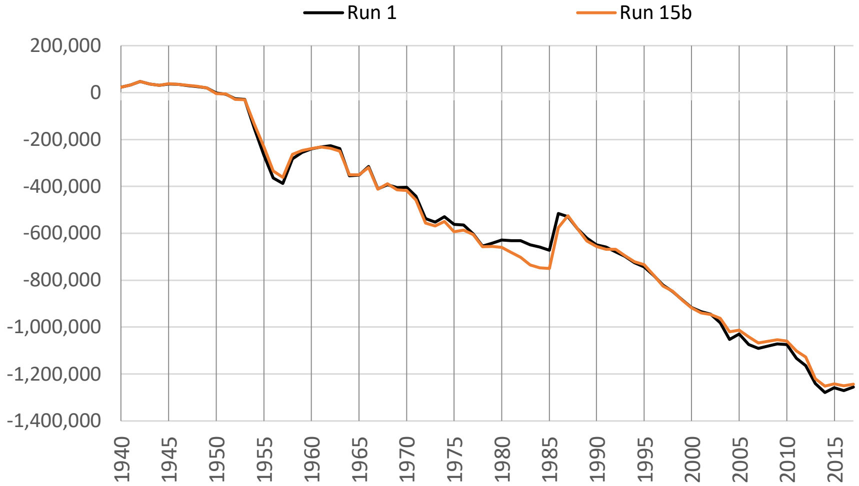
Note: HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

Run 15b - Early EPCWID Ops (Fabens Drain)
Cumulative Change in Ground Water Storage
Run 15b v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

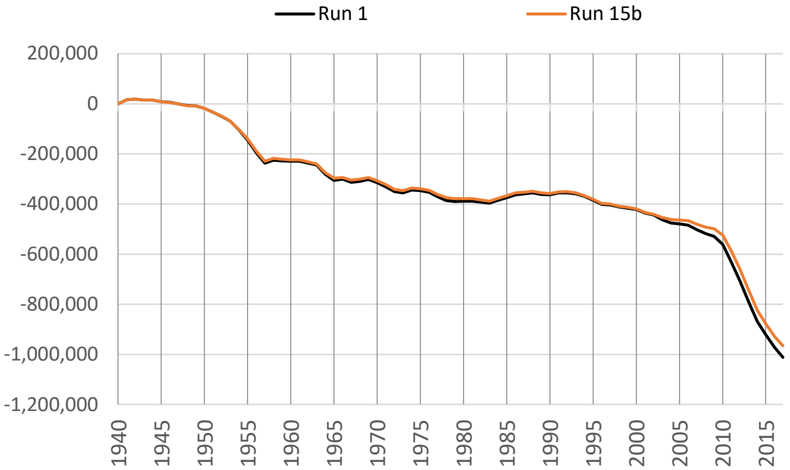
Rincon-Mesilla Alluvial Aquifer



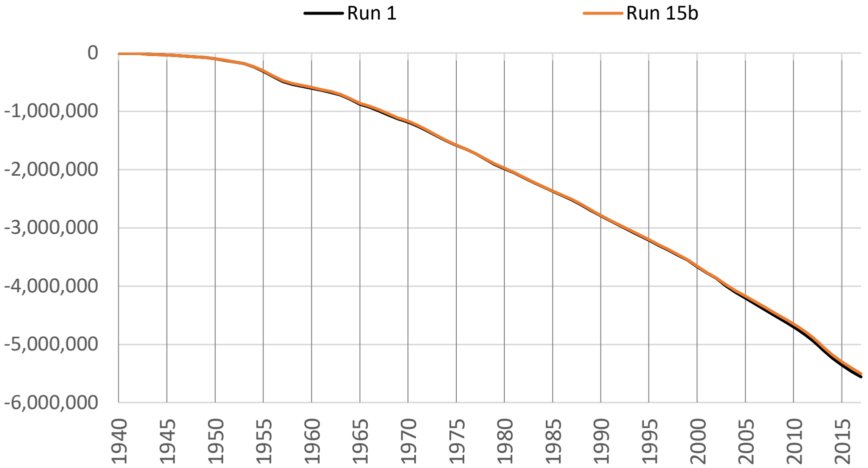
Hueco Alluvial Aquifer



Rincon-Mesilla Non-Alluvial Aquifer



Hueco Non-Alluvial Aquifer



***Note different scales.**

Run 15b - Early EPCWID Ops (Fabens Drain)

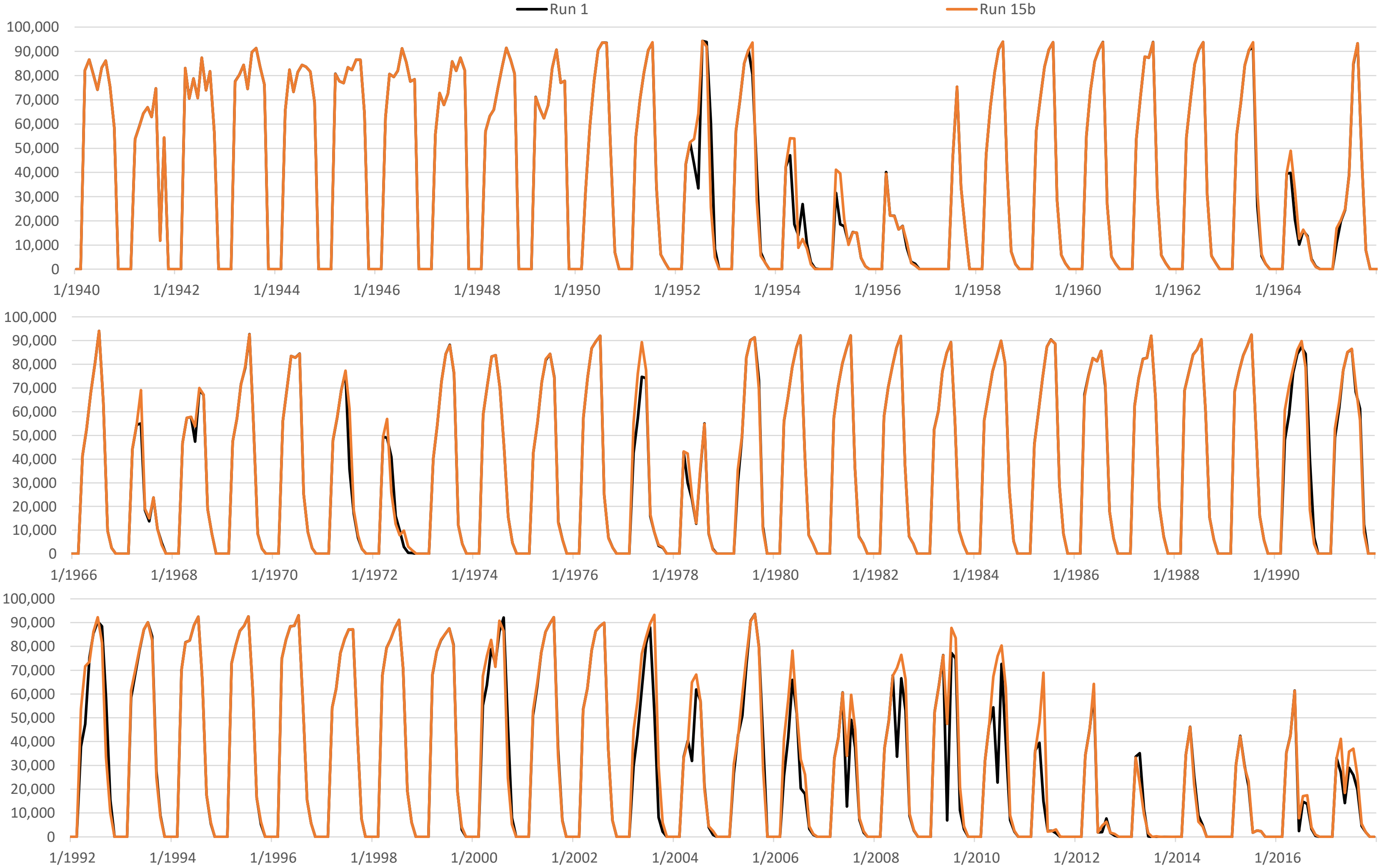
Monthly Net RHG Diversions

Run 15b v. Run 1

ILRG Model

1940 - 2017 (acre-feet)

EBID Total



Note: EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).

Run 15b - Early EPCWID Ops (Fabens Drain)

Monthly Net RHG Diversions

Run 15b v. Run 1

ILRG Model

1940 - 2017 (acre-feet)

EPCWID Total

Note: EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

Run 15b - Early EPCWID Ops (Fabens Drain)

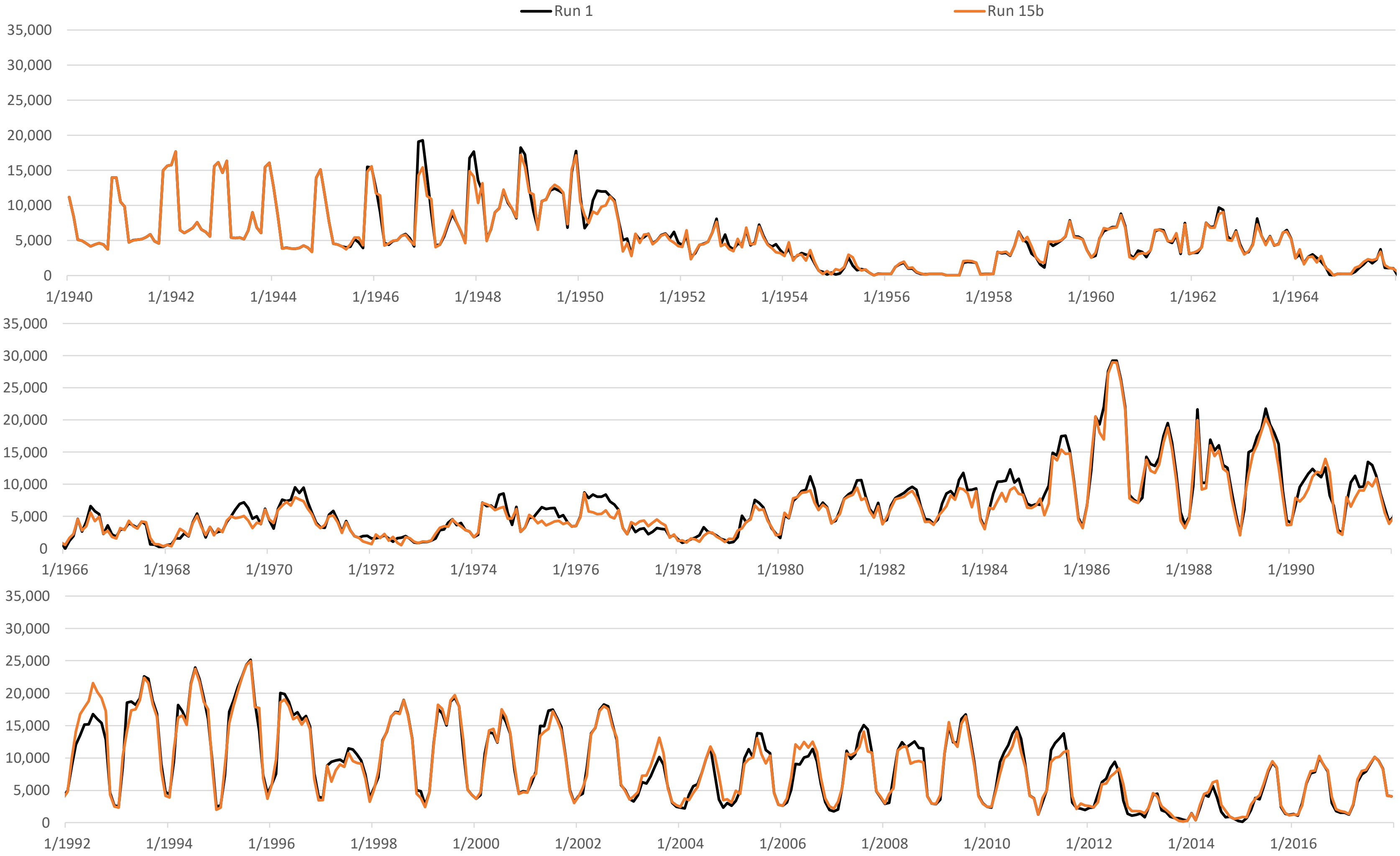
Monthly Net RHG Diversions

Run 15b v. Run 1

ILRG Model

1940 - 2017 (acre-feet)

HCCRD Total



Note: HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

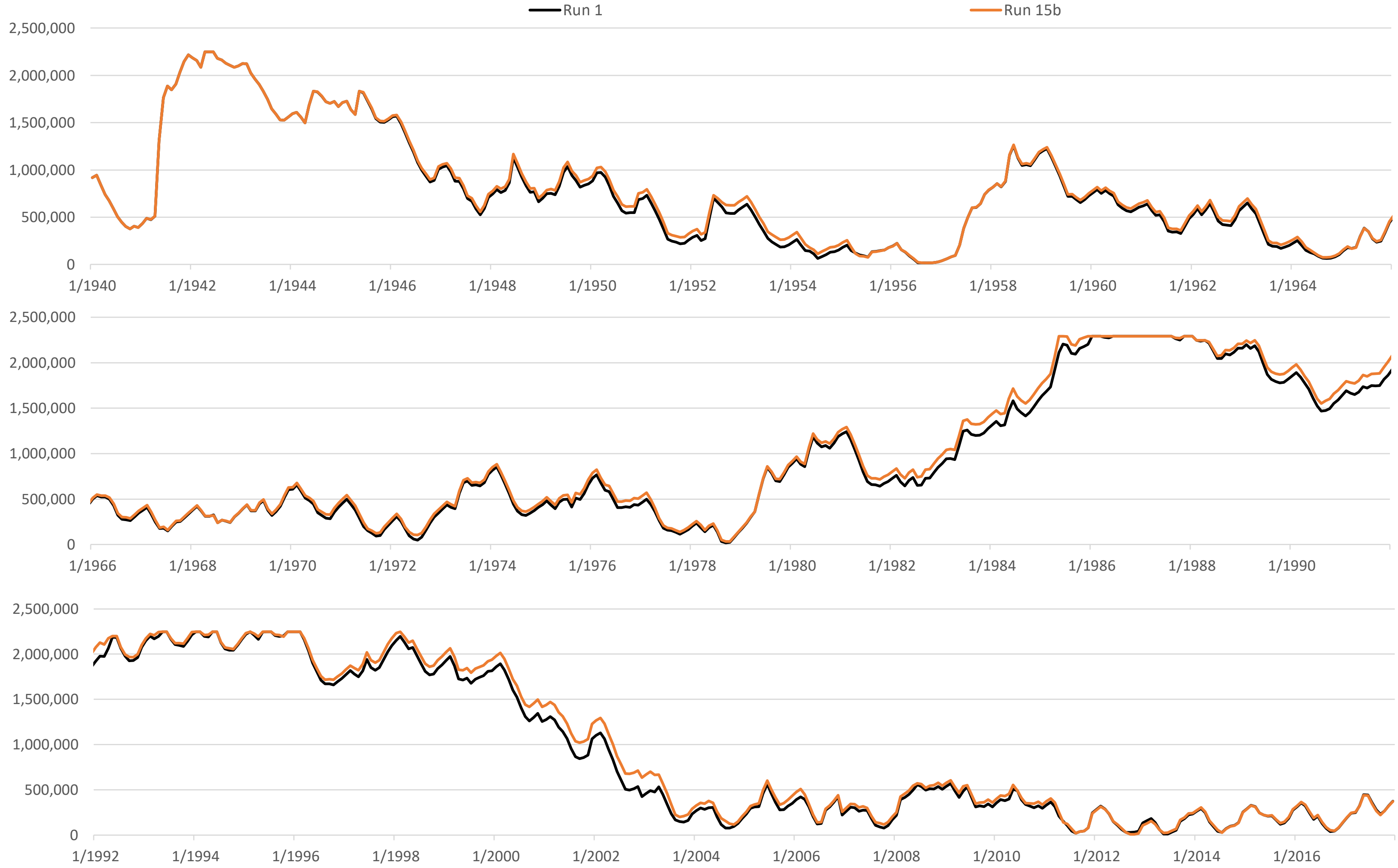
Run 15b - Early EPCWID Ops (Fabens Drain)

End of Month Reservoir Storage (Elephant Butte + Caballo)

Run 15b v. Run 1

ILRG Model

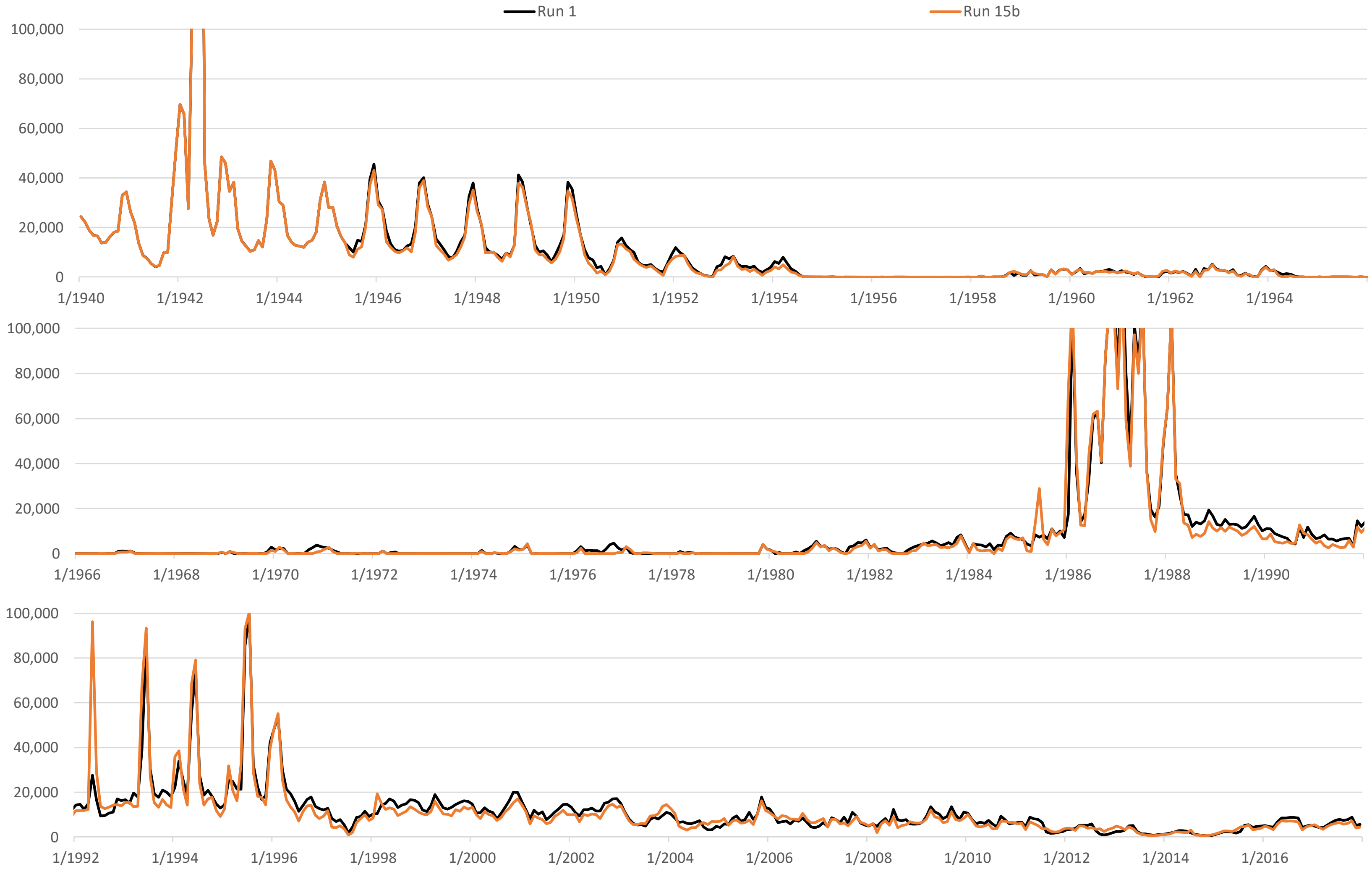
1940 - 2017 (acre-feet)



Run 15b - Early EPCWID Ops (Fabens Drain)
Monthly Caballo Releases
Run 15b v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

Run 15b - Early EPCWID Ops (Fabens Drain)
Monthly Rio Grande at El Paso Flow
Run 15b v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

Run 15b - Early EPCWID Ops (Fabens Drain)
Monthly Rio Grande at Fort Quitman Flow
Run 15b v. Run 1
ILRG Model
1940 - 2017 (acre-feet)



Appendix 30V

Comparison of ILRG Model Runs
Run 15c v. Run 15

Model Run Specifications

Model Version: LRG_v116

Name: **Run 15c - Early EPCWID Ops (TX Hueco Pumping Off)**

Run ID: LRG_v116_Operational_Run15c
Date: 8/28/2020

Name: **Run 15 - Early EPCWID Ops (WWTP & Fabens Drains)**

Run ID: LRG_v116_Operational_Run15
Date: 8/27/2020

Selected Model Inputs

Pumping and Returns	**Run 15c**	**Run 15**
Irrigation Pumping	TX Hueco Off	On
Irrigated Area	Hist	Hist
Non-Irrigation Pumping	TX Hueco Off	On
Non-Irrigation Pumping Returns	TX Hueco Off	On
Las Cruces Jornada Pumping Returns	On	On

Project Allocation Rules		
1950-2005	D1/D2	D1/D2
2006-2007	D3	D3
2008-2017	D3 + CO	D3 + CO

EPCWID Operations		
Charge EPCWID for Use of WWTP Returns	On	On
ACE and Haskell Credits for EPCWID	Off	Off
(1) Increased EPCWID Use of Fabens Drain Flows	On	On
Charge EPCWID for Fabens Drain Flow Use	On	On

Notes:

(1) Starting in July 1945, use 70% of simulated Fabens drain flow up to 6,000 af/month.

Run 15c - Early EPCWID Ops (TX Hueco Pumping Off)
Comparison of ILRG Model Runs
Run 15c v. Run 15
1951 - 2017 Annual Average
(1,000 acre-feet)

Run No.	15	15c	15c - 15		
Simulated Input or Output	**Run 15**	**Run 15c**	**Run 15c minus Run 15**		
Pumping Stress					
Irrigation Pumping	42.2	0.0	-42.2		
Non-Irrigation Pumping	180.9	118.3	-62.6		
WWTP Flows	58.0	46.7	-11.4		
Urban Deep Percolation	13.1	7.8	-5.3		
Total Stress	152.0	63.9	-88.2		
	Stress is Pumping minus WWTP and Urban Deep Perc				
Effects of Pumping Stress				***% Chg***	
FHG Deliveries (Mar - Oct)				***Stress***	***% Diff.***
EBID	177.9	177.6	-0.3	*0%*	*0%*
EPCWID (incl. EPW)	141.2	142.4	1.2	*-1%*	*1%*
HCCRD	32.4	34.7	2.3	*-3%*	*7%*
Total	351.5	354.7	3.2	*-4%*	*1%*
FHG Deliveries (Nov - Feb)					
EBID	0.0	0.0	0.0	*0%*	*1%*
EPCWID (incl. EPW)	1.9	1.4	-0.5	*1%*	*-26%*
HCCRD	2.7	2.6	-0.1	*0%*	*-5%*
Total	4.6	4.0	-0.6	*1%*	*-13%*
Irrigation Pumping					
EBID	130.4	130.7	0.2	*0%*	*0%*
EPCWID (Mesilla Valley)	7.0	6.9	0.0	*0%*	*-1%*
EPCWID (El Paso Valley)	37.5	0.0	-37.5		
HCCRD	4.7	0.0	-4.7		
Total	137.4	137.6	0.2	*0%*	*0%*
	Pumping turned off.	*Other values are simulated responses and are totaled.*			
Other Inflows/Outflows					
Net Reservoir Evaporation	129.6	130.3	0.7	*-1%*	*1%*
Riparian ET	70.5	75.0	4.5	*-5%*	*6%*
River Evaporation + Incidental Canal Loss	30.7	30.2	-0.5	*1%*	*-2%*
Total	230.8	235.5	4.7	*-5%*	*2%*
Rio Grande at Fort Quitman					
Reservoir Spills	38.6	37.3	-1.2	*1%*	*-3%*
Nov-Feb Flows	18.2	20.9	2.7	*-3%*	*15%*
Mar - Oct Flows	32.4	38.5	6.0	*-7%*	*19%*
Underflow (GW Model)	0.2	0.3	0.1	*0%*	*25%*
Total	89.4	97.0	7.6	*-9%*	*8%*

Run 15c - Early EPCWID Ops (TX Hueco Pumping Off)

Comparison of ILRG Model Runs

Run 15c v. Run 15

1951 - 2017 Annual Average

(1,000 acre-feet)

Run No.	15	15c	15c - 15		
Simulated Input or Output	**Run 15**	**Run 15c**	**Run 15c minus Run 15**		
Effects of Pumping Stress (continued)				*% Chg*	
Change in Storage				*Stress*	*% Diff.*
Reservoir Storage	-6.0	-5.9	0.1	*0%*	*-2%*
Alluvial GW Storage (RW Model)	-21.9	-15.6	6.3	*-7%*	*-29%*
Non-alluvial GW Storage (GW Models)	-94.6	-49.7	44.9	*-51%*	*-47%*
Soil Moisture Storage	0.6	0.6	0.0	*0%*	*3%*
Total	-121.9	-70.6	51.3	*-58%*	*-42%*
Summary of Effects					
FHG Deliveries (Mar-Oct)	351.5	354.7	3.2	*-4%*	*1%*
FHG Deliveries (Nov-Feb)	4.6	4.0	-0.6	*1%*	*-13%*
Irrigation Pumping	137.4	137.6	0.2	*0%*	*0%*
Riparian ET + Evaporation	230.8	235.5	4.7	*-5%*	*2%*
Fort Quitman Flow	89.4	97.0	7.6	*-9%*	*8%*
Change in Storage	-121.9	-70.6	51.3	*-58%*	*-42%*
Total	691.9	758.2	66.3	*-75%*	*10%*
Other Effects of Pumping Stress				*% Chg*	
Rio Grande at El Paso				*Stress*	*% Diff.*
Reservoir Spills	59.4	53.8	-5.6	*6%*	*-9%*
Nov-Feb Flows	22.7	23.3	0.6	*-1%*	*3%*
Mar - Oct Flows	247.4	252.5	5.0	*-6%*	*2%*
Total	329.5	329.5	0.0	*0%*	*0%*
Rio Grande below Caballo					
Reservoir Spills	79.3	71.2	-8.1	*9%*	*-10%*
Nov-Feb Flows	0.3	0.7	0.4	*0%*	*144%*
Mar - Oct Flows	525.0	532.0	7.0	*-8%*	*1%*
Total	604.6	603.9	-0.7	*1%*	*0%*
Surface Water Diversions (Mar - Oct)					
EBID	384.8	384.7	-0.2	*0%*	*0%*
EPCWID (incl. EPW)	221.7	220.5	-1.2	*1%*	*-1%*
HCCRD	64.4	69.8	5.4	*-6%*	*8%*
Total	671.0	675.0	4.0	*-5%*	*1%*
Surface Water Diversions (Nov - Feb)					
EBID	0.0	0.0	0.0	*0%*	*0%*
EPCWID (incl. EPW)	15.7	13.6	-2.2	*2%*	*-14%*
HCCRD	14.3	15.0	0.7	*-1%*	*5%*
Total	30.0	28.6	-1.4	*2%*	*-5%*

Run 15c - Early EPCWID Ops (TX Hueco Pumping Off)
Annual Differences in ILRG Model Outputs
Run 15c minus Run 15
1940 - 2017 (acre-feet)

	Net River Headgate Diversions						Farm Headgate Deliveries						Annual Flows		
	EBID		EPCWID (incl. EPW)		HCCRD		EBID		EPCWID (incl. EPW)		HCCRD				
Year	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Caballo Releases	Rio Grande at El Paso	Rio Grande at Fort Quitman
1940	19	19	-623	65	-150	555	-12	-12	376	376	-95	-95	-3,480	-3,374	6,877
1941	56	56	-111	-1,255	217	51	4	4	-2	-206	199	110	3,185	2,887	3,535
1942	-28	-28	-41	-2,038	-174	-173	8	8	467	-168	-196	-219	1,879	1,874	-231
1943	-22	-22	-137	-1,639	-155	-294	24	24	455	211	-106	-410	4,335	4,233	2,445
1944	-21	-21	-341	-1,730	188	-109	0	0	-232	-427	127	-104	1,976	1,940	2,124
1945	-15	-15	-927	-3,594	401	140	6	6	-323	-1,233	288	220	2,486	2,355	2,359
1946	-12	-12	-3	-1,753	571	565	9	9	664	-531	391	354	3,653	3,554	2,727
1947	-2	-2	-290	-2,231	331	176	3	2	950	116	261	293	1,573	1,597	2,084
1948	10	10	-2,036	-3,997	704	679	-10	-10	520	-499	276	226	-1,233	-1,158	4,036
1949	19	19	-3,073	-5,084	966	981	-1	-2	348	-330	-28	-57	-583	-620	5,250
1950	11	11	-4,462	-5,863	2,048	2,611	-28	-28	435	-304	-8	-14	-1,317	-1,314	6,147
1951	9	9	-6,191	-7,000	1,918	2,708	-5	-5	-157	-294	1,907	2,451	-4,118	-3,615	12,605
1952	-151	-151	-9,859	-9,501	2,174	2,924	-29	-30	-456	722	3,536	1,439	-7,506	-6,899	10,930
1953	15	15	-13,402	-12,656	2,738	4,102	-39	-39	-461	1,249	3,777	3,662	-12,853	-12,040	20,942
1954	11,625	11,625	5,507	5,115	5,194	7,284	3,773	3,773	12,592	13,905	4,941	6,958	31,617	15,397	15,771
1955	-9,862	-9,862	-9,031	-11,042	8,504	10,852	-5,676	-5,676	5,403	6,041	8,424	11,020	-19,433	-7,082	10,611
1956	2,524	2,524	-4,266	-7,059	8,666	11,399	582	582	9,079	9,676	8,632	11,410	3,377	-40	4,081
1957	29	29	-12,242	-14,706	3,238	6,473	31	31	1,158	1,942	2,962	4,997	-10,781	-8,546	2,111
1958	-2	-2	-43,445	-43,916	4,654	8,069	-97	-97	-2,468	-1,521	-1,204	265	-46,709	-42,098	13,687
1959	9	9	-26,926	-27,002	3,179	5,704	-80	-80	-1,958	-673	397	659	-26,236	-26,378	15,194
1960	8	8	-24,456	-24,143	2,706	4,088	-69	-69	-2,461	-945	0	0	-20,704	-20,633	13,154
1961	6	6	-21,105	-21,143	2,442	3,517	-53	-53	-2,070	-764	751	-199	-15,309	-15,593	14,241
1962	13	13	-17,941	-18,880	4,054	4,717	6	6	-1,649	-650	729	1,438	-12,228	-11,790	14,581
1963	0	0	-16,894	-17,159	3,412	4,560	3	2	-1,560	-710	2,288	2,252	-2,234	-2,900	13,871
1964	27,567	27,567	17,751	14,770	6,077	8,269	13,746	13,746	17,554	18,079	5,104	7,404	56,211	31,711	11,357
1965	15,717	15,717	-17,286	-18,840	6,746	9,894	7,992	7,992	12,743	13,912	8,597	11,685	-11,400	-3,419	10,165
1966	1,363	1,363	8,910	9,469	15,876	18,129	-10,253	-10,253	13,341	15,233	-339	-4,399	4,313	20,285	31,375
1967	19,143	19,143	9,302	8,155	6,770	10,587	8,799	8,799	18,379	19,594	6,113	8,067	31,717	13,276	11,347
1968	-4,775	-4,775	-23,805	-24,073	7,139	11,179	-3,439	-3,439	-971	257	6,810	8,125	-28,603	-16,501	12,942
1969	-157	-157	-20,725	-20,487	13,415	15,708	486	486	-1,051	164	13,235	10,193	-19,762	-17,262	15,648
1970	-1	-1	-16,668	-17,417	9,575	10,112	-28	-28	-1,752	165	-593	-5,967	-13,415	-13,364	21,250
1971	32,313	32,313	21,429	20,157	16,152	18,575	6,924	6,924	16,137	19,062	11,817	13,617	42,412	36,475	16,848
1972	1,094	1,094	-1,885	-3,889	9,080	10,763	356	356	5,963	7,762	8,186	8,686	3,980	1,421	7,543
1973	-172	-172	-21,489	-23,209	11,339	13,386	288	288	-336	1,024	11,379	9,438	-23,548	-18,271	3,136
1974	-151	-151	-17,864	-18,065	11,590	15,260	644	644	-2,155	-724	1,498	-1,180	-14,919	-13,304	20,957
1975	-8	-8	-9,672	-9,844	16,621	20,425	31	31	-979	512	16,219	14,377	-5,889	-5,561	7,235
1976	-36	-36	-6,383	-7,041	12,191	15,700	905	905	-939	12	1,208	-8,666	-4,459	-3,614	26,569
1977	24,846	24,846	-1,487	-2,965	6,516	9,435	14,316	14,316	279	715	5,518	4,335	20,260	8,926	9,539
1978	10,796	10,796	2,905	2,028	7,330	10,261	6,502	6,502	5,545	6,587	8,117	8,837	20,520	16,107	4,581

Run 15c - Early EPCWID Ops (TX Hueco Pumping Off)

Annual Differences in ILRG Model Outputs

Run 15c minus Run 15

1940 - 2017 (acre-feet)

	Net River Headgate Diversions						Farm Headgate Deliveries						Annual Flows		
	EBID		EPCWID (incl. EPW)		HCCRD		EBID		EPCWID (incl. EPW)		HCCRD				
Year	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Caballo Releases	Rio Grande at El Paso	Rio Grande at Fort Quitman
1979	-225	-225	-4,902	-6,473	7,852	9,524	211	213	-1,707	-1,296	8,107	9,864	-3,593	2,587	5,390
1980	-84	-84	-4,504	-5,980	6,214	6,882	141	141	-40	27	1,698	-586	-2,155	949	22,029
1981	-20	-20	2,879	258	5,715	5,889	301	301	359	-1,225	-970	-1,315	7,985	8,523	12,284
1982	-14	-14	4,133	1,228	4,896	5,062	101	101	1,110	-819	1,034	-1,658	11,778	12,237	9,134
1983	-13	-13	8,430	5,642	9,962	10,141	99	99	1,434	-250	0	0	15,259	15,224	16,839
1984	-10	-10	8,084	5,431	10,223	10,154	115	115	789	-1,038	-377	-377	10,878	11,558	10,919
1985	140	140	10,892	8,491	7,137	6,403	-432	-433	800	-1,241	0	0	-36,860	-33,233	-18,202
1986	19	19	20,992	19,581	7,954	6,310	54	53	1,564	-27	0	0	266	-1,881	85,213
1987	104	104	24,643	22,876	8,035	6,419	-760	-761	1,092	-1,300	0	0	100	366	69,510
1988	5	5	28,668	25,879	6,806	5,122	-75	-75	2,837	-840	0	0	23,412	20,920	3,869
1989	-19	-19	31,575	27,856	15,984	14,772	159	159	4,597	-356	0	0	37,628	36,060	15,800
1990	-1,112	-1,112	-22,358	-27,000	-8,546	-10,115	7,751	7,755	-18,963	-24,374	0	0	12,933	4,861	-3,943
1991	-1,036	-1,036	18,946	15,139	7,325	6,823	-914	-911	7,193	1,387	0	0	20,376	24,943	12,751
1992	-393	-393	14,488	12,089	4,739	4,595	-789	-787	1,920	-1,706	0	0	-63,014	-58,856	-57,500
1993	-5	-5	6,228	2,793	4,825	4,890	52	53	4,947	-299	0	0	-9,275	-8,198	-15,913
1994	4	4	-730	-2,893	2,796	2,608	29	29	3,800	560	0	0	-8,119	-6,987	-5,780
1995	3	3	-3,057	-6,489	842	757	23	24	3,398	-1,949	0	0	5,295	4,482	5,614
1996	-4	-4	2,439	-153	1,910	1,269	50	50	3,614	-185	0	0	8,869	8,957	-715
1997	-42	-42	-5,839	-10,695	8,726	7,111	235	235	1,601	-3,943	0	0	4,837	5,786	9,250
1998	2	2	1,129	-1,207	2,252	2,184	5	5	3,029	-383	0	0	-697	-769	7,658
1999	-174	-174	3,682	55	912	730	2,405	2,405	-70	-959	0	0	3,337	4,425	-1,306
2000	-14	-14	7,031	3,242	2,181	1,690	590	590	-2,104	-2,108	0	0	8,846	9,674	-6,019
2001	18	18	15,058	11,013	3,910	2,903	13	13	3,946	3,944	0	0	14,979	14,164	-5,271
2002	2	2	2,567	-128	162	-1,150	12	12	165	165	0	0	-47	402	-10,836
2003	-16,886	-16,886	19,514	17,183	4,659	3,086	-9,267	-9,267	-1,614	-1,620	0	0	3,752	11,623	-6,442
2004	-16,869	-16,869	-4,513	-8,111	112	-1,563	-11,175	-11,175	-8,908	-8,915	0	0	-5,573	-2,270	-4,625
2005	141	141	2,892	-895	340	-657	-183	-184	-1,212	-1,217	0	0	5,506	80	-6,477
2006	-4,541	-4,541	-8,028	-10,895	-2,956	-3,725	-3,664	-3,664	-8,369	-8,371	0	0	-12,890	-11,236	-10,060
2007	-8,209	-8,209	-7,504	-11,167	-884	-2,427	-5,211	-5,211	-5,440	-5,444	0	0	-16,710	-12,166	-7,143
2008	-9,400	-9,400	2,688	-670	1,416	-700	-5,963	-5,965	603	595	0	0	-807	-205	-6,241
2009	-6,202	-6,202	2,804	-1,203	342	-949	-3,722	-3,724	-516	-523	0	0	11	-575	-6,133
2010	1,148	1,148	2,649	-2,109	1,455	958	576	575	-381	-384	0	0	7,009	2,360	-2,529
2011	439	439	-2,648	-6,503	1,488	4,012	240	240	-2,497	-2,366	0	0	-4,495	-3,116	3,105
2012	-15,369	-15,369	6,582	2,882	2,559	3,170	-3,240	-3,240	-4,922	-5,370	0	0	869	10,788	4,505
2013	-12,556	-12,556	1,709	-1,428	3,161	4,182	-6,505	-6,505	-7,539	-7,624	1,940	3,194	774	9,536	-75
2014	-28,140	-28,140	14,088	10,334	11,279	13,354	-17,980	-17,980	3,746	3,770	7,328	8,996	-1,649	18,629	9,142
2015	-26,665	-26,665	-5,431	-8,737	2,943	3,741	-10,864	-10,864	-3,423	-4,635	-4,116	-2,894	-26,178	-1,079	14,344
2016	19,400	19,400	43	-3,561	682	830	12,256	12,256	-3,864	-4,535	0	0	23,702	3,075	-4,183
2017	-15,419	-15,419	2,868	-645	1,000	1,237	-8,985	-8,985	-234	-865	0	0	2,017	2,644	-2,423
Averages															
1951-2017	-153	-153	-1,180	-3,363	5,369	6,113	-279	-279	1,157	666	2,308	2,181	-707	-15	7,579
1951-1978	4,706	4,706	-9,901	-10,727	7,475	9,789	1,629	1,629	3,455	4,655	5,000	4,675	-3,061	-3,761	13,295
1979-2005	-1,351	-1,351	6,977	4,027	4,738	4,142	-417	-416	503	-1,851	352	220	2,471	3,171	5,305
2006-2017	-8,793	-8,793	818	-2,809	1,874	1,973	-4,422	-4,422	-2,736	-2,979	429	775	-2,362	1,554	-641
1985-2017	-4,292	-4,292	5,578	2,270	3,198	2,663	-1,978	-1,978	-643	-2,458	156	282	-54	1,612	1,786
1985-2005	-1,720	-1,720	8,297	5,173	3,955	3,056	-582	-581	554	-2,160	0	0	1,264	1,645	3,173

Notes:

EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).

EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

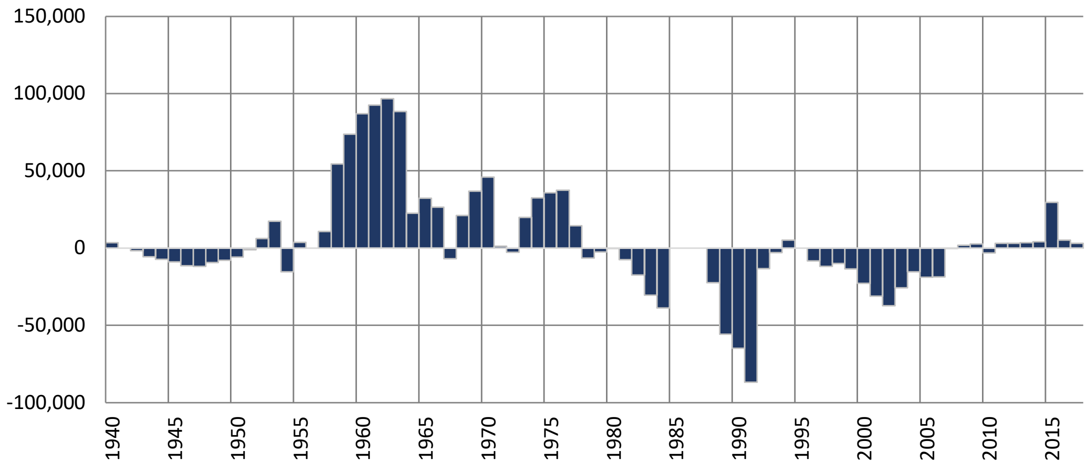
Run 15c - Early EPCWID Ops (TX Hueco Pumping Off)

Simulated Differences in ILRG Model Outputs

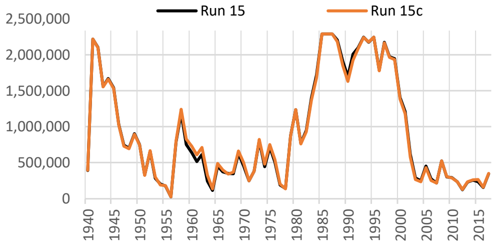
Run 15c minus Run 15

1940 - 2017 (acre-feet)

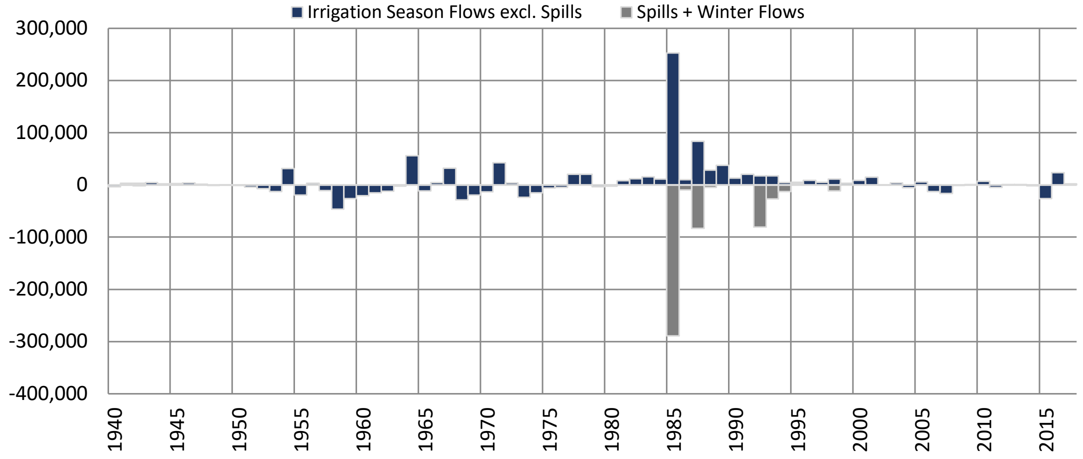
Total Project Storage (Year End)



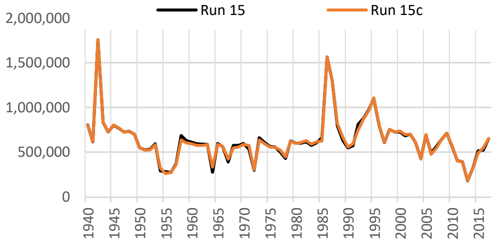
Period	Average Difference
1951-2017	133
1951-1978	-27
1979-2005	-460
2006-2017	1,839
1985-2017	1,271
1985-2005	946



Caballo Reservoir Outflows (Annual)



	Average Difference		
Period	Irr Season (excl. Spills)	Nov-Feb and Spills	Annual
1951-2017	6,992	-7,698	-707
1951-1978	-3,061	0	-3,061
1979-2005	21,574	-19,103	2,471
2006-2017	-2,362	0	-2,362
1985-2017	15,576	-15,630	-54
1985-2005	25,826	-24,561	1,264



Notes:

Reservoir storage does not include storage attributed to SJC, CO, or NM credit waters.

Average differences calculated as (Final Storage - Initial Storage)/(no. years).

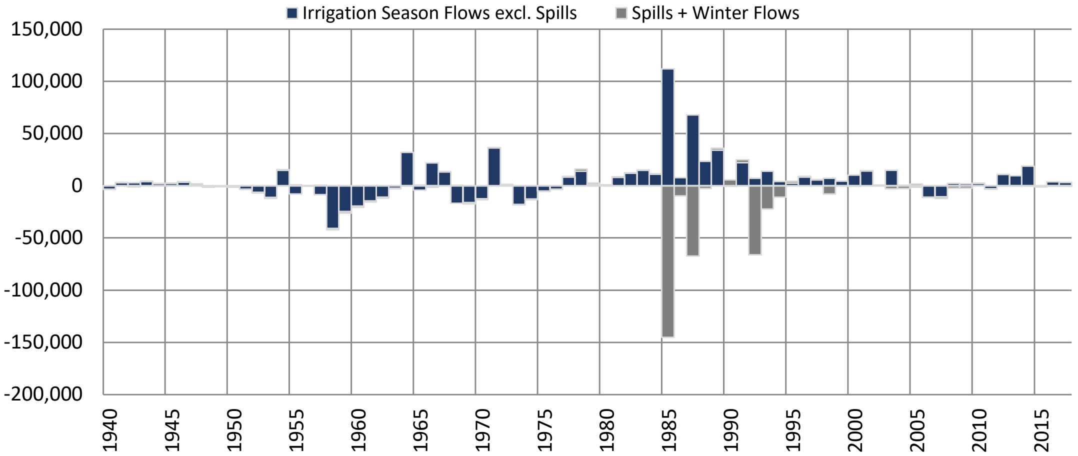
Run 15c - Early EPCWID Ops (TX Hueco Pumping Off)

Simulated Differences in ILRG Model Outputs

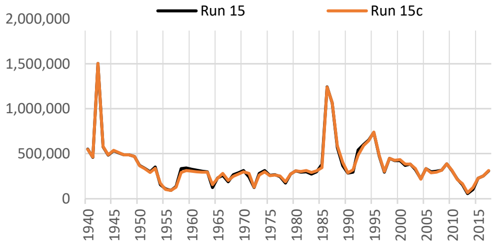
Run 15c minus Run 15

1940 - 2017 (acre-feet)

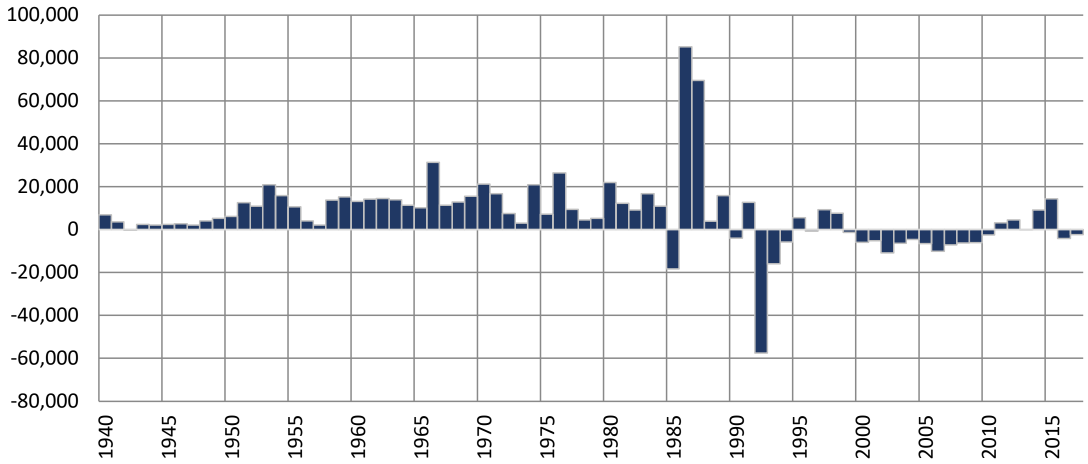
Rio Grande at El Paso (Annual)



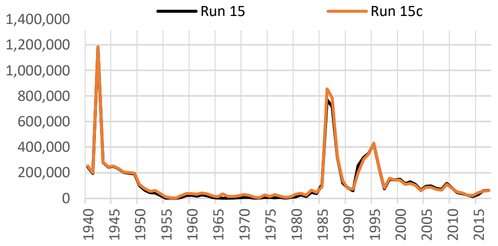
	Average Difference		
Period	Irr Season (excl. Spills)	Nov-Feb and Spills	Annual
1951-2017	5,031	-5,046	-15
1951-1978	-3,525	-236	-3,761
1979-2005	15,136	-11,965	3,171
2006-2017	2,257	-702	1,554
1985-2017	11,774	-10,162	1,612
1985-2005	17,213	-15,568	1,645



Rio Grande at Fort Quitman (Annual)



Period	Average Difference
1951-2017	7,529
1951-1978	13,231
1979-2005	5,252
2006-2017	-652
1985-2017	1,759
1985-2005	3,137



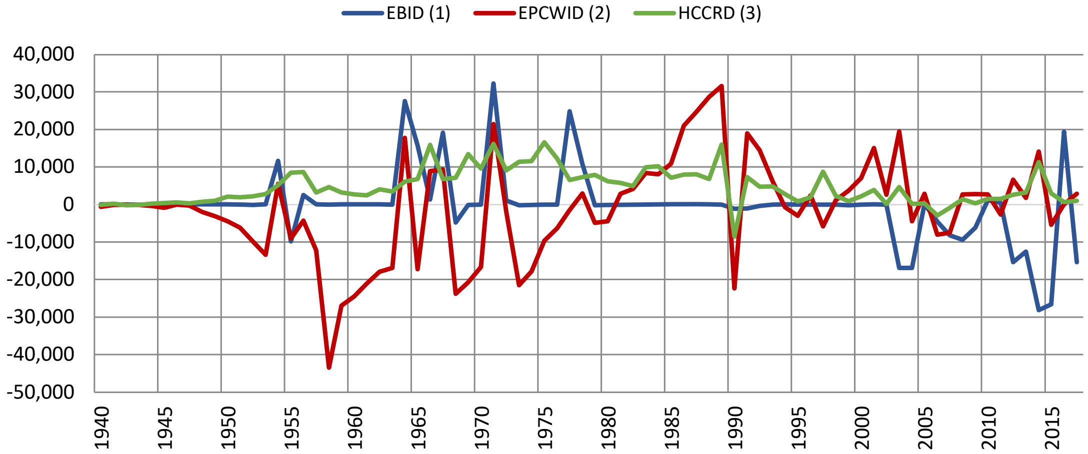
Run 15c - Early EPCWID Ops (TX Hueco Pumping Off)

Simulated Differences in ILRG Model Outputs

Run 15c minus Run 15

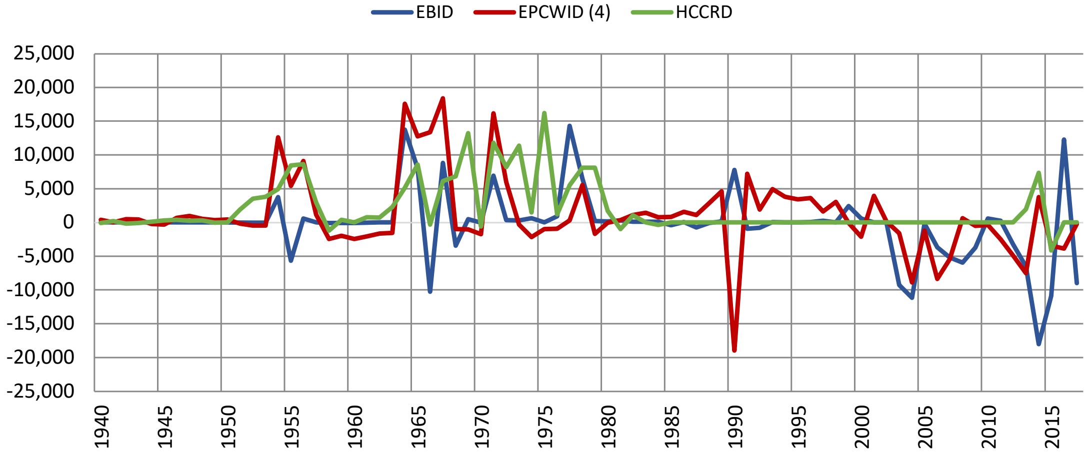
1940 - 2017 (acre-feet)

River Headgate (RHG) Diversions (Irrigation Season)



	Average Difference		
Period	EBID	EPCWID	HCCRD
1951-2017	-153	-1,180	5,369
1951-1978	4,706	-9,901	7,475
1979-2005	-1,351	6,977	4,738
2006-2017	-8,793	818	1,874
1985-2017	-4,292	5,578	3,198
1985-2005	-1,720	8,297	3,955

Farm Headgate (FHG) Deliveries (Irrigation Season)



	Average Difference		
Period	EBID	EPCWID	HCCRD
1951-2017	-279	1,157	2,308
1951-1978	1,629	3,455	5,000
1979-2005	-417	503	352
2006-2017	-4,422	-2,736	429
1985-2017	-1,978	-643	156
1985-2005	-582	554	0

Notes:

(1) EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).

(2) EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

(3) HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

(4) EPCWID FHG values include deliveries to Rogers WTP and R/U WTP.

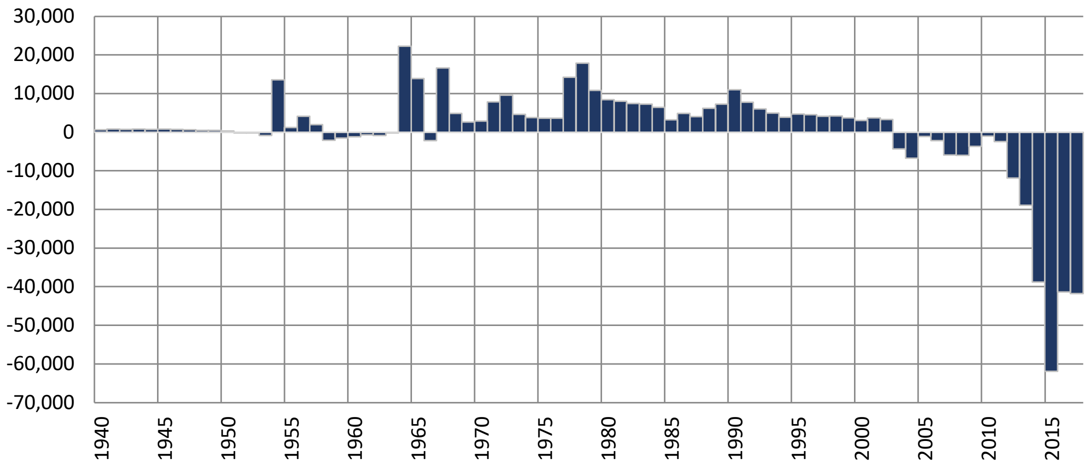
Run 15c - Early EPCWID Ops (TX Hueco Pumping Off)

Simulated Differences in ILRG Model Outputs

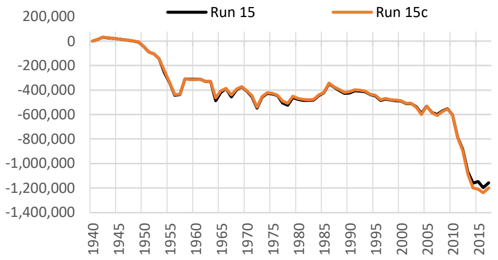
Run 15c minus Run 15

1940 - 2017 (acre-feet)

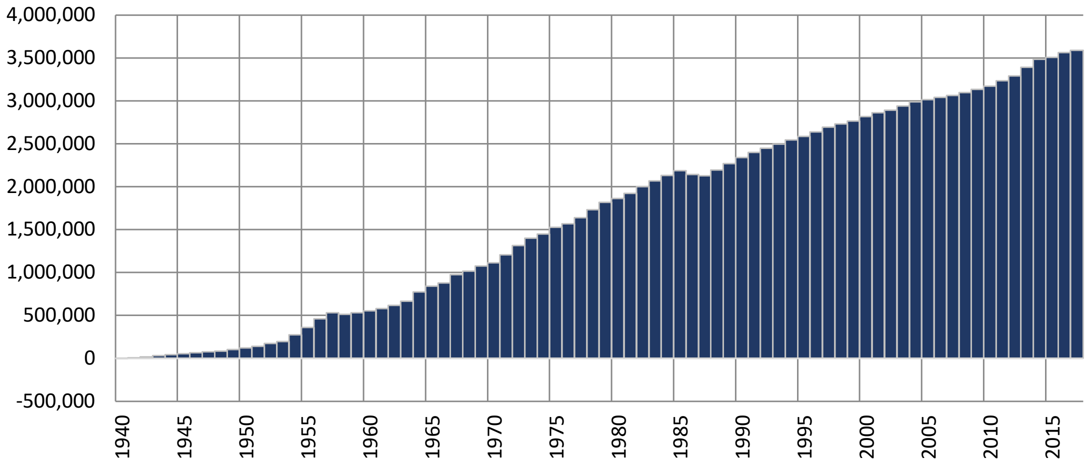
Cumulative Annual Rincon-Mesilla Groundwater Storage



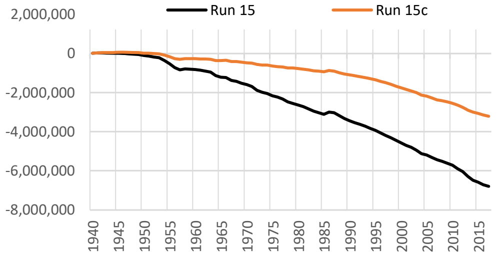
Period	Average Difference
1951-2017	-629
1951-1978	627
1979-2005	-703
2006-2017	-3,393
1985-2017	-1,464
1985-2005	-361



Cumulative Annual Hueco Groundwater Storage



Period	Average Difference
1951-2017	51,785
1951-1978	57,536
1979-2005	47,467
2006-2017	48,081
1985-2017	44,179
1985-2005	41,950

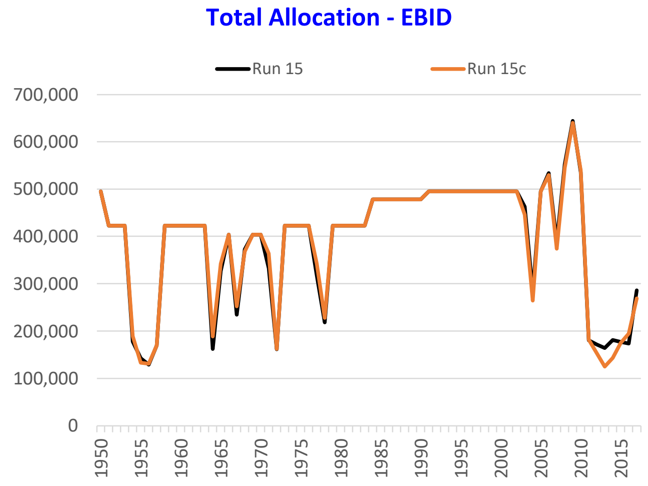


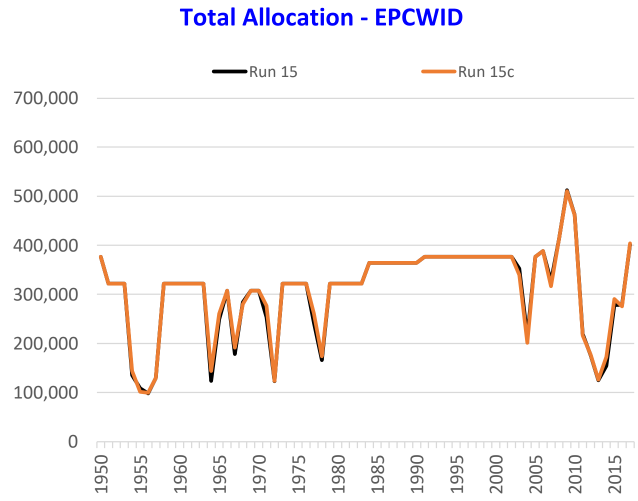
Notes:

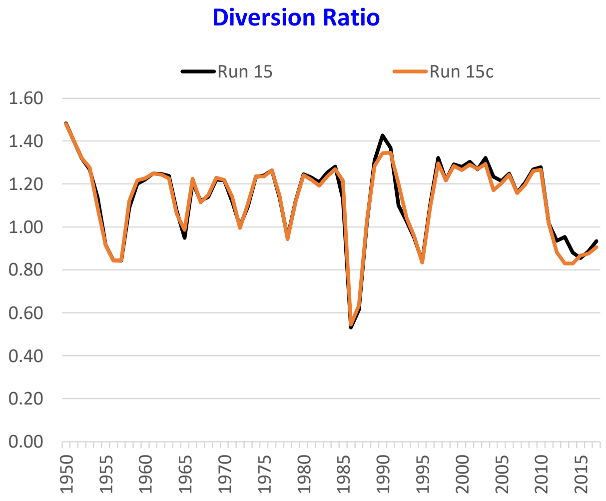
Cumulative storage change in alluvial and non-alluvial aquifers.

Average differences calculated as (Final Storage - Initial Storage)/(no. years).

Run 15c - Early EPCWID Ops (TX Hueco Pumping Off)
Annual Allocation and Charges
Run 15c v. Run 15
ILRG Model
1950 - 2017 (acre-feet)

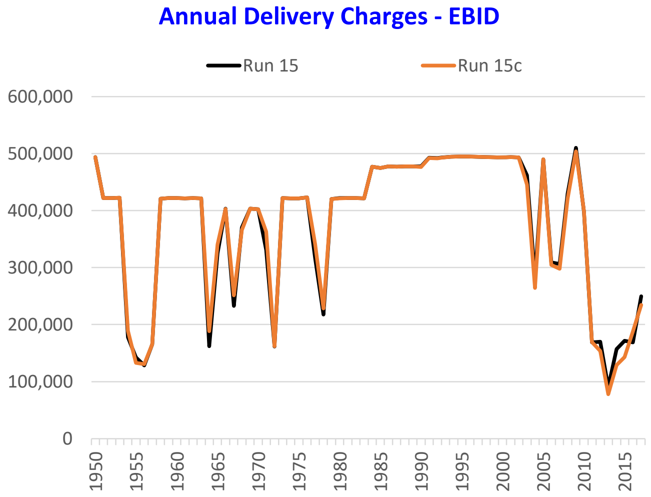

Total Allocation - EBID

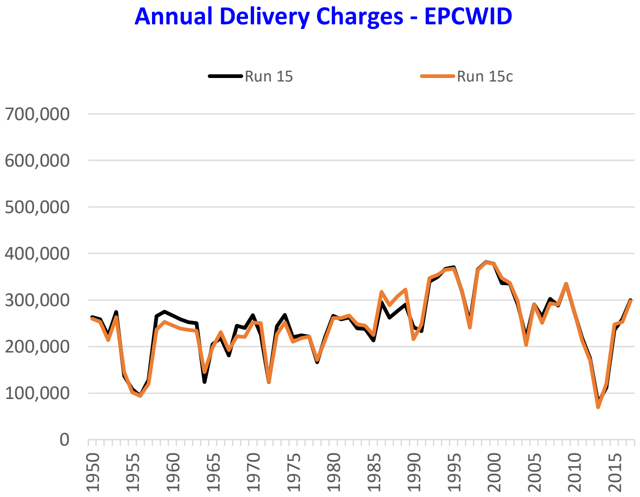

Total Allocation - EPCWID


Diversion Ratio

Note:

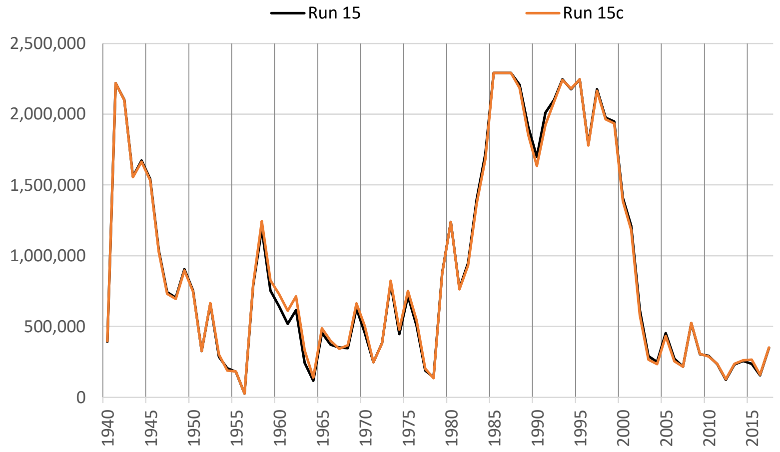
Computed as Total Charges/Caballo Release.


Annual Delivery Charges - EBID

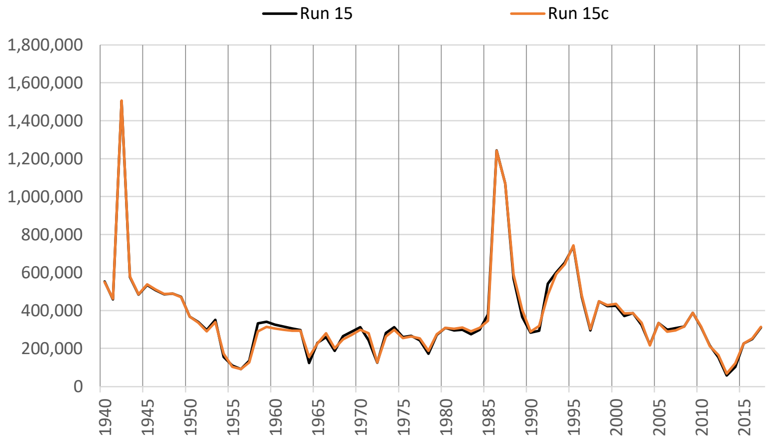

Annual Delivery Charges - EPCWID

Run 15c - Early EPCWID Ops (TX Hueco Pumping Off)
Annual Summary of Project Storage and Rio Grande Flows
Run 15c v. Run 15
ILRG Model
1940 - 2017 (acre-feet)

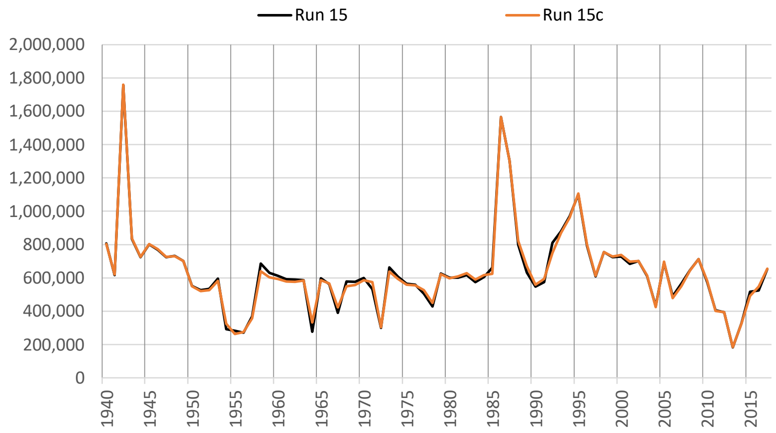
Total Year-End Project Reservoir Storage



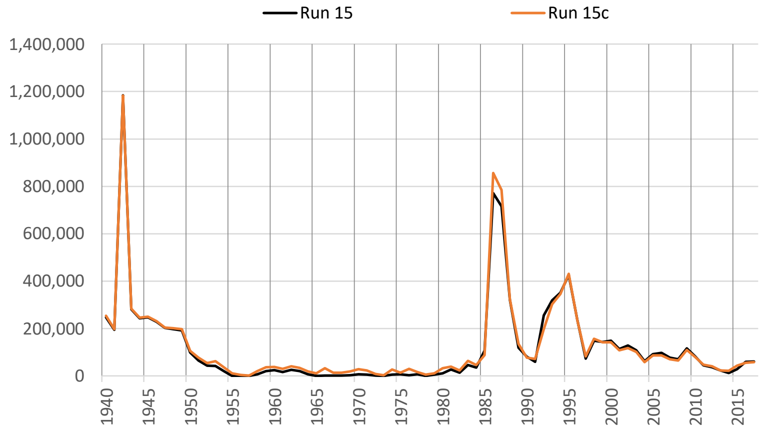
Rio Grande at El Paso



Rio Grande Below Caballo



Rio Grande at Fort Quitman

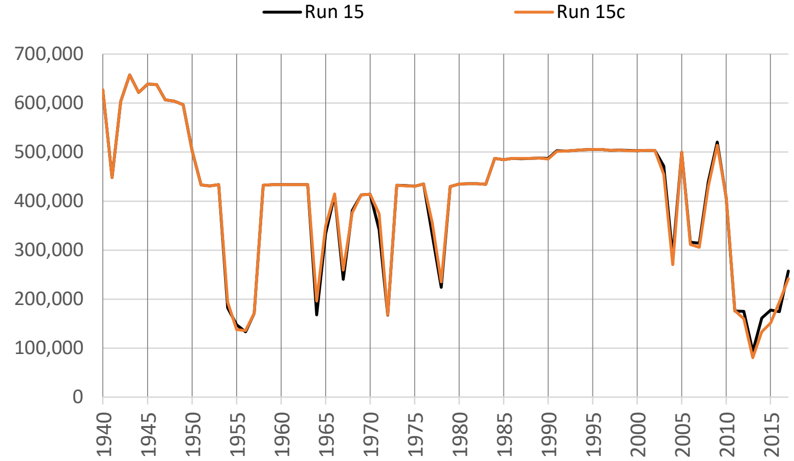


***Note different scales.**

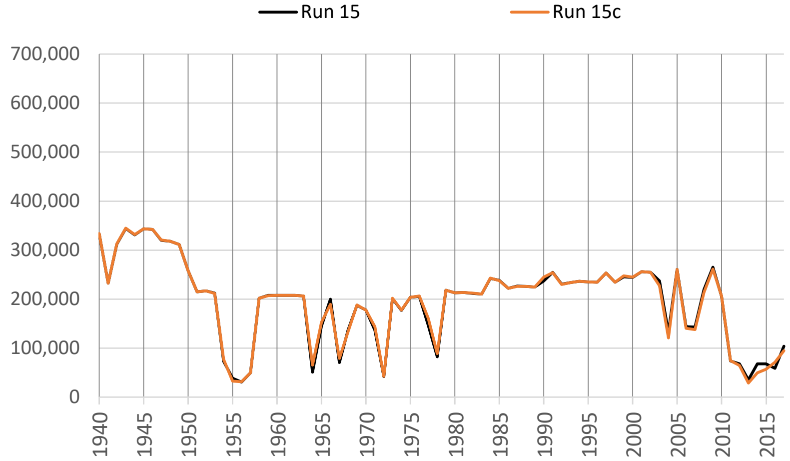
Run 15c - Early EPCWID Ops (TX Hueco Pumping Off)
Irrigation Season Summary of Irrigation Operations
Run 15c v. Run 15
ILRG Model
1940 - 2017 (acre-feet)

EBID Total

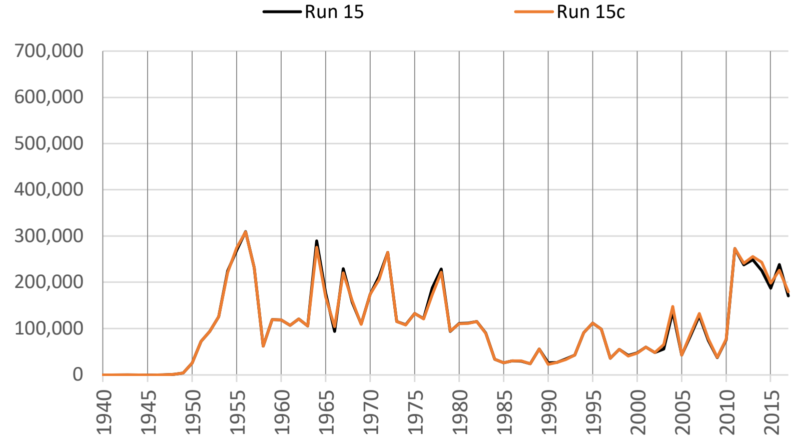
Net River Headgate Diversions



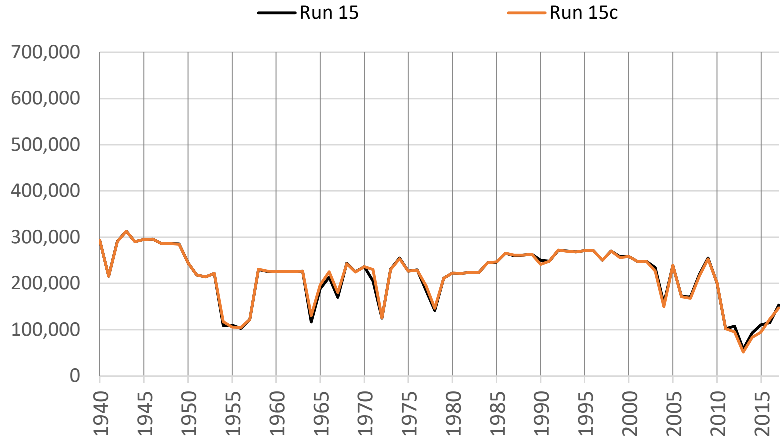
Farm Headgate Deliveries



Pumping



RHG Diversions - FHG Deliveries



Notes: EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).
Pumping includes Supplemental and Primary groundwater pumping.

Run 15c - Early EPCWID Ops (TX Hueco Pumping Off)

Irrigation Season Summary of Irrigation Operations

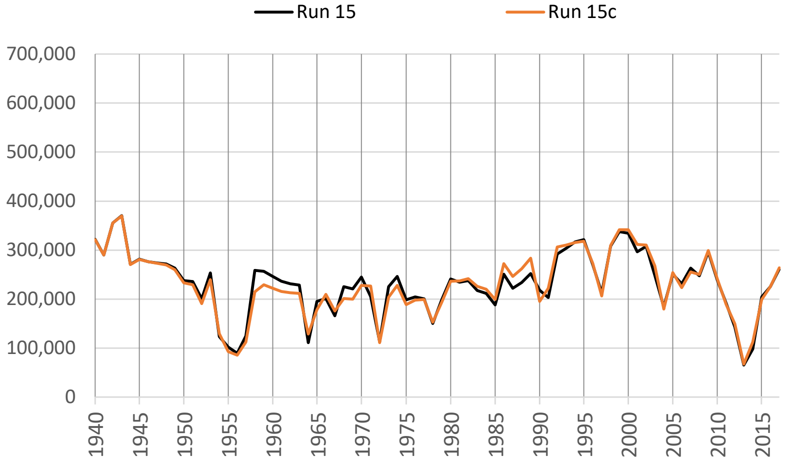
Run 15c v. Run 15

ILRG Model

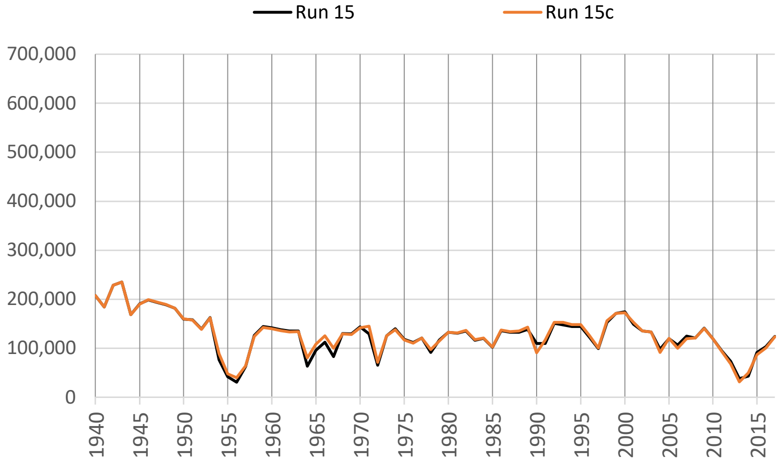
1940 - 2017 (acre-feet)

EPCWID Total

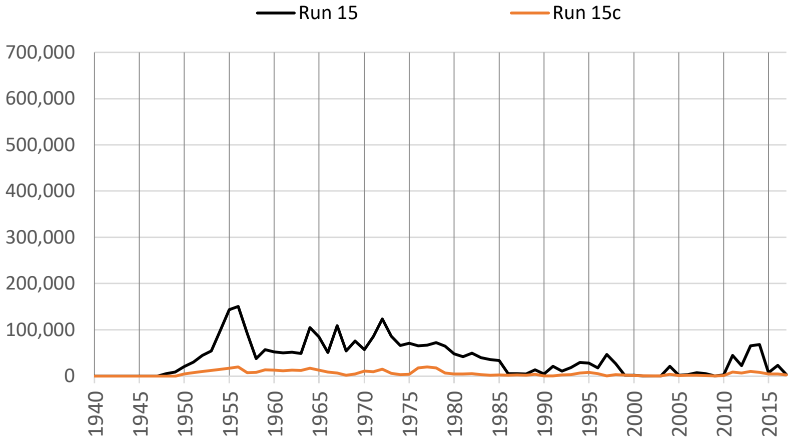
Net River Headgate Diversions



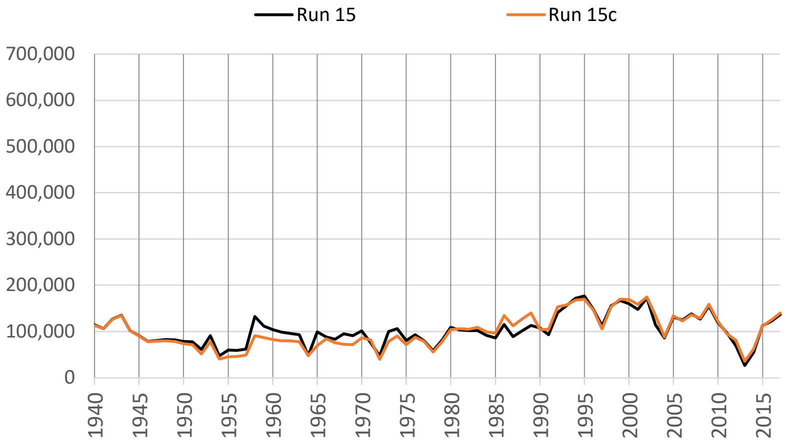
Farm Headgate Deliveries



Pumping



RHG Diversions - FHG Deliveries

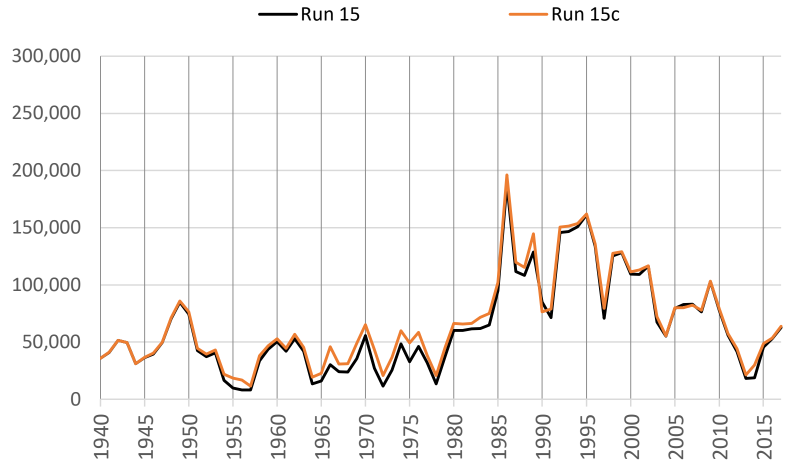


Note: EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

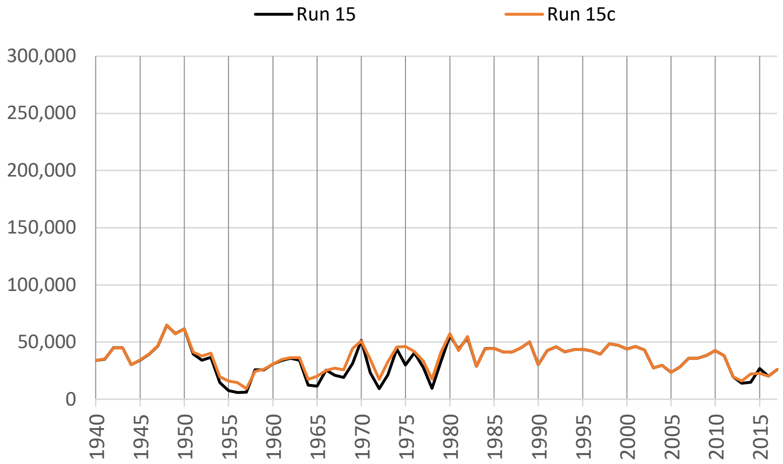
Run 15c - Early EPCWID Ops (TX Hueco Pumping Off)
Irrigation Season Summary of Irrigation Operations
Run 15c v. Run 15
ILRG Model
1940 - 2017 (acre-feet)

HCCRD Total

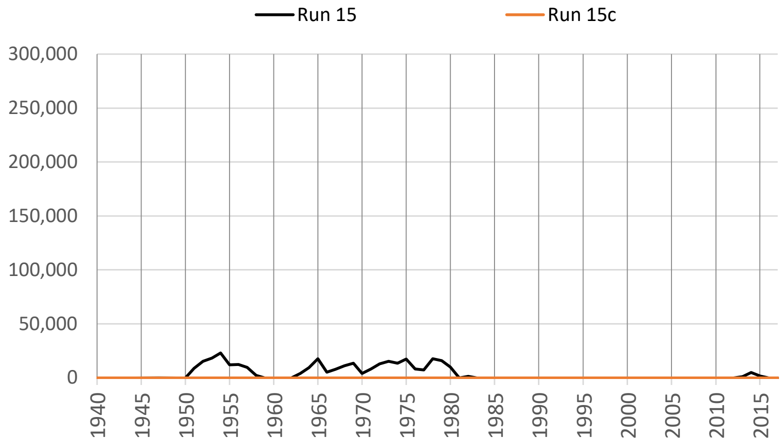
Net River Headgate Diversions



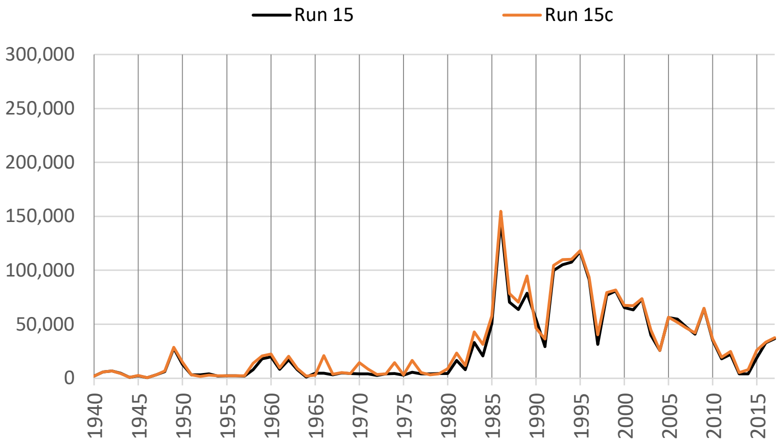
Farm Headgate Deliveries



Pumping



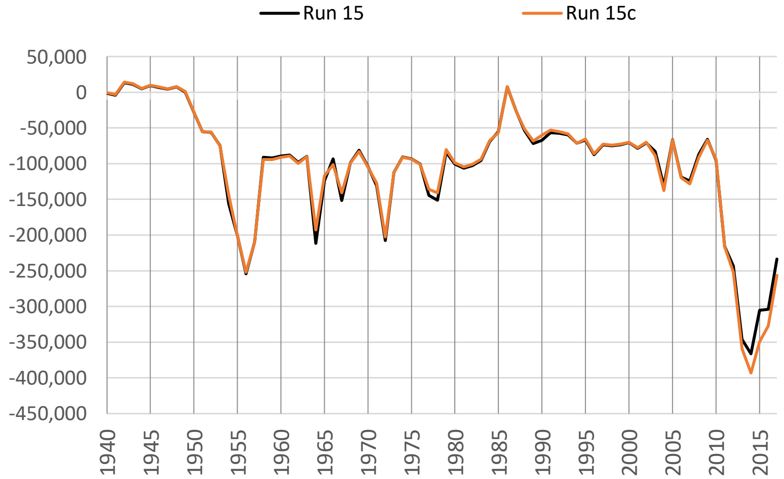
RHG Diversions - FHG Deliveries



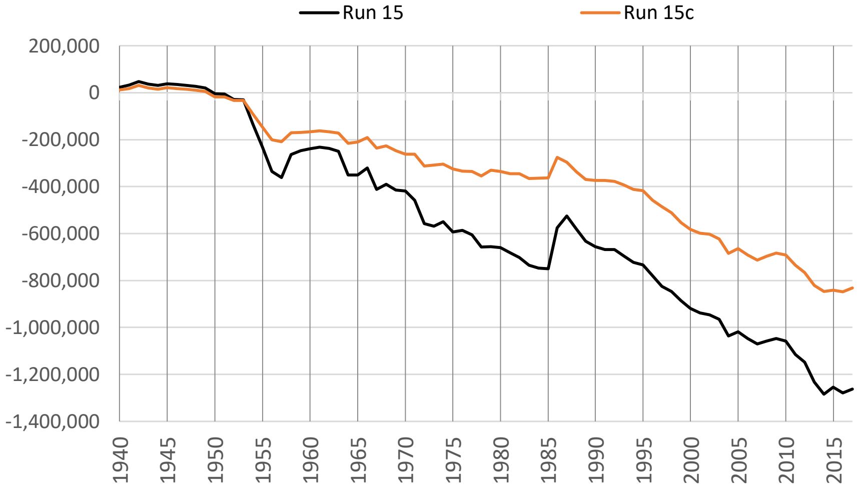
Note: HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

Run 15c - Early EPCWID Ops (TX Hueco Pumping Off)
Cumulative Change in Ground Water Storage
Run 15c v. Run 15
ILRG Model
1940 - 2017 (acre-feet)

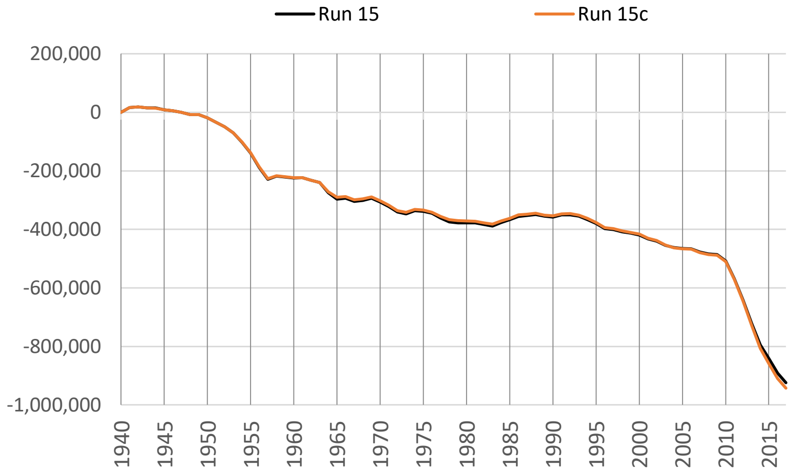
Rincon-Mesilla Alluvial Aquifer



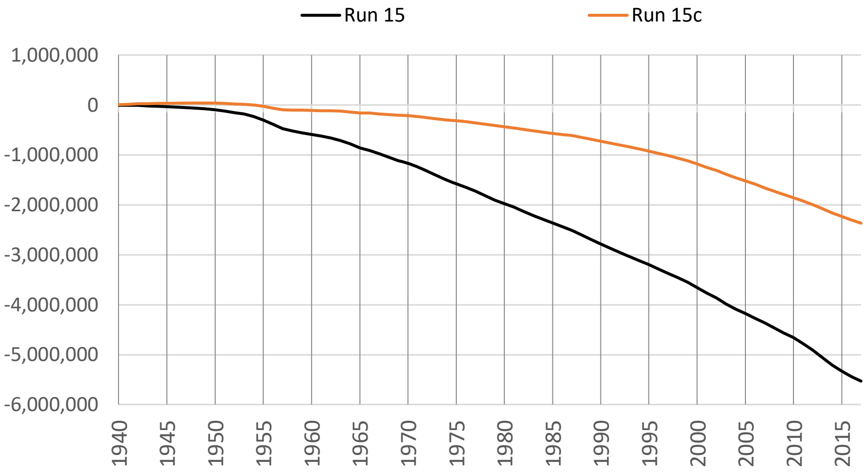
Hueco Alluvial Aquifer



Rincon-Mesilla Non-Alluvial Aquifer



Hueco Non-Alluvial Aquifer



***Note different scales.**

Run 15c - Early EPCWID Ops (TX Hueco Pumping Off)

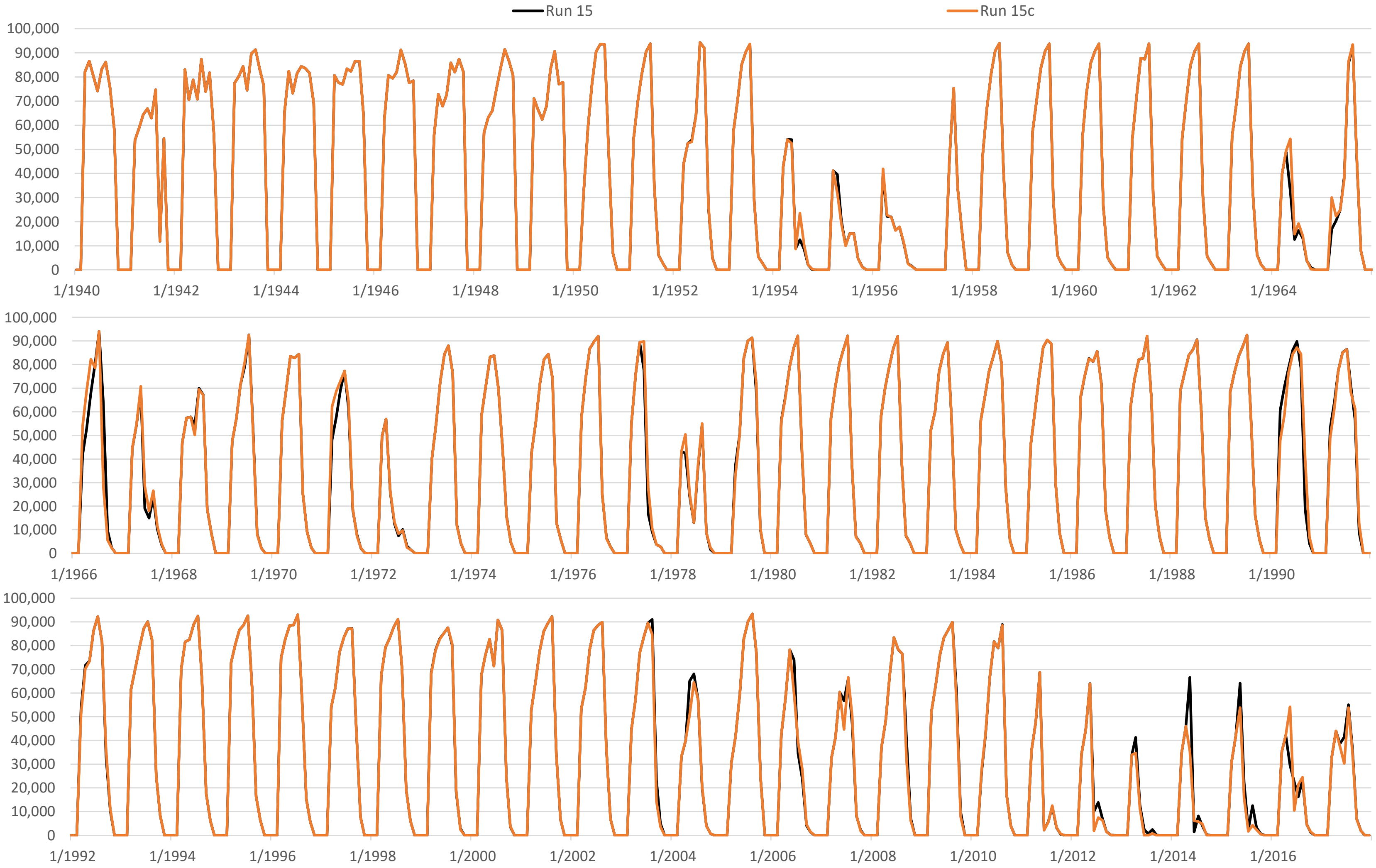
Monthly Net RHG Diversions

Run 15c v. Run 15

ILRG Model

1940 - 2017 (acre-feet)

EBID Total



Note: EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).

Run 15c - Early EPCWID Ops (TX Hueco Pumping Off)

Monthly Net RHG Diversions

Run 15c v. Run 15

ILRG Model

1940 - 2017 (acre-feet)

EPCWID Total

Note: EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

Run 15c - Early EPCWID Ops (TX Hueco Pumping Off)

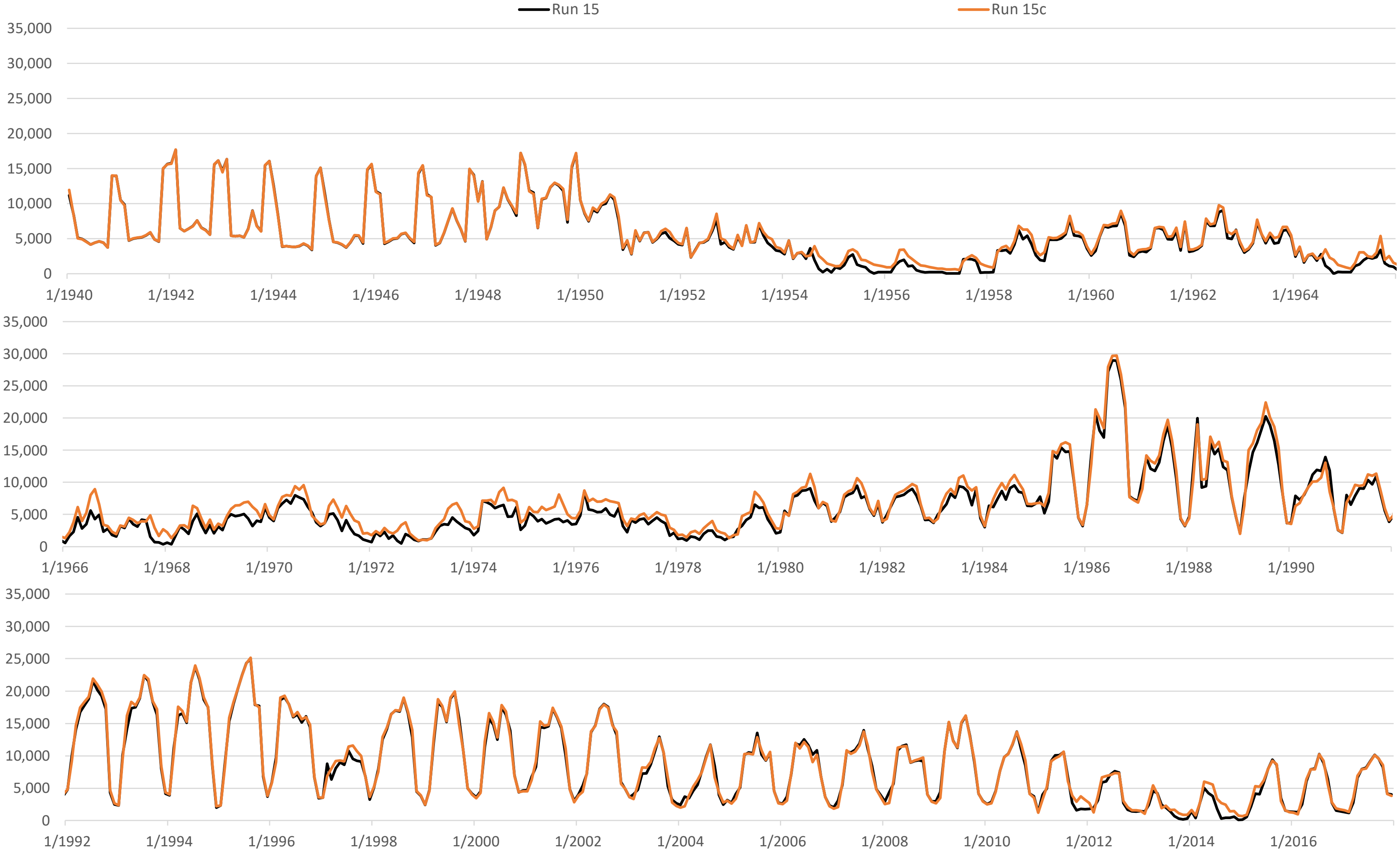
Monthly Net RHG Diversions

Run 15c v. Run 15

ILRG Model

1940 - 2017 (acre-feet)

HCCRD Total



Note: HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

Run 15c - Early EPCWID Ops (TX Hueco Pumping Off)

End of Month Reservoir Storage (Elephant Butte + Caballo)

Run 15c v. Run 15

ILRG Model

1940 - 2017 (acre-feet)

Run 15c - Early EPCWID Ops (TX Hueco Pumping Off)

Monthly Caballo Releases

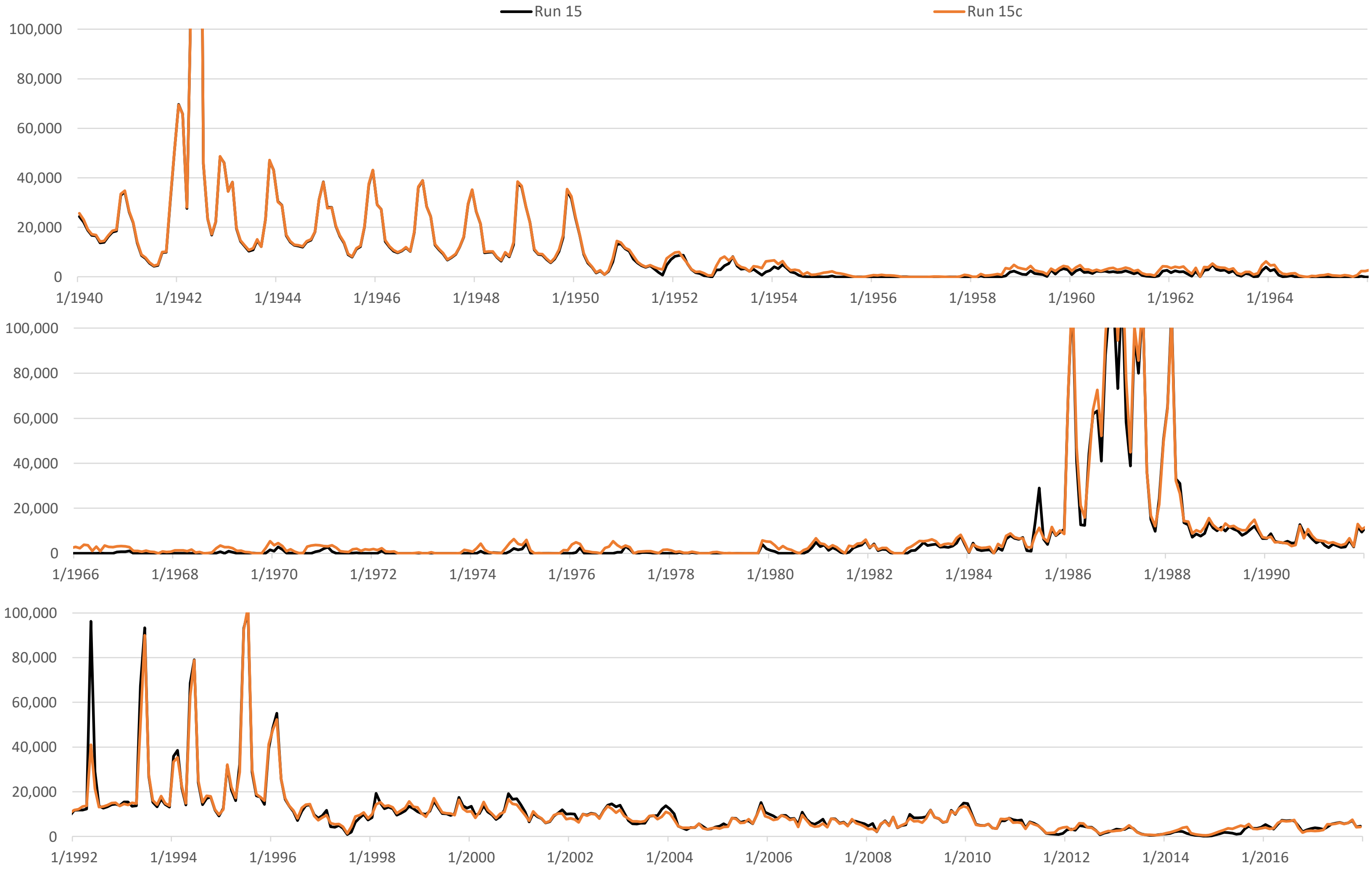
Run 15c v. Run 15

ILRG Model

1940 - 2017 (acre-feet)

Run 15c - Early EPCWID Ops (TX Hueco Pumping Off)
Monthly Rio Grande at El Paso Flow
Run 15c v. Run 15
ILRG Model
1940 - 2017 (acre-feet)

Run 15c - Early EPCWID Ops (TX Hueco Pumping Off)
Monthly Rio Grande at Fort Quitman Flow
Run 15c v. Run 15
ILRG Model
1940 - 2017 (acre-feet)



Appendix 30W

Comparison of ILRG Model Runs
Run 16 v. Run 1

Model Run Specifications

Model Version: LRG_v116

Name: **Run 16 - Conj Use 1: Hist All Acres D1/D2 (Hist M&I)**

Run ID: LRG_v116_Operational_Run16
Date: 8/27/2020

Name: **Run 1 - Historical Base Run (All Pumping On)**

Run ID: LRG_v116_Operational_Run1
Date: 8/23/2020

Selected Model Inputs

	Pumping and Returns	**Run 16**	**Run 1**
(1)	Irrigation Pumping	1978 Limit	On
	Irrigated Area	Hist	Hist
	Non-Irrigation Pumping	On	On
	Non-Irrigation Pumping Returns	On	On
	Las Cruces Jornada Pumping Returns	Off	On

	Project Allocation Rules		
	1950-2005	D1/D2	D1/D2
	2006-2007	D1/D2	D3
	2008-2017	D1/D2	D3 + CO

	EPCWID Operations		
	Charge EPCWID for Use of WWTP Returns	On	Off
	ACE and Haskell Credits for EPCWID	Off	On
(2)	Increased EPCWID Use of Fabens Drain Flows	On	Off
	Charge EPCWID for Fabens Drain Flow Use	On	Off

Notes:

(1) Ten-year average irrigation pumping limited to 1951-1978 average:
EBID = 166,866 AF, EPCWID=70,783 AF, HCCRD = 11,188 AF.

(2) Starting in July 1945, use 70% of simulated Fabens drain flow up to 6,000 AF/month.

Run 16 - Conj Use 1: Hist All Acres D1/D2 (Hist M&I)

Comparison of ILRG Model Runs

Run 16 v. Run 1

1951 - 2017 Annual Average

(1,000 acre-feet)

Run No.	1	16	16 - 1	
Simulated Input or Output	**Run 1**	**Run 16**	**Run 16 minus Run 1**	
Effects of Alternate Scenario				
FHG Deliveries (Mar - Oct)				***% Diff.***
EBID	167.6	182.8	15.1	*9%*
EPCWID (incl. EPW)	139.9	138.5	-1.4	*-1%*
HCCRD	32.8	32.3	-0.6	*-2%*
Total	340.3	353.5	13.2	*4%*
FHG Deliveries (Nov - Feb)				
EBID	0.0	0.0	0.0	*14%*
EPCWID (incl. EPW)	0.2	1.9	1.7	*899%*
HCCRD	2.4	2.8	0.4	*15%*
Total	2.6	4.6	2.0	*79%*
Irrigation Pumping				
EBID	140.4	125.3	-15.1	*-11%*
EPCWID (Mesilla Valley)	7.4	6.8	-0.5	*-7%*
EPCWID (El Paso Valley)	40.1	38.4	-1.7	*-4%*
HCCRD	4.2	4.5	0.3	*6%*
Total	192.1	175.0	-17.1	*-9%*
Other Inflows/Outflows				
Net Reservoir Evaporation	125.3	130.5	5.2	*4%*
Riparian ET	70.9	70.3	-0.6	*-1%*
River Evaporation + Incidental Canal Loss	30.3	30.9	0.5	*2%*
Total	226.6	231.7	5.1	*2%*
Rio Grande at Fort Quitman				
Reservoir Spills	33.3	39.2	6.0	*18%*
Nov-Feb Flows	21.4	18.7	-2.7	*-12%*
Mar - Oct Flows	41.1	31.5	-9.6	*-23%*
Underflow (GW Model)	0.2	0.2	0.0	*-5%*
Total	96.0	89.7	-6.3	*-7%*

Run 16 - Conj Use 1: Hist All Acres D1/D2 (Hist M&I)

Comparison of ILRG Model Runs

Run 16 v. Run 1
1951 - 2017 Annual Average
(1,000 acre-feet)

Run No.	**1**	**16**	**16 - 1**	
Simulated Input or Output	**Run 1**	**Run 16**	**Run 16 minus Run 1**	
Effects of Alternate Scenario (continued)				
Change in Storage				***% Diff.***
Reservoir Storage	-4.7	-7.2	-2.5	*54%*
Alluvial GW Storage (RW Model)	-23.6	-20.8	2.7	*-12%*
Non-alluvial GW Storage (GW Models)	-96.4	-95.1	1.2	*-1%*
Soil Moisture Storage	0.6	0.7	0.1	*23%*
Total	-124.0	-122.4	1.6	*-1%*
Summary of Effects				
FHG Deliveries (Mar-Oct)	340.3	353.5	13.2	*4%*
FHG Deliveries (Nov-Feb)	2.6	4.6	2.0	*79%*
Irrigation Pumping	192.1	175.0	-17.1	*-9%*
Riparian ET + Evaporation	226.6	231.7	5.1	*2%*
Fort Quitman Flow	96.0	89.7	-6.3	*-7%*
Change in Storage	-124.0	-122.4	1.6	*-1%*
Total	733.6	732.1	-1.5	*0%*
Other Effects of Alternate Scenario				
Rio Grande at El Paso				***% Diff.***
Reservoir Spills	49.4	59.8	10.4	*21%*
Nov-Feb Flows	22.8	23.9	1.1	*5%*
Mar - Oct Flows	263.8	243.2	-20.5	*-8%*
Total	336.0	326.9	-9.0	*-3%*
Rio Grande below Caballo				
Reservoir Spills	65.9	79.8	13.9	*21%*
Nov-Feb Flows	0.5	0.3	-0.2	*-38%*
Mar - Oct Flows	541.3	524.8	-16.5	*-3%*
Total	607.6	604.8	-2.8	*0%*
Surface Water Diversions (Mar - Oct)				
EBID	366.5	393.2	26.7	*7%*
EPCWID (incl. EPW)	236.8	217.9	-18.9	*-8%*
HCCRD	67.5	63.5	-4.1	*-6%*
Total	670.8	674.6	3.8	*1%*
Surface Water Diversions (Nov - Feb)				
EBID	0.0	0.0	0.0	*0%*
EPCWID (incl. EPW)	14.3	15.9	1.5	*11%*
HCCRD	14.2	14.2	0.0	*0%*
Total	28.5	30.1	1.5	*5%*

Run 16 - Conj Use 1: Hist All Acres D1/D2 (Hist M&I)

Annual Differences in ILRG Model Outputs

Run 16 minus Run 1

1940 - 2017 (acre-feet)

	Net River Headgate Diversions						Farm Headgate Deliveries						Annual Flows		
	EBID		EPCWID (incl. EPW)		HCCRD		EBID		EPCWID (incl. EPW)		HCCRD				
Year	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Caballo Releases	Rio Grande at El Paso	Rio Grande at Fort Quitman
1940	-53	-53	7	-1	2	-2	-2	-2	3	2	2	2	-47	-23	-58
1941	-163	-163	-6	-10	-3	-4	-4	-4	-1	0	-2	-4	39	69	13
1942	-32	-32	-1	-5	-1	-1	0	0	2	8	0	-1	29	10	-21
1943	-64	-64	-6	-9	2	2	-14	-14	-12	-13	2	-1	-24	-12	-49
1944	-81	-81	-145	-138	-112	-94	-5	-5	15	-3	-101	-102	-165	-157	-64
1945	2	2	-17,006	-5,526	1,400	926	-53	-53	-307	6,375	1,084	991	-10,929	-10,411	-16,323
1946	36	36	-10,388	-11,149	-392	-7,349	-110	-111	-718	3,359	-75	-239	-18,238	-17,652	-18,290
1947	56	56	-12,881	-6,763	699	-5,757	-15	-15	3,974	11,138	923	1,019	-10,314	-10,389	-19,231
1948	10	10	-10,680	-6,705	136	-4,668	-15	-16	-1,977	4,581	410	237	-8,507	-8,534	-10,864
1949	46	46	-20,056	-15,361	1,551	3,232	-52	-53	622	6,491	-292	-545	-18,658	-18,083	-19,524
1950	29	29	-22,082	-18,141	-9,743	-11,073	-11	-11	-2,678	2,554	239	421	-20,461	-20,090	-17,874
1951	1,031	1,031	-11,245	-5,715	-641	-2,838	547	546	-3,507	1,706	-204	-2,191	-8,348	-8,206	-12,045
1952	990	990	-10,233	-6,920	-853	-2,130	3,849	3,844	-3,031	-54	-2,245	544	-24,634	-18,190	-11,165
1953	374	374	-15,022	-11,706	-841	-1,985	2,382	2,381	-2,558	345	-1,245	629	-5,822	-11,205	-15,927
1954	19,739	19,739	5,460	6,461	-605	375	15,852	15,852	16,864	17,821	-76	883	15,482	12,026	-11,818
1955	32,943	32,943	21,327	21,393	1,984	3,109	17,392	17,392	21,131	21,074	1,922	2,971	52,041	26,214	387
1956	524	524	1,023	1,029	612	584	-2,350	-2,350	423	313	434	289	-1,809	815	-25
1957	10	10	-584	-750	511	465	70	70	546	503	679	589	-1,763	-567	-3
1958	-2	-2	-3,307	-3,505	725	1,767	284	284	-180	-162	74	57	-13,442	-3,255	1,339
1959	5	5	-10,171	-9,847	543	1,441	97	97	-543	-340	6	23	-14,382	-10,296	1,124
1960	8	8	-10,550	-10,104	-548	-806	50	50	-1,426	-893	0	0	-13,089	-11,463	-1,315
1961	15	15	232	1,210	666	825	55	55	1,142	2,161	648	-429	712	-74	1,657
1962	10	10	-13,593	-12,220	-2,152	-2,311	-12	-12	-1,497	-320	19	-302	-17,701	-15,415	-1,860
1963	8,891	8,891	-5,579	-3,708	-1,277	-1,593	4,851	4,851	-911	784	-512	-513	1,785	-2,062	-1,636
1964	23,204	23,204	8,235	9,175	124	794	11,907	11,907	18,886	19,528	1,039	970	23,728	12,129	-4,022
1965	7,408	7,408	257	251	1,741	1,728	3,891	3,891	3,488	3,464	591	573	-2,291	1,783	194
1966	-32	-32	-10,709	-10,021	-3,155	-3,397	247	247	-217	146	-3,085	-1,129	-14,406	-9,008	-1,155
1967	15,342	15,342	3,533	4,310	1,295	1,713	8,684	8,684	3,854	3,623	600	1,698	10,602	5,938	-647
1968	7,800	7,800	4,821	5,652	1,735	1,219	6,280	6,280	1,307	1,018	1,675	1,346	7,887	7,718	160
1969	-15	-15	-15,897	-15,394	-9,717	-9,437	246	246	72	403	-9,337	-7,757	-21,227	-16,233	-1,605
1970	3	3	-21,539	-20,839	-7,857	-7,439	40	40	-1,263	-577	-328	4,345	-25,952	-23,131	-10,302
1971	28,900	28,900	-7,514	-6,083	-1,590	-3,324	17,588	17,588	-682	203	-300	-1,644	8,431	-4,271	-1,438
1972	-1,887	-1,887	-8,572	-7,843	-1,433	-1,577	-3,840	-3,840	-6,353	-6,329	-1,650	-1,781	-12,198	-6,476	-1,223
1973	-89	-89	2,889	2,892	672	834	723	723	607	423	585	833	536	2,773	6
1974	-6	-6	-9,065	-8,753	-4,117	-4,195	249	249	399	672	-3,588	-2,517	-9,594	-9,130	-1,923
1975	-235	-235	-17,876	-17,250	-12,940	-12,503	1,176	1,176	-324	218	-12,707	-12,582	-22,064	-17,962	384
1976	7	7	-18,345	-17,517	-17,237	-17,463	722	722	-858	-140	-2,753	3,540	-21,570	-20,128	-19,603
1977	51,126	51,126	23,621	25,241	9,141	9,553	21,680	21,680	14,205	16,535	8,478	9,419	44,573	32,386	1,612
1978	15,194	15,194	-1,311	450	-3,123	-3,421	7,923	7,923	9,338	10,801	-2,853	-3,213	9,144	4,123	-1,212

Run 16 - Conj Use 1: Hist All Acres D1/D2 (Hist M&I)

Annual Differences in ILRG Model Outputs

Run 16 minus Run 1

1940 - 2017 (acre-feet)

	Net River Headgate Diversions						Farm Headgate Deliveries						Annual Flows		
	EBID		EPCWID (incl. EPW)		HCCRD		EBID		EPCWID (incl. EPW)		HCCRD				
Year	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Caballo Releases	Rio Grande at El Paso	Rio Grande at Fort Quitman
1979	55	55	-23,558	-20,095	-418	1,613	3,306	3,314	3,206	6,623	-548	1,441	-42,606	-11,941	5,272
1980	-75	-75	-31,743	-27,690	-5,346	-3,243	785	787	-1,279	2,177	-2,194	-2,062	-44,948	-31,160	-1,870
1981	-64	-64	-28,886	-26,043	-6,441	-7,207	867	867	-1,537	1,795	954	1,274	-34,879	-31,260	-8,339
1982	-11	-11	-29,287	-26,416	-4,337	-4,944	49	49	-1,897	1,722	-1,227	834	-34,147	-31,994	-6,927
1983	-15	-15	-28,951	-26,564	-11,438	-11,796	-21	-21	-2,538	515	0	0	-33,670	-32,176	-12,638
1984	-47	-47	-26,668	-24,607	-16,942	-17,587	31	31	-1,520	1,787	372	372	-23,624	-23,651	-18,212
1985	-248	-248	-28,222	-25,903	-12,287	-11,976	643	644	-1,860	1,072	0	0	70,857	64,458	41,662
1986	-89	-89	-41,044	-39,694	-7,558	-6,281	347	359	-1,832	-70	0	0	87,161	90,831	71,157
1987	-200	-200	-52,191	-49,430	-7,533	-6,773	1,313	1,317	-880	3,239	0	0	-233	-419	-42,294
1988	-16	-16	-50,098	-46,746	-7,257	-6,837	145	145	-4,805	-96	0	0	-50,221	-43,677	-36,523
1989	8	8	-43,409	-38,834	-12,628	-13,096	-176	-177	-5,883	362	0	0	-51,942	-49,965	-36,397
1990	1,051	1,051	14,131	17,993	-2,542	-2,825	-7,632	-7,635	18,211	24,082	0	0	-20,261	-11,653	-19,810
1991	887	887	-39,600	-35,505	-15,447	-15,784	961	958	-7,969	-1,568	0	0	-38,644	-41,903	-31,328
1992	3,401	3,401	36,106	38,951	28,853	29,509	-10,153	-10,167	30,532	35,119	0	0	105,968	109,428	81,676
1993	590	590	-51,481	-47,337	-8,622	-8,836	734	728	-8,833	-2,283	0	0	-9,067	-13,734	-2,865
1994	419	419	-36,186	-32,963	-3,094	-3,116	-176	-173	24	5,074	0	0	17,344	12,591	8,534
1995	917	917	-31,915	-28,019	-718	-947	8	9	1,843	8,160	0	0	11,046	8,868	1,579
1996	-66	-66	-45,781	-43,139	-5,766	-5,089	116	116	-5,781	-1,648	0	0	-58,665	-54,744	-40,926
1997	-26	-26	-32,316	-30,010	-10,312	-11,862	-235	-235	-7,286	-2,208	0	0	-30,534	-32,530	-25,051
1998	-18	-18	-31,189	-29,066	-582	-1,530	35	36	-2,064	1,397	0	0	-20,217	-21,158	-25,867
1999	-297	-297	-46,304	-45,381	-745	-1,374	-304	-304	-8,094	-6,652	0	0	-38,374	-38,603	-29,307
2000	-404	-404	-22,658	-22,758	4,185	3,931	-8,909	-8,909	-5,753	-5,768	0	0	-23,605	-15,846	-11,423
2001	285	285	-21,517	-21,830	-4,653	-4,370	-357	-357	5,189	5,179	0	0	-17,801	-25,166	-26,091
2002	-12	-12	-28,193	-28,292	-2,053	-1,249	-264	-264	-34	-36	0	0	-27,123	-29,531	-30,875
2003	102,398	102,398	15,467	15,573	10,450	11,471	54,538	54,538	17,954	17,973	0	0	75,821	41,098	6,834
2004	35,426	35,426	-25,446	-24,822	-1,350	424	24,473	24,473	-376	-360	0	0	-20,534	-15,032	-11,734
2005	3,026	3,026	-13,535	-13,333	-6,456	-5,695	5,434	5,421	6,188	6,189	0	0	-28,293	-14,530	-16,193
2006	63,122	63,122	-16,791	-16,657	992	2,386	41,741	41,741	-42	-30	0	0	19,682	-5,562	-7,784
2007	143,680	143,680	-25,351	-24,535	-8,598	-7,960	92,049	92,049	-1,878	-1,844	0	0	26,375	-11,345	-10,929
2008	178,820	178,820	-23,308	-22,378	-14,419	-13,386	112,948	112,972	-2,500	-2,424	0	0	58,279	995	-793
2009	136,024	136,024	-47,532	-45,965	-6,047	-4,941	87,280	87,293	-15,343	-15,273	0	0	-12,821	-8,211	3,668
2010	199,257	199,257	-33,667	-31,792	-12,799	-12,103	128,677	128,687	-9,609	-9,528	0	0	35,239	-1,676	8,971
2011	74,340	74,340	-99,204	-97,549	-39,000	-41,459	30,984	30,985	-59,217	-59,172	-13,971	-13,820	-107,333	-95,638	-13,363
2012	84,194	84,194	10,187	10,367	-6,717	-10,354	38,377	38,377	12,731	12,747	3,844	4,290	60,312	10,557	-16,246
2013	-47,106	-47,106	-48,733	-48,650	-9,924	-9,369	-23,114	-23,114	-34,322	-34,316	-5,871	-6,149	-118,077	-52,297	-9,606
2014	86,986	86,986	16,328	16,320	2,570	2,347	38,069	38,069	13,131	13,135	1,721	1,789	114,567	16,783	-6,580
2015	117,686	117,686	-40,078	-39,860	-4,207	-5,421	55,308	55,308	-22,178	-22,167	1,156	991	17,162	-48,732	-15,377
2016	102,147	102,147	-72,554	-72,163	-12,452	-14,454	50,495	50,495	-44,358	-44,341	0	0	-54,665	-79,836	-37,474
2017	293,517	293,517	-21,107	-19,441	-2,935	-3,480	175,420	175,443	-10,640	-10,575	776	799	112,753	-5,300	-6,392
Averages															
1951-2017	26,728	26,728	-18,896	-17,379	-4,073	-4,085	15,140	15,141	-1,379	312	-584	-233	-2,763	-9,027	-6,297
1951-1978	7,545	7,545	-4,276	-3,218	-1,726	-1,786	4,306	4,306	2,461	3,319	-862	-191	-1,978	-2,899	-3,288
1979-2005	5,440	5,440	-27,573	-25,258	-4,113	-3,906	2,428	2,428	479	3,769	-98	69	-10,415	-9,015	-8,072
2006-2017	119,389	119,389	-33,484	-32,692	-9,461	-9,850	69,020	69,025	-14,519	-14,482	-1,029	-1,008	12,623	-23,355	-9,325
1985-2017	47,870	47,870	-29,612	-27,965	-5,444	-5,470	26,933	26,934	-4,719	-2,625	-374	-367	2,550	-10,954	-8,701
1985-2005	7,001	7,001	-27,399	-25,264	-3,148	-2,967	2,883	2,882	881	4,150	0	0	-3,206	-3,868	-8,345

Notes:

EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).

EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

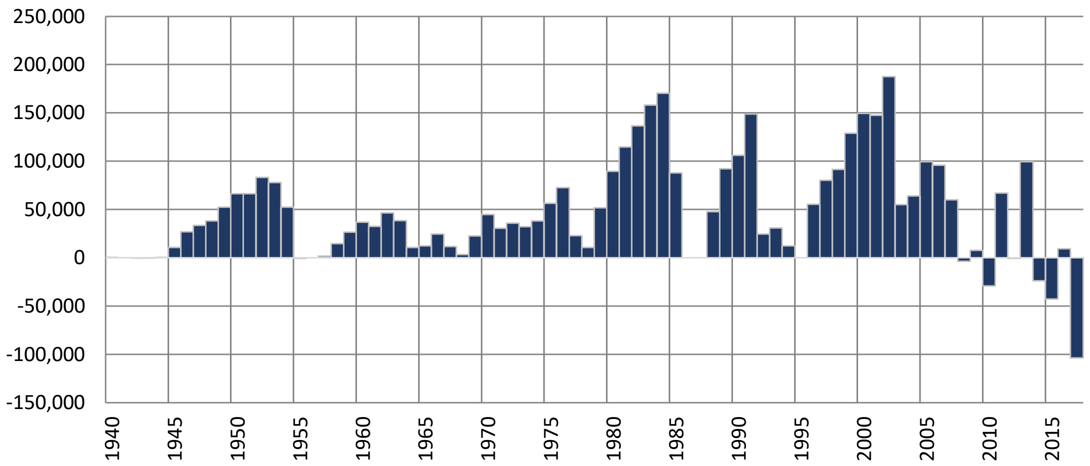
Run 16 - Conj Use 1: Hist All Acres D1/D2 (Hist M&I)

Simulated Differences in ILRG Model Outputs

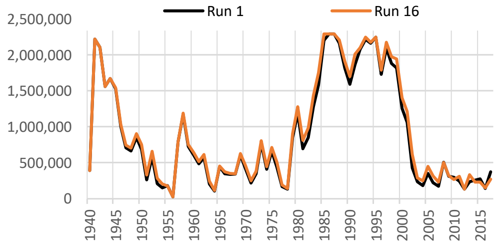
Run 16 minus Run 1

1940 - 2017 (acre-feet)

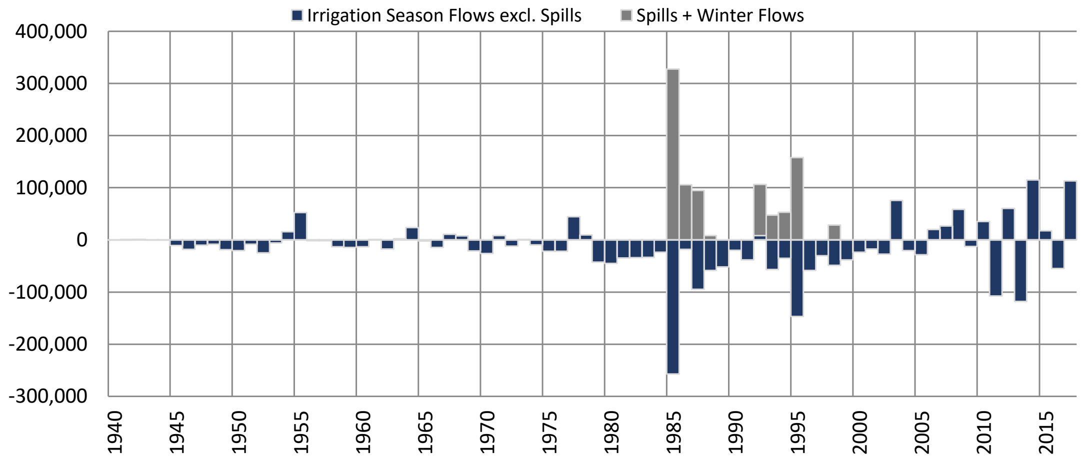
Total Project Storage (Year End)



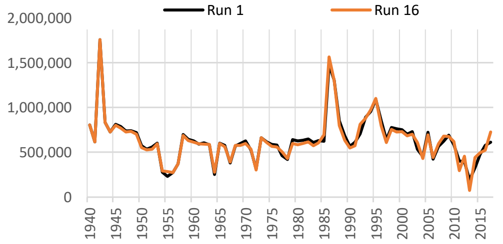
Period	Average Difference
1951-2017	-2,534
1951-1978	-1,979
1979-2005	3,291
2006-2017	-16,936
1985-2017	-8,303
1985-2005	-3,370



Caballo Reservoir Outflows (Annual)



	Average Difference		
Period	Irr Season (excl. Spills)	Nov-Feb and Spills	Annual
1951-2017	-16,502	13,740	-2,763
1951-1978	-1,978	0	-1,978
1979-2005	-44,510	34,095	-10,415
2006-2017	12,623	0	12,623
1985-2017	-25,346	27,896	2,550
1985-2005	-47,042	43,836	-3,206



Notes:

Reservoir storage does not include storage attributed to SJC, CO, or NM credit waters.

Average differences calculated as (Final Storage - Initial Storage)/(no. years).

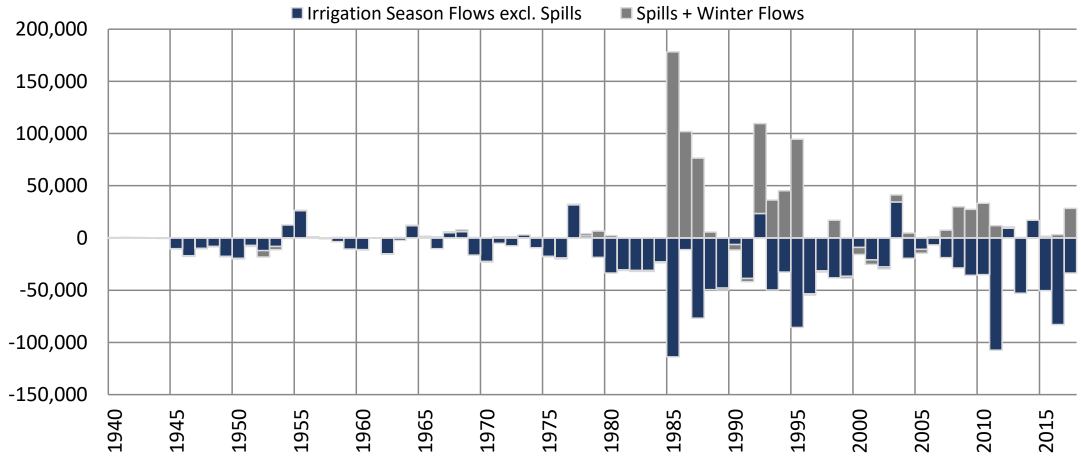
Run 16 - Conj Use 1: Hist All Acres D1/D2 (Hist M&I)

Simulated Differences in ILRG Model Outputs

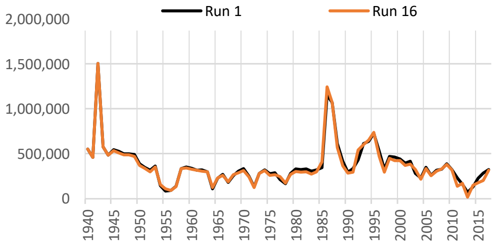
Run 16 minus Run 1

1940 - 2017 (acre-feet)

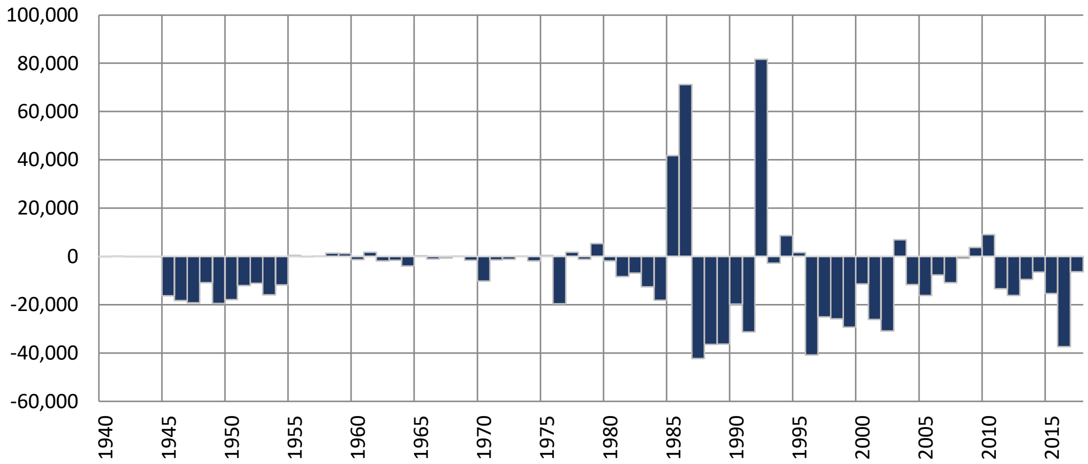
Rio Grande at El Paso (Annual)



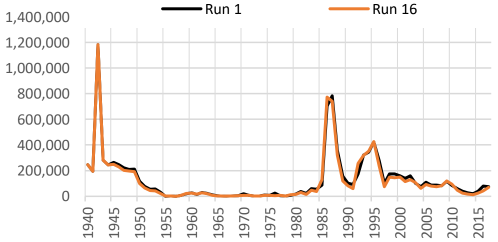
	Average Difference		
Period	Irr Season (excl. Spills)	Nov-Feb and Spills	Annual
1951-2017	-20,531	11,504	-9,027
1951-1978	-2,827	-72	-2,899
1979-2005	-32,234	23,219	-9,015
2006-2017	-35,509	12,153	-23,355
1985-2017	-34,200	23,246	-10,954
1985-2005	-33,452	29,584	-3,868



Rio Grande at Fort Quitman (Annual)



Period	Average Difference
1951-2017	-6,287
1951-1978	-3,280
1979-2005	-8,058
2006-2017	-9,318
1985-2017	-8,692
1985-2005	-8,334



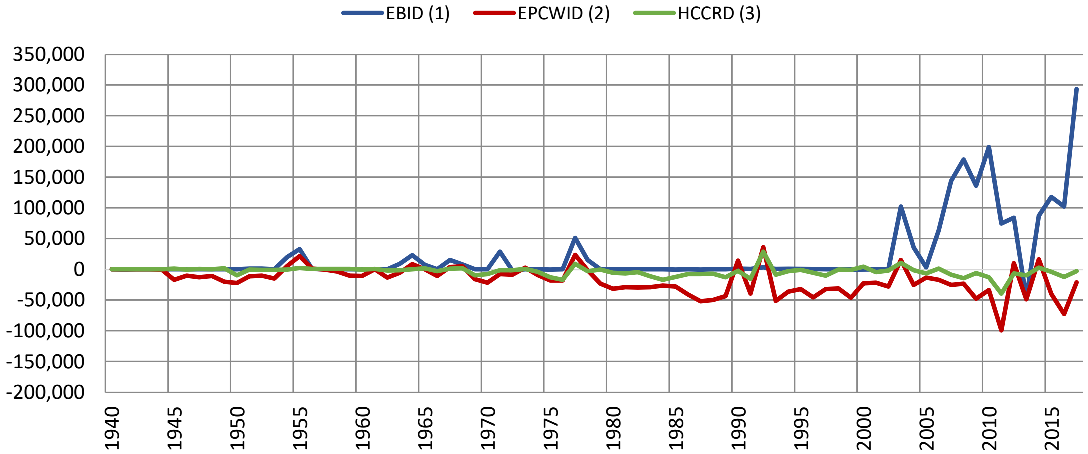
Run 16 - Conj Use 1: Hist All Acres D1/D2 (Hist M&I)

Simulated Differences in ILRG Model Outputs

Run 16 minus Run 1

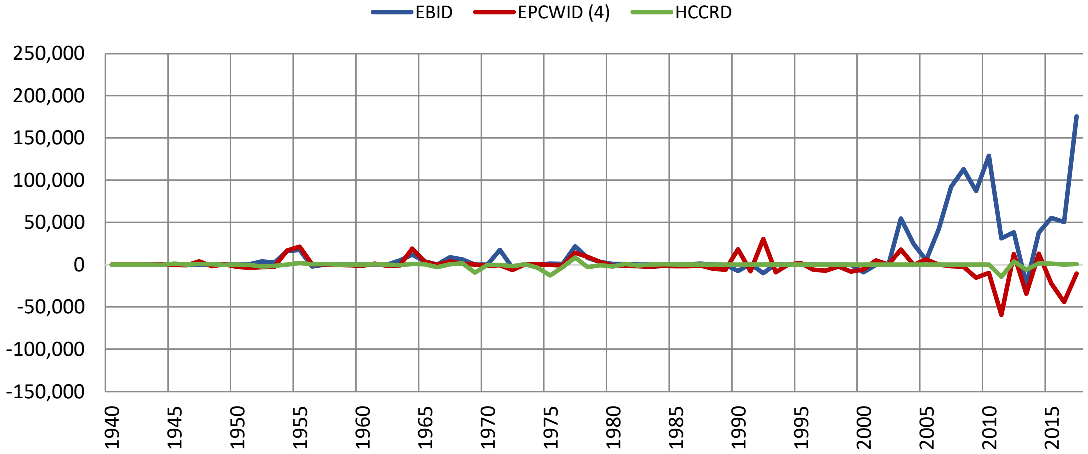
1940 - 2017 (acre-feet)

River Headgate (RHG) Diversions (Irrigation Season)



	Average Difference		
Period	EBID	EPCWID	HCCRD
1951-2017	26,728	-18,896	-4,073
1951-1978	7,545	-4,276	-1,726
1979-2005	5,440	-27,573	-4,113
2006-2017	119,389	-33,484	-9,461
1985-2017	47,870	-29,612	-5,444
1985-2005	7,001	-27,399	-3,148

Farm Headgate (FHG) Deliveries (Irrigation Season)



	Average Difference		
Period	EBID	EPCWID	HCCRD
1951-2017	15,140	-1,379	-584
1951-1978	4,306	2,461	-862
1979-2005	2,428	479	-98
2006-2017	69,020	-14,519	-1,029
1985-2017	26,933	-4,719	-374
1985-2005	2,883	881	0

Notes:

(1) EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).

(2) EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

(3) HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

(4) EPCWID FHG values include deliveries to Rogers WTP and R/U WTP.

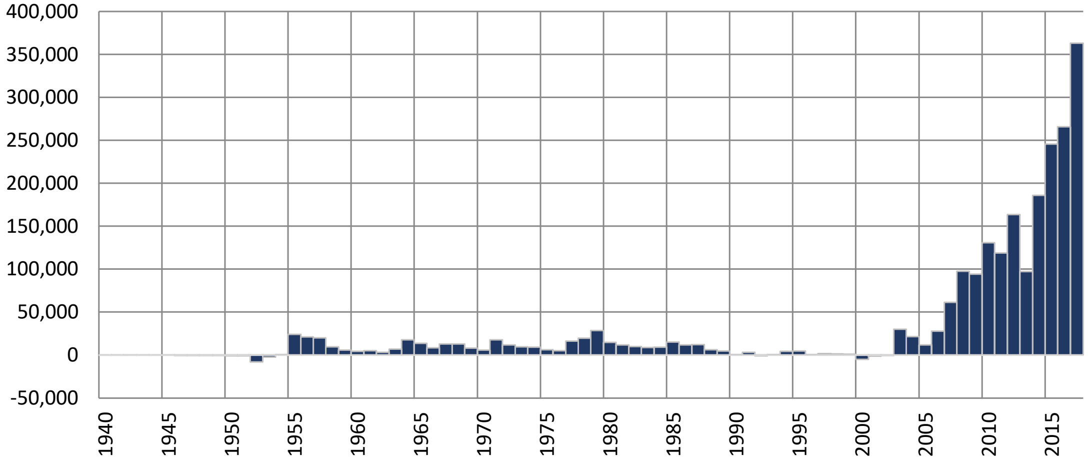
Run 16 - Conj Use 1: Hist All Acres D1/D2 (Hist M&I)

Simulated Differences in ILRG Model Outputs

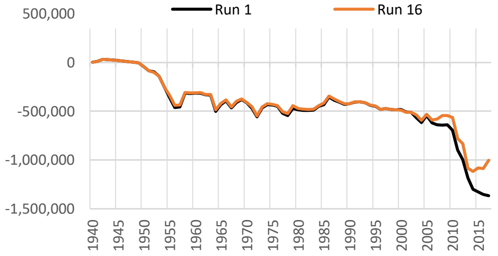
Run 16 minus Run 1

1940 - 2017 (acre-feet)

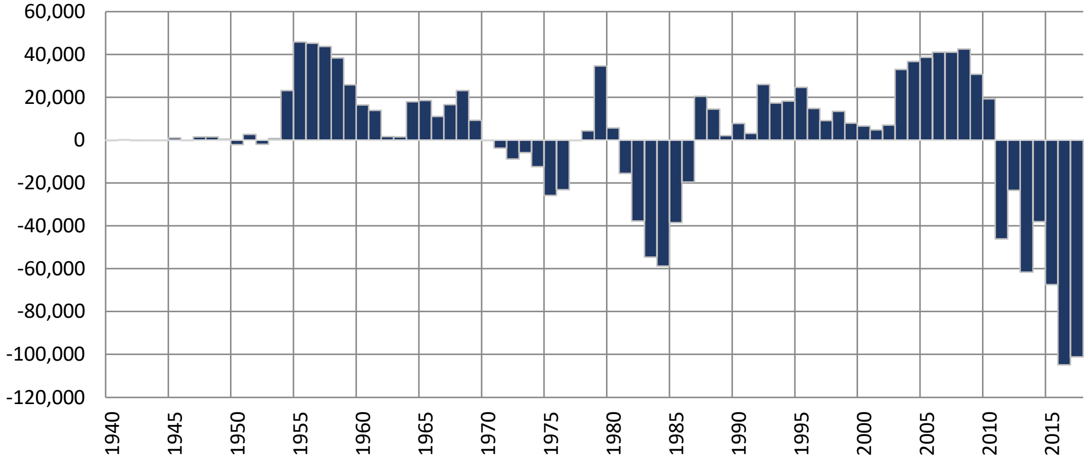
Cumulative Annual Rincon-Mesilla Groundwater Storage



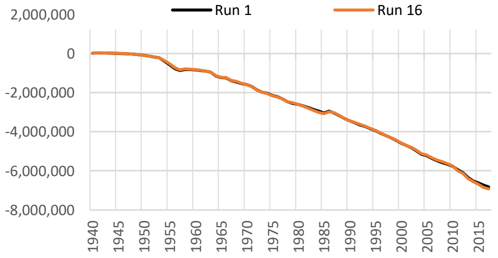
Period	Average Difference
1951-2017	5,433
1951-1978	734
1979-2005	-300
2006-2017	29,295
1985-2017	10,725
1985-2005	114



Cumulative Annual Hueco Groundwater Storage



Period	Average Difference
1951-2017	-1,478
1951-1978	231
1979-2005	1,269
2006-2017	-11,651
1985-2017	-1,287
1985-2005	4,635



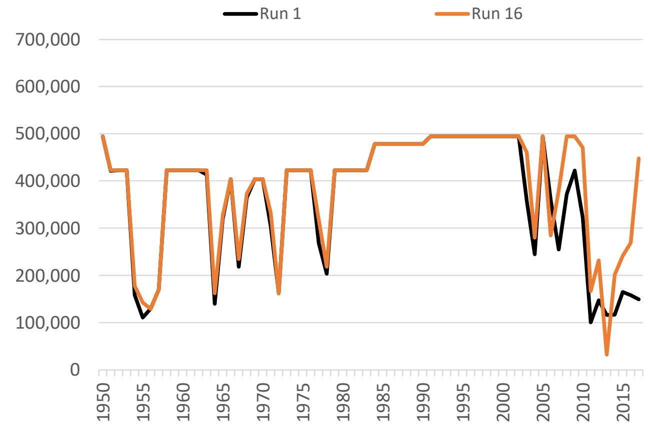
Notes:

Cumulative storage change in alluvial and non-alluvial aquifers.

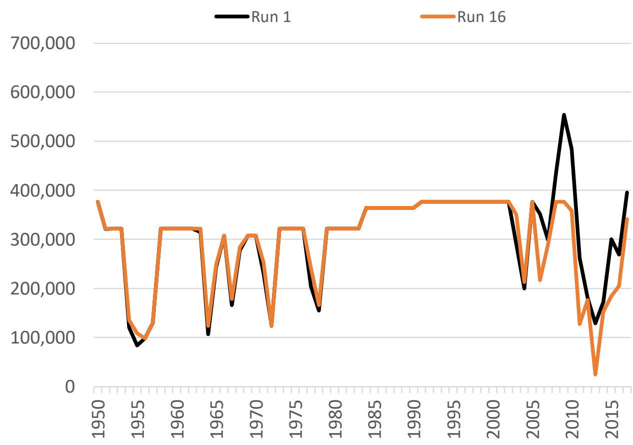
Average differences calculated as (Final Storage - Initial Storage)/(no. years).

Run 16 - Conj Use 1: Hist All Acres D1/D2 (Hist M&I)
Annual Allocation and Charges
Run 16 v. Run 1
ILRG Model
1950 - 2017 (acre-feet)

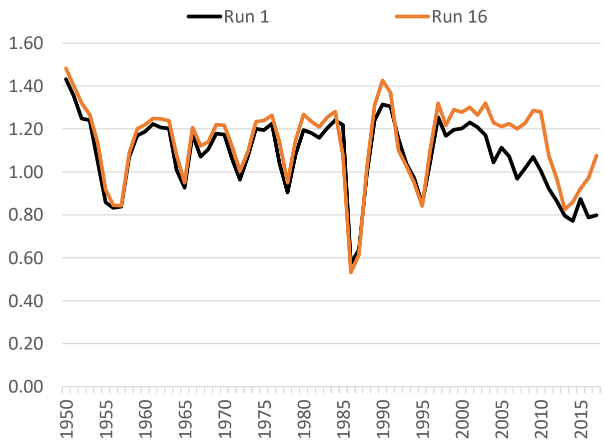
Total Allocation - EBID



Total Allocation - EPCWID



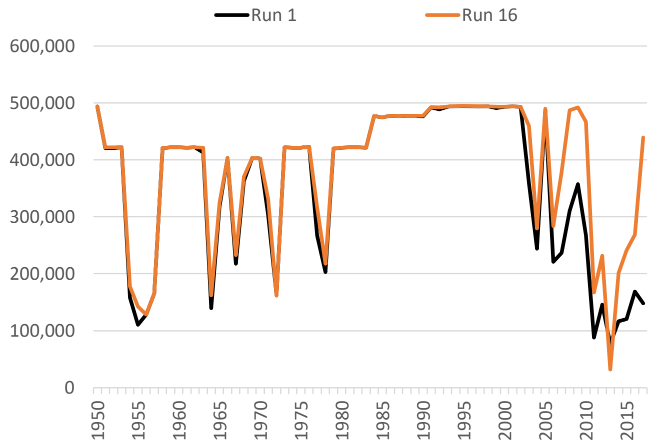
Diversion Ratio



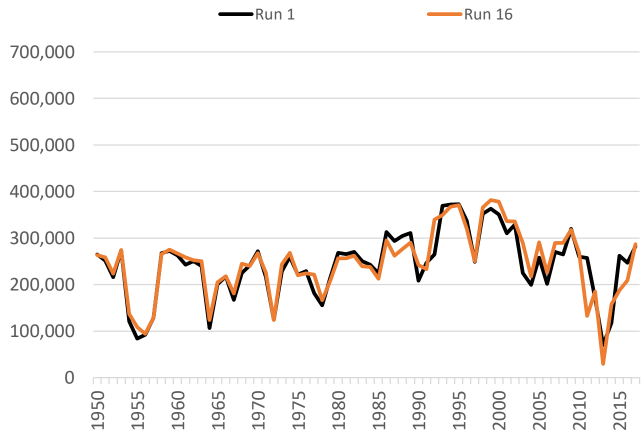
Note:

Computed as Total Charges/Caballo Release.

Annual Delivery Charges - EBID

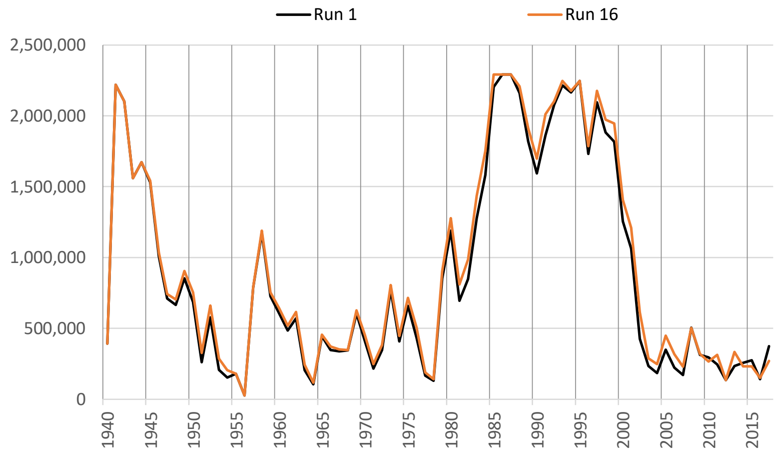


Annual Delivery Charges - EPCWID

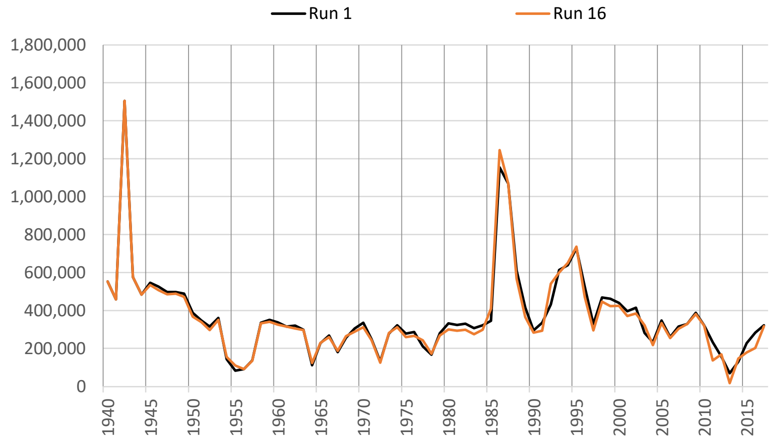


Run 16 - Conj Use 1: Hist All Acres D1/D2 (Hist M&I)
Annual Summary of Project Storage and Rio Grande Flows
Run 16 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

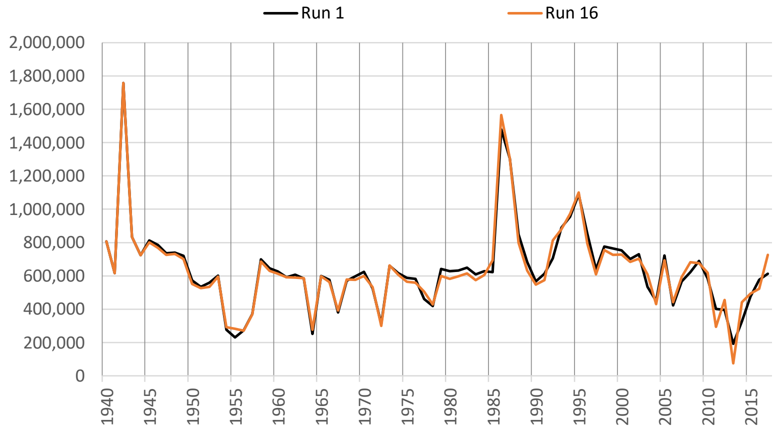
Total Year-End Project Reservoir Storage



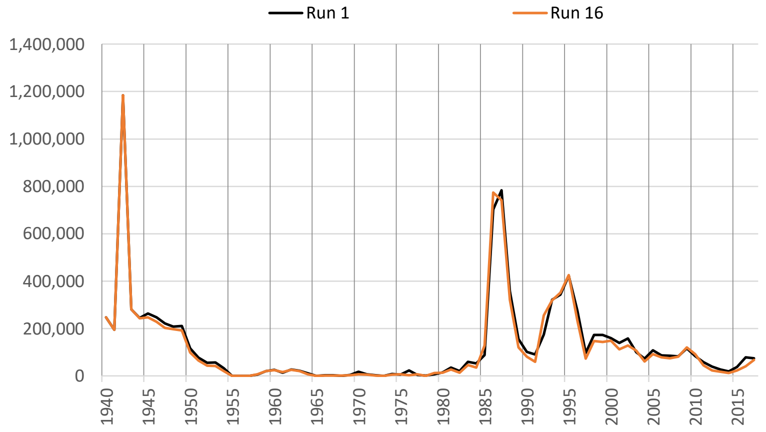
Rio Grande at El Paso



Rio Grande Below Caballo



Rio Grande at Fort Quitman



***Note different scales.**

Run 16 - Conj Use 1: Hist All Acres D1/D2 (Hist M&I)

Irrigation Season Summary of Irrigation Operations

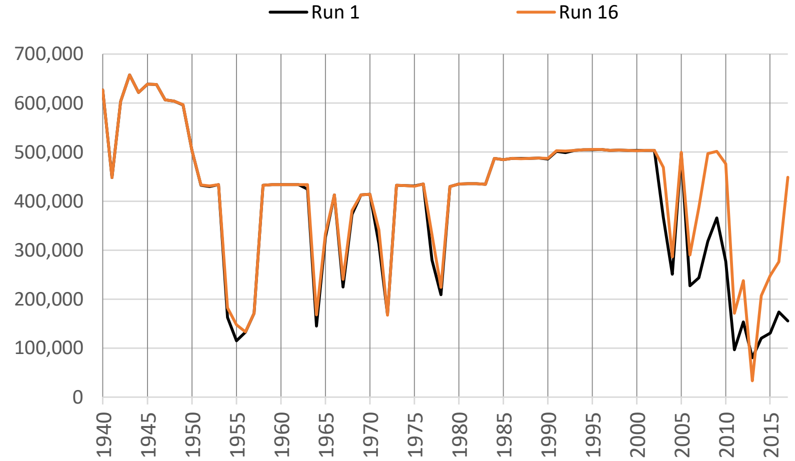
Run 16 v. Run 1

ILRG Model

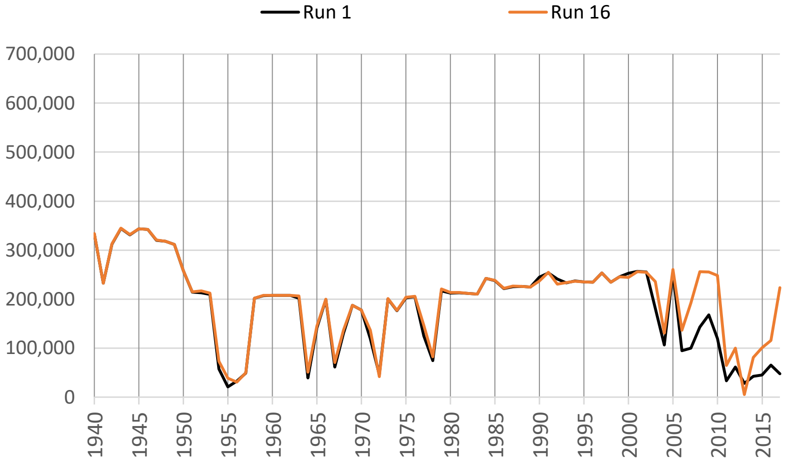
1940 - 2017 (acre-feet)

EBID Total

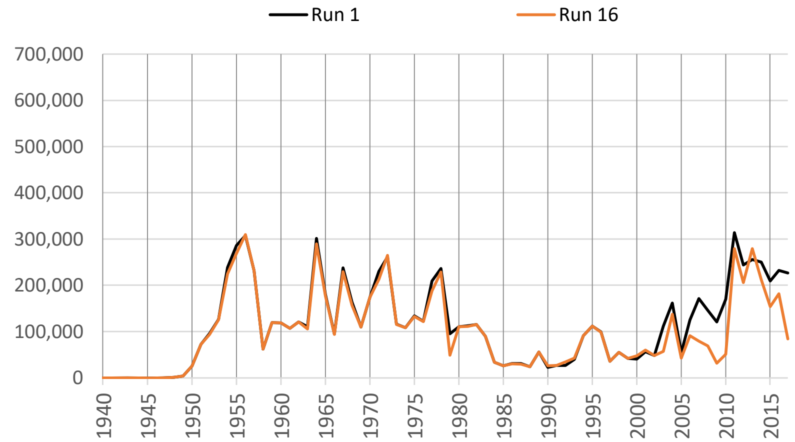
Net River Headgate Diversions



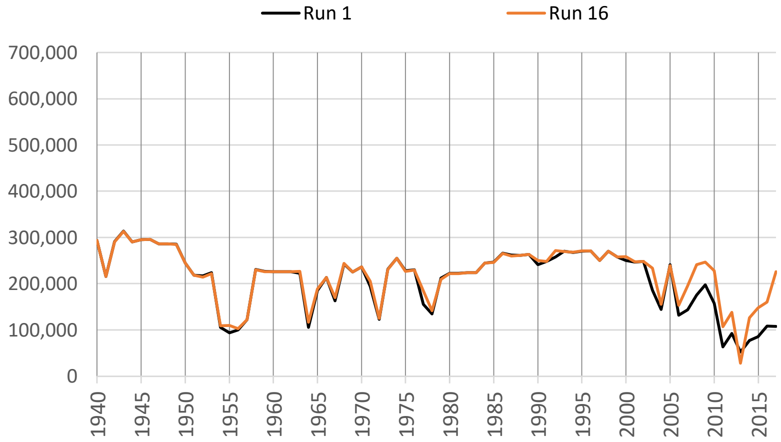
Farm Headgate Deliveries



Pumping



RHG Diversions - FHG Deliveries



Notes: EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).
Pumping includes Supplemental and Primary groundwater pumping.

Run 16 - Conj Use 1: Hist All Acres D1/D2 (Hist M&I)

Irrigation Season Summary of Irrigation Operations

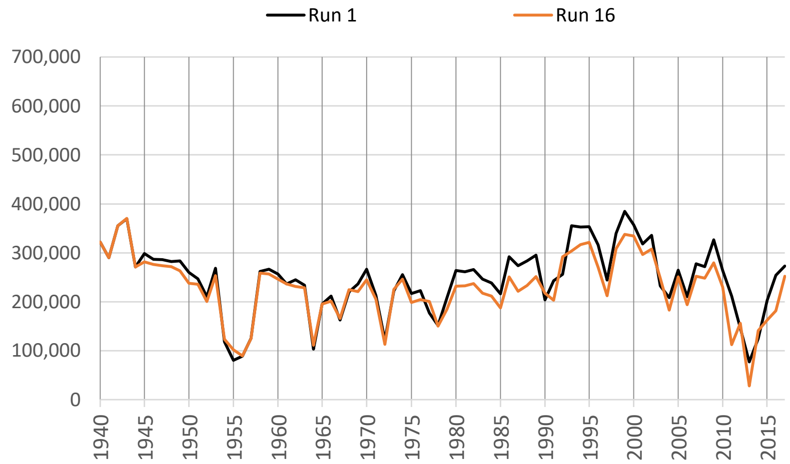
Run 16 v. Run 1

ILRG Model

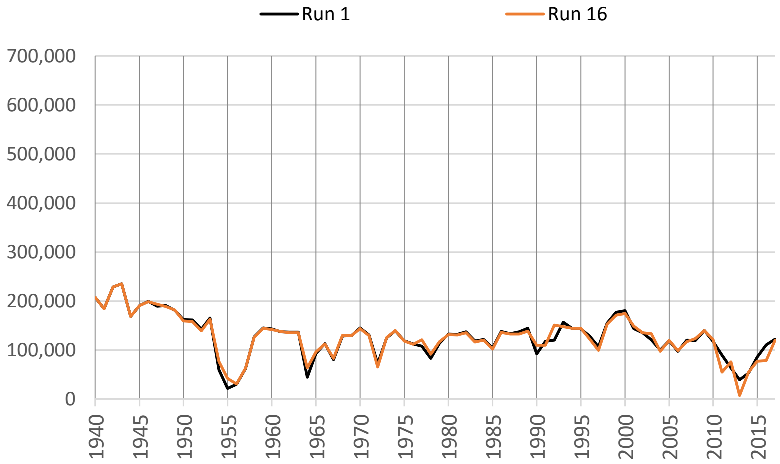
1940 - 2017 (acre-feet)

EPCWID Total

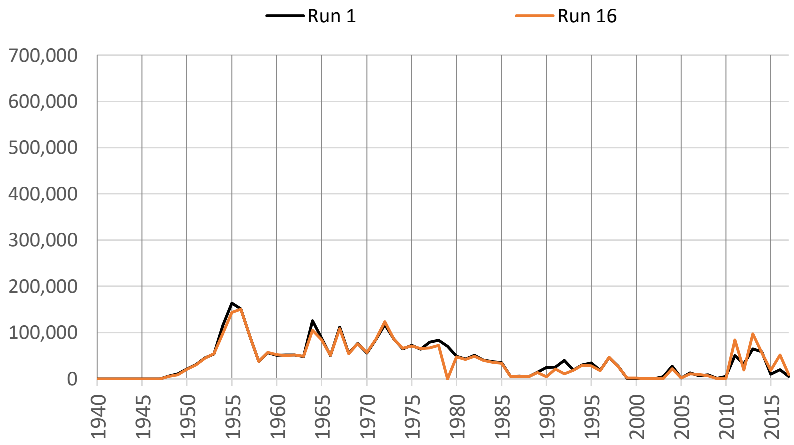
Net River Headgate Diversions



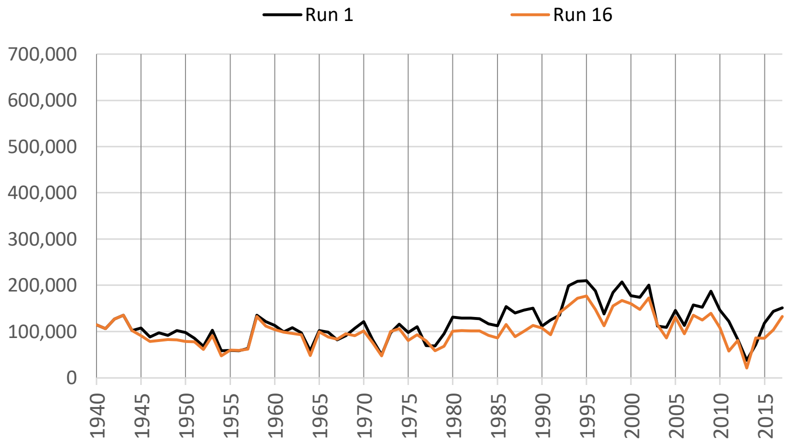
Farm Headgate Deliveries



Pumping



RHG Diversions - FHG Deliveries



Note: EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

Run 16 - Conj Use 1: Hist All Acres D1/D2 (Hist M&I)

Irrigation Season Summary of Irrigation Operations

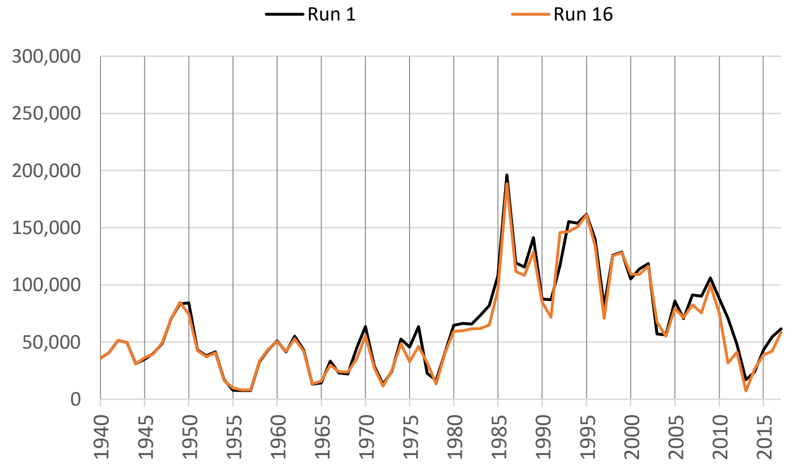
Run 16 v. Run 1

ILRG Model

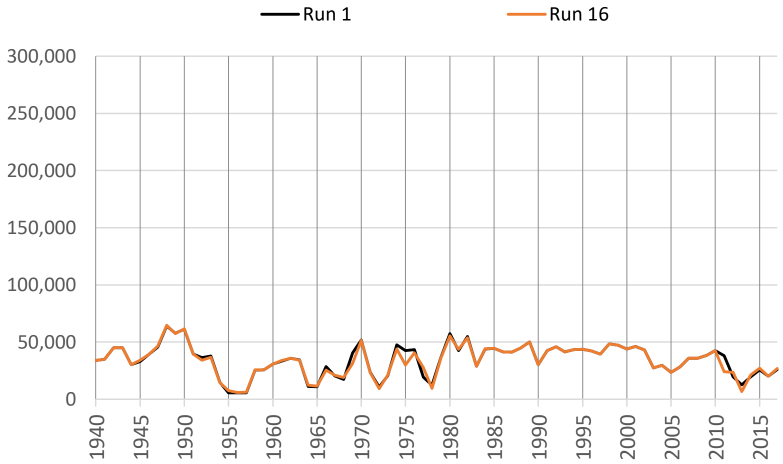
1940 - 2017 (acre-feet)

HCCRD Total

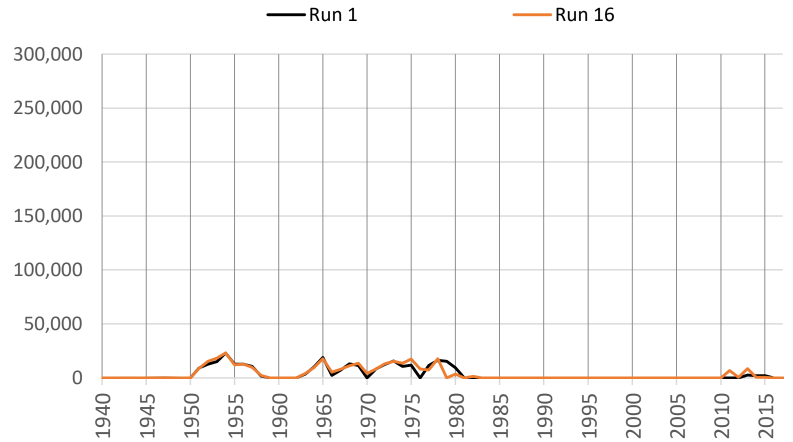
Net River Headgate Diversions



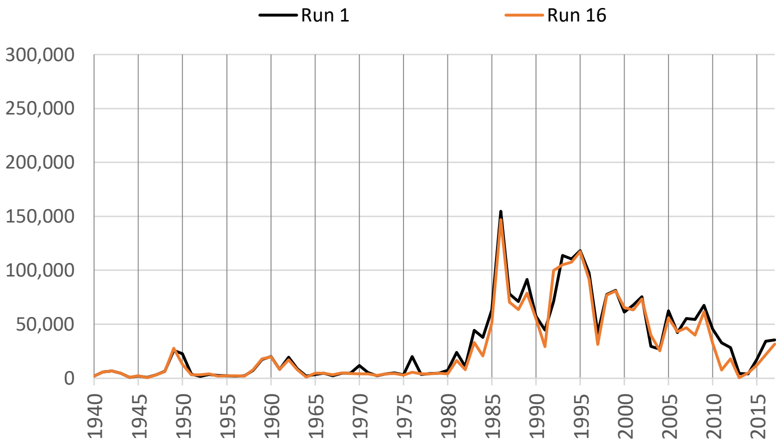
Farm Headgate Deliveries



Pumping



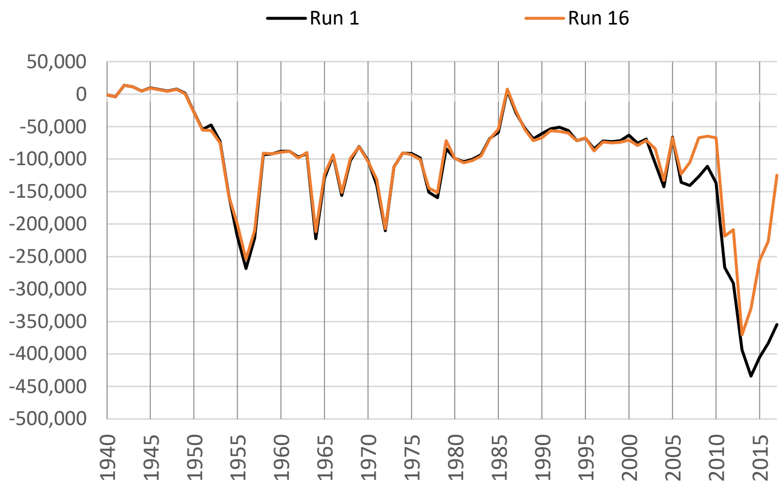
RHG Diversions - FHG Deliveries



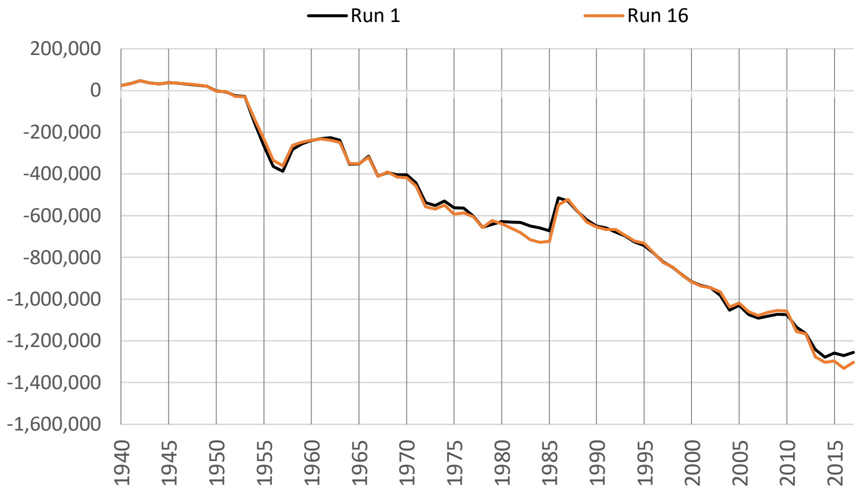
Note: HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

Run 16 - Conj Use 1: Hist All Acres D1/D2 (Hist M&I)
Cumulative Change in Ground Water Storage
Run 16 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

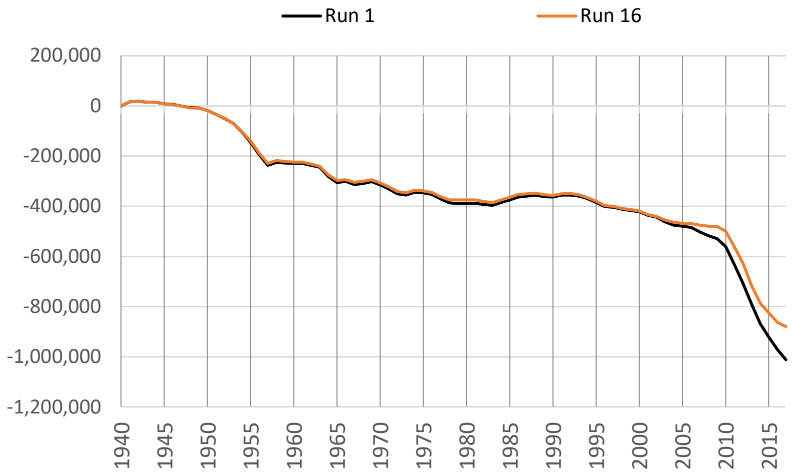
Rincon-Mesilla Alluvial Aquifer



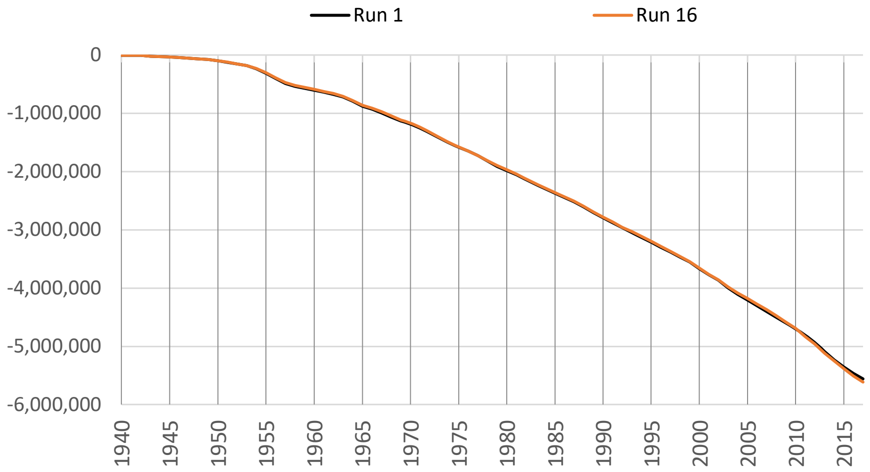
Hueco Alluvial Aquifer



Rincon-Mesilla Non-Alluvial Aquifer



Hueco Non-Alluvial Aquifer



***Note different scales.**

Run 16 - Conj Use 1: Hist All Acres D1/D2 (Hist M&I)

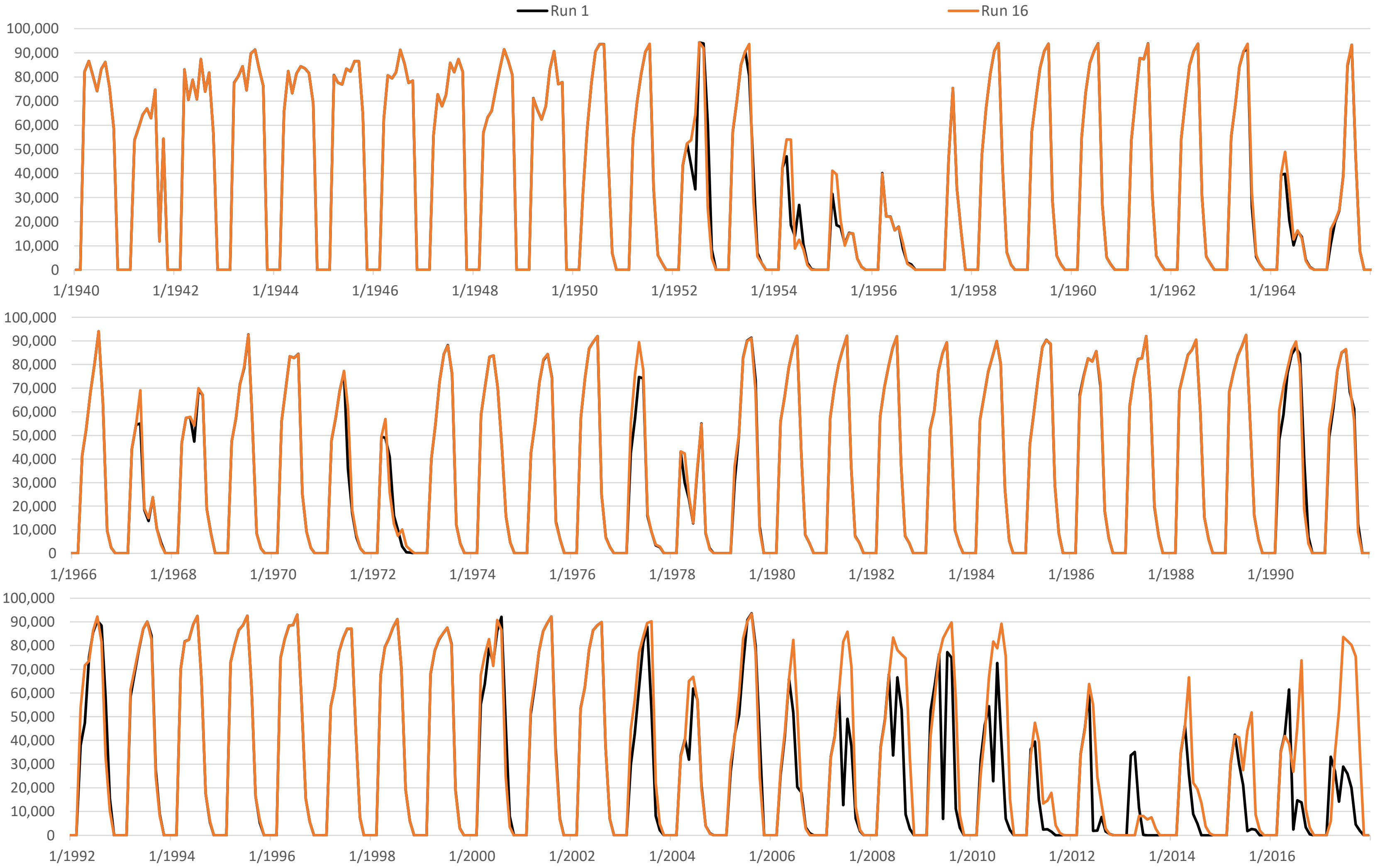
Monthly Net RHG Diversions

Run 16 v. Run 1

ILRG Model

1940 - 2017 (acre-feet)

EBID Total



Note: EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).

Run 16 - Conj Use 1: Hist All Acres D1/D2 (Hist M&I)

Monthly Net RHG Diversions

Run 16 v. Run 1

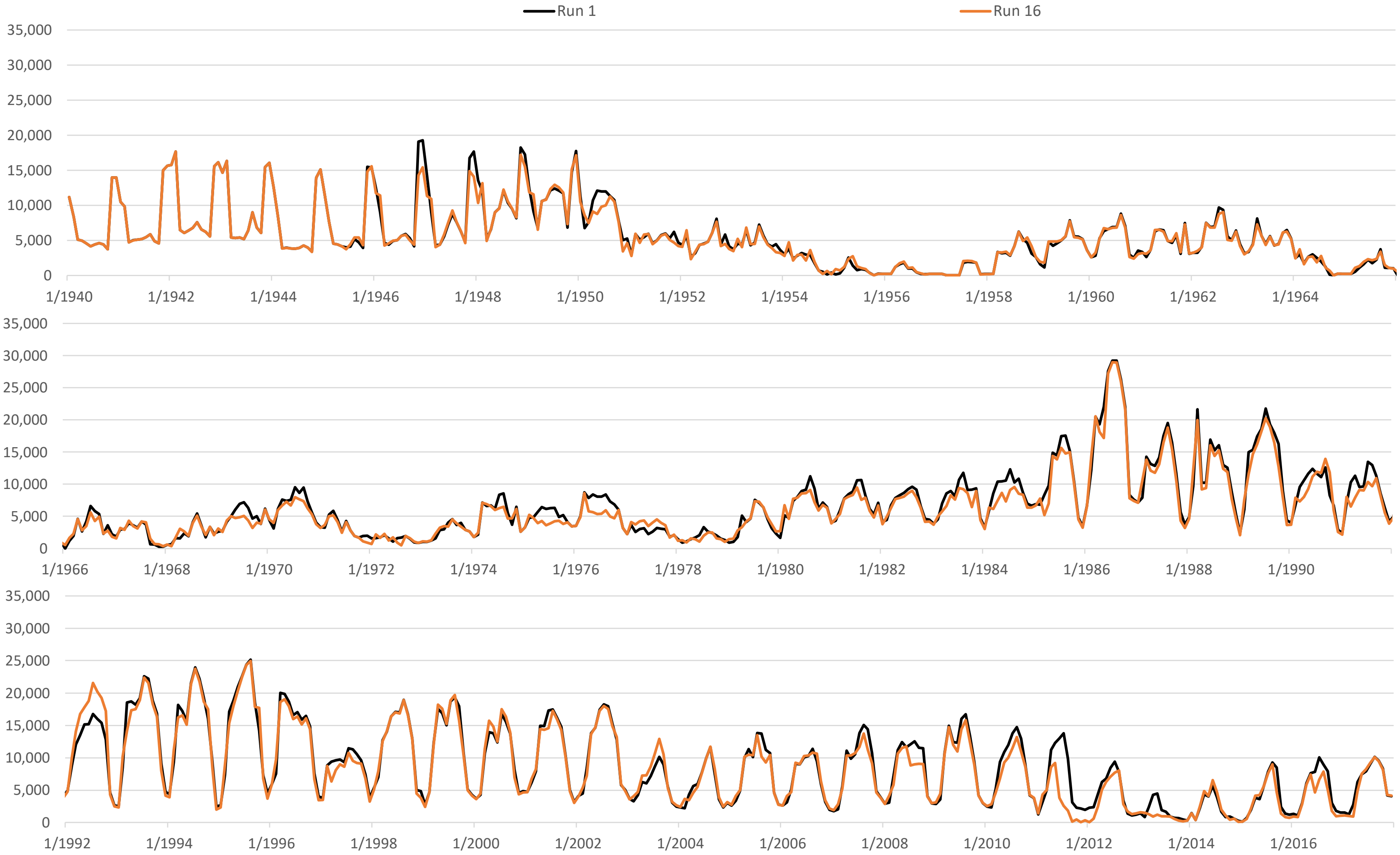
ILRG Model

1940 - 2017 (acre-feet)

EPCWID Total

Note: EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

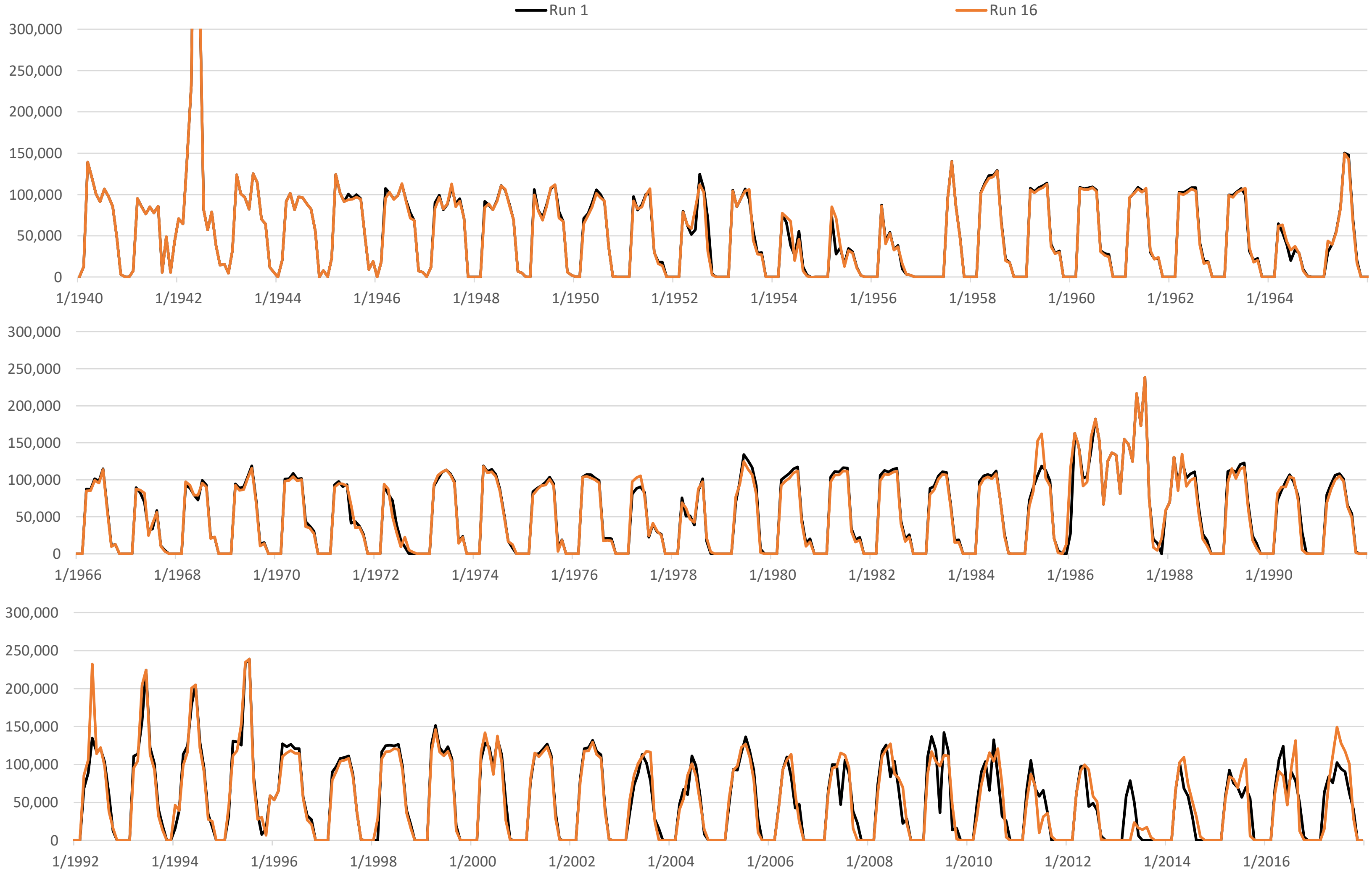
Run 16 - Conj Use 1: Hist All Acres D1/D2 (Hist M&I)
Monthly Net RHG Diversions
Run 16 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)
HCCRD Total



Note: HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

Run 16 - Conj Use 1: Hist All Acres D1/D2 (Hist M&I)
End of Month Reservoir Storage (Elephant Butte + Caballo)
Run 16 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

Run 16 - Conj Use 1: Hist All Acres D1/D2 (Hist M&I)
Monthly Caballo Releases
Run 16 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)



Run 16 - Conj Use 1: Hist All Acres D1/D2 (Hist M&I)
Monthly Rio Grande at El Paso Flow
Run 16 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

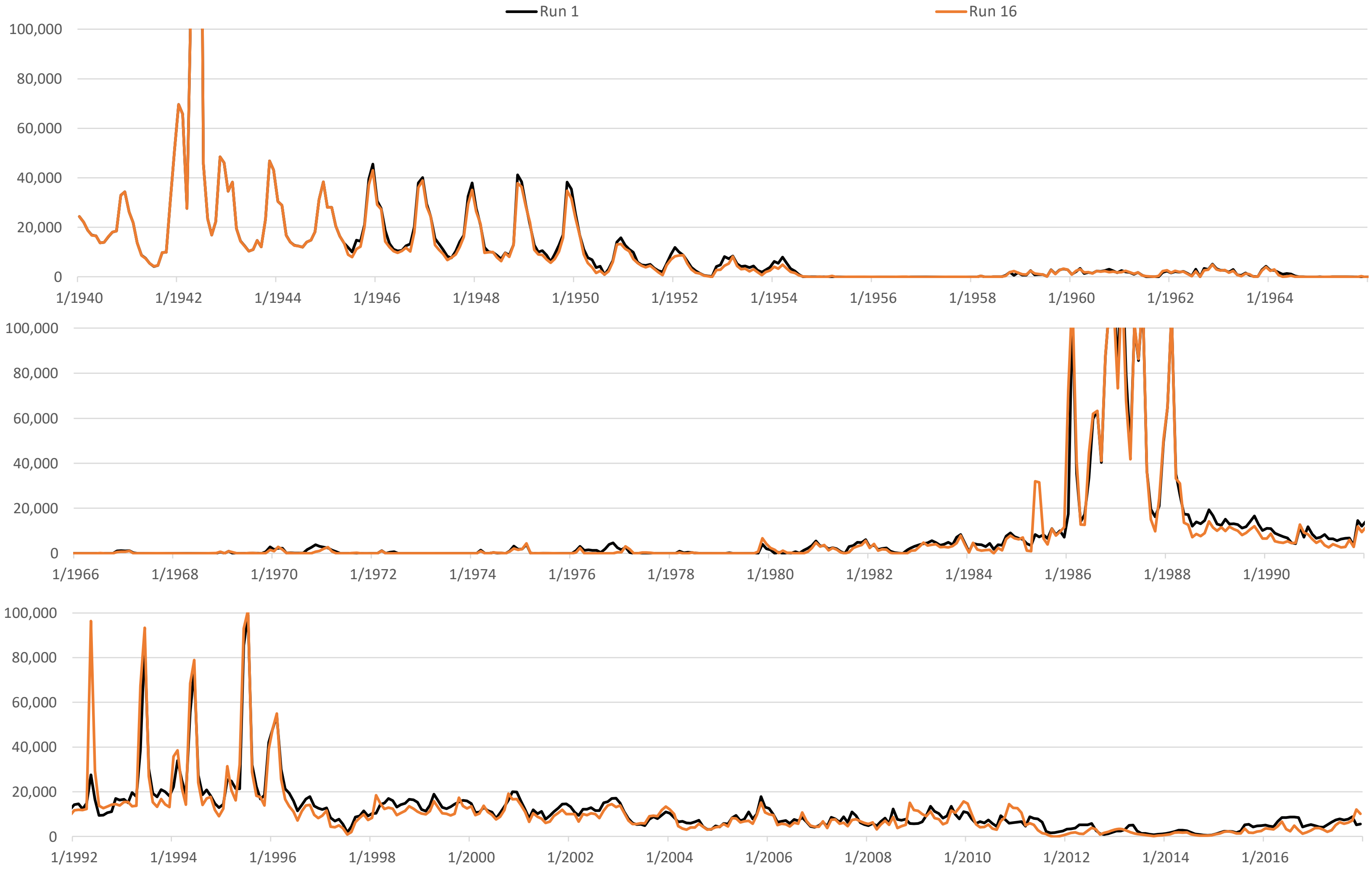
Run 16 - Conj Use 1: Hist All Acres D1/D2 (Hist M&I)

Monthly Rio Grande at Fort Quitman Flow

Run 16 v. Run 1

ILRG Model

1940 - 2017 (acre-feet)



Appendix 30X

Comparison of ILRG Model Runs

Run 16a v. Run 1

Model Run Specifications

Model Version: LRG_v116

Name: **Run 16a - Conj Use 1a: Hist All Acres D1/D2 (1978 M**

Run ID: LRG_v116_Operational_Run16a
Date: 8/28/2020

Name: **Run 1 - Historical Base Run (All Pumping On)**

Run ID: LRG_v116_Operational_Run1
Date: 8/23/2020

Selected Model Inputs

Pumping and Returns	**Run 16a**	**Run 1**
(1) Irrigation Pumping	1978 Limit	On
Irrigated Area	Hist	Hist
(2) Non-Irrigation Pumping	1978 Limit	On
Non-Irrigation Pumping Returns	Reduced	On
Las Cruces Jornada Pumping Returns	Off	On

Project Allocation Rules		
1950-2005	D1/D2	D1/D2
2006-2007	D1/D2	D3
2008-2017	D1/D2	D3 + CO

EPCWID Operations		
Charge EPCWID for Use of WWTP Returns	On	Off
ACE and Haskell Credits for EPCWID	Off	On
(3) Increased EPCWID Use of Fabens Drain Flows	On	Off
Charge EPCWID for Fabens Drain Flow Use	On	Off

Notes:

(1) Ten-year average irrigation pumping limited to 1951-1978 average:
EBID = 166,866 AF, EPCWID=70,783 AF, HCCRD = 11,188 AF.

(2) Annual non-Irrigation pumping limited to 1951-1978 maximum: NM = 20,993 AF,
TX (Hueco) = 89,979 AF, TX (Mesilla) = 30,264 AF. Returns reduced based on pumping change.

(3) Starting in July 1945, use 70% of simulated Fabens drain flow up to 6,000 AF/month.

Run 16a - Conj Use 1a: Hist All Acres D1/D2 (1978 M&I)

Comparison of ILRG Model Runs

Run 16a v. Run 1

1951 - 2017 Annual Average

(1,000 acre-feet)

Run No.	1	16a	16a - 1	
Simulated Input or Output	**Run 1**	**Run 16a**	**Run 16a minus Run 1**	
Effects of Alternate Scenario				
FHG Deliveries (Mar - Oct)				***% Diff.***
EBID	167.6	183.3	15.7	*9%*
EPCWID (incl. EPW)	139.9	138.8	-1.0	*-1%*
HCCRD	32.8	32.3	-0.6	*-2%*
Total	340.3	354.4	14.1	*4%*
FHG Deliveries (Nov - Feb)				
EBID	0.0	0.0	0.0	*122%*
EPCWID (incl. EPW)	0.2	1.8	1.6	*873%*
HCCRD	2.4	2.8	0.4	*15%*
Total	2.6	4.6	2.0	*77%*
Irrigation Pumping				
EBID	140.4	124.8	-15.6	*-11%*
EPCWID (Mesilla Valley)	7.4	6.8	-0.5	*-7%*
EPCWID (El Paso Valley)	40.1	38.2	-1.9	*-5%*
HCCRD	4.2	4.5	0.3	*6%*
Total	192.1	174.3	-17.8	*-9%*
Other Inflows/Outflows				
Net Reservoir Evaporation	125.3	130.6	5.3	*4%*
Riparian ET	70.9	70.4	-0.5	*-1%*
River Evaporation + Incidental Canal Loss	30.3	30.9	0.5	*2%*
Total	226.6	231.9	5.3	*2%*
Rio Grande at Fort Quitman				
Reservoir Spills	33.3	39.4	6.1	*18%*
Nov-Feb Flows	21.4	19.3	-2.1	*-10%*
Mar - Oct Flows	41.1	32.5	-8.6	*-21%*
Underflow (GW Model)	0.2	0.2	0.0	*-5%*
Total	96.0	91.3	-4.6	*-5%*

Run 16a - Conj Use 1a: Hist All Acres D1/D2 (1978 M&I)

Comparison of ILRG Model Runs

Run 16a v. Run 1

1951 - 2017 Annual Average

(1,000 acre-feet)

Run No.	1	16a	16a - 1	
Simulated Input or Output	**Run 1**	**Run 16a**	**Run 16a minus Run 1**	
Effects of Alternate Scenario (continued)				
Change in Storage				***% Diff.***
Reservoir Storage	-4.7	-7.0	-2.3	*50%*
Alluvial GW Storage (RW Model)	-23.6	-19.7	3.9	*-16%*
Non-alluvial GW Storage (GW Models)	-96.4	-90.8	5.6	*-6%*
Soil Moisture Storage	0.6	0.7	0.2	*26%*
Total	-124.0	-116.7	7.3	*-6%*
Summary of Effects				
FHG Deliveries (Mar-Oct)	340.3	354.4	14.1	*4%*
FHG Deliveries (Nov-Feb)	2.6	4.6	2.0	*77%*
Irrigation Pumping	192.1	174.3	-17.8	*-9%*
Riparian ET + Evaporation	226.6	231.9	5.3	*2%*
Fort Quitman Flow	96.0	91.3	-4.6	*-5%*
Change in Storage	-124.0	-116.7	7.3	*-6%*
Total	733.6	739.8	6.3	*1%*
Other Effects of Alternate Scenario				
Rio Grande at El Paso				***% Diff.***
Reservoir Spills	49.4	60.0	10.7	*22%*
Nov-Feb Flows	22.8	24.5	1.7	*7%*
Mar - Oct Flows	263.8	244.6	-19.1	*-7%*
Total	336.0	329.2	-6.8	*-2%*
Rio Grande below Caballo				
Reservoir Spills	65.9	79.9	14.1	*21%*
Nov-Feb Flows	0.5	0.3	-0.1	*-32%*
Mar - Oct Flows	541.3	524.4	-16.9	*-3%*
Total	607.6	604.6	-3.0	*0%*
Surface Water Diversions (Mar - Oct)				
EBID	366.5	394.0	27.6	*8%*
EPCWID (incl. EPW)	236.8	218.6	-18.2	*-8%*
HCCRD	67.5	64.1	-3.5	*-5%*
Total	670.8	676.7	5.9	*1%*
Surface Water Diversions (Nov - Feb)				
EBID	0.0	0.0	0.0	*0%*
EPCWID (incl. EPW)	14.3	15.9	1.5	*11%*
HCCRD	14.2	14.2	0.0	*0%*
Total	28.5	30.1	1.5	*5%*

Run 16a - Conj Use 1a: Hist All Acres D1/D2 (1978 M&I)
Annual Differences in ILRG Model Outputs
Run 16a minus Run 1
1940 - 2017 (acre-feet)

	Net River Headgate Diversions						Farm Headgate Deliveries						Annual Flows		
	EBID		EPCWID (incl. EPW)		HCCRD		EBID		EPCWID (incl. EPW)		HCCRD				
Year	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Caballo Releases	Rio Grande at El Paso	Rio Grande at Fort Quitman
1940	-53	-53	7	-1	2	-2	-2	-2	3	2	2	2	-47	-23	-55
1941	-159	-159	-7	-12	-3	-4	-4	-4	-1	0	-2	-5	39	67	13
1942	-33	-33	1	-3	-1	0	0	0	3	8	0	-1	28	12	-27
1943	-64	-64	-5	-8	3	3	-14	-14	-13	-13	2	-1	-23	-12	-84
1944	-81	-81	-145	-137	-110	-92	-5	-5	17	-1	-99	-101	-173	-165	-43
1945	2	2	-17,012	-5,525	1,399	925	-53	-53	-305	6,380	1,082	989	-10,953	-10,435	-16,299
1946	36	36	-10,406	-11,162	-393	-7,351	-110	-111	-718	3,365	-77	-241	-18,289	-17,701	-18,269
1947	56	56	-12,900	-6,767	701	-5,755	-15	-16	3,975	11,149	926	1,022	-10,371	-10,445	-19,232
1948	11	11	-10,723	-6,735	133	-4,672	-15	-16	-1,979	4,593	411	236	-8,615	-8,639	-10,836
1949	47	47	-20,112	-15,398	1,548	3,242	-52	-53	624	6,507	-293	-545	-18,804	-18,225	-19,519
1950	29	29	-22,153	-18,183	-9,753	-11,080	-12	-12	-2,685	2,576	239	421	-20,596	-20,223	-17,827
1951	1,031	1,031	-11,340	-5,770	-648	-2,850	546	545	-3,518	1,746	-208	-2,200	-8,571	-8,416	-12,003
1952	1,000	1,000	-10,361	-6,996	-860	-2,145	3,908	3,903	-3,061	-31	-2,254	529	-25,067	-18,571	-11,123
1953	375	375	-15,146	-11,776	-850	-1,993	2,378	2,377	-2,553	402	-1,254	629	-6,064	-11,485	-15,960
1954	20,494	20,494	5,816	6,889	-708	321	15,843	15,843	17,425	18,414	-186	824	17,441	12,937	-11,777
1955	32,352	32,352	20,903	21,004	2,054	3,056	17,019	17,019	20,883	20,821	1,998	2,946	50,778	25,749	388
1956	694	694	1,159	1,165	628	596	-2,258	-2,258	551	428	437	285	-1,497	944	-25
1957	11	11	-591	-757	507	453	73	73	552	502	670	569	-1,747	-568	-3
1958	-1	-1	-3,376	-3,576	700	1,752	290	290	-178	-170	65	43	-13,555	-3,327	1,336
1959	6	6	-10,187	-9,864	550	1,454	99	99	-542	-340	6	23	-14,411	-10,311	1,133
1960	8	8	-10,550	-10,095	-550	-804	52	52	-1,419	-879	0	0	-13,095	-11,461	-1,291
1961	15	15	97	1,132	654	819	55	55	1,134	2,196	634	-425	355	-377	1,671
1962	9	9	-13,813	-12,407	-2,138	-2,291	-12	-12	-1,532	-333	10	-320	-17,970	-15,688	-1,815
1963	8,891	8,891	-5,684	-3,795	-1,274	-1,583	4,851	4,852	-925	786	-513	-515	1,691	-2,160	-1,615
1964	23,604	23,604	8,507	9,452	-406	267	12,110	12,110	18,851	19,489	748	679	24,270	12,383	-3,995
1965	7,442	7,442	950	943	2,097	2,127	3,949	3,949	3,457	3,444	959	995	-1,688	2,487	286
1966	-31	-31	-11,023	-10,332	-3,002	-3,099	249	249	-237	131	-2,942	-841	-14,868	-9,371	-1,125
1967	15,316	15,316	3,502	4,274	1,300	1,731	8,586	8,586	3,822	3,595	621	1,679	10,536	5,905	-611
1968	7,816	7,816	4,866	5,703	1,778	1,265	6,309	6,309	1,299	1,014	1,714	1,368	7,983	7,767	183
1969	-14	-14	-15,919	-15,417	-9,692	-9,382	239	239	25	355	-9,300	-7,727	-21,260	-16,252	-1,579
1970	3	3	-21,567	-20,864	-7,833	-7,409	42	42	-1,265	-578	-309	4,357	-25,992	-23,158	-10,290
1971	28,902	28,902	-7,531	-6,096	-1,584	-3,315	17,630	17,630	-682	207	-294	-1,639	8,397	-4,292	-1,422
1972	-1,862	-1,862	-8,585	-7,848	-1,477	-1,619	-3,792	-3,792	-6,318	-6,292	-1,696	-1,826	-12,187	-6,474	-1,223
1973	-94	-94	2,899	2,901	675	836	729	729	609	424	594	844	522	2,778	6
1974	-7	-7	-9,064	-8,755	-4,105	-4,184	251	251	403	676	-3,578	-2,510	-9,595	-9,129	-1,923
1975	-235	-235	-17,901	-17,273	-12,929	-12,489	1,176	1,176	-325	220	-12,691	-12,566	-22,096	-17,985	386
1976	7	7	-18,365	-17,533	-17,231	-17,454	723	723	-859	-138	-2,743	3,548	-21,598	-20,148	-19,601
1977	51,179	51,179	23,605	25,227	9,139	9,566	21,760	21,760	14,206	16,538	8,478	9,432	44,584	32,370	1,612
1978	15,244	15,244	-1,280	479	-3,115	-3,412	7,976	7,976	9,369	10,814	-2,846	-3,204	9,226	4,158	-1,211

Run 16a - Conj Use 1a: Hist All Acres D1/D2 (1978 M&I)

Annual Differences in ILRG Model Outputs

Run 16a minus Run 1

1940 - 2017 (acre-feet)

	Net River Headgate Diversions						Farm Headgate Deliveries						Annual Flows		
	EBID		EPCWID (incl. EPW)		HCCRD		EBID		EPCWID (incl. EPW)		HCCRD				
Year	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Caballo Releases	Rio Grande at El Paso	Rio Grande at Fort Quitman
1979	55	55	-23,524	-20,053	-346	1,701	3,304	3,312	3,198	6,630	-471	1,535	-42,558	-11,869	5,271
1980	-75	-75	-31,768	-27,701	-5,345	-3,237	785	786	-1,284	2,177	-2,198	-2,069	-44,997	-31,184	-1,862
1981	-64	-64	-28,915	-26,060	-6,442	-7,208	866	866	-1,537	1,799	953	1,273	-34,914	-31,288	-8,342
1982	-12	-12	-28,406	-25,790	-4,200	-4,849	58	58	-1,805	1,479	-1,147	891	-32,686	-30,795	-6,877
1983	-15	-15	-28,775	-26,395	-11,379	-11,735	2	3	-2,408	633	0	0	-33,700	-31,916	-12,564
1984	-52	-52	-26,697	-24,594	-16,867	-17,468	83	86	-1,513	1,795	371	371	-24,092	-23,403	-18,063
1985	-251	-251	-27,158	-25,057	-11,977	-11,684	693	699	-1,770	785	0	0	70,207	64,516	41,038
1986	-98	-98	-39,439	-38,273	-7,422	-6,249	419	442	-1,571	-93	0	0	87,166	91,493	70,462
1987	-225	-225	-48,108	-45,809	-6,405	-5,920	1,300	1,312	-568	2,719	0	0	-219	688	-45,431
1988	-18	-18	-46,157	-43,231	-6,179	-6,090	206	215	-4,123	52	0	0	-47,111	-39,691	-36,302
1989	3	3	-37,055	-33,377	-10,288	-10,961	-40	-30	-4,710	47	0	0	-49,446	-46,555	-36,243
1990	1,037	1,037	17,358	20,949	-1,434	-1,912	-7,444	-7,436	18,831	24,184	0	0	-18,580	-7,523	-18,909
1991	873	873	-39,203	-35,165	-14,918	-15,274	1,221	1,232	-7,584	-1,296	0	0	-39,224	-39,587	-30,207
1992	3,356	3,356	36,126	38,909	28,900	29,568	-9,960	-9,956	30,572	35,098	0	0	99,843	106,675	79,727
1993	550	550	-51,876	-47,688	-8,671	-8,894	1,026	1,042	-8,847	-2,164	0	0	-10,167	-11,086	343
1994	393	393	-36,706	-33,470	-3,199	-3,174	241	269	-31	5,082	0	0	16,747	17,060	13,443
1995	892	892	-32,459	-28,541	-830	-1,045	448	465	1,786	8,189	0	0	13,222	16,063	9,083
1996	-90	-90	-46,190	-43,526	-5,866	-5,128	577	596	-5,774	-1,582	0	0	-63,641	-52,977	-38,712
1997	-52	-52	-32,740	-30,203	-9,814	-11,095	321	336	-7,372	-2,213	0	0	-34,746	-30,737	-23,288
1998	-50	-50	-31,772	-29,653	-655	-1,591	619	640	-2,077	1,458	0	0	-20,698	-13,713	-17,842
1999	-1,292	-1,292	-49,620	-48,576	26,534	25,956	-10,168	-10,155	-18,682	-17,151	0	0	-2,482	7,830	21,426
2000	-365	-365	-19,777	-19,931	4,907	4,540	-7,221	-7,213	-2,945	-2,963	0	0	-27,724	-14,037	-11,014
2001	265	265	-15,822	-16,021	-2,730	-2,534	422	432	8,959	8,952	0	0	-17,568	-17,492	-22,495
2002	-42	-42	-27,960	-27,931	-1,649	-746	411	418	-2	1	0	0	-33,470	-27,260	-27,816
2003	100,416	100,416	16,216	16,449	11,207	12,322	54,067	54,081	17,881	17,903	0	0	68,064	42,900	8,935
2004	34,561	34,561	-26,139	-25,264	-1,293	592	24,223	24,225	-750	-732	0	0	-27,330	-14,022	-10,214
2005	2,986	2,986	-12,986	-12,749	-6,310	-5,520	6,212	6,216	6,624	6,630	0	0	-34,384	-12,008	-14,436
2006	69,817	69,817	-13,191	-12,769	2,027	3,614	46,429	46,440	2,843	2,861	0	0	24,407	3,949	-2,688
2007	150,366	150,366	-21,009	-19,962	-7,796	-6,721	96,729	96,736	1,167	1,208	0	0	24,069	-6,367	-7,132
2008	178,658	178,658	-23,951	-22,761	-14,153	-12,811	113,901	113,943	-2,209	-2,125	0	0	48,762	3,822	2,099
2009	135,903	135,903	-46,916	-45,195	-5,945	-4,740	88,198	88,236	-14,681	-14,605	0	0	-17,190	-3,981	7,362
2010	211,026	211,026	-32,156	-30,129	-12,631	-11,764	136,591	136,645	-8,088	-7,993	0	0	42,177	6,732	13,066
2011	83,246	83,246	-94,298	-92,275	-37,537	-39,791	36,672	36,681	-55,533	-55,481	-12,671	-12,445	-108,422	-90,823	-11,593
2012	92,854	92,854	12,616	12,777	-6,131	-9,738	44,356	44,356	15,729	16,029	3,811	4,334	57,992	13,565	-16,101
2013	-37,660	-37,660	-45,363	-45,495	-9,919	-9,449	-20,662	-20,662	-32,046	-32,035	-5,314	-5,574	-98,715	-49,719	-9,518
2014	81,516	81,516	11,439	11,371	-140	-555	35,096	35,096	11,948	11,956	-418	-419	101,194	10,849	-7,245
2015	120,356	120,356	-38,188	-38,000	-4,492	-5,743	57,882	57,882	-20,321	-20,305	1,076	919	13,977	-47,873	-17,851
2016	106,390	106,390	-70,094	-69,645	-11,954	-13,918	54,092	54,092	-42,297	-42,274	0	0	-58,081	-75,425	-36,494
2017	299,940	299,940	-18,902	-17,195	-1,971	-2,441	179,461	179,498	-7,500	-7,427	0	0	107,957	1,313	-2,883
Averages															
1951-2017	27,571	27,571	-18,202	-16,687	-3,457	-3,455	15,704	15,711	-1,035	607	-595	-242	-3,013	-6,800	-4,649
1951-1978	7,577	7,577	-4,285	-3,214	-1,726	-1,778	4,313	4,313	2,470	3,337	-853	-179	-1,981	-2,918	-3,271
1979-2005	5,285	5,285	-26,650	-24,398	-2,692	-2,505	2,321	2,331	463	3,608	-92	74	-10,537	-5,182	-4,848
2006-2017	124,368	124,368	-31,668	-30,773	-9,220	-9,505	72,396	72,412	-12,582	-12,516	-1,126	-1,099	11,510	-19,496	-7,415
1985-2017	49,553	49,553	-28,227	-26,589	-4,204	-4,209	28,070	28,084	-4,035	-2,039	-410	-400	2,018	-6,467	-5,377
1985-2005	6,802	6,802	-26,260	-24,198	-1,338	-1,183	2,741	2,754	850	3,948	0	0	-3,407	978	-4,212

Notes:

EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).

EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

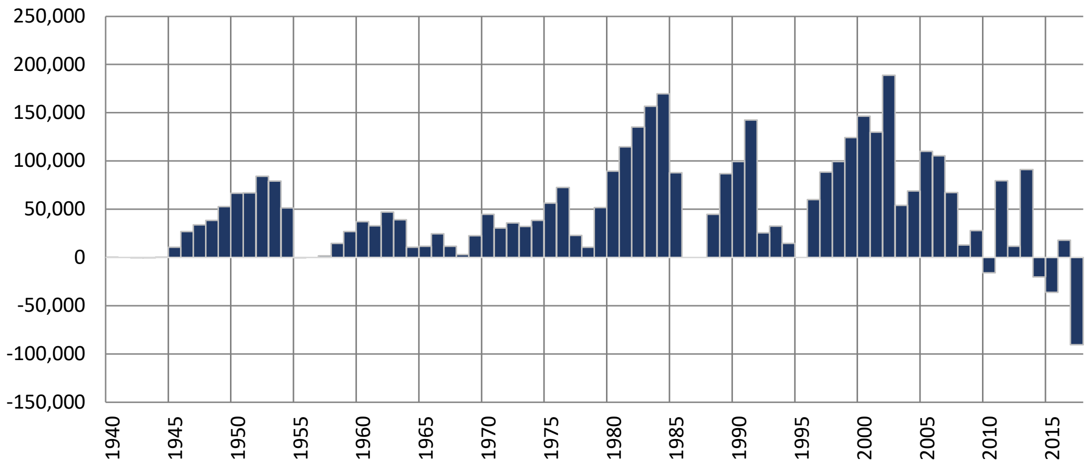
Run 16a - Conj Use 1a: Hist All Acres D1/D2 (1978 M&I)

Simulated Differences in ILRG Model Outputs

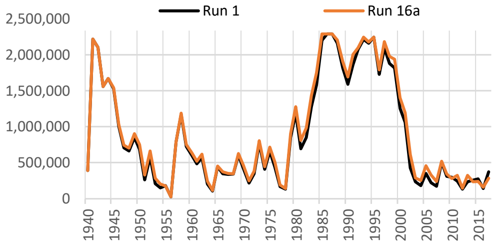
Run 16a minus Run 1

1940 - 2017 (acre-feet)

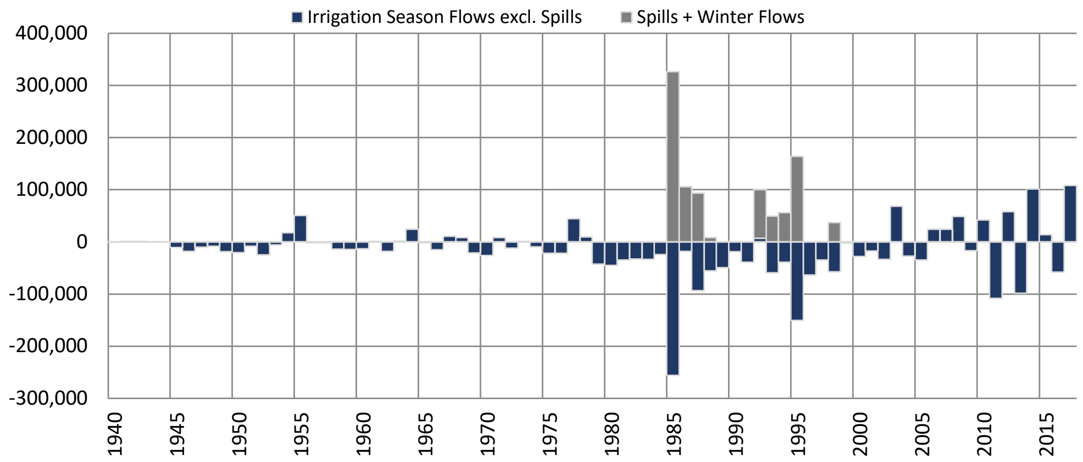
Total Project Storage (Year End)



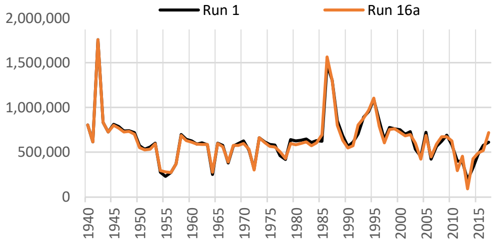
Period	Average Difference
1951-2017	-2,345
1951-1978	-1,996
1979-2005	3,675
2006-2017	-16,703
1985-2017	-7,885
1985-2005	-2,846



Caballo Reservoir Outflows (Annual)



	Average Difference		
Period	Irr Season (excl. Spills)	Nov-Feb and Spills	Annual
1951-2017	-16,926	13,913	-3,013
1951-1978	-1,981	0	-1,981
1979-2005	-45,062	34,525	-10,537
2006-2017	11,510	0	11,510
1985-2017	-26,230	28,248	2,018
1985-2005	-47,797	44,390	-3,407



Notes:

Reservoir storage does not include storage attributed to SJC, CO, or NM credit waters.

Average differences calculated as (Final Storage - Initial Storage)/(no. years).

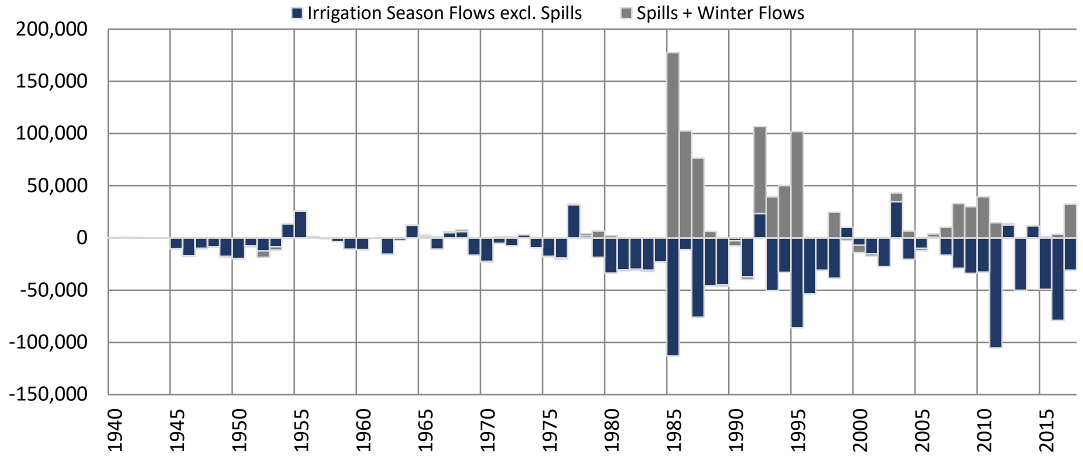
Run 16a - Conj Use 1a: Hist All Acres D1/D2 (1978 M&I)

Simulated Differences in ILRG Model Outputs

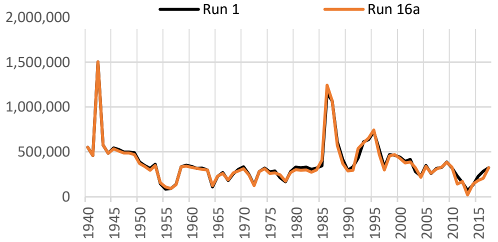
Run 16a minus Run 1

1940 - 2017 (acre-feet)

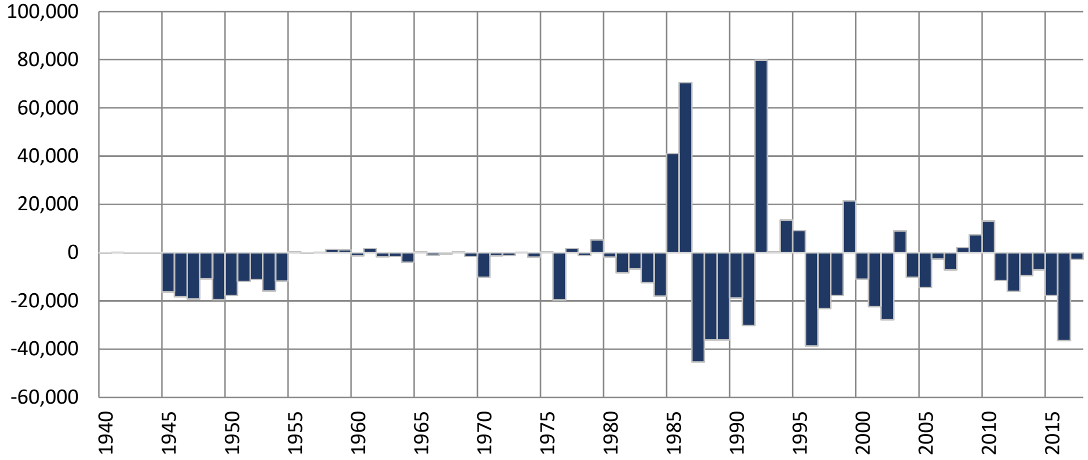
Rio Grande at El Paso (Annual)



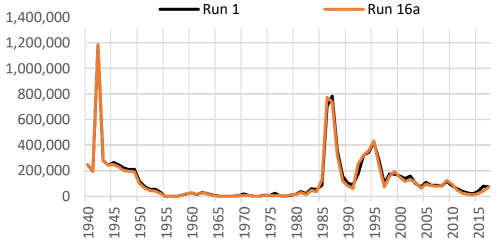
	Average Difference		
Period	Irr Season (excl. Spills)	Nov-Feb and Spills	Annual
1951-2017	-19,143	12,343	-6,800
1951-1978	-2,844	-74	-2,918
1979-2005	-29,667	24,485	-5,182
2006-2017	-33,494	13,997	-19,496
1985-2017	-31,412	24,945	-6,467
1985-2005	-30,222	31,200	978



Rio Grande at Fort Quitman (Annual)



Period	Average Difference
1951-2017	-4,638
1951-1978	-3,263
1979-2005	-4,833
2006-2017	-7,408
1985-2017	-5,367
1985-2005	-4,201



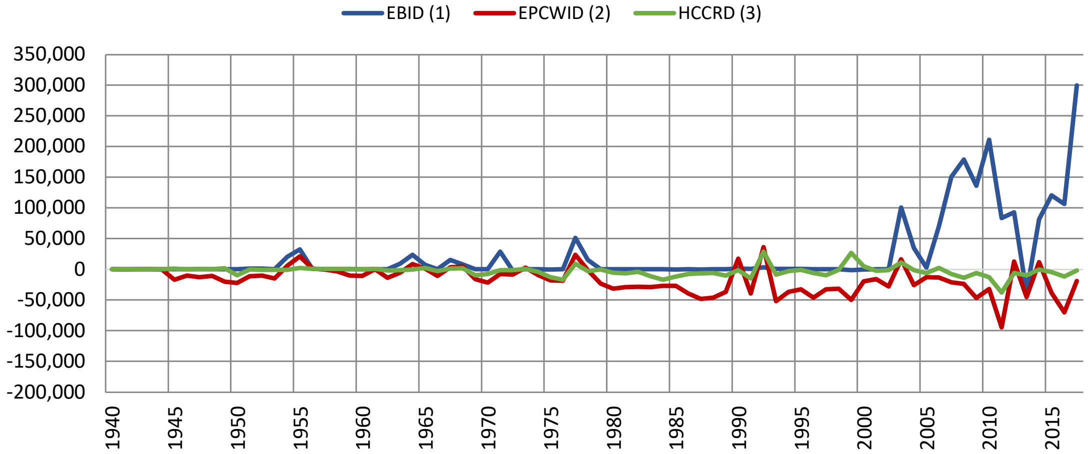
Run 16a - Conj Use 1a: Hist All Acres D1/D2 (1978 M&I)

Simulated Differences in ILRG Model Outputs

Run 16a minus Run 1

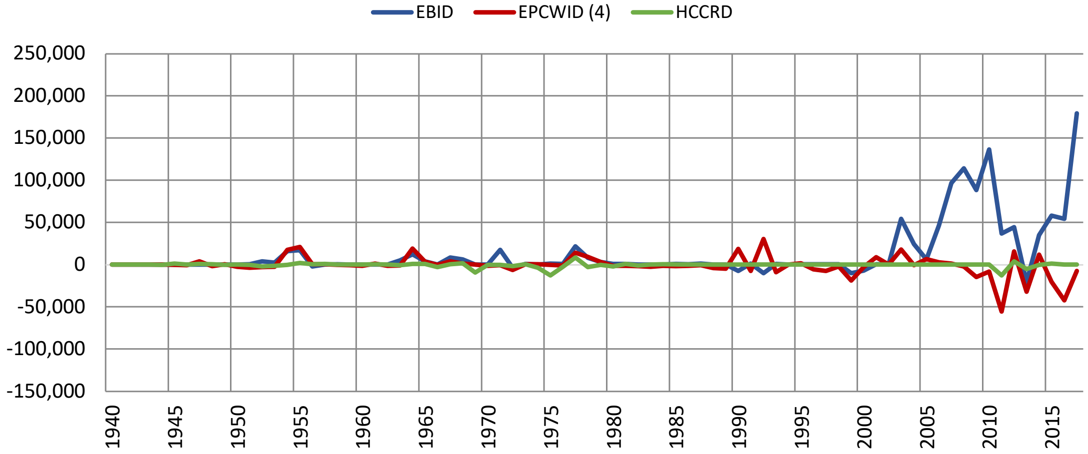
1940 - 2017 (acre-feet)

River Headgate (RHG) Diversions (Irrigation Season)



	Average Difference		
Period	EBID	EPCWID	HCCRD
1951-2017	27,571	-18,202	-3,457
1951-1978	7,577	-4,285	-1,726
1979-2005	5,285	-26,650	-2,692
2006-2017	124,368	-31,668	-9,220
1985-2017	49,553	-28,227	-4,204
1985-2005	6,802	-26,260	-1,338

Farm Headgate (FHG) Deliveries (Irrigation Season)



	Average Difference		
Period	EBID	EPCWID	HCCRD
1951-2017	15,704	-1,035	-595
1951-1978	4,313	2,470	-853
1979-2005	2,321	463	-92
2006-2017	72,396	-12,582	-1,126
1985-2017	28,070	-4,035	-410
1985-2005	2,741	850	0

Notes:

(1) EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).

(2) EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

(3) HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

(4) EPCWID FHG values include deliveries to Rogers WTP and R/U WTP.

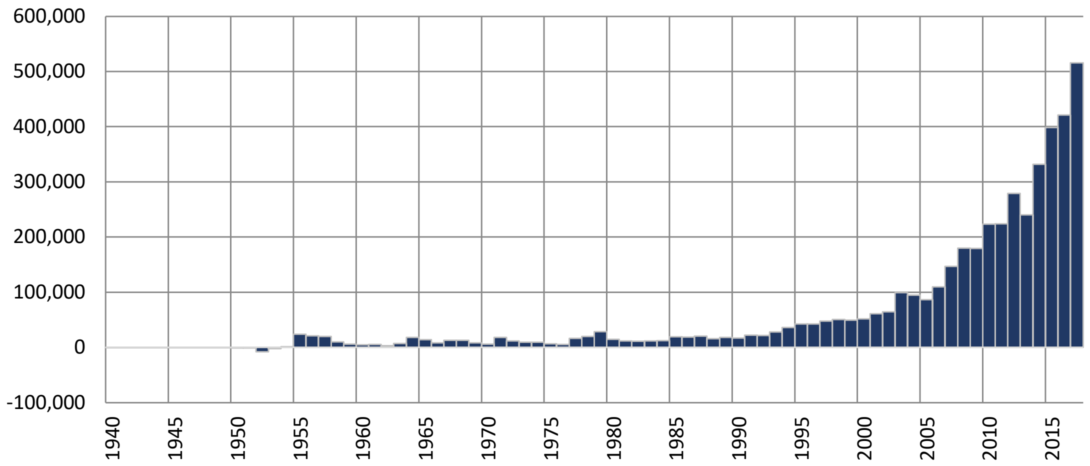
Run 16a - Conj Use 1a: Hist All Acres D1/D2 (1978 M&I)

Simulated Differences in ILRG Model Outputs

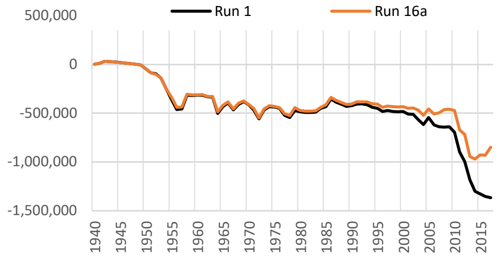
Run 16a minus Run 1

1940 - 2017 (acre-feet)

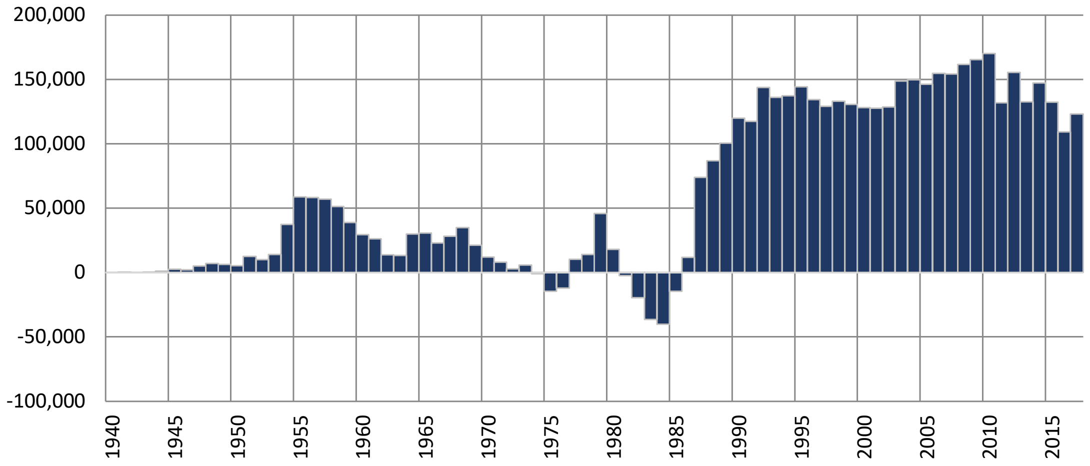
Cumulative Annual Rincon-Mesilla Groundwater Storage



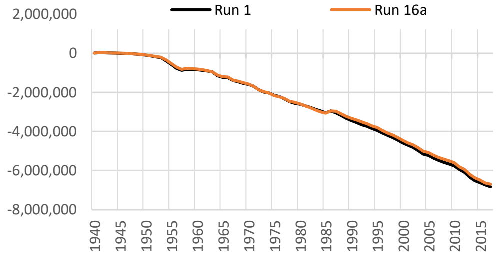
Period	Average Difference
1951-2017	7,710
1951-1978	738
1979-2005	2,470
2006-2017	35,772
1985-2017	15,253
1985-2005	3,528



Cumulative Annual Hueco Groundwater Storage



Period	Average Difference
1951-2017	1,761
1951-1978	318
1979-2005	4,891
2006-2017	-1,915
1985-2017	4,955
1985-2005	8,880



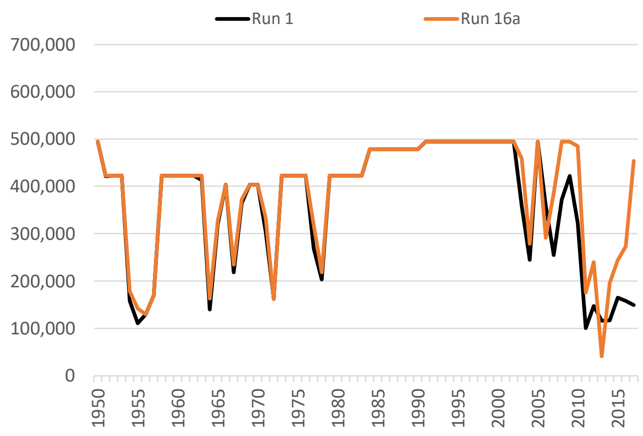
Notes:

Cumulative storage change in alluvial and non-alluvial aquifers.

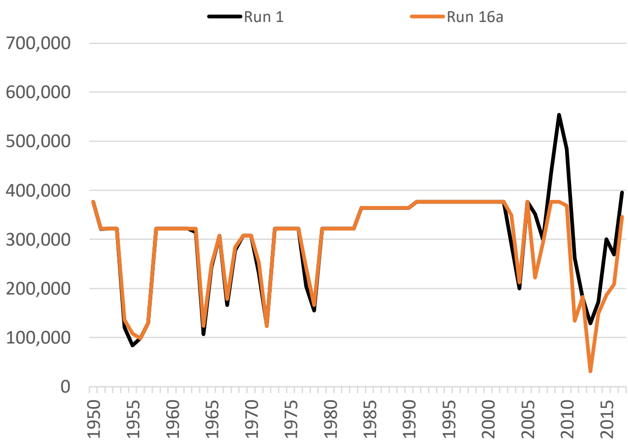
Average differences calculated as (Final Storage - Initial Storage)/(no. years).

Run 16a - Conj Use 1a: Hist All Acres D1/D2 (1978 M&I)
Annual Allocation and Charges
Run 16a v. Run 1
ILRG Model
1950 - 2017 (acre-feet)

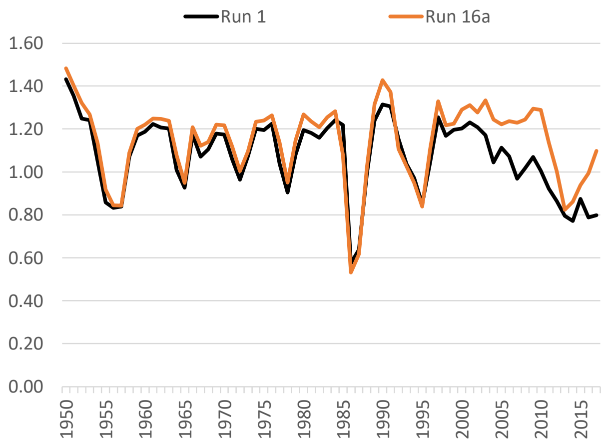
Total Allocation - EBID



Total Allocation - EPCWID

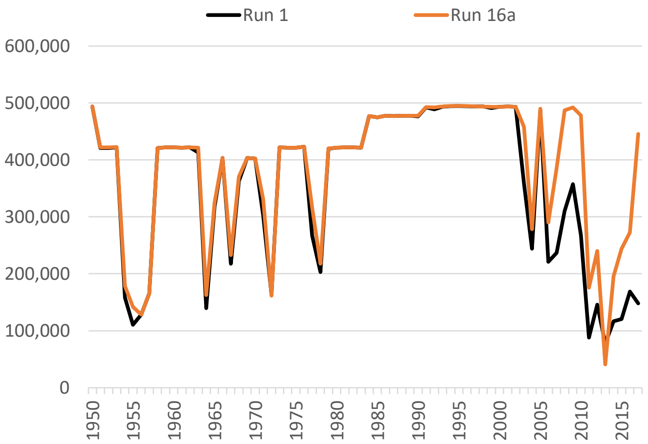


Diversion Ratio

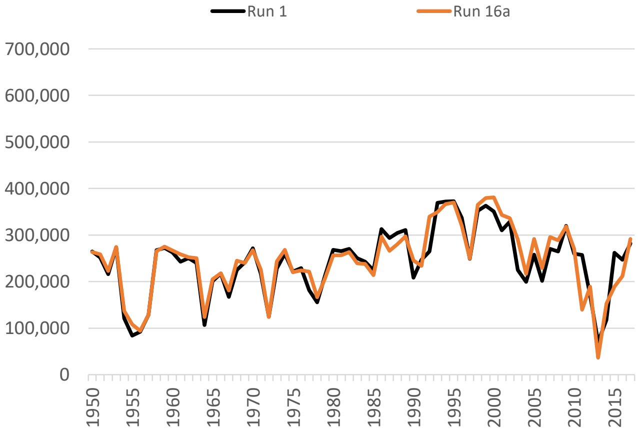


Note:
Computed as Total Charges/Caballo Release.

Annual Delivery Charges - EBID

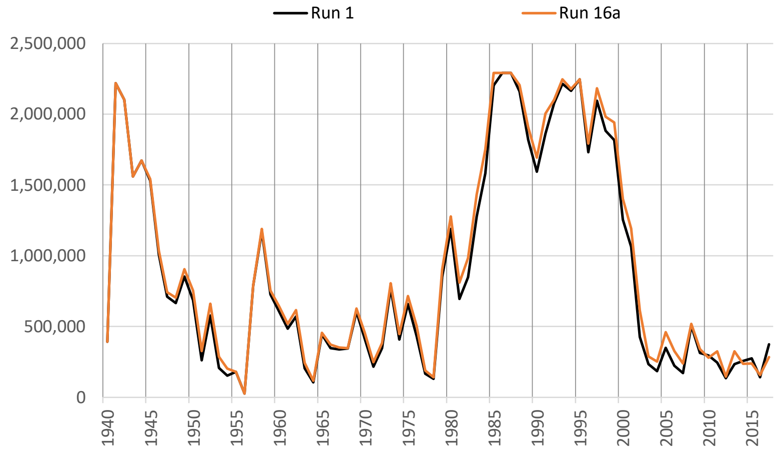


Annual Delivery Charges - EPCWID

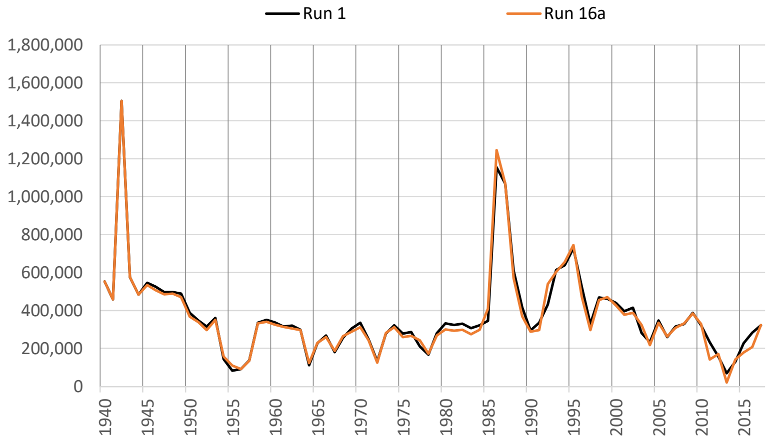


Run 16a - Conj Use 1a: Hist All Acres D1/D2 (1978 M&I)
Annual Summary of Project Storage and Rio Grande Flows
Run 16a v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

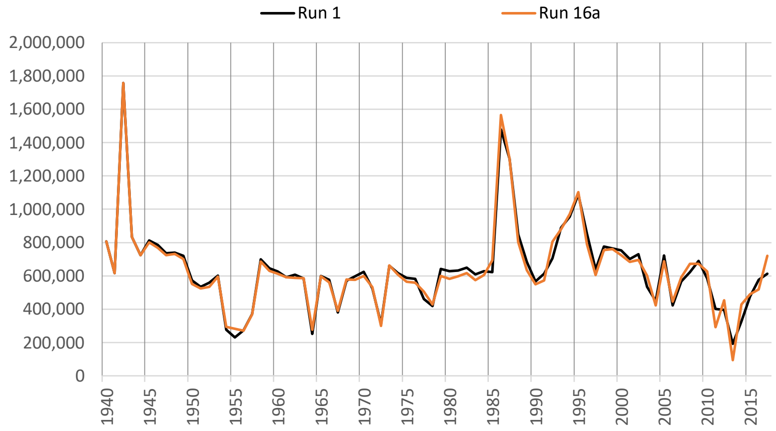
Total Year-End Project Reservoir Storage



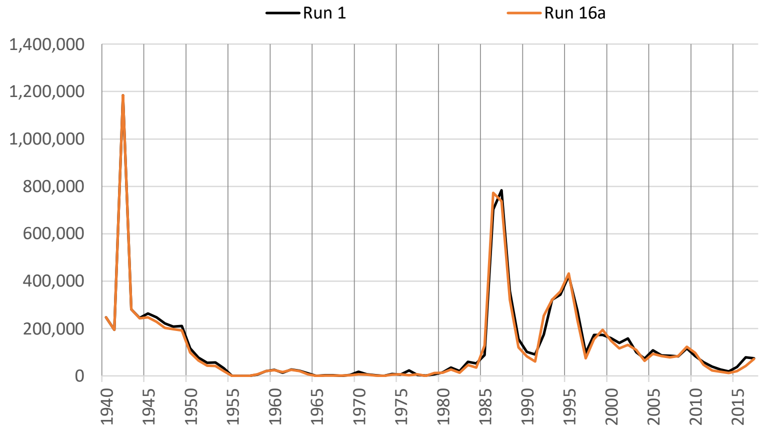
Rio Grande at El Paso



Rio Grande Below Caballo



Rio Grande at Fort Quitman

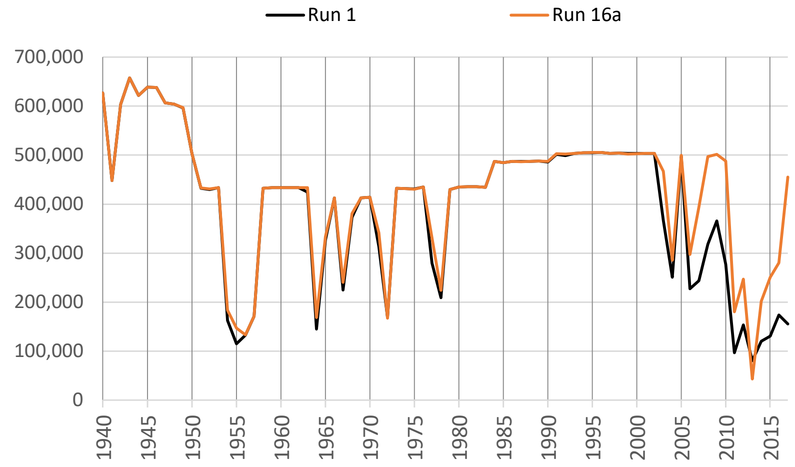


***Note different scales.**

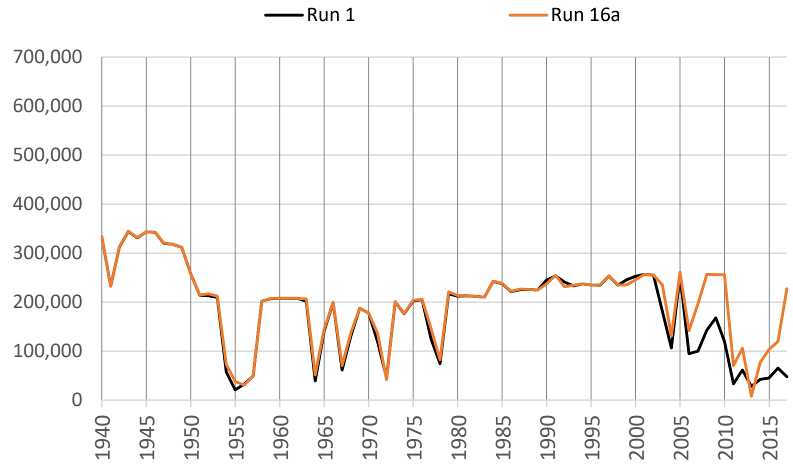
Run 16a - Conj Use 1a: Hist All Acres D1/D2 (1978 M&I)
Irrigation Season Summary of Irrigation Operations
Run 16a v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

EBID Total

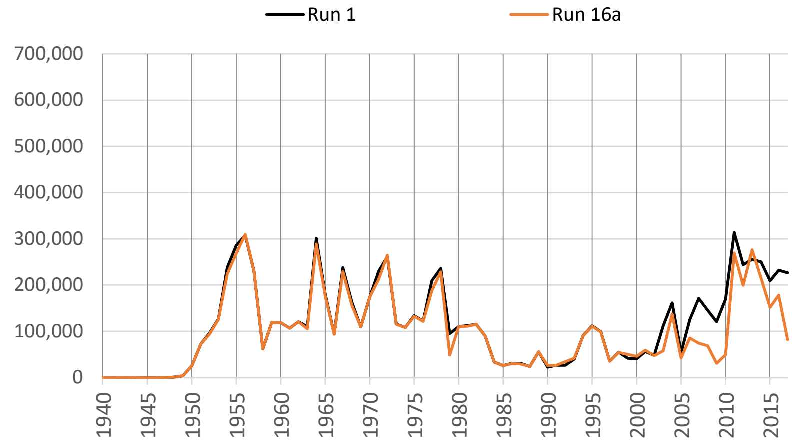
Net River Headgate Diversions



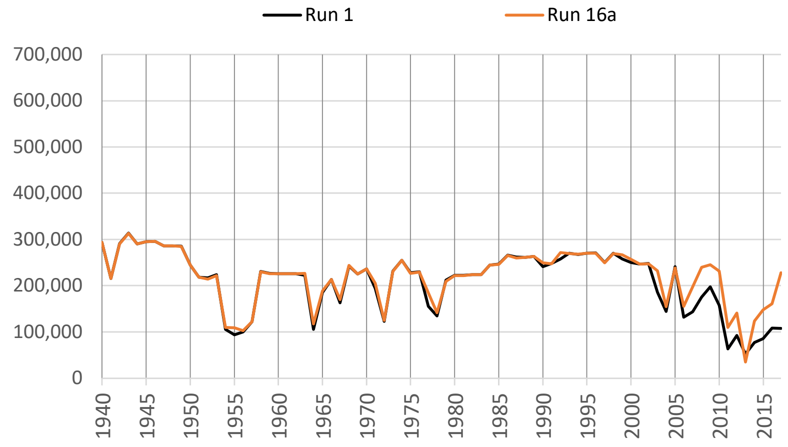
Farm Headgate Deliveries



Pumping



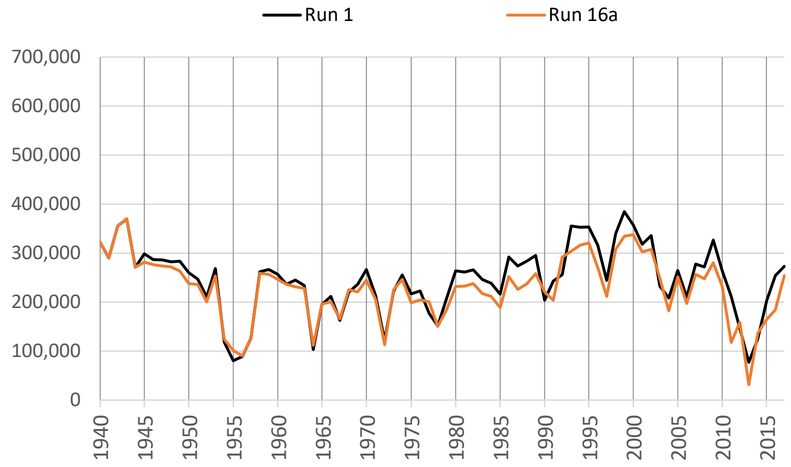
RHG Diversions - FHG Deliveries

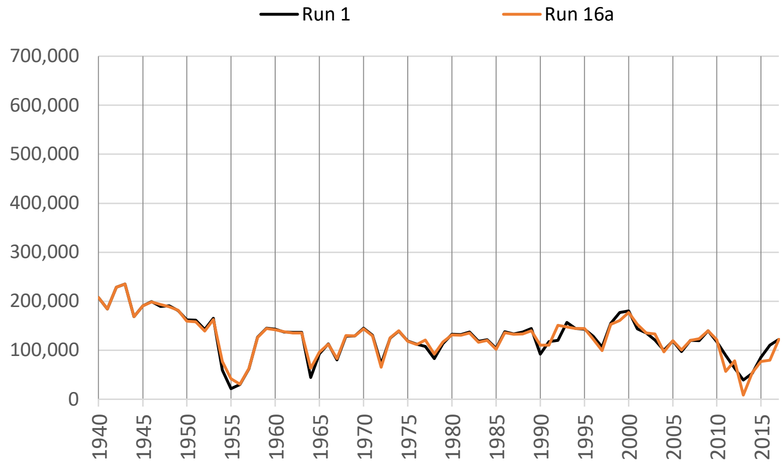


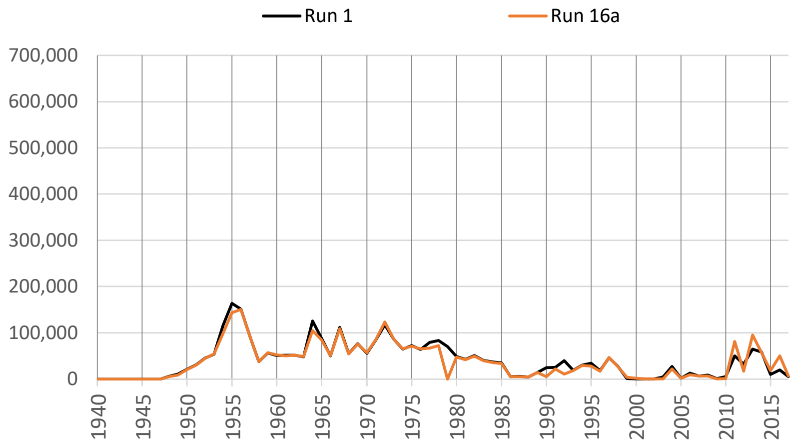
Notes: EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).
Pumping includes Supplemental and Primary groundwater pumping.

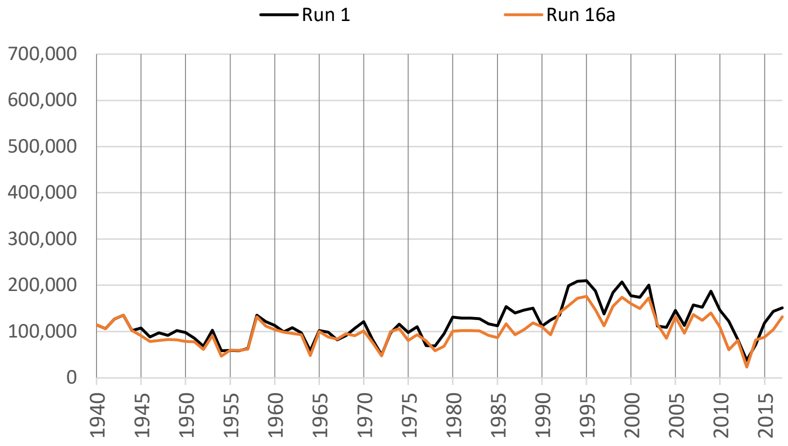
Run 16a - Conj Use 1a: Hist All Acres D1/D2 (1978 M&I)
Irrigation Season Summary of Irrigation Operations
Run 16a v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

EPCWID Total


Net River Headgate Diversions


Farm Headgate Deliveries


Pumping

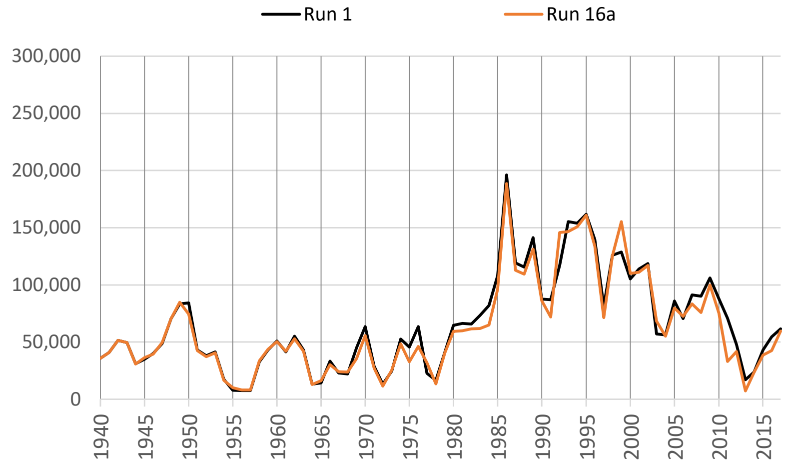

RHG Diversions - FHG Deliveries

Note: EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

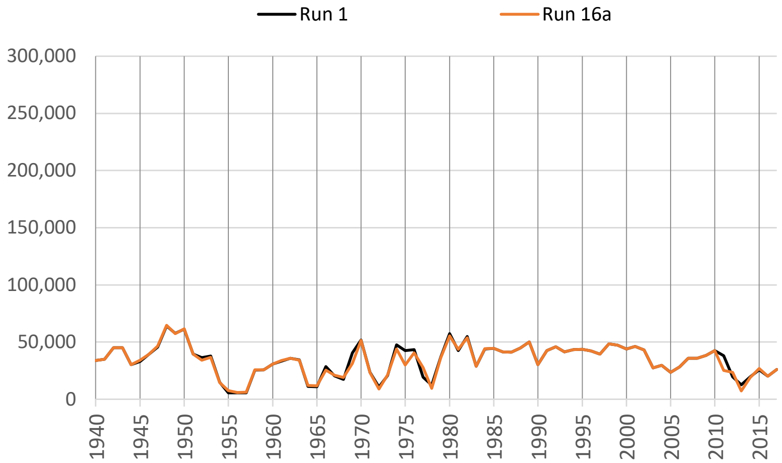
Run 16a - Conj Use 1a: Hist All Acres D1/D2 (1978 M&I)
Irrigation Season Summary of Irrigation Operations
Run 16a v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

HCCRD Total

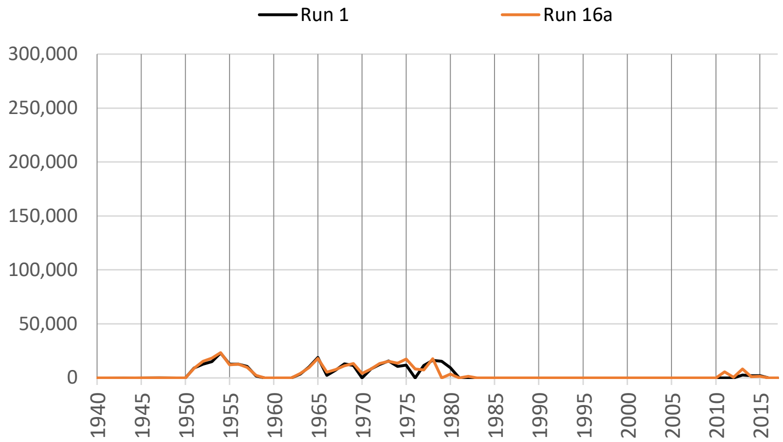
Net River Headgate Diversions



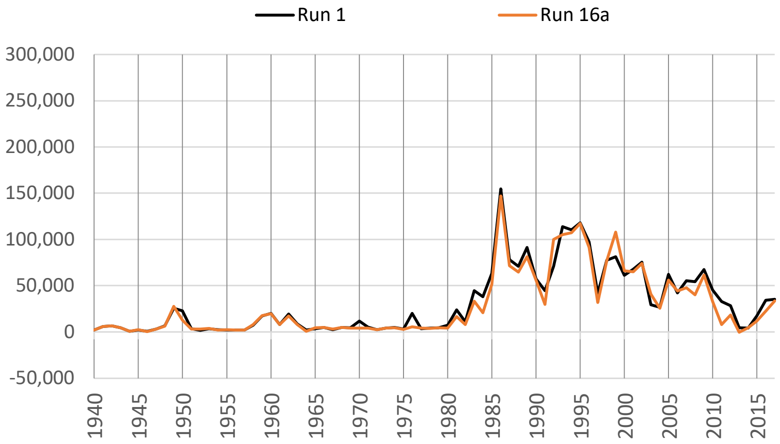
Farm Headgate Deliveries



Pumping



RHG Diversions - FHG Deliveries



Note: HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

Run 16a - Conj Use 1a: Hist All Acres D1/D2 (1978 M&I)

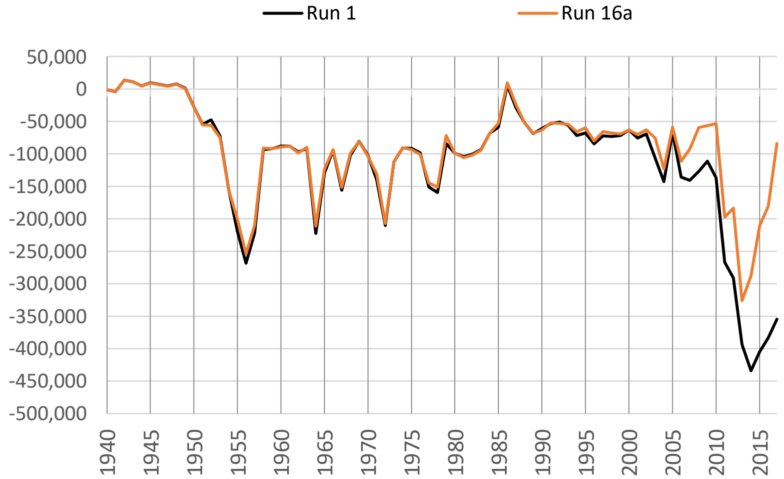
Cumulative Change in Ground Water Storage

Run 16a v. Run 1

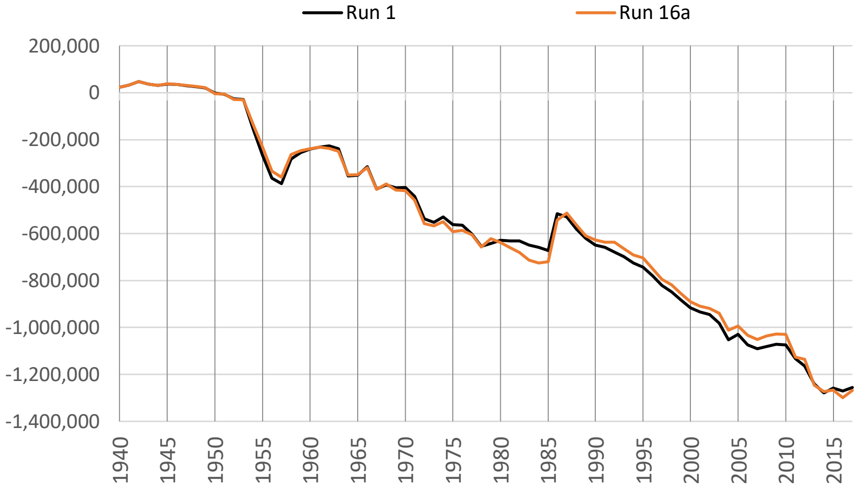
ILRG Model

1940 - 2017 (acre-feet)

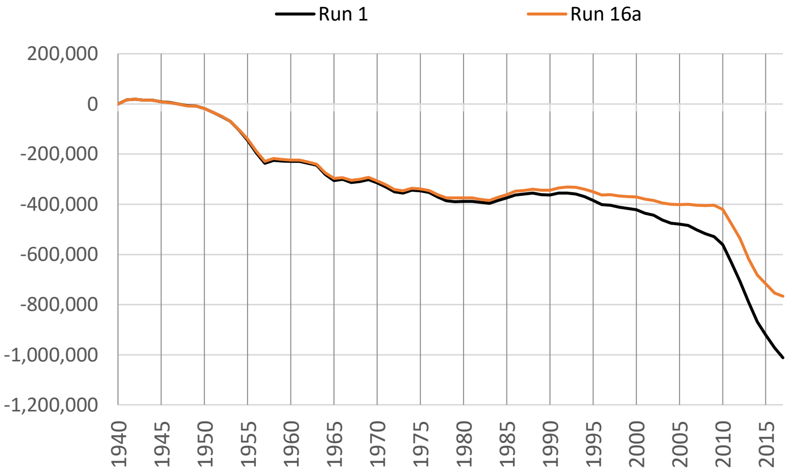
Rincon-Mesilla Alluvial Aquifer



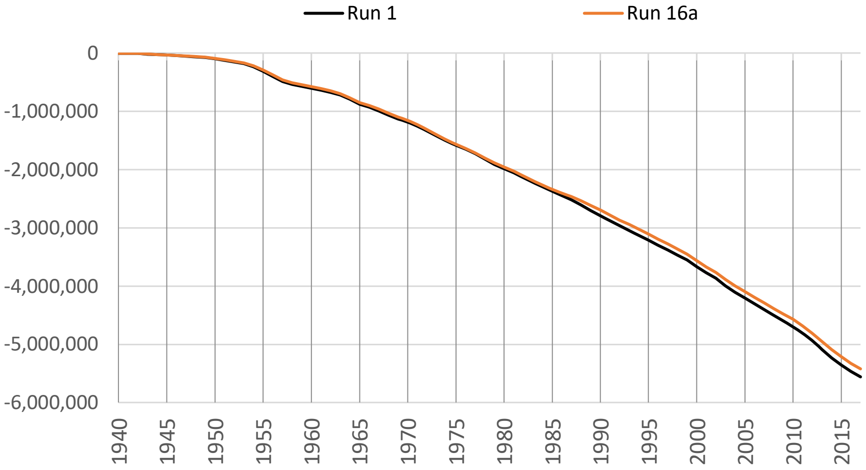
Hueco Alluvial Aquifer



Rincon-Mesilla Non-Alluvial Aquifer



Hueco Non-Alluvial Aquifer



***Note different scales.**

Run 16a - Conj Use 1a: Hist All Acres D1/D2 (1978 M&I)

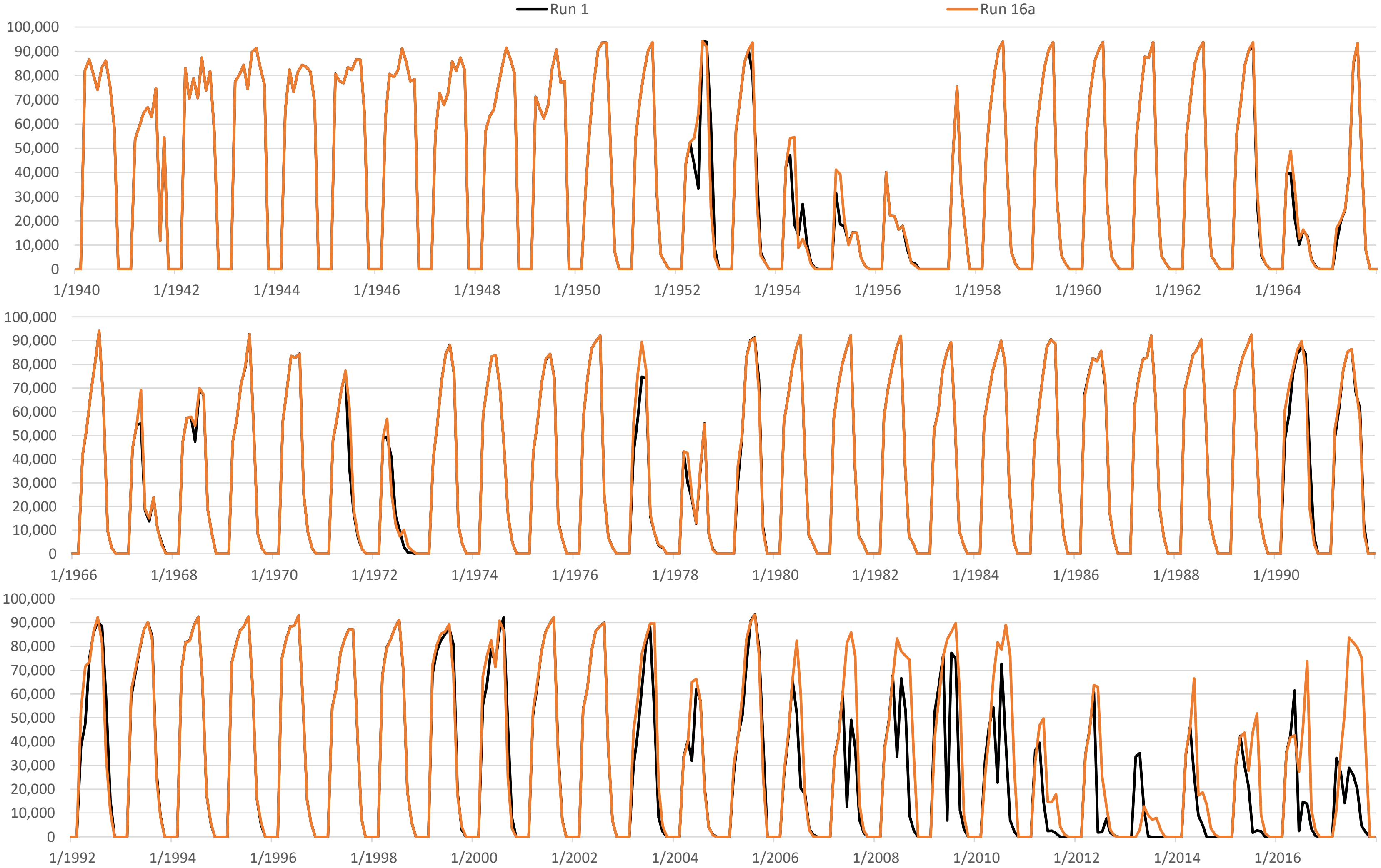
Monthly Net RHG Diversions

Run 16a v. Run 1

ILRG Model

1940 - 2017 (acre-feet)

EBID Total



Note: EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).

Run 16a - Conj Use 1a: Hist All Acres D1/D2 (1978 M&I)

Monthly Net RHG Diversions

Run 16a v. Run 1

ILRG Model

1940 - 2017 (acre-feet)

EPCWID Total

Note: EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

Run 16a - Conj Use 1a: Hist All Acres D1/D2 (1978 M&I)

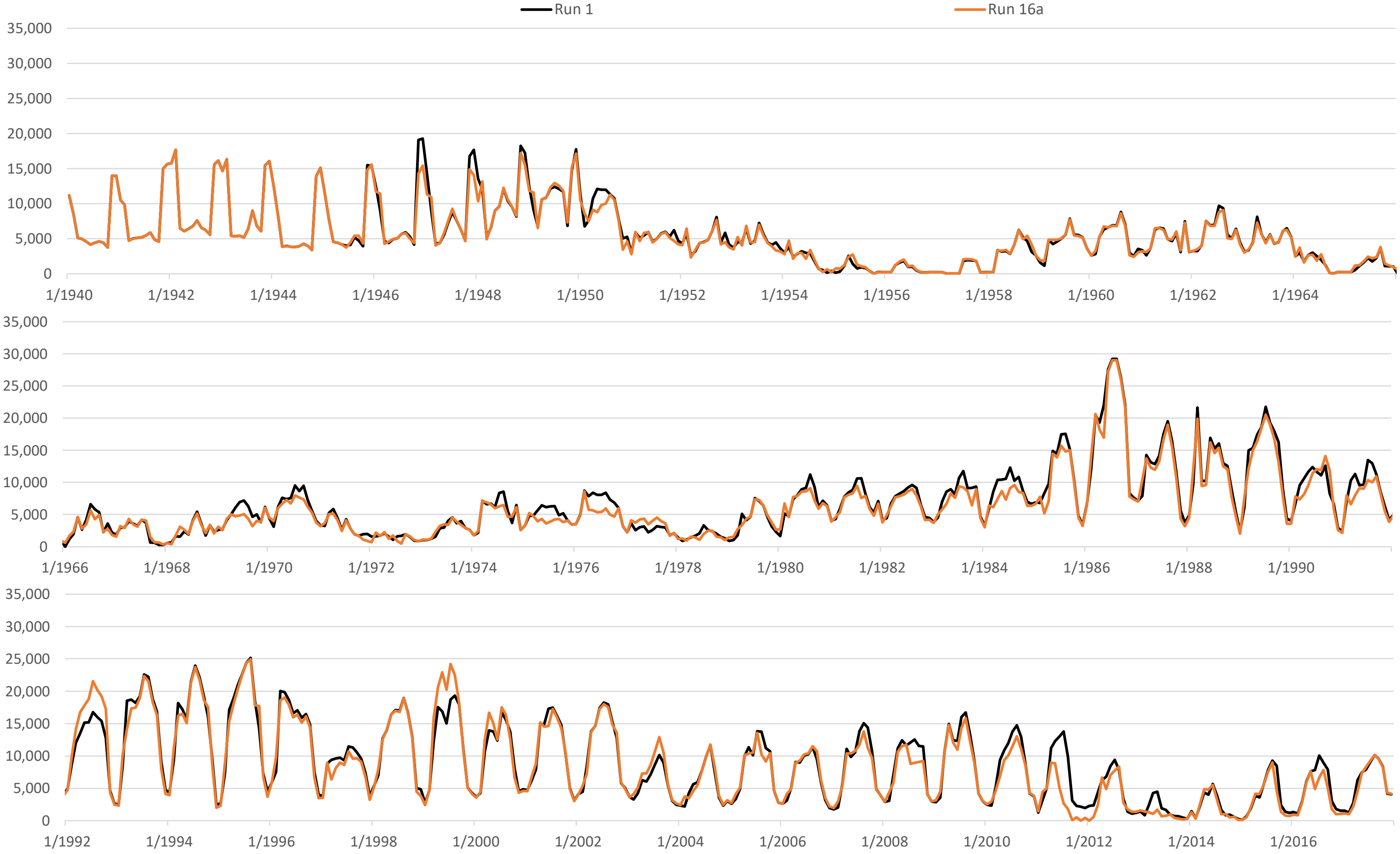
Monthly Net RHG Diversions

Run 16a v. Run 1

ILRG Model

1940 - 2017 (acre-feet)

HCCRD Total



Note: HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

Run 16a - Conj Use 1a: Hist All Acres D1/D2 (1978 M&I)

End of Month Reservoir Storage (Elephant Butte + Caballo)

Run 16a v. Run 1

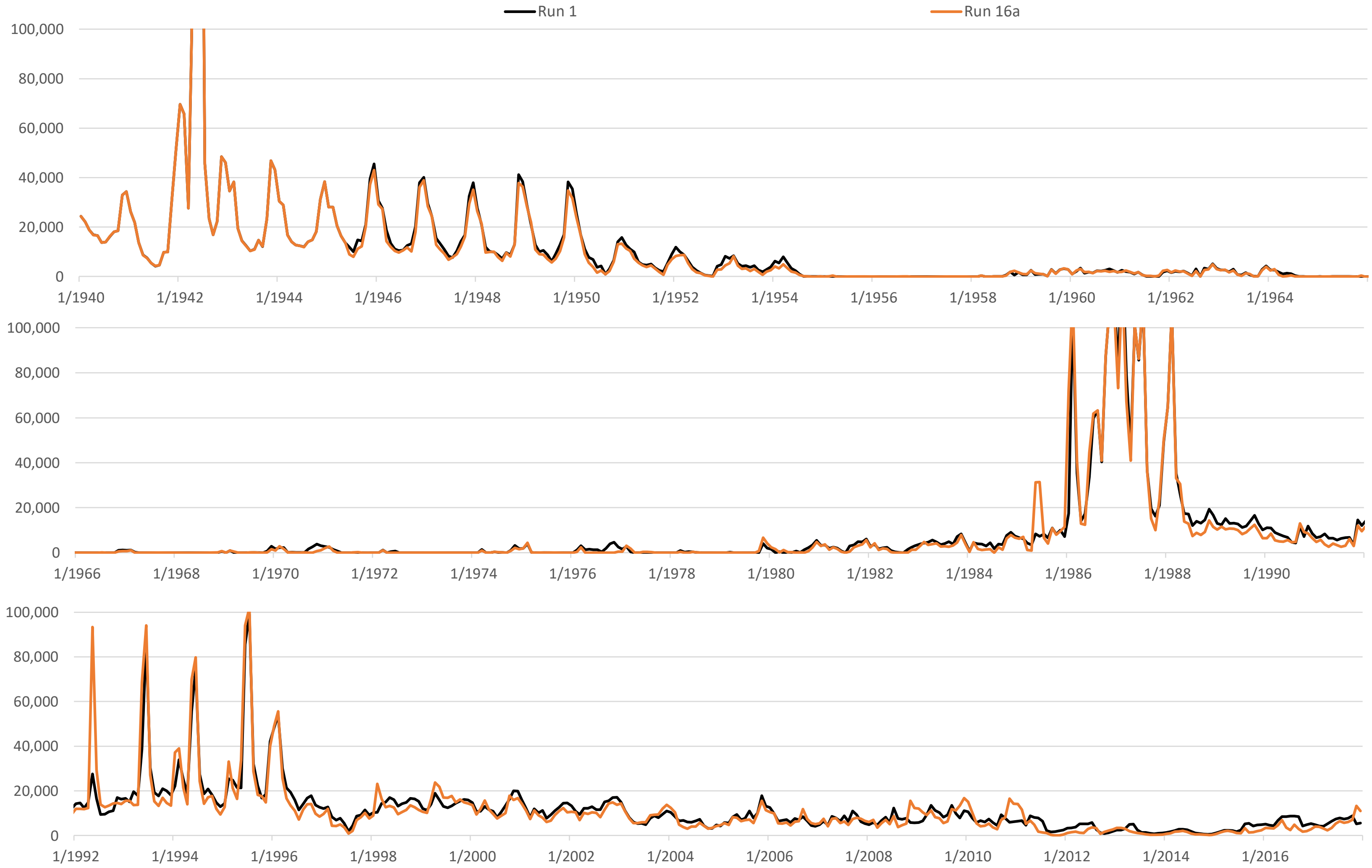
ILRG Model

1940 - 2017 (acre-feet)

Run 16a - Conj Use 1a: Hist All Acres D1/D2 (1978 M&I)
Monthly Caballo Releases
Run 16a v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

Run 16a - Conj Use 1a: Hist All Acres D1/D2 (1978 M&I)
Monthly Rio Grande at El Paso Flow
Run 16a v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

Run 16a - Conj Use 1a: Hist All Acres D1/D2 (1978 M&I)
Monthly Rio Grande at Fort Quitman Flow
Run 16a v. Run 1
ILRG Model
1940 - 2017 (acre-feet)



Appendix 30Y

Comparison of ILRG Model Runs

Run 17 v. Run 1

Model Run Specifications

Model Version: LRG_v116

Name: **Run 17 - Conj Use 2: Hist Proj Acres (Hist M&I)**

Run ID: LRG_v116_Operational_Run17
Date: 8/28/2020

Name: **Run 1 - Historical Base Run (All Pumping On)**

Run ID: LRG_v116_Operational_Run1
Date: 8/23/2020

Selected Model Inputs

Pumping and Returns	**Run 17**	**Run 1**
(1) Irrigation Pumping	Conj	On
(2) Irrigated Area	Project	Hist
Non-Irrigation Pumping	On	On
Non-Irrigation Pumping Returns	On	On
Las Cruces Jornada Pumping Returns	Off	On

Project Allocation Rules		
1950-2005	D1/D2	D1/D2
2006-2007	D1/D2	D3
2008-2017	D1/D2	D3 + CO

EPCWID Operations		
Charge EPCWID for Use of WWTP Returns	On	Off
ACE and Haskell Credits for EPCWID	Off	On
(3) Increased EPCWID Use of Fabens Drain Flows	On	Off
Charge EPCWID for Fabens Drain Flow Use	On	Off

Notes:

(1) Conjunctive use pumping on historical Project acres; no pumping on NM GW only acres.

(2) Project acres set to historical. New Mexico groundwater only acres set to 0.

(3) Starting in July 1945, use 70% of simulated Fabens drain flow up to 6,000 AF/month.

Run 17 - Conj Use 2: Hist Proj Acres (Hist M&I)

Comparison of ILRG Model Runs

Run 17 v. Run 1

1951 - 2017 Annual Average

(1,000 acre-feet)

Run No.	1	17	17 - 1	
Simulated Input or Output	**Run 1**	**Run 17**	**Run 17 minus Run 1**	
Effects of Alternate Scenario				
FHG Deliveries (Mar - Oct)				***% Diff.***
EBID	167.6	186.0	18.4	*11%*
EPCWID (incl. EPW)	139.9	140.4	0.5	*0%*
HCCRD	32.8	32.6	-0.3	*-1%*
Total	340.3	359.0	18.7	*5%*
FHG Deliveries (Nov - Feb)				
EBID	0.0	0.0	0.0	*59%*
EPCWID (incl. EPW)	0.2	1.9	1.7	*888%*
HCCRD	2.4	2.8	0.4	*16%*
Total	2.6	4.7	2.1	*79%*
Irrigation Pumping				
EBID	140.4	106.4	-34.1	*-24%*
EPCWID (Mesilla Valley)	7.4	6.8	-0.5	*-7%*
EPCWID (El Paso Valley)	40.1	37.9	-2.2	*-6%*
HCCRD	4.2	4.5	0.2	*6%*
Total	192.1	155.5	-36.6	*-19%*
Other Inflows/Outflows				
Net Reservoir Evaporation	125.3	132.1	6.8	*5%*
Riparian ET	70.9	71.3	0.4	*1%*
River Evaporation + Incidental Canal Loss	30.3	31.0	0.7	*2%*
Total	226.6	234.4	7.9	*3%*
Rio Grande at Fort Quitman				
Reservoir Spills	33.3	41.4	8.1	*24%*
Nov-Feb Flows	21.4	20.1	-1.3	*-6%*
Mar - Oct Flows	41.1	33.5	-7.6	*-18%*
Underflow (GW Model)	0.2	0.2	0.0	*0%*
Total	96.0	95.2	-0.8	*-1%*

Run 17 - Conj Use 2: Hist Proj Acres (Hist M&I)

Comparison of ILRG Model Runs

Run 17 v. Run 1

1951 - 2017 Annual Average

(1,000 acre-feet)

Run No.	1	17	17 - 1	
Simulated Input or Output	**Run 1**	**Run 17**	**Run 17 minus Run 1**	
Effects of Alternate Scenario (continued)				
Change in Storage				***% Diff.***
Reservoir Storage	-4.7	-7.0	-2.3	*49%*
Alluvial GW Storage (RW Model)	-23.6	-20.0	3.5	*-15%*
Non-alluvial GW Storage (GW Models)	-96.4	-93.8	2.6	*-3%*
Soil Moisture Storage	0.6	0.8	0.2	*30%*
Total	-124.0	-120.0	4.0	*-3%*
Summary of Effects				
FHG Deliveries (Mar-Oct)	340.3	359.0	18.7	*5%*
FHG Deliveries (Nov-Feb)	2.6	4.7	2.1	*79%*
Irrigation Pumping	192.1	155.5	-36.6	*-19%*
Riparian ET + Evaporation	226.6	234.4	7.9	*3%*
Fort Quitman Flow	96.0	95.2	-0.8	*-1%*
Change in Storage	-124.0	-120.0	4.0	*-3%*
Total	733.6	728.8	-4.8	*-1%*
Other Effects of Alternate Scenario				
Rio Grande at El Paso				***% Diff.***
Reservoir Spills	49.4	61.9	12.5	*25%*
Nov-Feb Flows	22.8	25.7	2.9	*13%*
Mar - Oct Flows	263.8	247.7	-16.1	*-6%*
Total	336.0	335.2	-0.7	*0%*
Rio Grande below Caballo				
Reservoir Spills	65.9	81.4	15.5	*24%*
Nov-Feb Flows	0.5	0.4	-0.1	*-14%*
Mar - Oct Flows	541.3	521.2	-20.0	*-4%*
Total	607.6	603.0	-4.6	*-1%*
Surface Water Diversions (Mar - Oct)				
EBID	366.5	397.1	30.6	*8%*
EPCWID (incl. EPW)	236.8	220.4	-16.4	*-7%*
HCCRD	67.5	64.8	-2.8	*-4%*
Total	670.8	682.3	11.5	*2%*
Surface Water Diversions (Nov - Feb)				
EBID	0.0	0.0	0.0	*0%*
EPCWID (incl. EPW)	14.3	16.2	1.8	*13%*
HCCRD	14.2	14.4	0.2	*2%*
Total	28.5	30.6	2.1	*7%*

Run 17 - Conj Use 2: Hist Proj Acres (Hist M&I)

Annual Differences in ILRG Model Outputs

Run 17 minus Run 1

1940 - 2017 (acre-feet)

	Net River Headgate Diversions						Farm Headgate Deliveries						Annual Flows		
	EBID		EPCWID (incl. EPW)		HCCRD		EBID		EPCWID (incl. EPW)		HCCRD				
Year	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Caballo Releases	Rio Grande at El Paso	Rio Grande at Fort Quitman
1940	-53	-53	7	0	1	-3	-2	-2	3	3	1	1	-47	-22	-56
1941	-161	-161	1	-4	-2	-3	-4	-4	-1	0	-1	-4	39	69	15
1942	-32	-32	1	-3	0	0	0	0	3	8	0	-1	28	9	-24
1943	-64	-64	-5	-7	3	3	-14	-14	-13	-13	3	0	-23	-11	-51
1944	-81	-81	-143	-136	-73	-72	-5	-5	17	-1	-62	-64	-161	-154	-77
1945	2	2	-17,009	-5,529	1,397	918	-53	-53	-309	6,372	1,082	989	-10,931	-10,413	-16,332
1946	36	36	-10,387	-11,148	-392	-7,349	-110	-111	-718	3,359	-75	-239	-18,237	-17,651	-18,286
1947	56	56	-12,882	-6,764	698	-5,758	-15	-15	3,974	11,138	922	1,018	-10,315	-10,391	-19,245
1948	-731	-731	-10,605	-6,629	136	-4,668	443	446	-1,907	4,651	410	237	-9,038	-8,638	-10,948
1949	-1,761	-1,761	-20,135	-15,464	1,552	3,218	87	93	574	6,443	-292	-545	-21,157	-18,336	-19,823
1950	34	34	-22,030	-18,087	-9,742	-11,051	1,090	1,092	-2,643	2,575	239	421	-21,480	-18,949	-17,136
1951	1,030	1,030	-11,183	-5,661	-628	-2,813	1,865	1,866	-3,429	1,783	-195	-2,179	-12,503	-7,038	-11,101
1952	1,131	1,131	-10,202	-6,873	-840	-2,131	5,988	5,984	-2,937	55	-2,250	534	-33,323	-17,725	-10,510
1953	387	387	-14,992	-11,598	-831	-1,994	4,103	4,101	-2,469	512	-1,235	636	-12,609	-8,862	-15,405
1954	32,647	32,647	13,668	15,715	-601	655	20,961	20,961	24,601	25,602	341	1,572	37,156	27,455	-10,091
1955	29,822	29,822	18,441	19,808	2,654	2,913	15,997	15,997	20,866	20,792	2,878	3,108	34,917	25,155	474
1956	7,900	7,900	7,772	7,928	1,288	1,255	-347	-347	3,666	3,545	1,017	846	8,703	8,292	-25
1957	35	35	-697	169	457	391	226	226	607	544	574	435	-4,879	608	-2
1958	-38	-38	-4,528	-4,067	456	1,873	1,977	1,977	-112	-206	-83	-68	-37,931	-2,324	1,570
1959	-1	-1	-11,806	-11,047	783	2,240	1,713	1,713	-647	-389	6	23	-27,509	-10,021	2,161
1960	10	10	-10,956	-10,145	-495	-584	1,633	1,633	-1,459	-829	0	0	-22,995	-10,388	-473
1961	9	9	-406	1,053	715	1,027	1,578	1,579	1,116	2,320	661	-446	-9,699	353	2,311
1962	24	24	-14,159	-12,401	-2,058	-2,097	1,652	1,653	-1,520	-197	17	-306	-27,690	-14,796	-1,450
1963	8,883	8,883	-6,126	-3,827	-1,228	-1,423	6,384	6,385	-966	906	-486	-485	-3,356	3,567	-1,084
1964	32,095	32,095	10,297	11,602	427	1,292	26,437	26,437	20,253	20,886	1,432	1,363	21,471	19,095	-3,500
1965	39,578	39,578	15,846	15,836	3,136	3,537	21,668	21,668	18,431	18,382	2,607	3,028	23,229	24,537	1,369
1966	1,316	1,316	17,465	19,815	9,730	10,903	-8,659	-8,659	15,537	16,654	-2,495	-2,851	-7,166	25,577	16,069
1967	23,405	23,405	8,722	10,525	2,502	3,634	13,029	13,029	11,334	11,497	1,984	1,998	16,387	12,407	1,414
1968	10,724	10,724	661	2,487	2,693	2,114	9,434	9,434	1,929	1,650	2,665	2,209	-5,852	7,439	1,152
1969	-34	-34	-17,854	-16,949	-8,961	-7,873	1,927	1,927	-268	73	-8,329	-6,852	-33,641	-16,532	-868
1970	-18	-18	-22,589	-21,352	-7,268	-6,453	1,276	1,276	-1,434	-583	100	4,592	-36,576	-22,740	-9,632
1971	53,002	53,002	27,446	29,994	9,350	9,209	20,679	20,679	16,667	18,077	7,697	7,820	46,234	40,940	5,372
1972	-5,536	-5,536	-12,267	-10,906	-711	357	-5,035	-5,035	-6,798	-6,345	-895	215	-26,595	-10,821	-917
1973	-68	-68	2,143	2,165	800	959	2,261	2,261	735	550	738	759	-11,345	2,948	32
1974	-53	-53	-9,412	-8,767	-4,002	-3,882	1,740	1,740	459	763	-3,542	-2,322	-19,860	-8,131	-1,527
1975	-206	-206	-18,674	-17,751	-12,501	-11,800	1,768	1,769	-570	51	-12,167	-12,058	-30,996	-16,774	708
1976	-15	-15	-18,687	-17,508	-17,167	-17,134	2,301	2,302	-814	-15	-2,355	3,911	-31,508	-19,194	-19,452
1977	77,828	77,828	24,370	27,562	9,162	10,572	37,684	37,684	14,809	16,595	8,543	10,358	51,789	37,961	1,995
1978	35,367	35,367	5,548	10,021	-2,418	-714	20,102	20,102	15,457	16,966	-2,118	-478	19,422	17,950	-1,016

Run 17 - Conj Use 2: Hist Proj Acres (Hist M&I)

Annual Differences in ILRG Model Outputs

Run 17 minus Run 1

1940 - 2017 (acre-feet)

	Net River Headgate Diversions						Farm Headgate Deliveries						Annual Flows		
	EBID		EPCWID (incl. EPW)		HCCRD		EBID		EPCWID (incl. EPW)		HCCRD				
Year	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Caballo Releases	Rio Grande at El Paso	Rio Grande at Fort Quitman
1979	720	720	-7,256	-5,046	-2,338	-689	154	156	7,551	8,874	-2,200	-547	-36,132	-6,325	-22
1980	-14	-14	-24,317	-22,038	-4,584	-3,273	2,140	2,141	-243	1,641	-1,154	-407	-40,650	-24,511	-4,357
1981	-100	-100	-27,561	-24,583	-6,124	-6,578	2,618	2,618	-1,173	1,946	926	1,234	-43,512	-28,550	-7,465
1982	-50	-50	-29,001	-25,819	-4,172	-4,571	1,679	1,679	-1,741	1,835	-1,159	872	-44,793	-30,123	-6,181
1983	-40	-40	-28,876	-26,195	-11,283	-11,438	1,728	1,729	-2,403	625	0	0	-44,345	-30,437	-11,899
1984	-147	-147	-26,551	-24,114	-16,732	-17,020	2,090	2,094	-1,309	1,952	356	356	-31,756	-20,359	-16,617
1985	-316	-316	-28,709	-26,291	-6,336	-5,902	-138	-131	-1,355	1,668	0	0	104,758	108,717	70,535
1986	-113	-113	-41,920	-40,555	-5,674	-4,222	2,612	2,631	-1,899	-123	0	0	87,161	102,665	82,595
1987	-514	-514	-52,256	-49,488	-7,438	-6,591	2,677	2,688	-713	3,425	0	0	-219	9,749	-5,380
1988	-101	-101	-50,254	-46,902	-6,789	-6,293	2,199	2,206	-4,720	-7	0	0	-57,573	-40,326	-32,309
1989	4	4	-43,683	-39,058	-12,023	-12,608	2,015	2,019	-5,771	522	0	0	-54,203	-41,928	-29,445
1990	961	961	14,044	18,123	-2,040	-2,064	-5,780	-5,777	18,301	24,124	0	0	-27,521	-8,001	-16,961
1991	856	856	-39,780	-36,102	-15,108	-15,226	3,181	3,185	-7,905	-2,174	0	0	-45,547	-37,642	-26,808
1992	3,062	3,062	36,945	39,809	29,516	30,312	-8,096	-8,102	31,444	36,066	0	0	121,075	136,620	111,402
1993	468	468	-51,861	-47,677	-8,035	-8,202	3,272	3,274	-8,774	-2,150	0	0	-5,948	612	10,538
1994	393	393	-36,337	-33,145	-3,005	-2,818	2,606	2,616	240	5,238	0	0	11,521	22,670	19,668
1995	892	892	-32,246	-28,358	-656	-789	2,797	2,800	1,936	8,295	0	0	18,098	29,893	22,099
1996	-78	-78	-45,928	-43,282	-5,735	-4,932	2,578	2,578	-5,626	-1,471	0	0	-71,383	-51,045	-36,621
1997	3	3	-32,585	-29,901	-9,926	-10,992	2,248	2,253	-7,355	-2,249	0	0	-38,880	-28,214	-21,758
1998	-49	-49	-31,635	-29,490	-498	-1,434	2,834	2,839	-1,921	1,618	0	0	-18,158	-4,363	-8,080
1999	-1,301	-1,301	-49,705	-48,648	26,570	26,035	-8,610	-8,609	-18,835	-17,311	0	0	-6,139	10,833	24,095
2000	-392	-392	-19,739	-19,814	4,962	4,638	-5,373	-5,372	-2,994	-3,013	0	0	-31,962	-11,492	-8,533
2001	288	288	-15,654	-15,845	-2,558	-2,321	2,249	2,250	8,968	8,961	0	0	-20,922	-15,075	-20,505
2002	-55	-55	-27,797	-27,738	-1,556	-604	2,506	2,507	33	36	0	0	-38,045	-24,673	-24,785
2003	111,630	111,630	17,543	17,830	11,433	12,637	62,374	62,375	18,816	18,841	0	0	76,621	52,295	15,104
2004	39,350	39,350	-22,973	-21,780	-524	1,645	28,483	28,484	1,453	1,476	0	0	-26,544	-7,097	-6,046
2005	2,705	2,705	-12,787	-12,447	-5,869	-4,916	7,702	7,700	7,078	7,082	0	0	-40,544	-10,601	-11,648
2006	76,905	76,905	-11,188	-10,660	2,202	3,849	51,465	51,466	4,622	4,640	0	0	27,754	8,595	-697
2007	158,420	158,420	-15,535	-14,441	-7,290	-5,990	102,912	102,912	4,731	4,775	0	0	28,136	-195	-4,396
2008	178,407	178,407	-24,607	-23,296	-13,732	-12,149	115,244	115,280	-1,947	-1,863	0	0	42,673	4,780	4,570
2009	135,714	135,714	-46,367	-44,647	-5,779	-4,527	89,666	89,685	-14,269	-14,194	0	0	-20,593	-2,403	9,175
2010	219,126	219,126	-30,915	-28,893	-12,254	-11,324	143,121	143,170	-7,016	-6,917	0	0	50,294	13,025	17,032
2011	86,936	86,936	-91,647	-89,526	-36,700	-38,784	39,196	39,198	-53,613	-53,562	-12,017	-11,731	-112,225	-87,508	-10,096
2012	98,153	98,153	16,038	16,264	-4,991	-8,345	47,721	47,721	17,875	18,105	4,724	5,334	58,728	16,350	-14,678
2013	-33,792	-33,792	-44,407	-44,281	-9,331	-8,590	-20,918	-20,918	-30,121	-30,113	-5,157	-5,434	-96,363	-48,020	-8,623
2014	82,432	82,432	11,922	11,921	913	699	36,002	36,002	12,599	12,604	566	598	94,518	11,604	-6,240
2015	124,873	124,873	-35,076	-34,741	-4,921	-6,042	61,106	61,106	-17,754	-17,741	1,174	1,069	10,810	-44,930	-16,968
2016	112,054	112,054	-66,285	-65,618	-10,938	-12,714	59,036	59,036	-39,303	-39,281	0	0	-59,769	-67,772	-32,494
2017	305,878	305,878	-15,093	-13,293	-913	-1,268	183,213	183,249	-3,972	-3,898	-165	-170	110,258	6,113	453
Averages															
1951-2017	30,633	30,633	-16,361	-14,536	-2,773	-2,528	18,401	18,404	537	2,208	-284	98	-4,598	-718	-818
1951-1978	12,472	12,472	-1,149	565	-556	-213	7,512	7,512	5,109	6,059	-175	549	-4,883	3,176	-1,872
1979-2005	5,854	5,854	-26,329	-24,021	-2,464	-2,156	4,250	4,253	781	3,916	-120	56	-11,316	1,974	2,245
2006-2017	128,759	128,759	-29,430	-28,434	-8,645	-8,765	75,647	75,659	-10,681	-10,620	-906	-861	11,185	-15,863	-5,247
1985-2017	51,600	51,600	-27,893	-26,120	-3,789	-3,631	30,670	30,676	-3,266	-1,169	-330	-313	2,117	98	1,339
1985-2005	7,509	7,509	-27,015	-24,798	-1,014	-698	4,968	4,972	971	4,231	0	0	-3,064	9,219	5,103

Notes:

EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).

EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

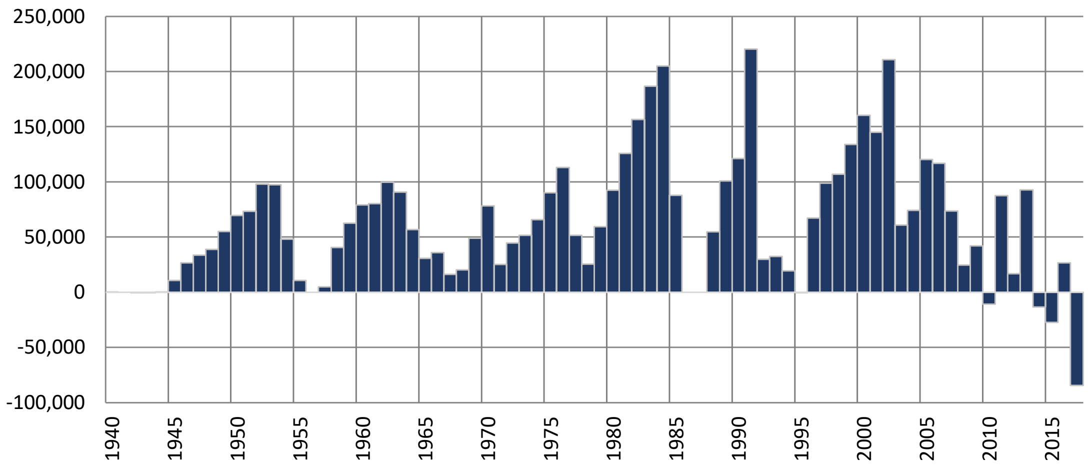
Run 17 - Conj Use 2: Hist Proj Acres (Hist M&I)

Simulated Differences in ILRG Model Outputs

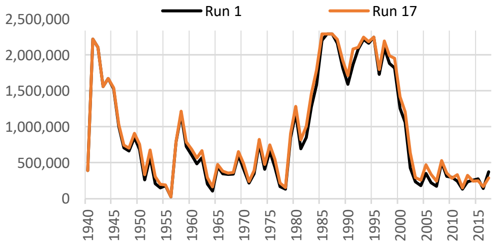
Run 17 minus Run 1

1940 - 2017 (acre-feet)

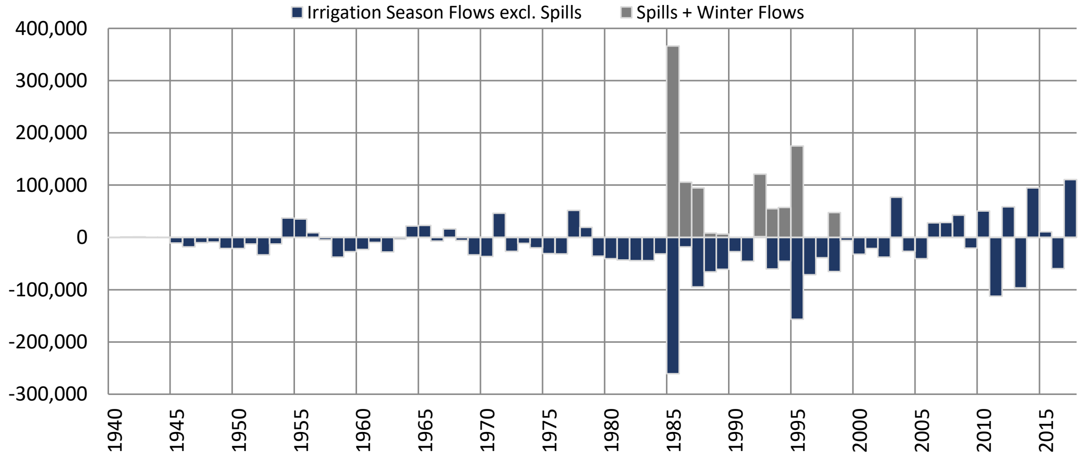
Total Project Storage (Year End)



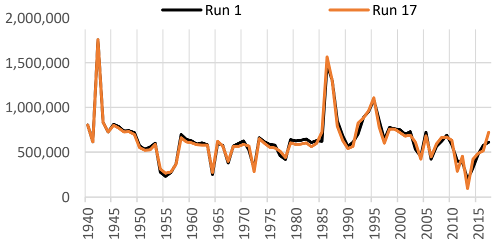
	Average
Period	Difference
1951-2017	-2,301
1951-1978	-1,580
1979-2005	3,516
2006-2017	-17,074
1985-2017	-8,772
1985-2005	-4,029



Caballo Reservoir Outflows (Annual)



	Average Difference		
	Irr Season	Nov-Feb	
Period	(excl. Spills)	and Spills	Annual
1951-2017	-20,036	15,438	-4,598
1951-1978	-4,883	0	-4,883
1979-2005	-49,626	38,310	-11,316
2006-2017	11,185	0	11,185
1985-2017	-29,227	31,344	2,117
1985-2005	-52,320	49,255	-3,064



Notes:

Reservoir storage does not include storage attributed to SJC, CO, or NM credit waters.

Average differences calculated as (Final Storage - Initial Storage)/(no. years).

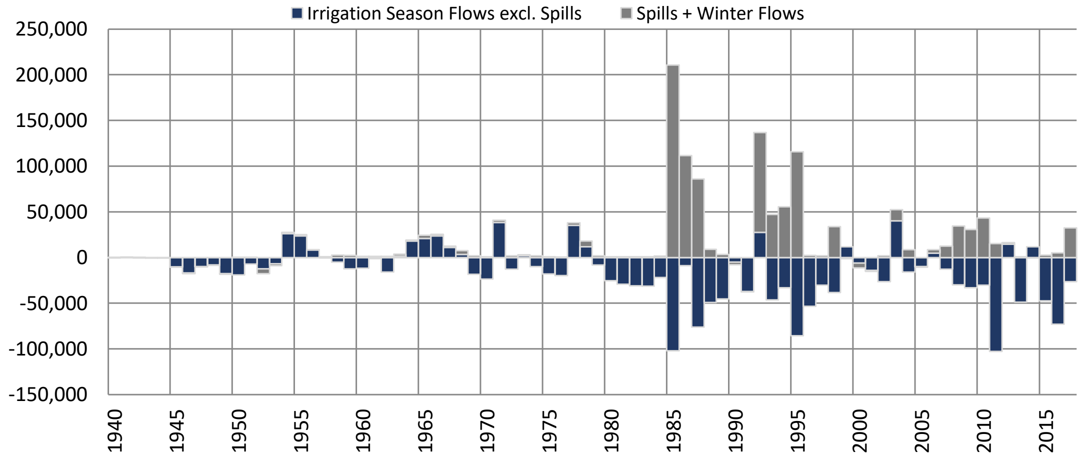
Run 17 - Conj Use 2: Hist Proj Acres (Hist M&I)

Simulated Differences in ILRG Model Outputs

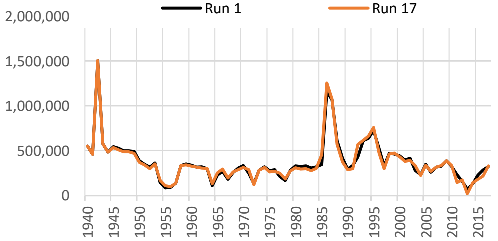
Run 17 minus Run 1

1940 - 2017 (acre-feet)

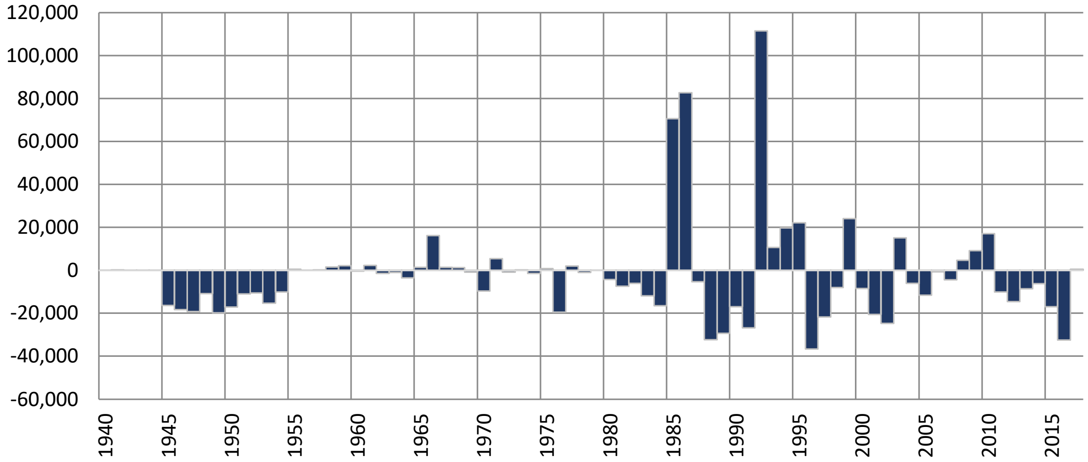
Rio Grande at El Paso (Annual)



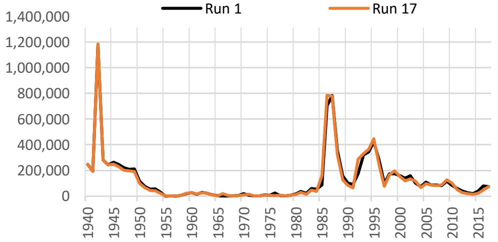
	Average Difference		
Period	Irr Season (excl. Spills)	Nov-Feb and Spills	Annual
1951-2017	-16,051	15,333	-718
1951-1978	1,763	1,414	3,176
1979-2005	-27,828	29,802	1,974
2006-2017	-31,118	15,255	-15,863
1985-2017	-29,625	29,723	98
1985-2005	-28,771	37,990	9,219



Rio Grande at Fort Quitman (Annual)



Period	Average Difference
1951-2017	-817
1951-1978	-1,875
1979-2005	2,248
2006-2017	-5,243
1985-2017	1,342
1985-2005	5,105



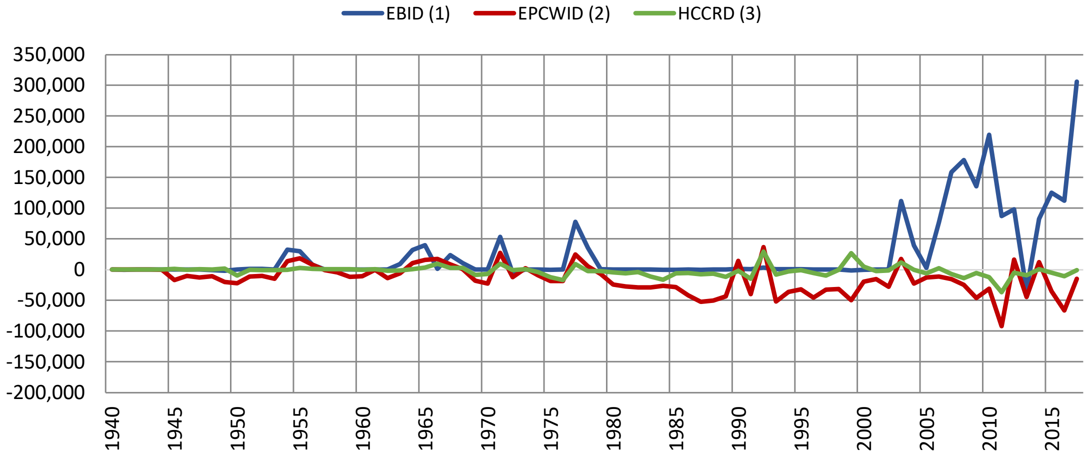
Run 17 - Conj Use 2: Hist Proj Acres (Hist M&I)

Simulated Differences in ILRG Model Outputs

Run 17 minus Run 1

1940 - 2017 (acre-feet)

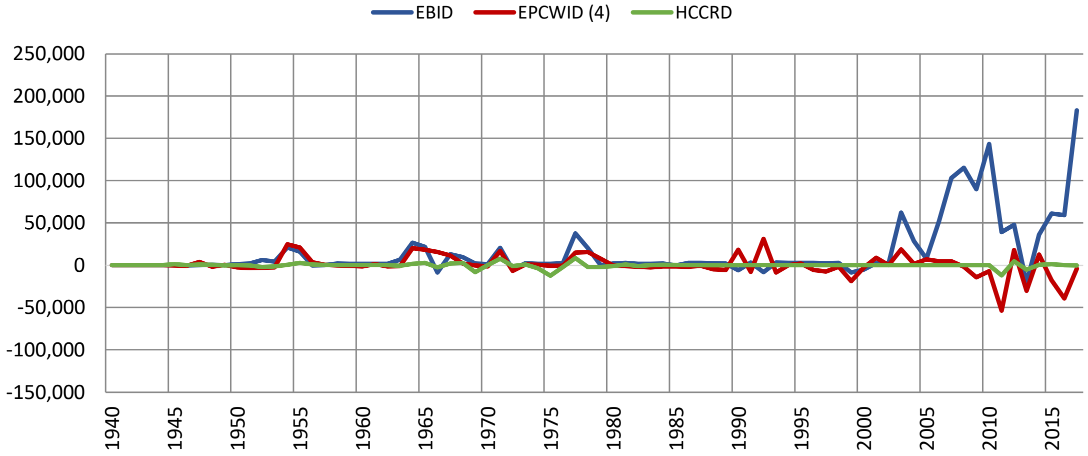
River Headgate (RHG) Diversions (Irrigation Season)



Average Difference

Period	EBID	EPCWID	HCCRD
1951-2017	30,633	-16,361	-2,773
1951-1978	12,472	-1,149	-556
1979-2005	5,854	-26,329	-2,464
2006-2017	128,759	-29,430	-8,645
1985-2017	51,600	-27,893	-3,789
1985-2005	7,509	-27,015	-1,014

Farm Headgate (FHG) Deliveries (Irrigation Season)



Average Difference

Period	EBID	EPCWID	HCCRD
1951-2017	18,401	537	-284
1951-1978	7,512	5,109	-175
1979-2005	4,250	781	-120
2006-2017	75,647	-10,681	-906
1985-2017	30,670	-3,266	-330
1985-2005	4,968	971	0

Notes:

(1) EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).

(2) EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

(3) HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

(4) EPCWID FHG values include deliveries to Rogers WTP and R/U WTP.

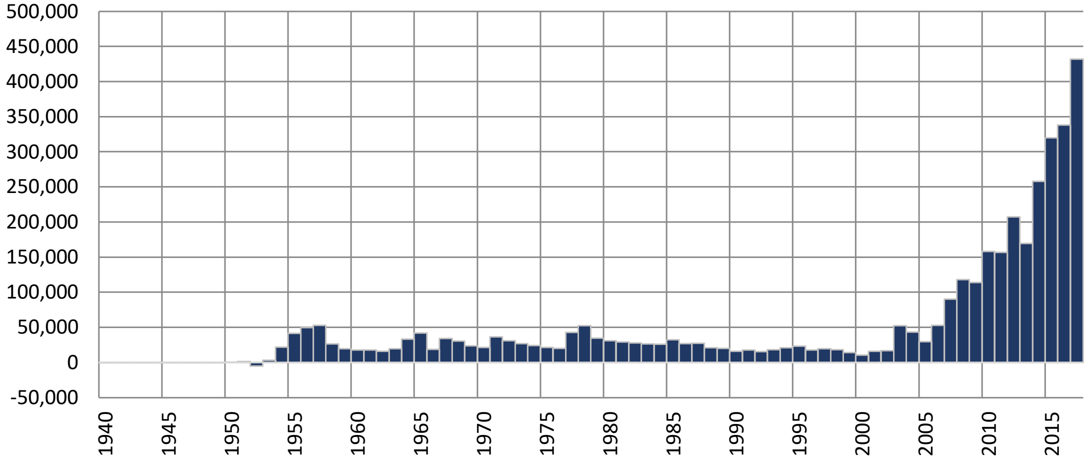
Run 17 - Conj Use 2: Hist Proj Acres (Hist M&I)

Simulated Differences in ILRG Model Outputs

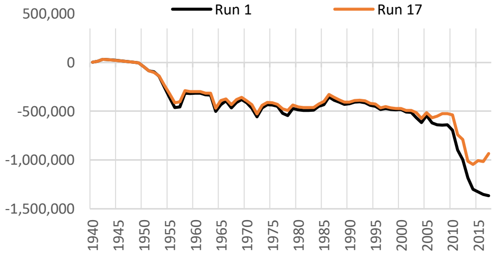
Run 17 minus Run 1

1940 - 2017 (acre-feet)

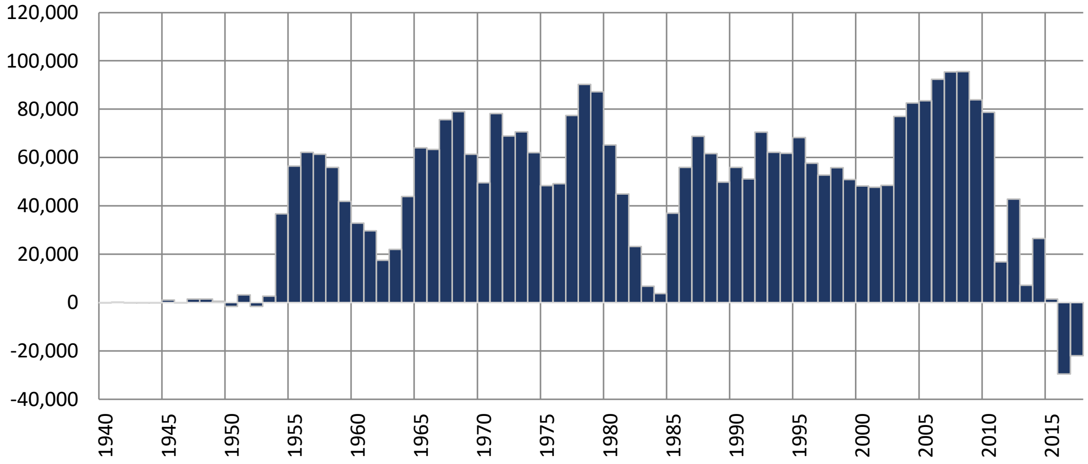
Cumulative Annual Rincon-Mesilla Groundwater Storage



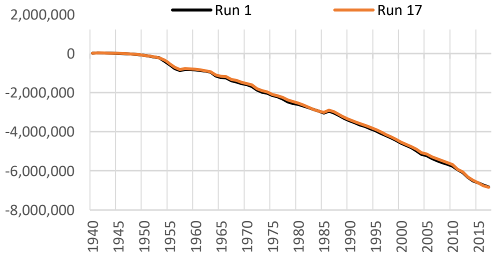
Period	Average Difference
1951-2017	6,444
1951-1978	1,862
1979-2005	-846
2006-2017	33,537
1985-2017	12,308
1985-2005	177



Cumulative Annual Hueco Groundwater Storage



Period	Average Difference
1951-2017	-304
1951-1978	3,286
1979-2005	-251
2006-2017	-8,796
1985-2017	-780
1985-2005	3,800

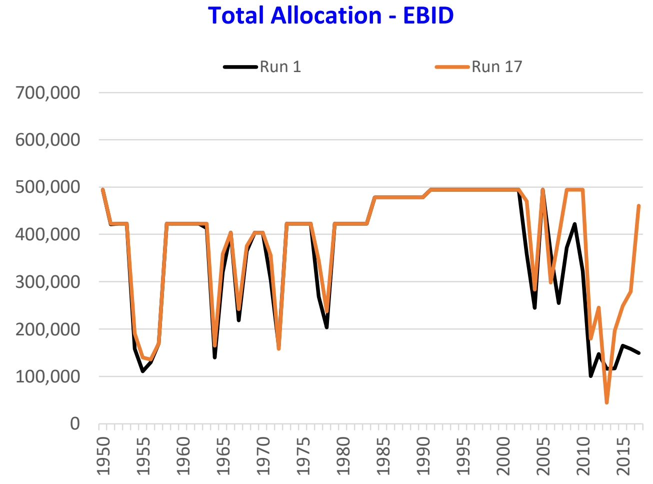


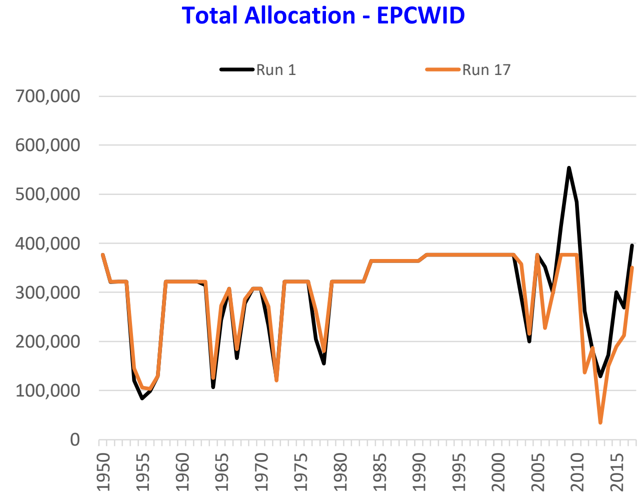
Notes:

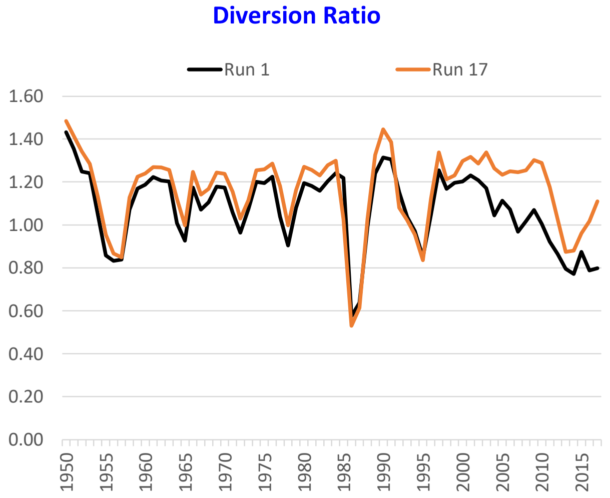
Cumulative storage change in alluvial and non-alluvial aquifers.

Average differences calculated as (Final Storage - Initial Storage)/(no. years).

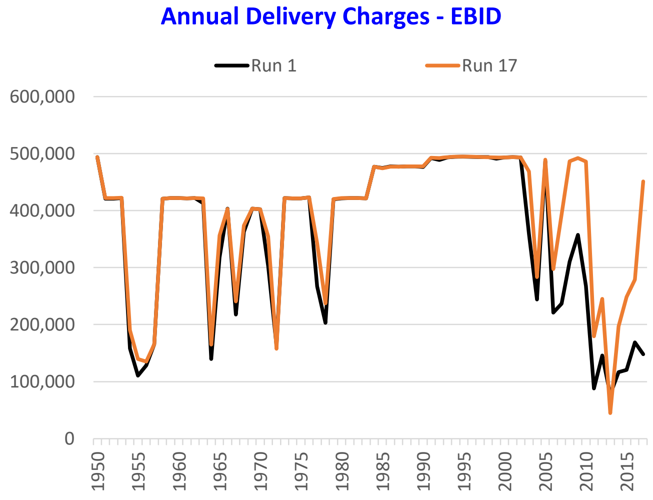
Run 17 - Conj Use 2: Hist Proj Acres (Hist M&I)
Annual Allocation and Charges
Run 17 v. Run 1
ILRG Model
1950 - 2017 (acre-feet)

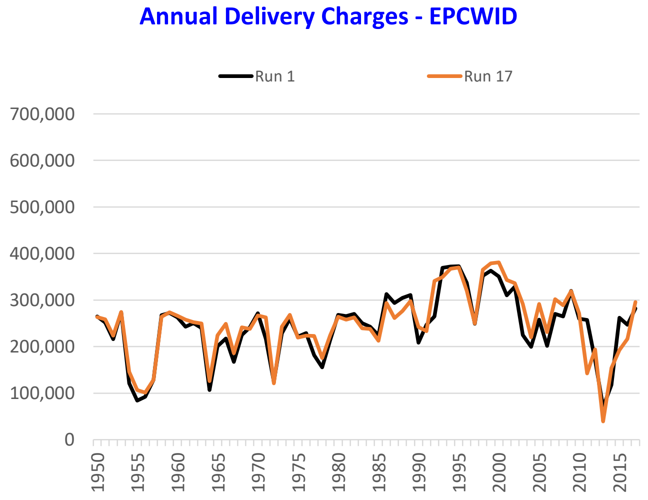




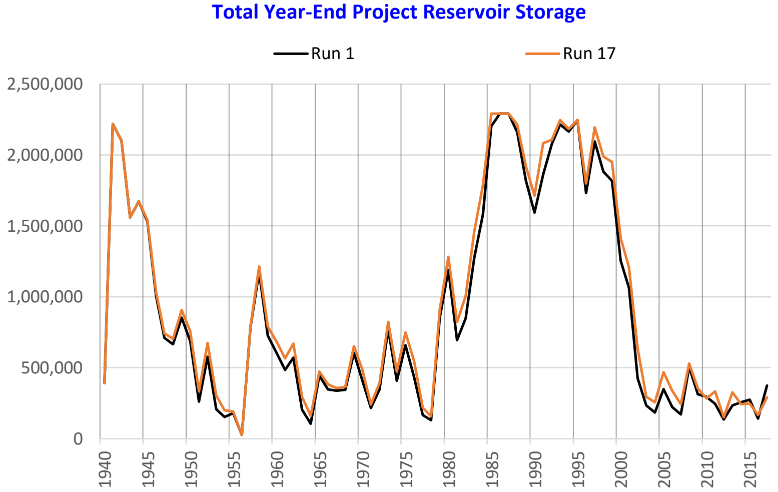


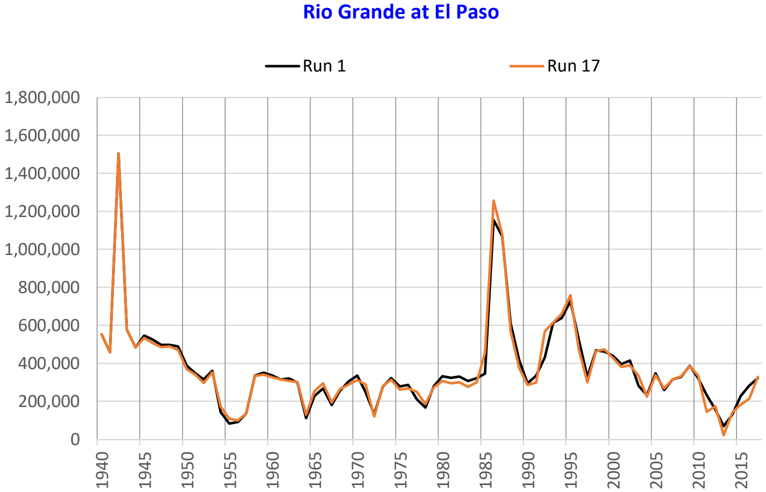
Note:
Computed as Total Charges/Caballo Release.

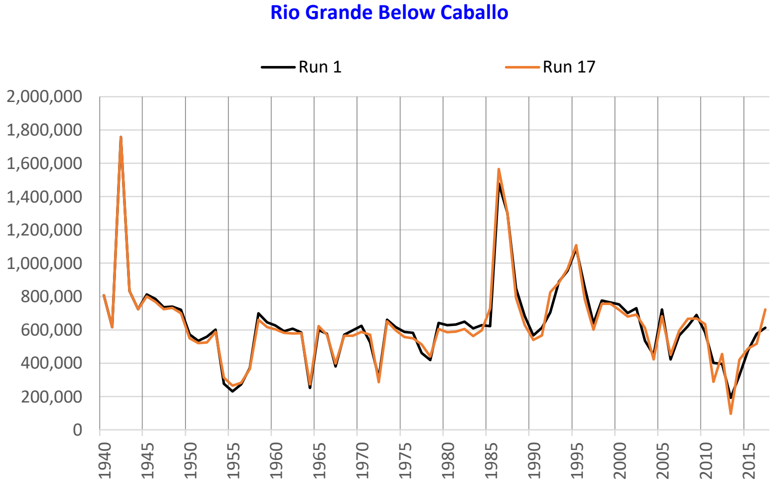


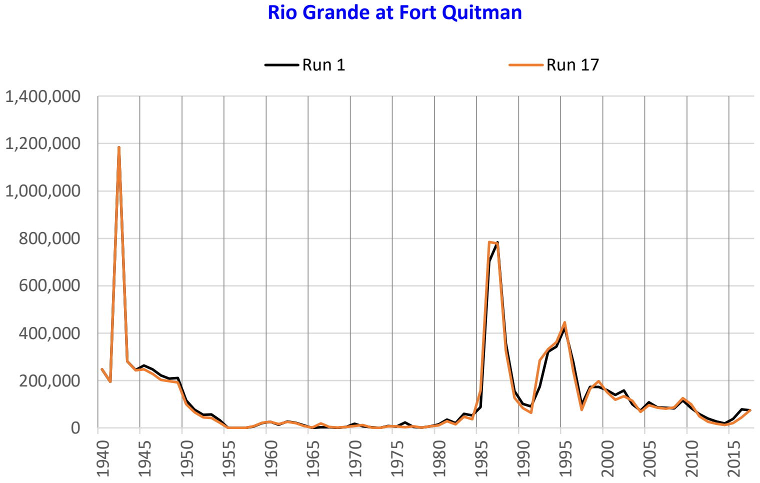


Run 17 - Conj Use 2: Hist Proj Acres (Hist M&I)
Annual Summary of Project Storage and Rio Grande Flows
Run 17 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)







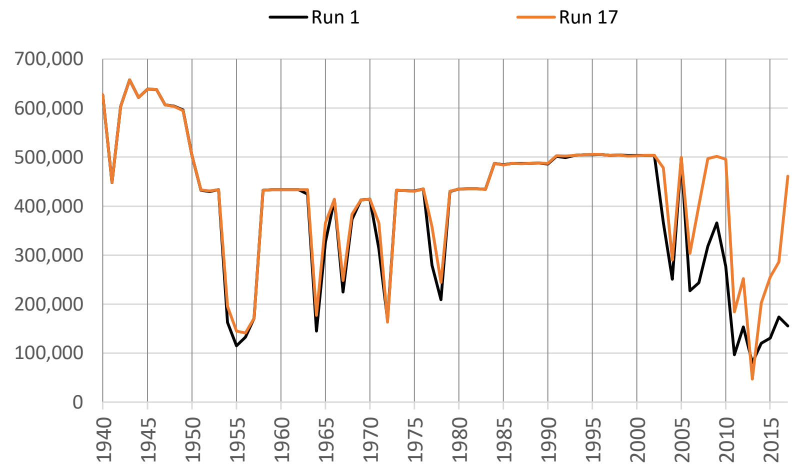


***Note different scales.**

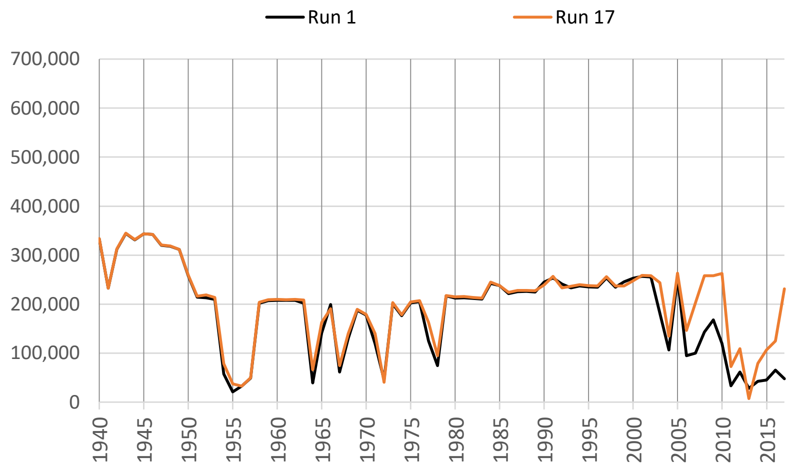
Run 17 - Conj Use 2: Hist Proj Acres (Hist M&I)
Irrigation Season Summary of Irrigation Operations
Run 17 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

EBID Total

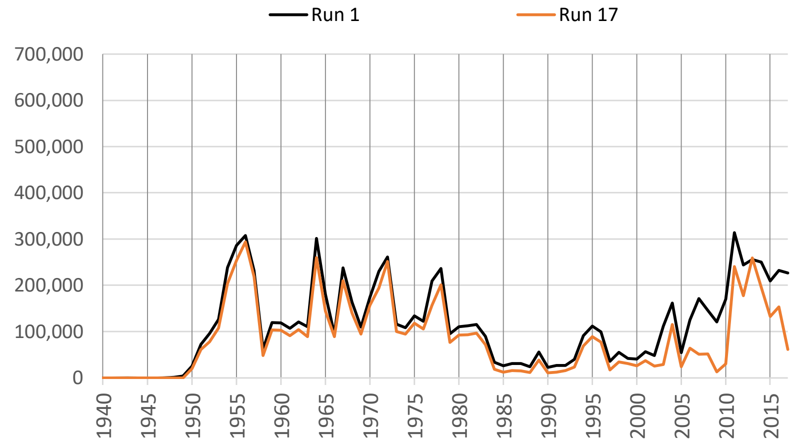
Net River Headgate Diversions



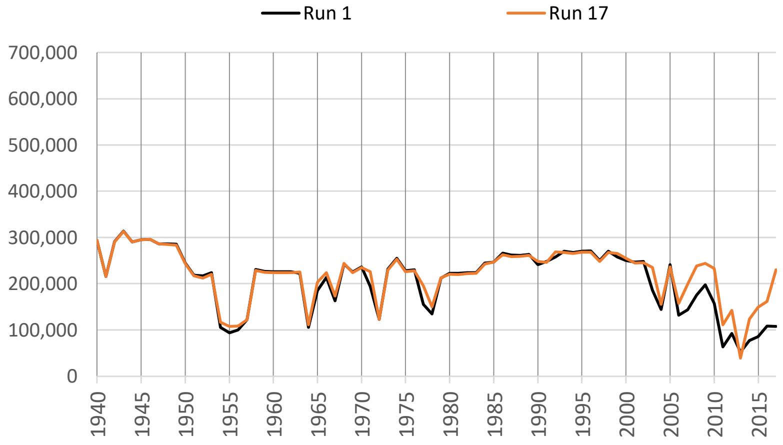
Farm Headgate Deliveries



Pumping



RHG Diversions - FHG Deliveries



Notes: EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).
Pumping includes Supplemental and Primary groundwater pumping.

Run 17 - Conj Use 2: Hist Proj Acres (Hist M&I)

Irrigation Season Summary of Irrigation Operations

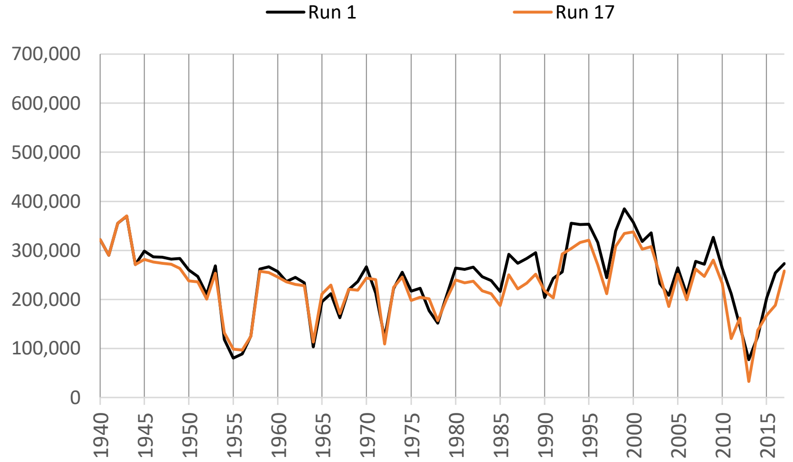
Run 17 v. Run 1

ILRG Model

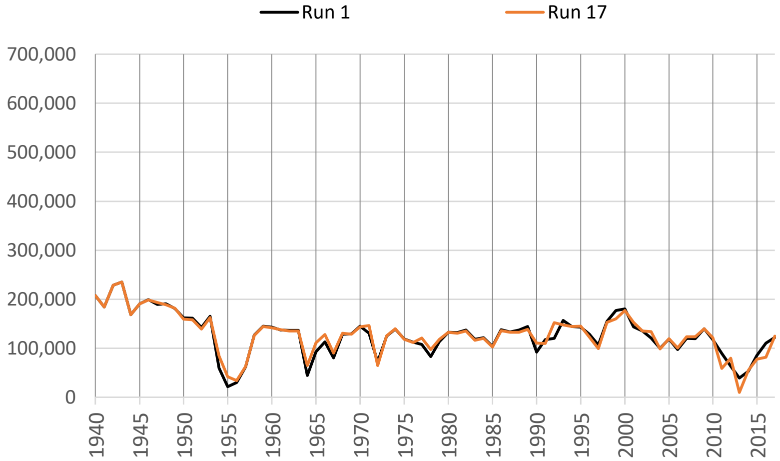
1940 - 2017 (acre-feet)

EPCWID Total

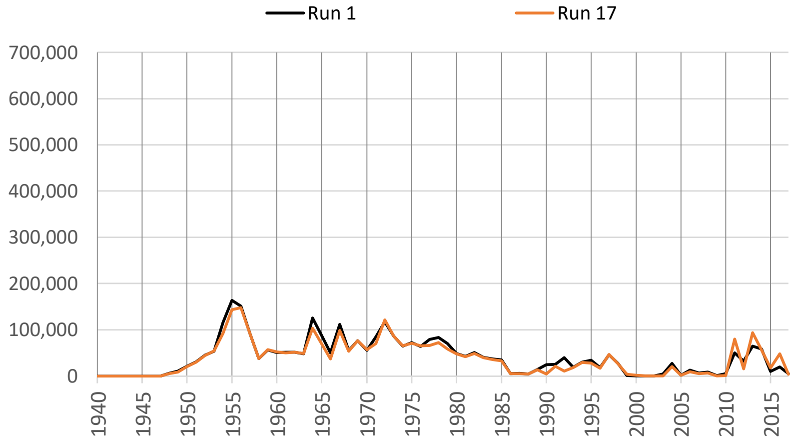
Net River Headgate Diversions



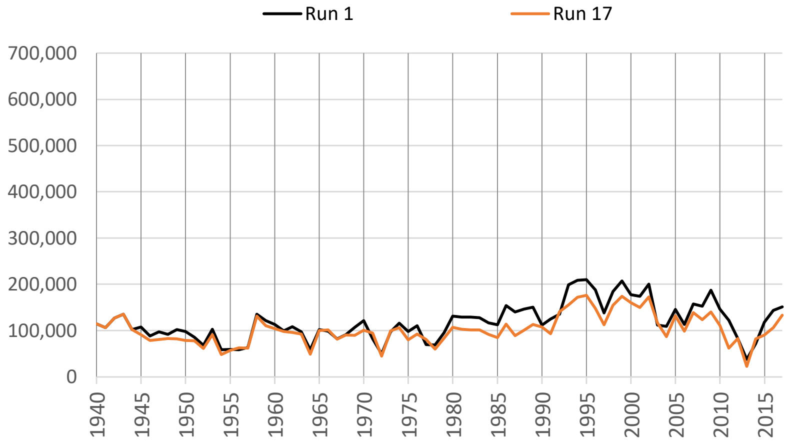
Farm Headgate Deliveries



Pumping



RHG Diversions - FHG Deliveries

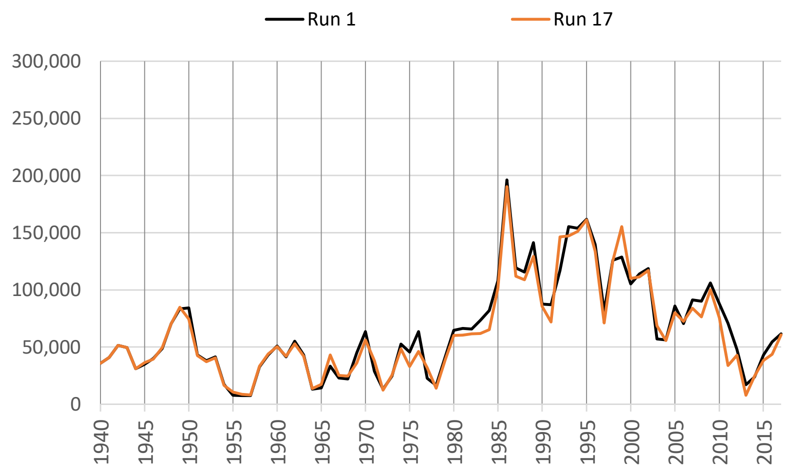


Note: EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

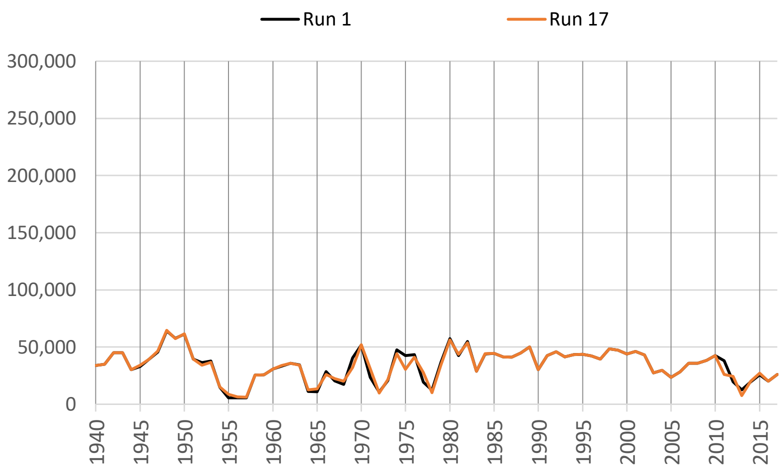
Run 17 - Conj Use 2: Hist Proj Acres (Hist M&I)
Irrigation Season Summary of Irrigation Operations
Run 17 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

HCCRD Total

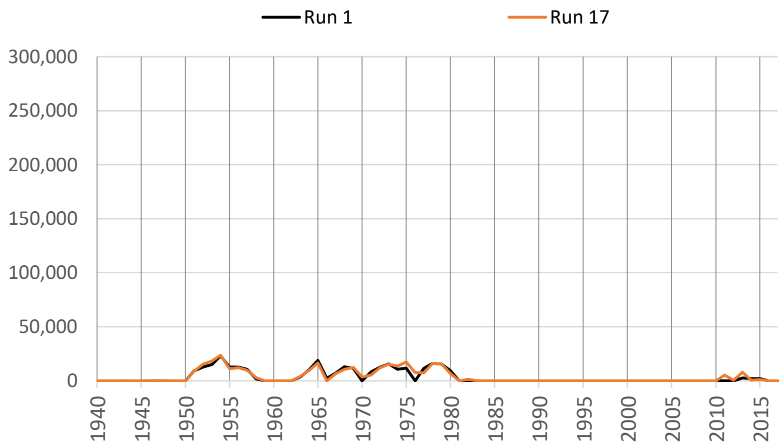
Net River Headgate Diversions



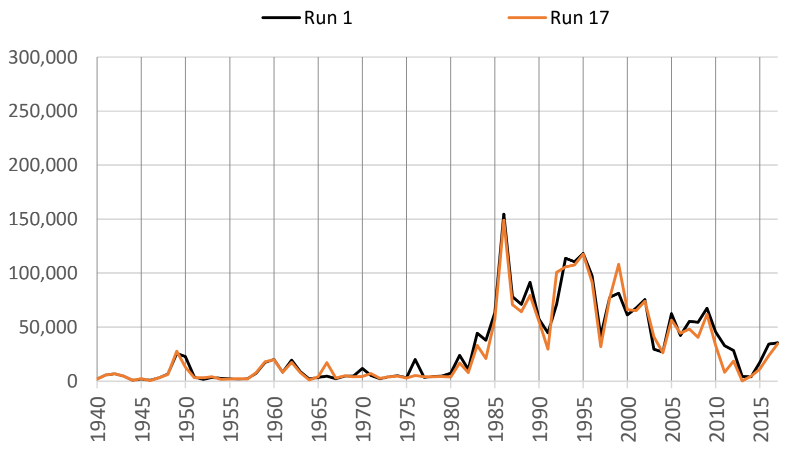
Farm Headgate Deliveries



Pumping



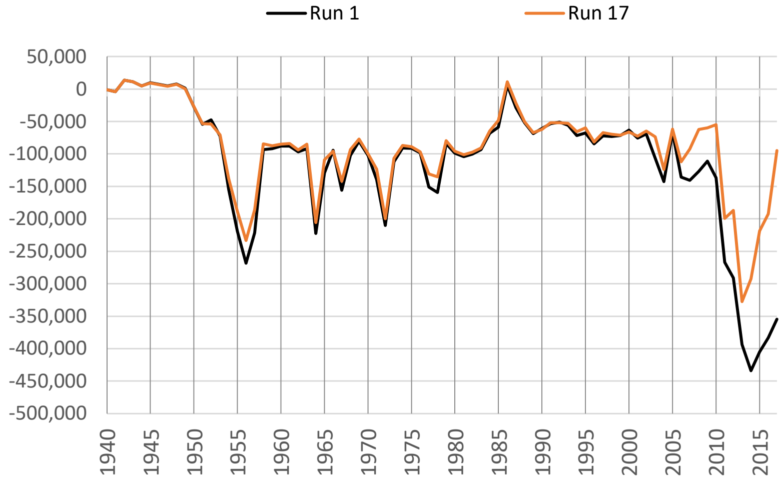
RHG Diversions - FHG Deliveries



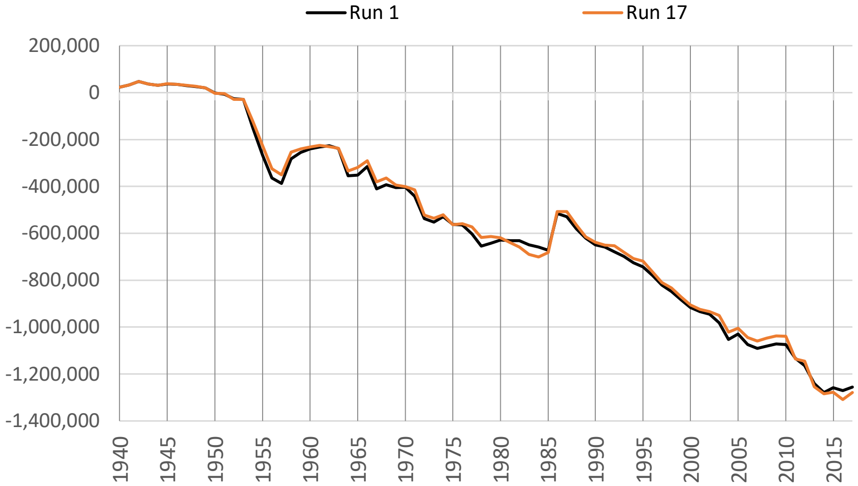
Note: HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

Run 17 - Conj Use 2: Hist Proj Acres (Hist M&I)
Cumulative Change in Ground Water Storage
Run 17 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

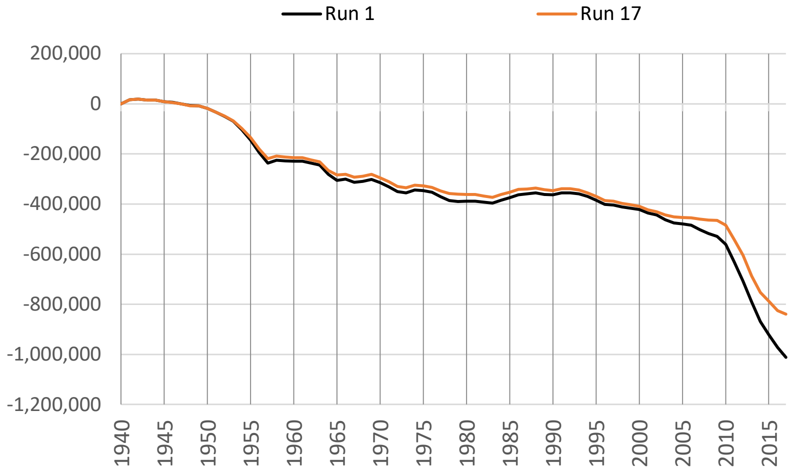
Rincon-Mesilla Alluvial Aquifer



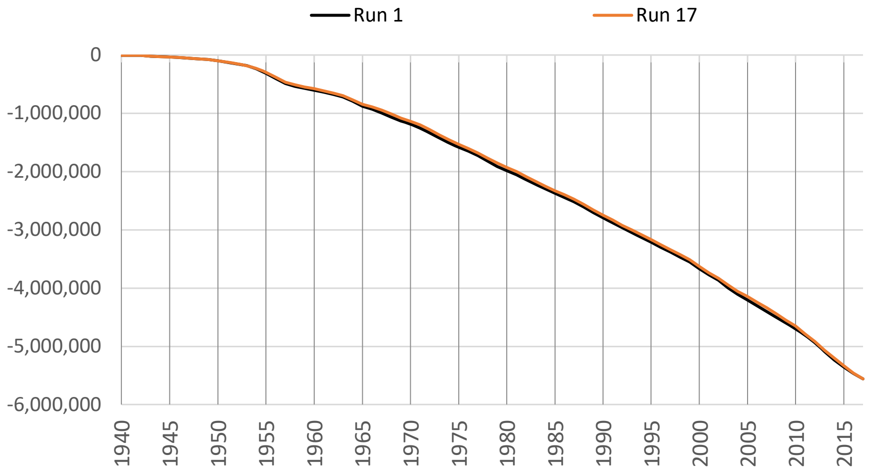
Hueco Alluvial Aquifer



Rincon-Mesilla Non-Alluvial Aquifer



Hueco Non-Alluvial Aquifer



***Note different scales.**

Run 17 - Conj Use 2: Hist Proj Acres (Hist M&I)

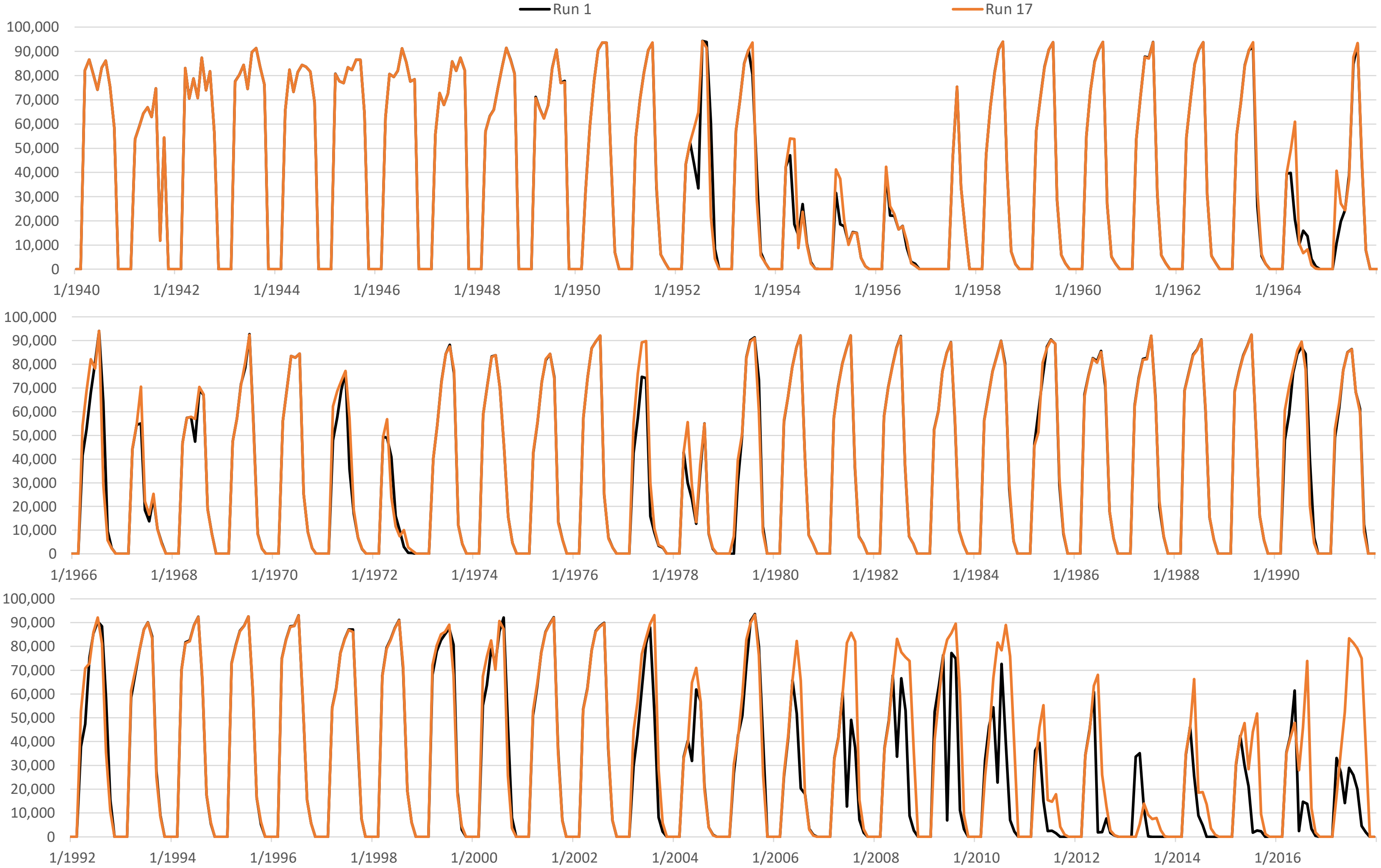
Monthly Net RHG Diversions

Run 17 v. Run 1

ILRG Model

1940 - 2017 (acre-feet)

EBID Total



Note: EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).

Run 17 - Conj Use 2: Hist Proj Acres (Hist M&I)

Monthly Net RHG Diversions

Run 17 v. Run 1

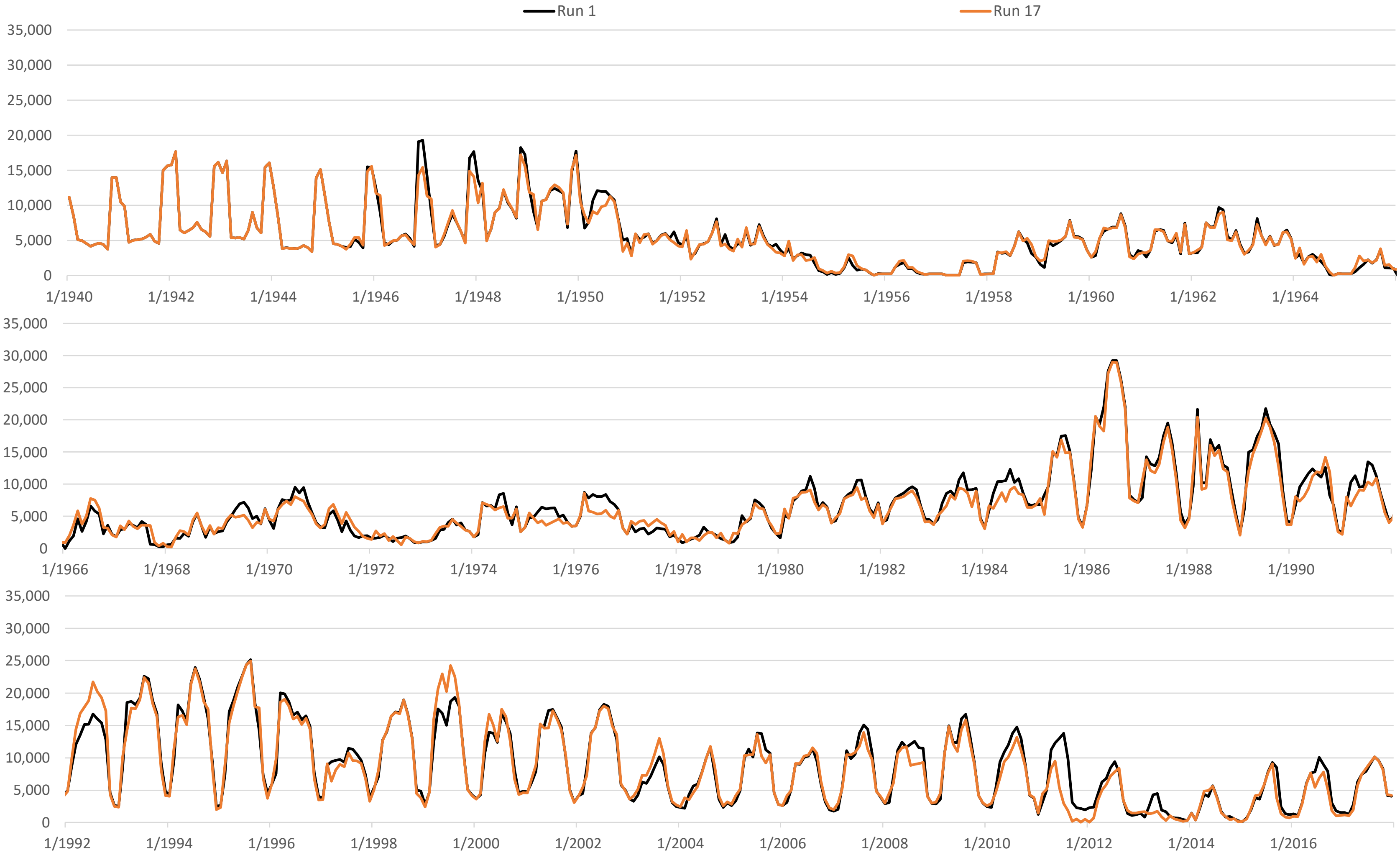
ILRG Model

1940 - 2017 (acre-feet)

EPCWID Total

Note: EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

Run 17 - Conj Use 2: Hist Proj Acres (Hist M&I)
Monthly Net RHG Diversions
Run 17 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)
HCCRD Total



Note: HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

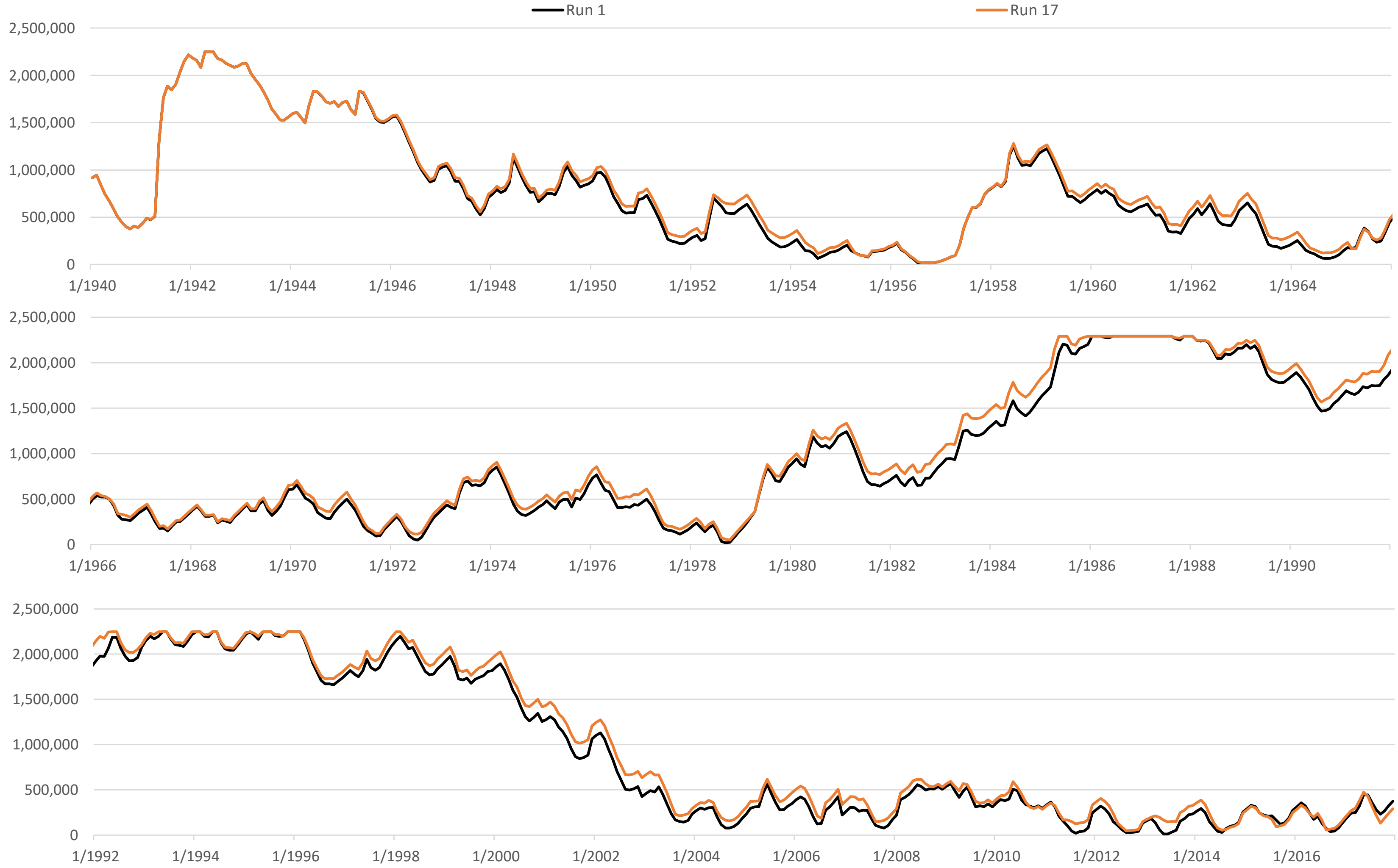
Run 17 - Conj Use 2: Hist Proj Acres (Hist M&I)

End of Month Reservoir Storage (Elephant Butte + Caballo)

Run 17 v. Run 1

ILRG Model

1940 - 2017 (acre-feet)



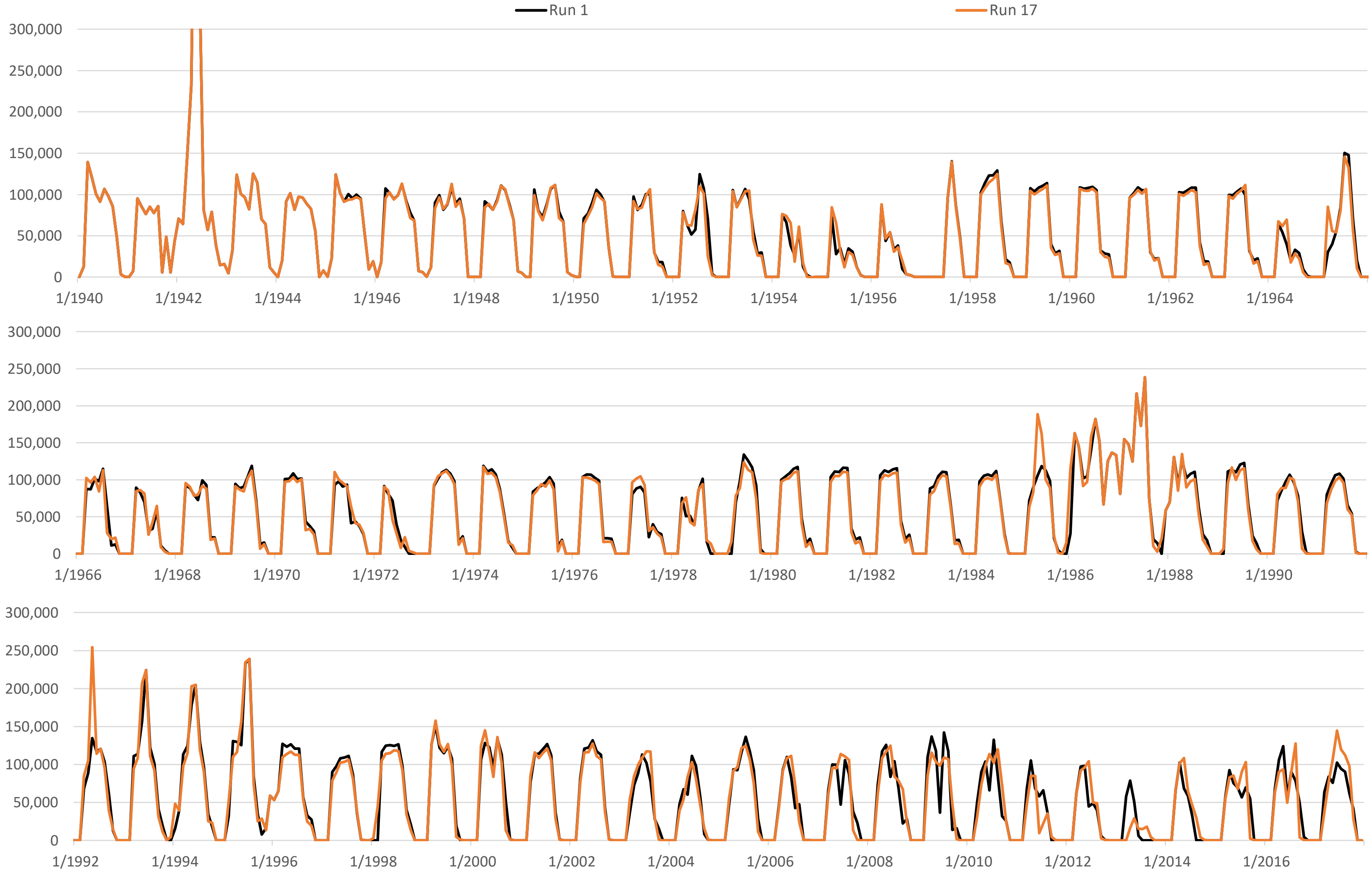
Run 17 - Conj Use 2: Hist Proj Acres (Hist M&I)

Monthly Caballo Releases

Run 17 v. Run 1

ILRG Model

1940 - 2017 (acre-feet)



Run 17 - Conj Use 2: Hist Proj Acres (Hist M&I)

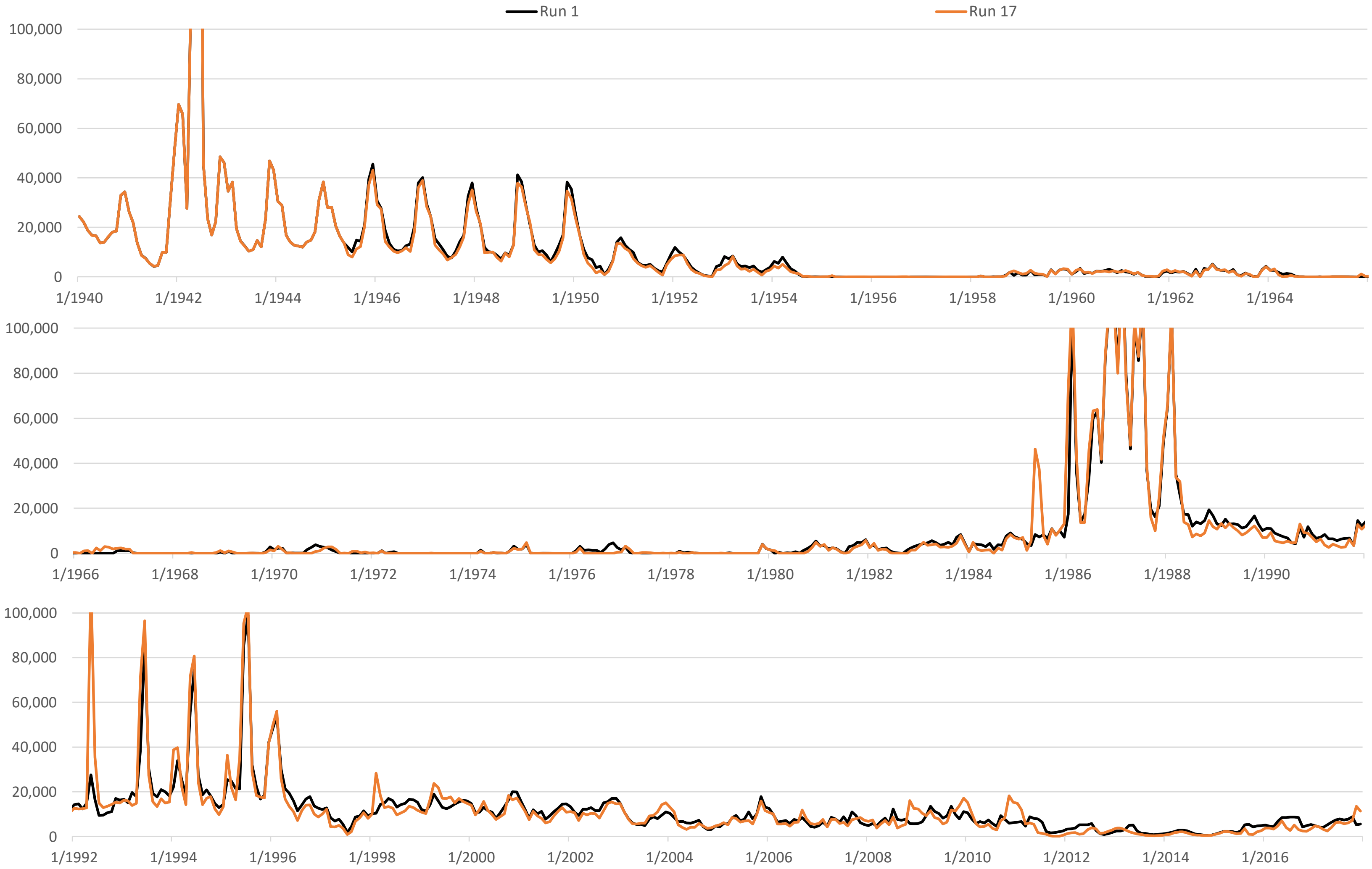
Monthly Rio Grande at El Paso Flow

Run 17 v. Run 1

ILRG Model

1940 - 2017 (acre-feet)

Run 17 - Conj Use 2: Hist Proj Acres (Hist M&I)
Monthly Rio Grande at Fort Quitman Flow
Run 17 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)



Appendix 30Z

Comparison of ILRG Model Runs
Run 17a v. Run 1

Model Run Specifications

Model Version: LRG_v116

Name: **Run 17a - Conj Use 2a: Hist Proj Acres (Pre-Comp M&**

Run ID: LRG_v116_Operational_Run17a
Date: 8/31/2020

Name: **Run 1 - Historical Base Run (All Pumping On)**

Run ID: LRG_v116_Operational_Run1
Date: 8/23/2020

Selected Model Inputs

Pumping and Returns	**Run 17a**	**Run 1**
(1) Irrigation Pumping	Conj	On
(2) Irrigated Area	Project	Hist
(3) Non-Irrigation Pumping	Pre-Comp	On
Non-Irrigation Pumping Returns	Pre-Comp	On
Las Cruces Jornada Pumping Returns	Off	On

Project Allocation Rules		
1950-2005	D1/D2	D1/D2
2006-2007	D1/D2	D3
2008-2017	D1/D2	D3 + CO

EPCWID Operations		
Charge EPCWID for Use of WWTP Returns	On	Off
ACE and Haskell Credits for EPCWID	Off	On
(4) Increased EPCWID Use of Fabens Drain Flows	On	Off
Charge EPCWID for Fabens Drain Flow Use	On	Off

Notes:

(1) Conjunctive use pumping on historical Project acres; no pumping on NM GW only acres.
(2) Project acres set to historical. New Mexico groundwater only acres set to 0.
(3) Limit M&I pumping to pre-compact levels. Reduce corresponding return flows.
(4) Starting in July 1945, use 70% of simulated Fabens drain flow up to 6,000 AF/month.

Run 17a - Conj Use 2a: Hist Proj Acres (Pre-Comp M&I)

Comparison of ILRG Model Runs

Run 17a v. Run 1

1951 - 2017 Annual Average

(1,000 acre-feet)

Run No.	1	17a	17a - 1	
Simulated Input or Output	**Run 1**	**Run 17a**	**Run 17a minus Run 1**	
Effects of Alternate Scenario				
FHG Deliveries (Mar - Oct)				***% Diff.***
EBID	167.6	190.7	23.0	*14%*
EPCWID (incl. EPW)	139.9	142.9	3.1	*2%*
HCCRD	32.8	33.5	0.6	*2%*
Total	340.3	367.1	26.7	*8%*
FHG Deliveries (Nov - Feb)				
EBID	0.0	0.0	0.0	*228%*
EPCWID (incl. EPW)	0.2	0.8	0.6	*317%*
HCCRD	2.4	2.5	0.1	*4%*
Total	2.6	3.3	0.7	*27%*
Irrigation Pumping				
EBID	140.4	102.0	-38.4	*-27%*
EPCWID (Mesilla Valley)	7.4	6.5	-0.8	*-11%*
EPCWID (El Paso Valley)	40.1	37.3	-2.8	*-7%*
HCCRD	4.2	3.5	-0.7	*-16%*
Total	192.1	149.5	-42.7	*-22%*
Other Inflows/Outflows				
Net Reservoir Evaporation	125.3	133.8	8.5	*7%*
Riparian ET	70.9	74.4	3.5	*5%*
River Evaporation + Incidental Canal Loss	30.3	30.9	0.6	*2%*
Total	226.6	239.2	12.6	*6%*
Rio Grande at Fort Quitman				
Reservoir Spills	33.3	44.4	11.1	*33%*
Nov-Feb Flows	21.4	23.7	2.3	*11%*
Mar - Oct Flows	41.1	38.7	-2.4	*-6%*
Underflow (GW Model)	0.2	0.2	0.0	*7%*
Total	96.0	107.0	11.0	*11%*

Run 17a - Conj Use 2a: Hist Proj Acres (Pre-Comp M&I)

Comparison of ILRG Model Runs

Run 17a v. Run 1

1951 - 2017 Annual Average

(1,000 acre-feet)

Run No.	1	17a	17a - 1	
Simulated Input or Output	**Run 1**	**Run 17a**	**Run 17a minus Run 1**	
Effects of Alternate Scenario (continued)				
Change in Storage				***% Diff.***
Reservoir Storage	-4.7	-6.0	-1.4	*29%*
Alluvial GW Storage (RW Model)	-23.6	-2.5	21.0	*-89%*
Non-alluvial GW Storage (GW Models)	-96.4	-23.5	72.8	*-76%*
Soil Moisture Storage	0.6	0.9	0.3	*46%*
Total	-124.0	-31.2	92.8	*-75%*
Summary of Effects				
FHG Deliveries (Mar-Oct)	340.3	367.1	26.7	*8%*
FHG Deliveries (Nov-Feb)	2.6	3.3	0.7	*27%*
Irrigation Pumping	192.1	149.5	-42.7	*-22%*
Riparian ET + Evaporation	226.6	239.2	12.6	*6%*
Fort Quitman Flow	96.0	107.0	11.0	*11%*
Change in Storage	-124.0	-31.2	92.8	*-75%*
Total	733.6	834.7	101.2	*14%*
Other Effects of Alternate Scenario				
Rio Grande at El Paso				***% Diff.***
Reservoir Spills	49.4	64.0	14.6	*30%*
Nov-Feb Flows	22.8	31.8	9.0	*40%*
Mar - Oct Flows	263.8	264.6	0.8	*0%*
Total	336.0	360.4	24.4	*7%*
Rio Grande below Caballo				
Reservoir Spills	65.9	81.6	15.7	*24%*
Nov-Feb Flows	0.5	0.4	-0.1	*-11%*
Mar - Oct Flows	541.3	518.6	-22.7	*-4%*
Total	607.6	600.5	-7.1	*-1%*
Surface Water Diversions (Mar - Oct)				
EBID	366.5	402.1	35.6	*10%*
EPCWID (incl. EPW)	236.8	230.0	-6.8	*-3%*
HCCRD	67.5	68.6	1.1	*2%*
Total	670.8	700.7	29.9	*4%*
Surface Water Diversions (Nov - Feb)				
EBID	0.0	0.0	0.0	*0%*
EPCWID (incl. EPW)	14.3	14.5	0.1	*1%*
HCCRD	14.2	14.2	0.0	*0%*
Total	28.5	28.6	0.1	*0%*

Run 17a - Conj Use 2a: Hist Proj Acres (Pre-Comp M&I)
Annual Differences in ILRG Model Outputs
Run 17a minus Run 1
1940 - 2017 (acre-feet)

	Net River Headgate Diversions						Farm Headgate Deliveries						Annual Flows		
	EBID		EPCWID (incl. EPW)		HCCRD		EBID		EPCWID (incl. EPW)		HCCRD				
Year	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Caballo Releases	Rio Grande at El Paso	Rio Grande at Fort Quitman
1940	-54	-54	-7	9	16	26	-1	-1	-24	-25	0	0	-31	15	227
1941	-256	-256	36	624	50	251	-6	-5	1	115	30	41	59	109	884
1942	-107	-107	-89	-223	-60	-44	-3	-1	-60	-111	-13	-10	432	451	-336
1943	-169	-169	-20	-200	-56	-61	3	6	-2	-69	-52	-226	2,051	2,114	970
1944	-173	-173	-353	-369	-209	-192	-28	-24	191	153	-224	-318	-2,415	-2,169	311
1945	-108	-108	-17,272	-6,278	1,381	846	-58	-55	-214	6,280	1,033	946	-12,166	-11,390	-15,886
1946	-80	-80	-10,300	-11,454	-321	-7,209	-101	-97	-359	3,326	-74	-246	-18,519	-17,645	-17,661
1947	-54	-54	-12,948	-7,286	638	-5,841	-15	-8	4,500	11,403	837	936	-11,913	-11,555	-18,882
1948	-875	-875	-11,022	-7,341	-30	-4,811	434	445	-1,461	4,833	356	173	-12,471	-11,651	-11,066
1949	-1,928	-1,928	-20,447	-16,359	1,497	3,042	89	104	903	6,471	-290	-542	-22,928	-19,731	-19,653
1950	37	37	-22,020	-18,838	-9,737	-10,963	1,250	1,263	-2,236	2,323	249	439	-22,312	-19,350	-16,402
1951	1,032	1,032	-11,222	-6,165	-558	-2,653	1,996	2,007	-2,919	1,877	-173	-2,116	-12,942	-6,721	-10,185
1952	1,203	1,203	-10,262	-7,462	-689	-1,850	7,175	7,178	-2,656	-122	-1,981	820	-35,747	-16,512	-9,822
1953	247	247	-15,266	-12,637	-663	-1,729	4,399	4,403	-2,688	-352	-1,066	805	-14,715	-5,581	-14,132
1954	38,979	38,979	17,530	19,000	-281	945	26,049	26,049	26,999	27,848	551	1,904	45,082	38,047	-8,445
1955	29,659	29,659	18,867	19,263	3,109	3,304	16,038	16,038	20,426	20,212	3,171	3,596	32,942	30,491	740
1956	9,004	9,004	6,035	3,725	1,155	589	2,056	2,056	2,590	2,170	807	211	10,716	12,787	32
1957	-66	-66	-1,012	-1,079	846	466	291	291	-574	-811	865	428	-6,344	6,245	-1
1958	-304	-304	-2,983	-2,205	922	2,170	2,725	2,726	263	180	56	-141	-47,931	10,311	2,279
1959	-263	-263	-11,360	-10,743	894	2,173	2,493	2,494	-1,150	-1,135	-6	-22	-36,993	-1,712	2,302
1960	-274	-274	-12,776	-12,677	-115	-554	2,482	2,483	-1,995	-1,720	0	0	-30,487	-1,100	835
1961	-305	-305	-2,789	-2,484	1,077	1,313	2,496	2,497	237	758	880	-644	-17,908	10,224	4,477
1962	-309	-309	-15,058	-14,718	-882	-1,070	2,614	2,615	-1,831	-1,198	213	81	-34,580	-3,159	215
1963	8,494	8,494	-7,385	-6,334	-487	-618	7,521	7,522	-1,562	-503	-6	6	-10,602	18,254	1,542
1964	51,050	51,050	27,389	26,532	1,114	1,992	27,132	27,132	32,004	32,097	2,246	2,438	62,565	52,729	-1,192
1965	34,553	34,553	8,560	7,646	3,282	4,079	20,044	20,045	15,018	14,612	2,991	4,060	-5,139	35,806	2,593
1966	784	784	14,302	16,022	10,908	12,527	-7,308	-7,308	14,770	15,242	-2,873	-3,003	-25,853	38,358	19,584
1967	48,161	48,161	25,939	27,849	4,003	6,603	27,398	27,398	21,610	21,381	2,916	4,296	41,261	45,053	3,674
1968	15,588	15,588	5,300	7,652	5,608	7,780	15,116	15,117	702	331	5,652	6,944	-19,221	28,909	3,036
1969	-796	-796	-12,389	-11,717	-4,825	-3,318	4,007	4,008	407	429	-4,243	-3,561	-46,045	-459	1,292
1970	-432	-432	-17,269	-16,574	-2,718	-2,073	2,731	2,731	-1,364	-916	762	1,780	-43,063	-7,591	-2,654
1971	74,569	74,569	36,609	38,572	11,144	11,327	34,620	34,620	17,006	17,645	8,700	8,888	57,141	68,064	8,852
1972	7,107	7,107	-1,315	-372	-1,479	-1,650	1,349	1,349	-5,500	-5,556	-1,746	-2,318	-10,570	16,746	433
1973	-987	-987	14,942	14,516	4,521	2,633	4,575	4,576	1,412	1,182	4,418	2,695	-24,905	28,524	239
1974	-767	-767	1,840	2,515	750	425	4,038	4,040	649	943	-288	9	-30,029	16,103	1,699
1975	807	807	24,496	24,967	11,311	11,340	-8,813	-8,812	15,837	16,568	10,175	10,074	-11,791	37,356	3,195
1976	-257	-257	-7,100	-7,454	-11,441	-12,294	3,858	3,860	-918	-404	-297	-2,022	-30,188	-321	-8,560
1977	80,287	80,287	39,054	41,387	11,319	12,915	40,148	40,148	15,210	15,471	10,135	11,320	62,118	70,001	5,415
1978	31,035	31,035	10,890	13,781	1,484	4,125	19,206	19,206	10,118	10,146	2,456	3,084	14,608	41,694	1,367

Run 17a - Conj Use 2a: Hist Proj Acres (Pre-Comp M&I)

Annual Differences in ILRG Model Outputs

Run 17a minus Run 1

1940 - 2017 (acre-feet)

	Net River Headgate Diversions						Farm Headgate Deliveries						Annual Flows		
	EBID		EPCWID (incl. EPW)		HCCRD		EBID		EPCWID (incl. EPW)		HCCRD				
Year	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Caballo Releases	Rio Grande at El Paso	Rio Grande at Fort Quitman
1979	289	289	11,232	11,914	1,421	3,084	2,118	2,124	5,842	5,873	1,619	3,404	-32,174	33,259	2,858
1980	-623	-623	-6,671	-5,961	71	821	4,036	4,043	299	791	1,040	928	-38,565	9,443	279
1981	-656	-656	-7,424	-7,026	-1,356	-2,118	4,489	4,493	129	612	49	49	-37,340	4,626	-952
1982	-593	-593	-7,476	-7,510	-70	-785	3,406	3,410	204	723	44	199	-34,913	6,580	-1,141
1983	-525	-525	-6,838	-7,015	-2,979	-3,620	3,513	3,518	1	454	0	0	-34,654	5,326	-3,042
1984	-725	-725	-4,711	-4,482	-7,255	-8,101	4,139	4,149	177	719	0	0	-25,200	14,563	-5,477
1985	-912	-912	-6,714	-6,402	-1,844	-2,696	5,325	5,343	-178	493	0	0	75,749	105,022	58,320
1986	-1,139	-1,139	-20,564	-20,677	2,356	1,862	4,092	4,127	58	96	0	0	87,161	130,523	148,238
1987	-1,414	-1,414	-31,595	-30,132	-1,027	-1,937	4,050	4,076	635	3,151	0	0	-153	36,023	46,250
1988	-789	-789	-26,544	-25,130	-906	-2,393	4,271	4,292	-2,799	-500	0	0	-57,280	-13,183	-14,669
1989	-551	-551	-13,046	-11,726	2,741	747	4,485	4,501	-1,898	-119	0	0	-44,328	-4,840	-12,678
1990	438	438	44,601	45,569	10,646	9,210	-3,988	-3,974	21,431	23,058	0	0	-17,187	31,726	1,994
1991	-145	-145	-21,342	-20,668	-9,747	-10,789	4,717	4,737	-3,635	-2,543	0	0	-46,146	-9,448	-12,960
1992	2,291	2,291	50,022	50,790	34,088	34,171	-6,269	-6,255	33,244	34,894	0	0	100,845	145,293	120,131
1993	-62	-62	-48,520	-47,007	-5,505	-6,022	5,572	5,596	-5,188	-2,528	0	0	-2,484	29,692	35,183
1994	-108	-108	-36,277	-35,052	-1,909	-2,169	5,473	5,507	3,313	5,533	0	0	-4,016	44,460	44,473
1995	311	311	-34,364	-33,155	-1,125	-1,788	5,904	5,929	5,108	7,329	0	0	32,748	78,094	67,838
1996	-704	-704	-45,113	-44,337	-5,342	-5,286	5,655	5,677	-2,633	-1,088	0	0	-91,836	-30,025	-23,998
1997	-579	-579	-30,176	-30,475	-5,593	-7,472	5,280	5,303	-5,827	-5,614	0	0	-49,447	544	-8,589
1998	-742	-742	-28,331	-28,382	984	-463	6,094	6,128	755	1,264	0	0	-16,707	40,114	35,417
1999	-1,840	-1,840	-47,002	-48,227	27,492	27,034	-5,469	-5,449	-17,405	-16,392	0	0	-18,180	37,795	47,349
2000	-907	-907	-15,480	-18,001	6,802	6,701	-2,212	-2,196	-3,728	-3,728	0	0	-46,081	15,880	7,034
2001	-343	-343	-12,356	-15,324	801	760	6,269	6,287	9,611	9,626	0	0	-44,602	5,156	-10,880
2002	-614	-614	-31,634	-33,370	-1,865	-1,649	6,128	6,144	392	419	0	0	-68,860	-12,334	-13,600
2003	135,314	135,314	35,837	34,273	16,278	16,730	80,149	80,183	20,892	20,957	0	0	97,211	102,926	44,585
2004	76,300	76,300	5,279	5,121	4,601	5,795	55,128	55,138	16,491	16,546	0	0	-3,199	46,550	12,580
2005	1,513	1,513	-15,034	-17,299	-1,079	-358	10,617	10,639	9,272	9,320	0	0	-80,194	5,459	5,288
2006	118,920	118,920	21,138	19,600	13,545	15,229	74,858	74,873	18,898	18,937	0	0	53,810	67,692	39,070
2007	194,557	194,557	-12,122	-13,426	-1,382	-447	128,817	128,846	12,911	12,992	0	0	28,043	32,096	17,518
2008	177,329	177,329	-35,813	-36,411	-5,239	-4,637	118,900	118,966	-2,448	-2,296	0	0	-1,078	18,678	32,301
2009	134,978	134,978	-47,858	-49,032	-3,169	-2,198	93,251	93,308	-11,243	-11,122	0	0	-44,521	20,059	44,973
2010	218,710	218,710	-31,667	-32,677	-2,697	-1,432	146,656	146,753	-2,552	-2,388	0	0	22,698	30,524	43,703
2011	178,637	178,637	-30,256	-30,403	-16,380	-15,895	96,406	96,419	-3,323	-3,244	0	0	-5,805	5,246	12,570
2012	111,777	111,777	29,317	26,744	1,298	136	57,910	57,910	20,273	20,321	0	0	37,014	51,357	9,818
2013	-11,936	-11,936	-29,229	-31,682	-6,887	-6,837	-14,727	-14,727	-27,956	-27,927	-2,794	-3,031	-41,592	-15,638	-6,064
2014	61,402	61,402	3,631	260	-2,821	-4,537	24,389	24,389	407	426	-2,540	-3,715	54,277	12,047	-7,535
2015	129,129	129,129	-22,738	-25,230	-5,077	-6,487	64,714	64,714	-19,363	-19,327	306	350	12,176	-4,771	-15,293
2016	113,989	113,989	-62,220	-64,129	-10,940	-12,976	62,199	62,199	-38,986	-38,937	0	0	-91,925	-38,451	-25,907
2017	328,247	328,247	-11,806	-12,309	225	-434	201,363	201,417	1,882	2,000	0	0	72,010	35,915	14,983
Averages															
1951-2017	35,612	35,612	-6,810	-6,680	1,052	1,010	23,047	23,060	3,062	3,659	627	713	-7,065	24,426	11,027
1951-1978	15,279	15,279	4,413	5,386	1,761	2,104	9,516	9,517	6,146	6,656	1,583	1,772	-6,022	20,091	315
1979-2005	7,499	7,499	-12,972	-12,952	2,247	1,825	8,258	8,277	3,132	4,050	102	170	-14,809	31,823	21,105
2006-2017	146,312	146,312	-19,135	-20,725	-3,294	-3,376	87,895	87,922	-4,292	-4,214	-419	-533	7,925	17,896	13,345
1985-2017	59,426	59,426	-16,908	-17,524	949	590	38,061	38,085	800	1,503	-152	-194	-3,087	30,309	22,347
1985-2005	9,777	9,777	-15,636	-15,696	3,374	2,857	9,584	9,606	3,710	4,770	0	0	-9,380	37,401	27,491

Notes:

EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).

EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

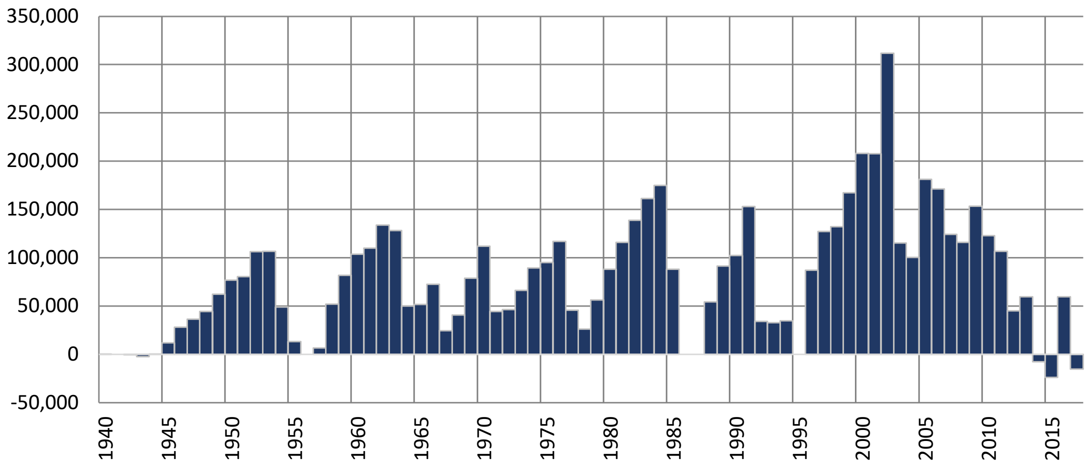
Run 17a - Conj Use 2a: Hist Proj Acres (Pre-Comp M&I)

Simulated Differences in ILRG Model Outputs

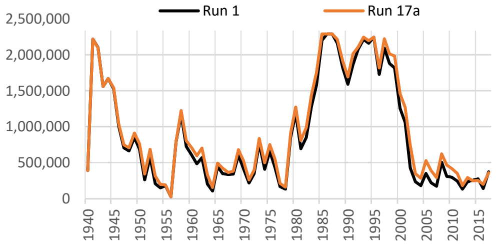
Run 17a minus Run 1

1940 - 2017 (acre-feet)

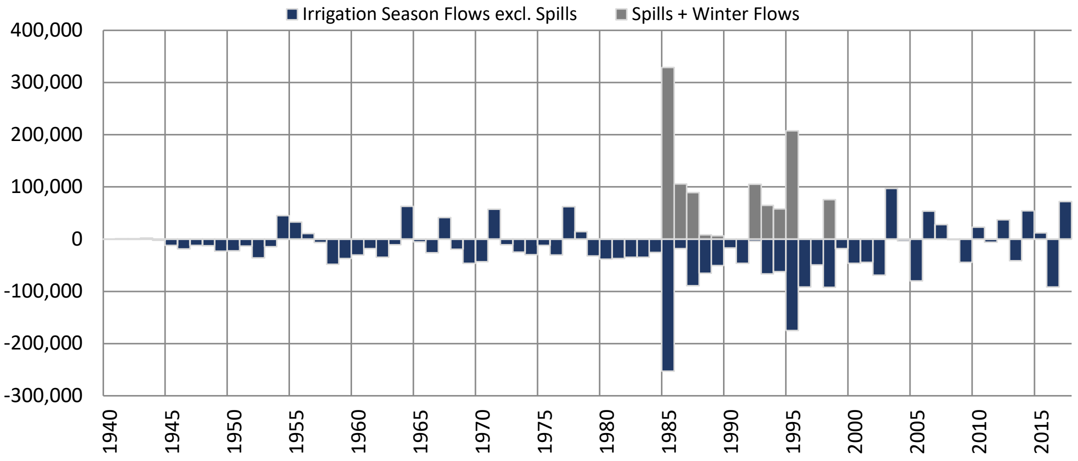
Total Project Storage (Year End)



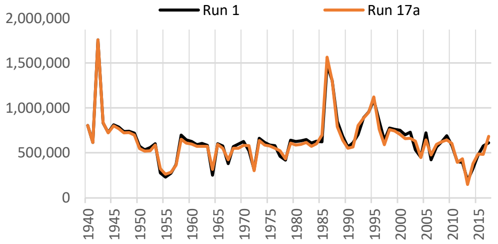
Period	Average Difference
1951-2017	-1,373
1951-1978	-1,806
1979-2005	5,744
2006-2017	-16,378
1985-2017	-5,765
1985-2005	299



Caballo Reservoir Outflows (Annual)



	Average Difference		
Period	Irr Season (excl. Spills)	Nov-Feb and Spills	Annual
1951-2017	-22,711	15,646	-7,065
1951-1978	-6,022	0	-6,022
1979-2005	-53,633	38,825	-14,809
2006-2017	7,925	0	7,925
1985-2017	-34,853	31,766	-3,087
1985-2005	-59,298	49,917	-9,380



Notes:

Reservoir storage does not include storage attributed to SJC, CO, or NM credit waters.

Average differences calculated as (Final Storage - Initial Storage)/(no. years).

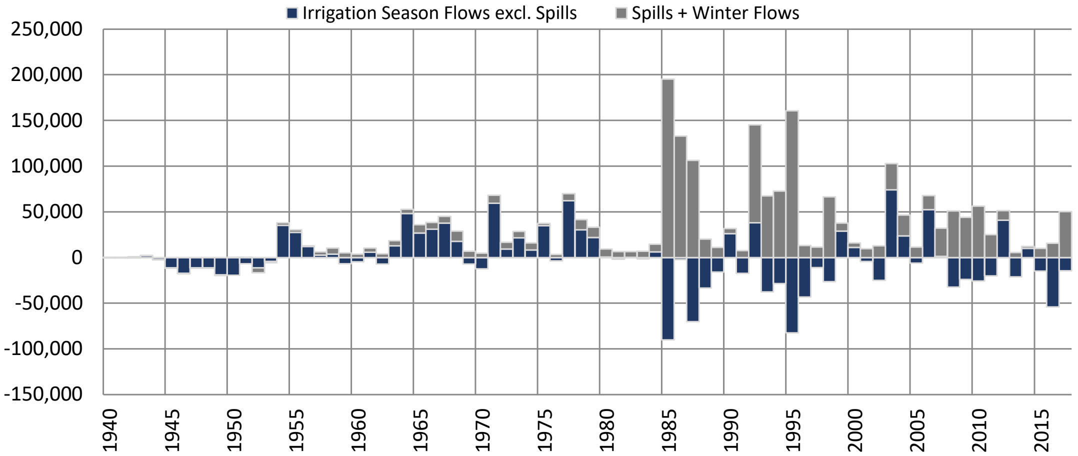
Run 17a - Conj Use 2a: Hist Proj Acres (Pre-Comp M&I)

Simulated Differences in ILRG Model Outputs

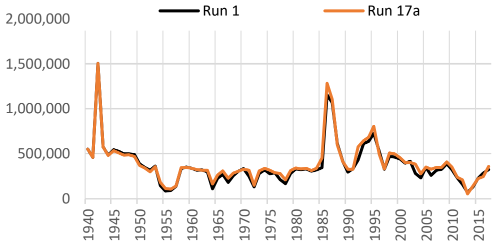
Run 17a minus Run 1

1940 - 2017 (acre-feet)

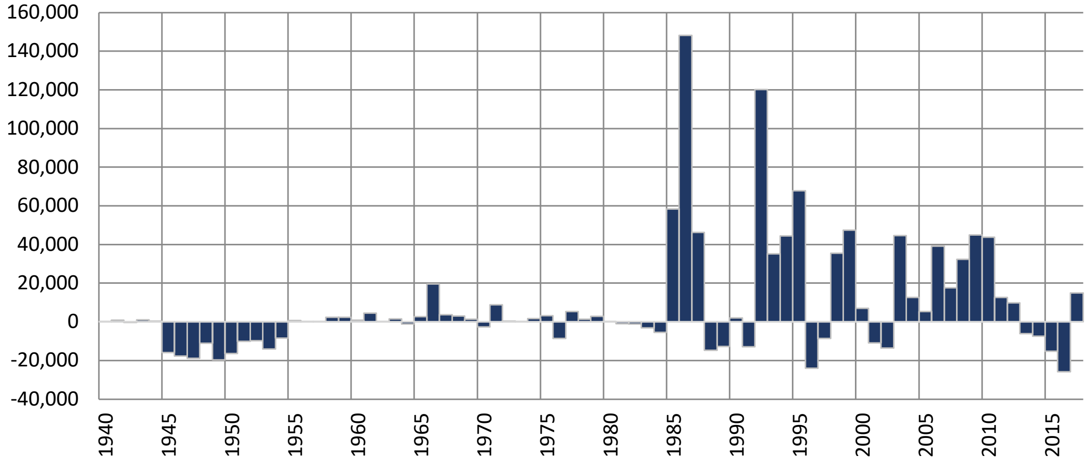
Rio Grande at El Paso (Annual)



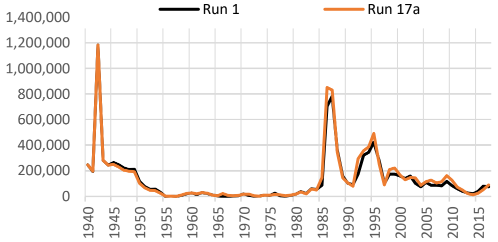
	Average Difference		
Period	Irr Season (excl. Spills)	Nov-Feb and Spills	Annual
1951-2017	809	23,617	24,426
1951-1978	15,105	4,985	20,091
1979-2005	-9,887	41,710	31,823
2006-2017	-8,484	26,380	17,896
1985-2017	-11,946	42,254	30,309
1985-2005	-13,924	51,325	37,401



Rio Grande at Fort Quitman (Annual)



Period	Average Difference
1951-2017	11,011
1951-1978	296
1979-2005	21,087
2006-2017	13,341
1985-2017	22,338
1985-2005	27,478



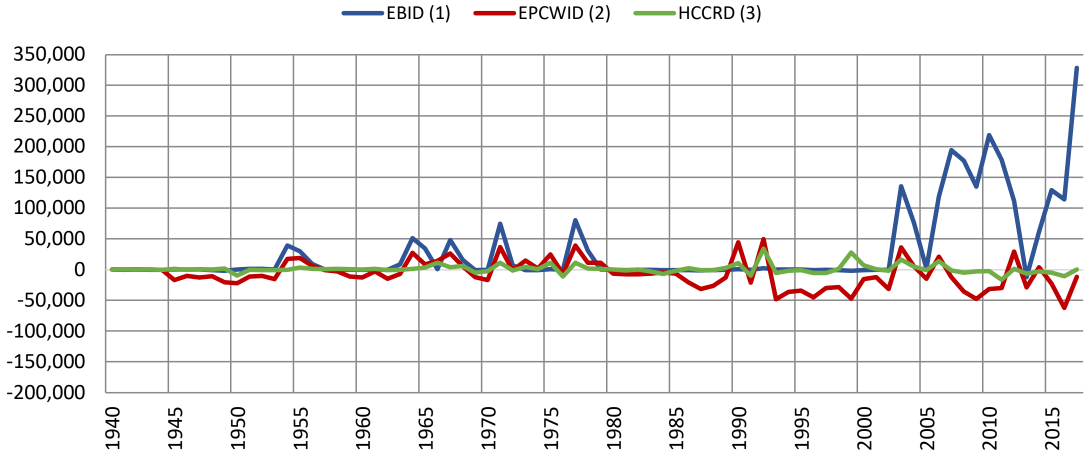
Run 17a - Conj Use 2a: Hist Proj Acres (Pre-Comp M&I)

Simulated Differences in ILRG Model Outputs

Run 17a minus Run 1

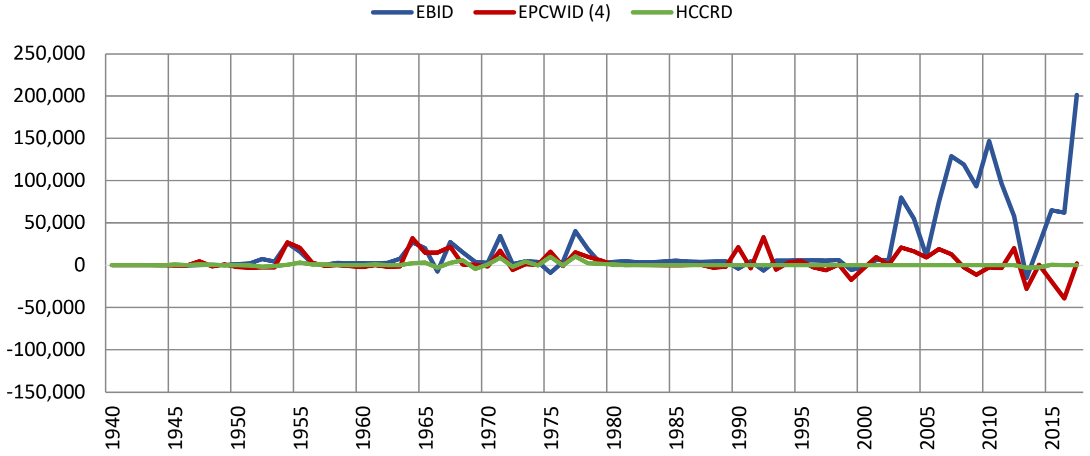
1940 - 2017 (acre-feet)

River Headgate (RHG) Diversions (Irrigation Season)



	Average Difference		
Period	EBID	EPCWID	HCCRD
1951-2017	35,612	-6,810	1,052
1951-1978	15,279	4,413	1,761
1979-2005	7,499	-12,972	2,247
2006-2017	146,312	-19,135	-3,294
1985-2017	59,426	-16,908	949
1985-2005	9,777	-15,636	3,374

Farm Headgate (FHG) Deliveries (Irrigation Season)



	Average Difference		
Period	EBID	EPCWID	HCCRD
1951-2017	23,047	3,062	627
1951-1978	9,516	6,146	1,583
1979-2005	8,258	3,132	102
2006-2017	87,895	-4,292	-419
1985-2017	38,061	800	-152
1985-2005	9,584	3,710	0

Notes:

(1) EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).

(2) EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

(3) HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

(4) EPCWID FHG values include deliveries to Rogers WTP and R/U WTP.

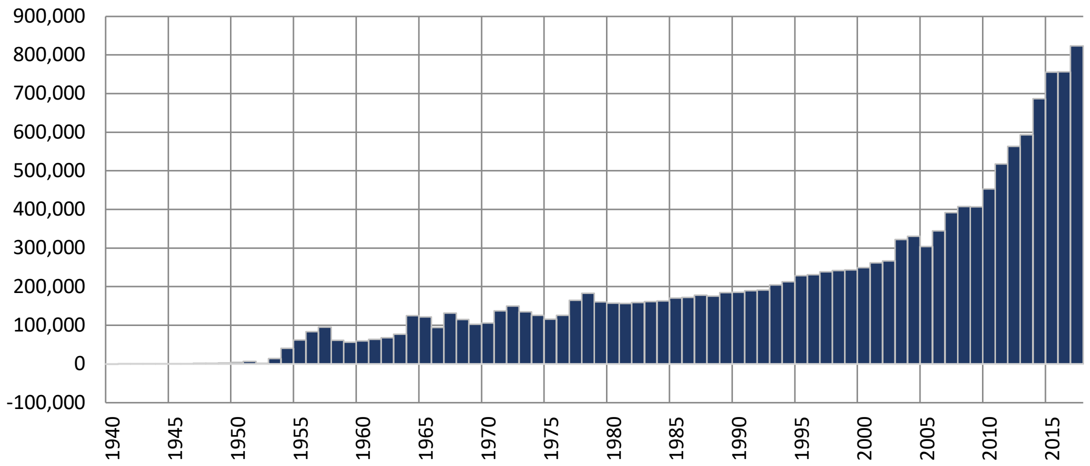
Run 17a - Conj Use 2a: Hist Proj Acres (Pre-Comp M&I)

Simulated Differences in ILRG Model Outputs

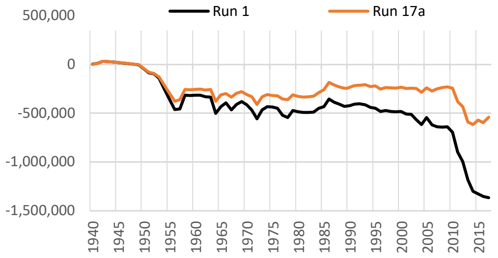
Run 17a minus Run 1

1940 - 2017 (acre-feet)

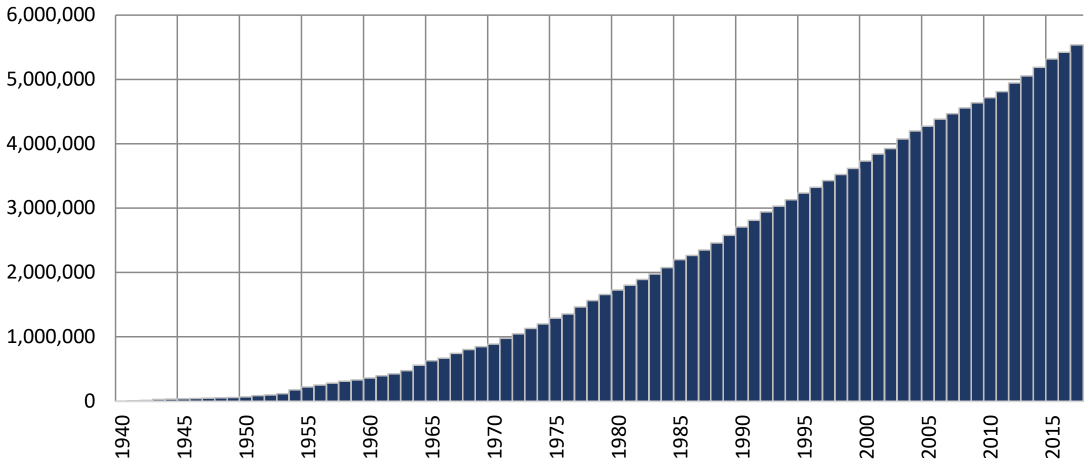
Cumulative Annual Rincon-Mesilla Groundwater Storage



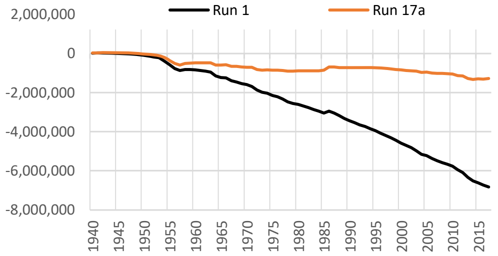
Period	Average Difference
1951-2017	12,238
1951-1978	6,386
1979-2005	4,499
2006-2017	43,306
1985-2017	20,023
1985-2005	6,718



Cumulative Annual Hueco Groundwater Storage



Period	Average Difference
1951-2017	81,627
1951-1978	53,476
1979-2005	100,319
2006-2017	105,256
1985-2017	104,913
1985-2005	104,718

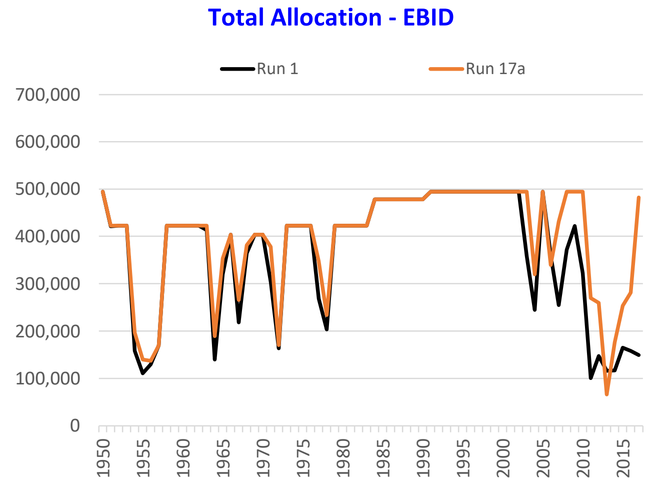


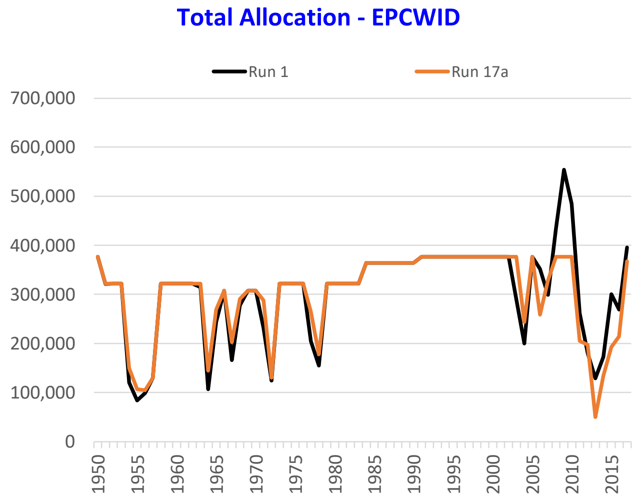
Notes:

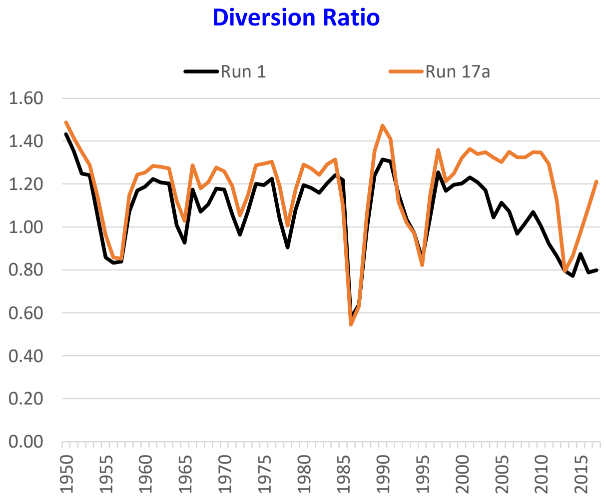
Cumulative storage change in alluvial and non-alluvial aquifers.

Average differences calculated as (Final Storage - Initial Storage)/(no. years).

Run 17a - Conj Use 2a: Hist Proj Acres (Pre-Comp M&I)
Annual Allocation and Charges
Run 17a v. Run 1
ILRG Model
1950 - 2017 (acre-feet)

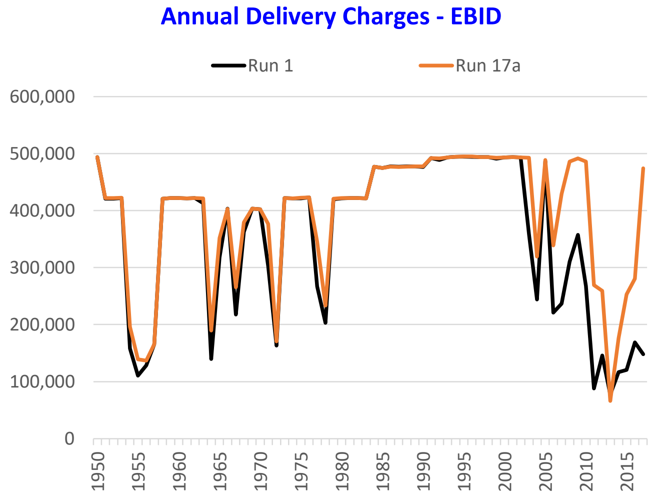


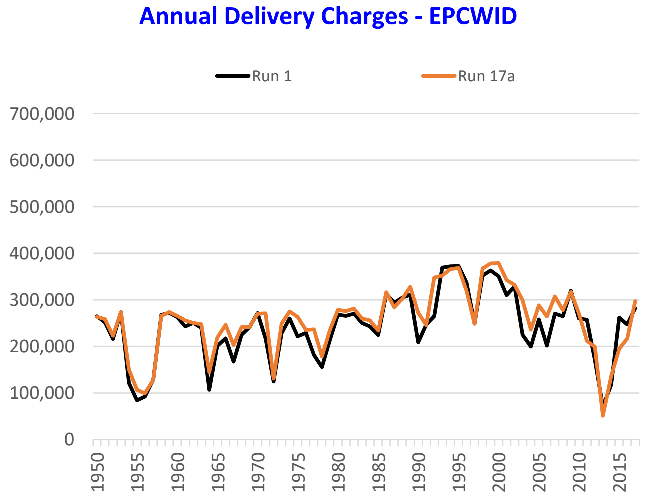




Note:

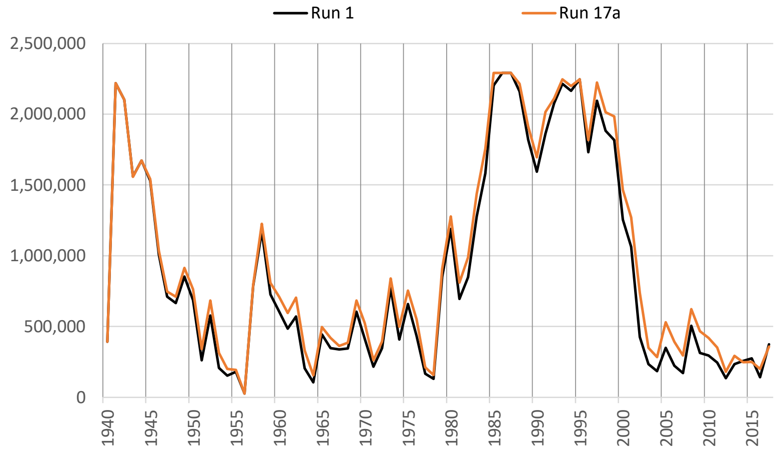
Computed as Total Charges/Caballo Release.



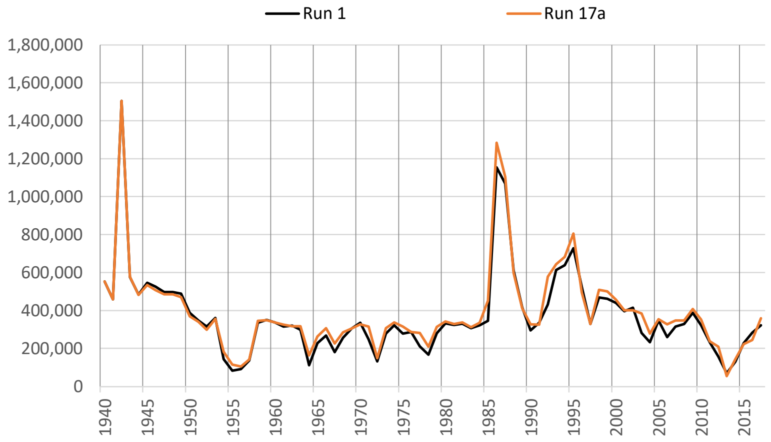


Run 17a - Conj Use 2a: Hist Proj Acres (Pre-Comp M&I)
Annual Summary of Project Storage and Rio Grande Flows
Run 17a v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

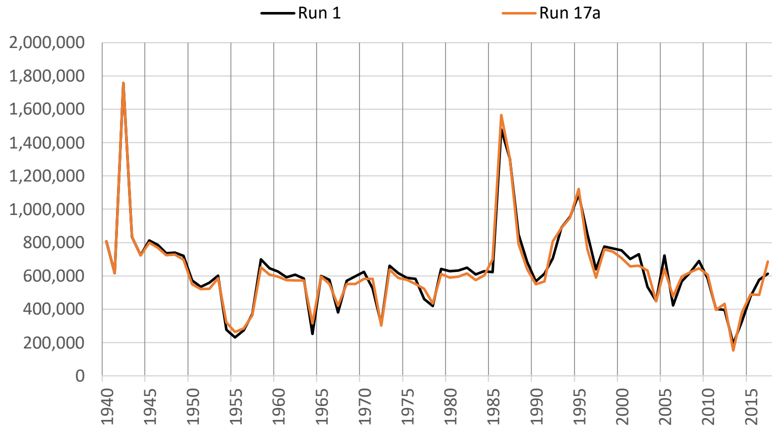
Total Year-End Project Reservoir Storage



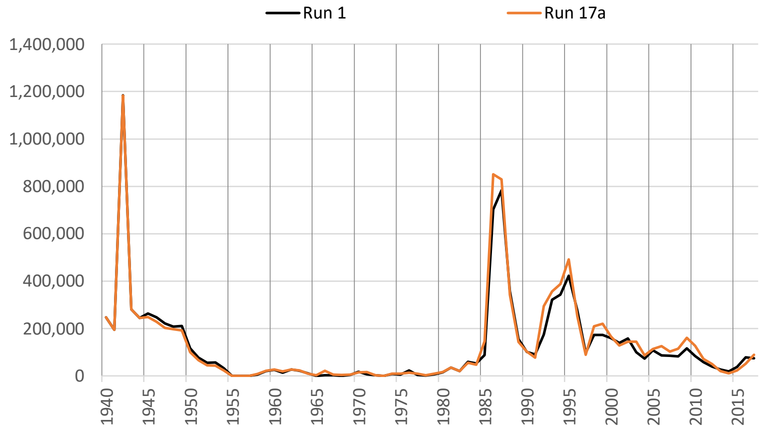
Rio Grande at El Paso



Rio Grande Below Caballo



Rio Grande at Fort Quitman

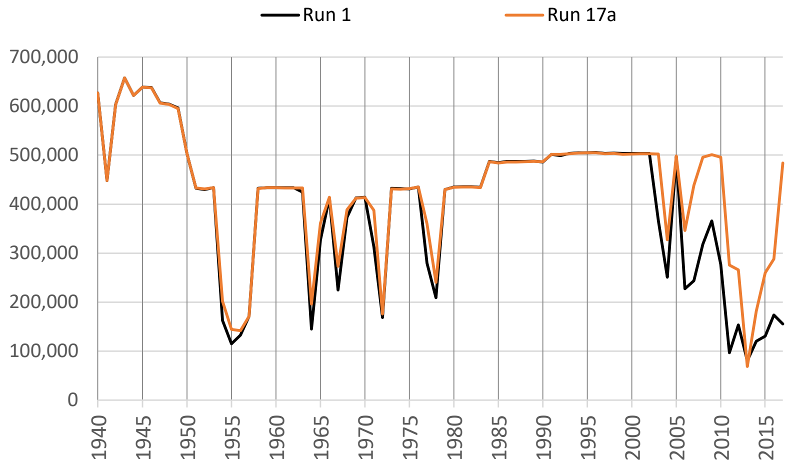


***Note different scales.**

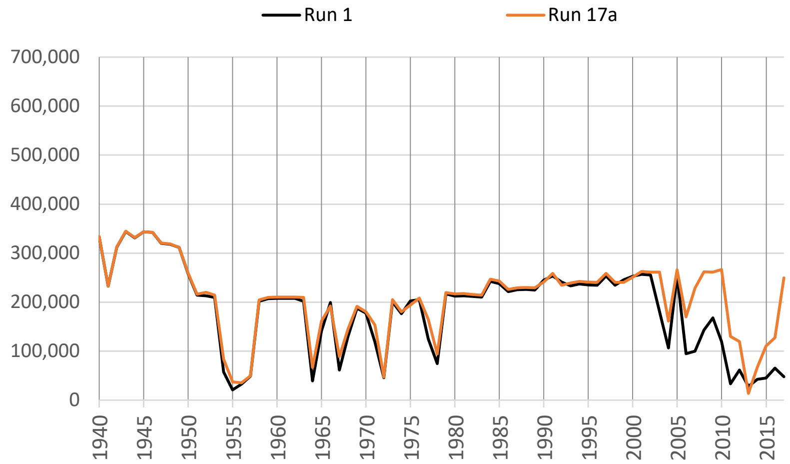
Run 17a - Conj Use 2a: Hist Proj Acres (Pre-Comp M&I)
Irrigation Season Summary of Irrigation Operations
Run 17a v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

EBID Total

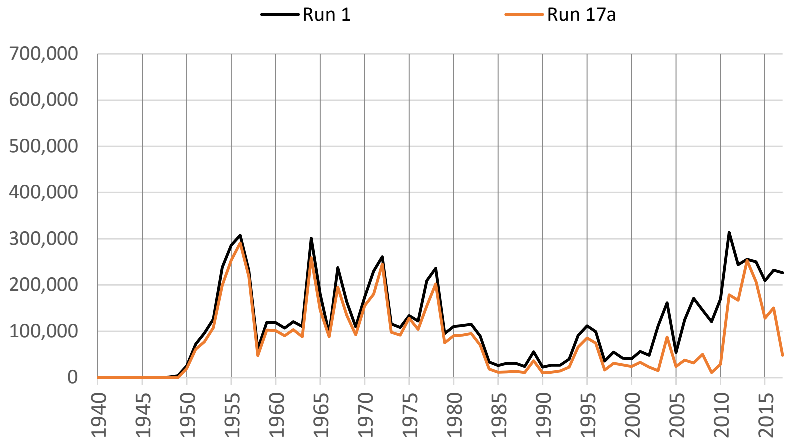
Net River Headgate Diversions



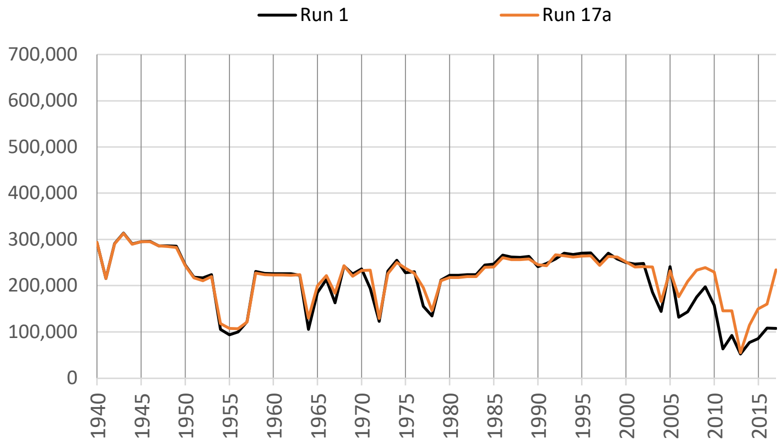
Farm Headgate Deliveries



Pumping



RHG Diversions - FHG Deliveries

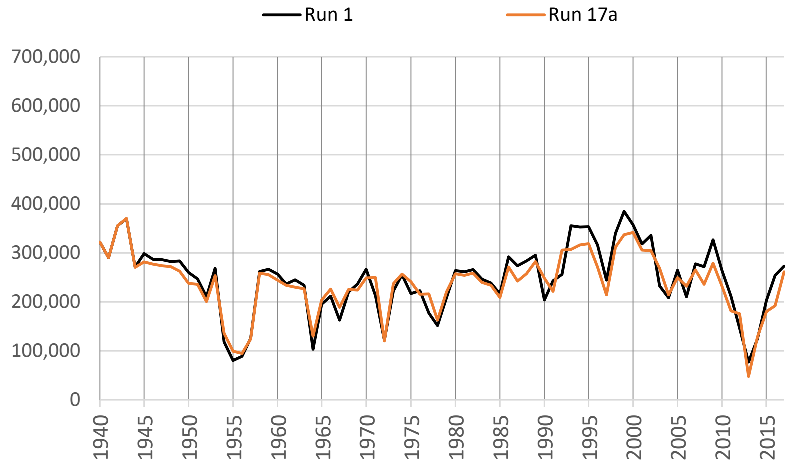


Notes: EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).
Pumping includes Supplemental and Primary groundwater pumping.

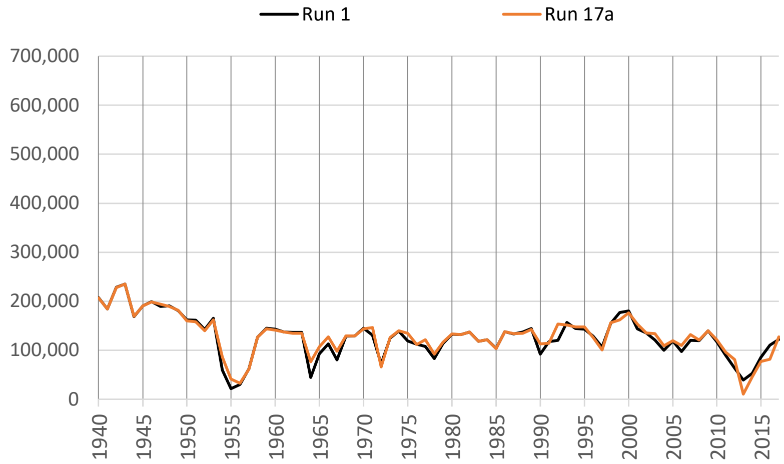
Run 17a - Conj Use 2a: Hist Proj Acres (Pre-Comp M&I)
Irrigation Season Summary of Irrigation Operations
Run 17a v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

EPCWID Total

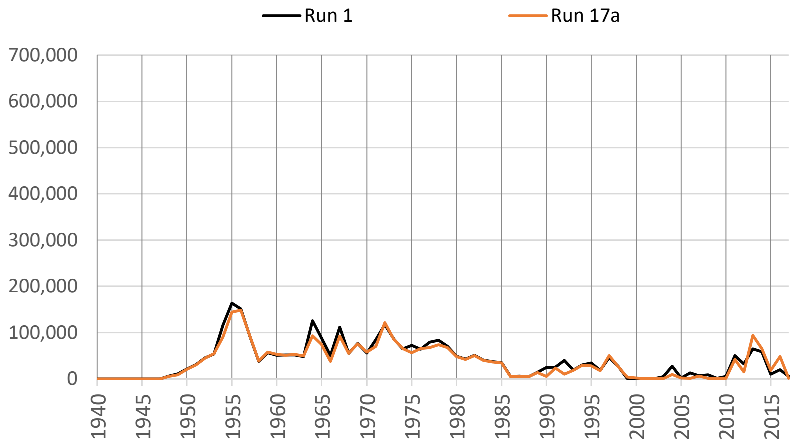
Net River Headgate Diversions



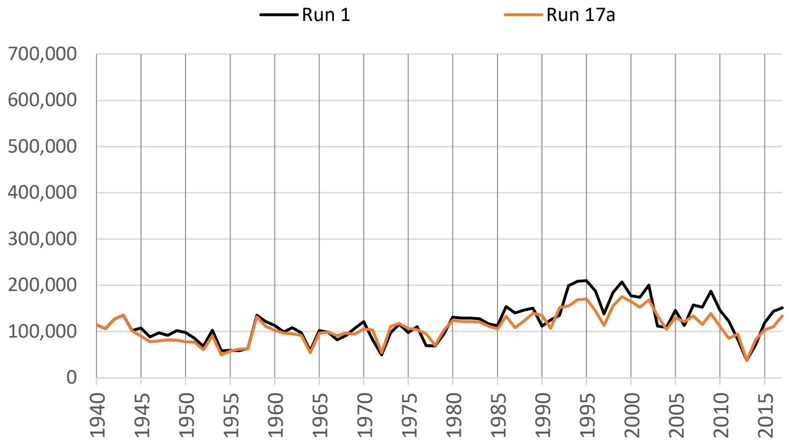
Farm Headgate Deliveries



Pumping



RHG Diversions - FHG Deliveries

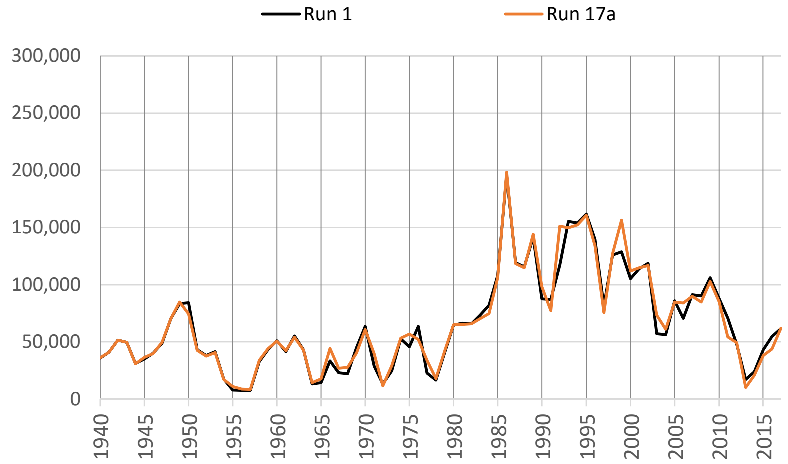


Note: EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

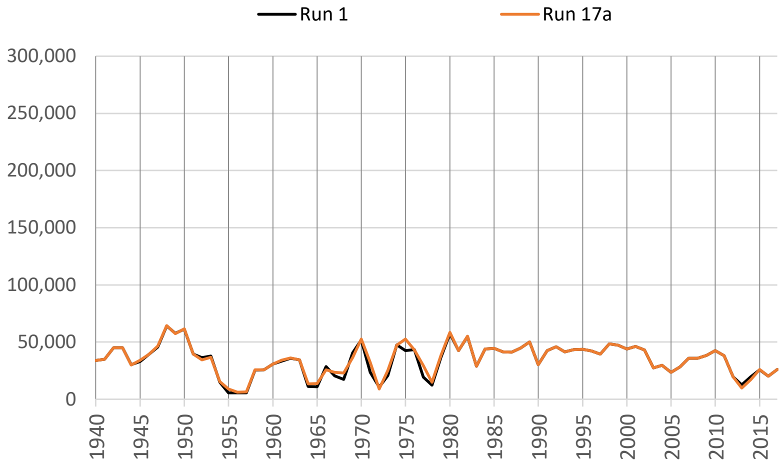
Run 17a - Conj Use 2a: Hist Proj Acres (Pre-Comp M&I)
Irrigation Season Summary of Irrigation Operations
Run 17a v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

HCCRD Total

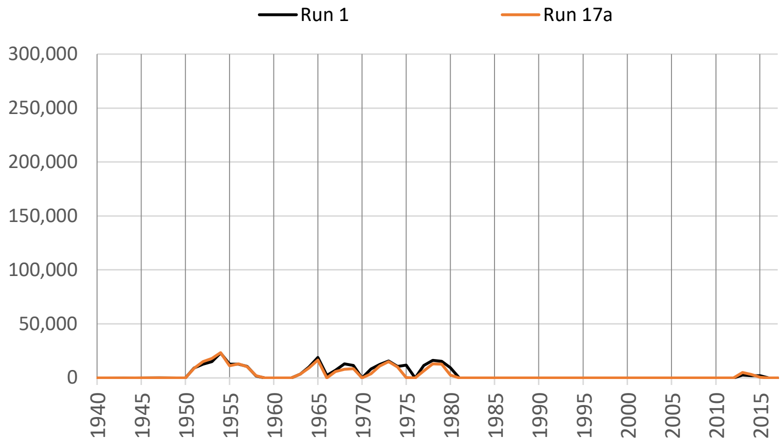
Net River Headgate Diversions



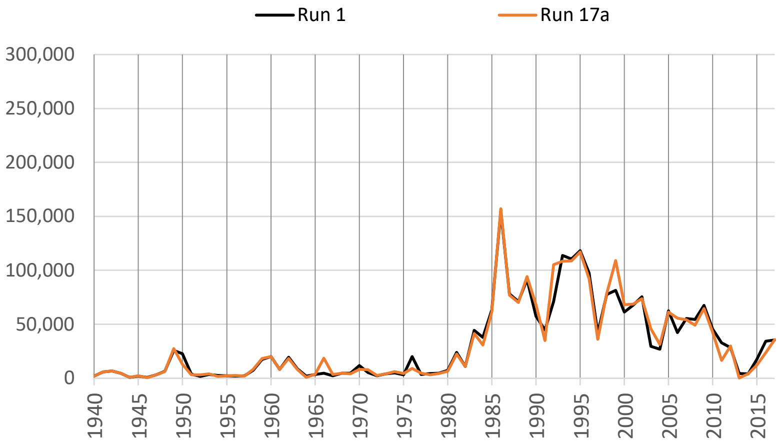
Farm Headgate Deliveries



Pumping

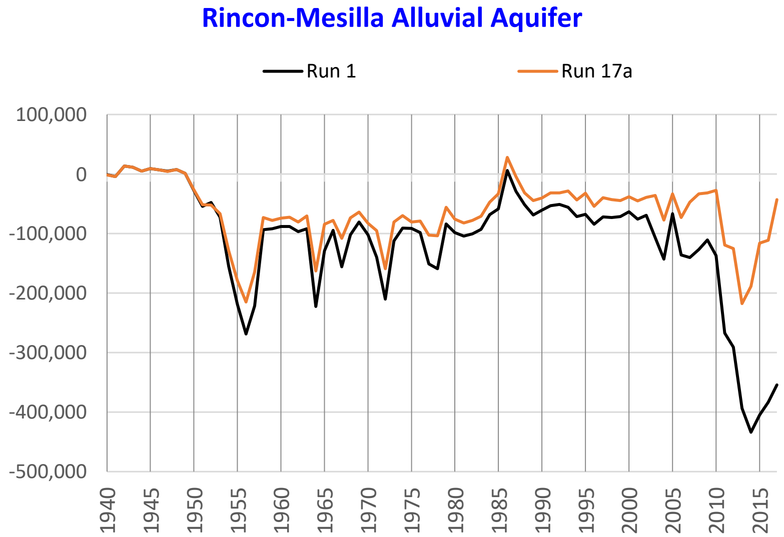


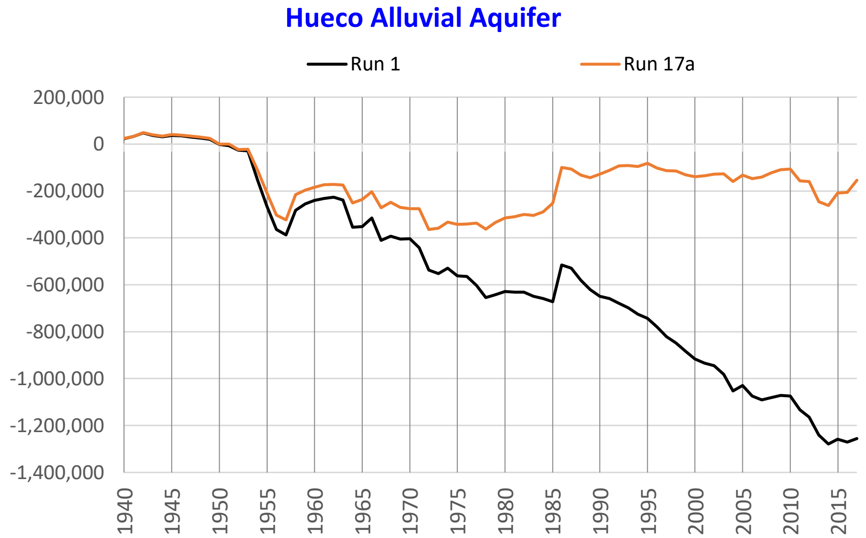
RHG Diversions - FHG Deliveries

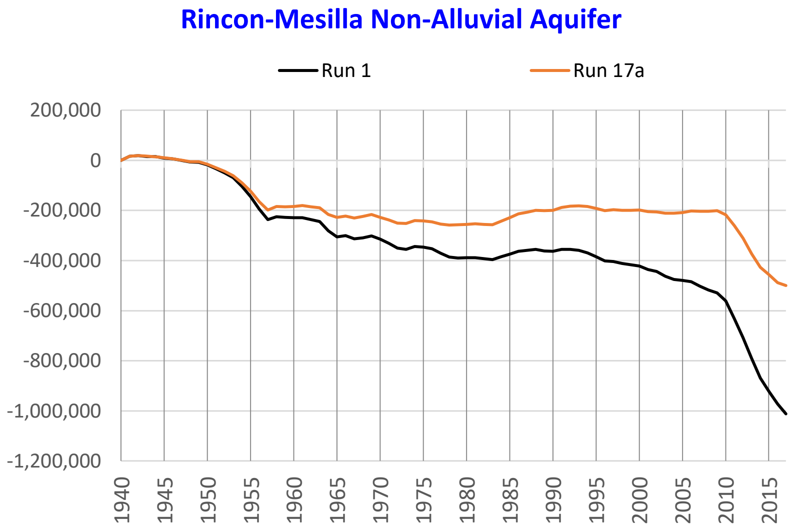


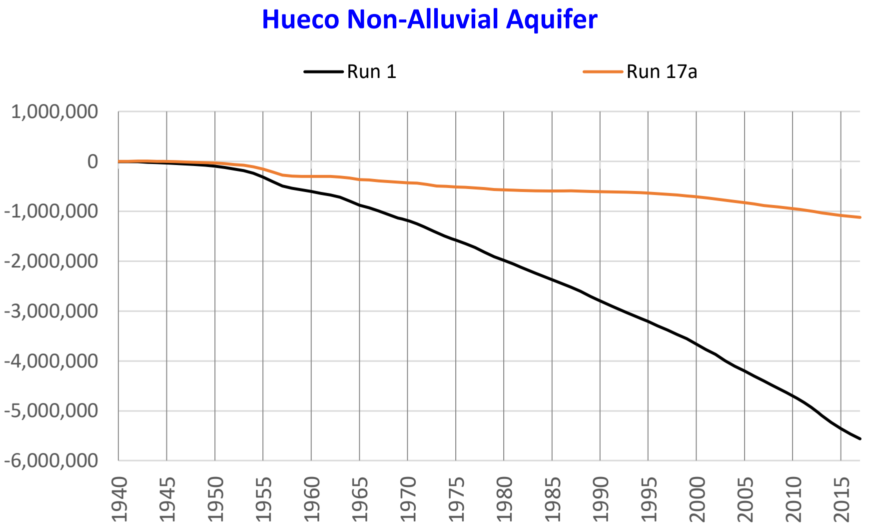
Note: HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

Run 17a - Conj Use 2a: Hist Proj Acres (Pre-Comp M&I)
Cumulative Change in Ground Water Storage
Run 17a v. Run 1
ILRG Model
1940 - 2017 (acre-feet)









***Note different scales.**

Run 17a - Conj Use 2a: Hist Proj Acres (Pre-Comp M&I)

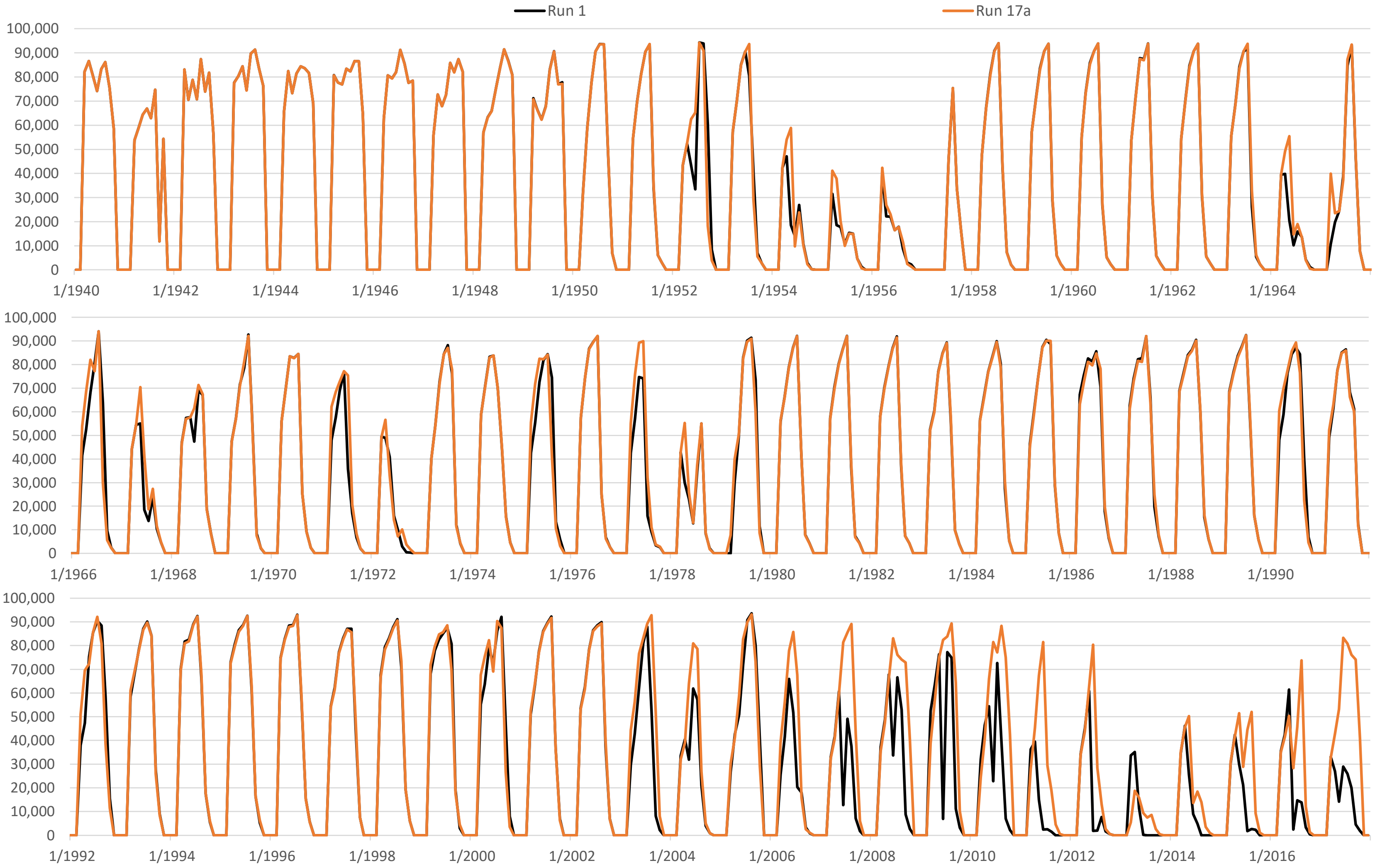
Monthly Net RHG Diversions

Run 17a v. Run 1

ILRG Model

1940 - 2017 (acre-feet)

EBID Total

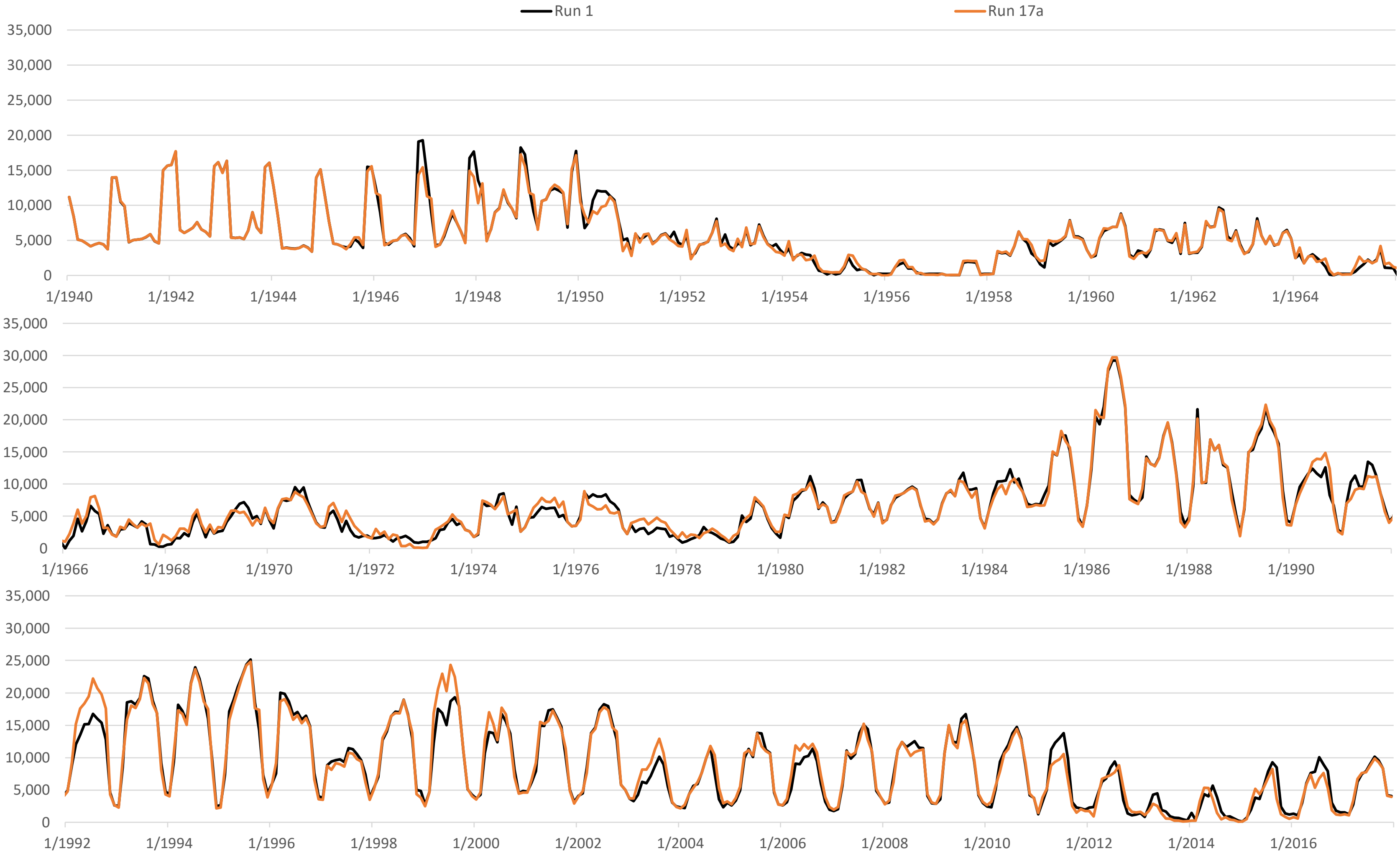


Note: EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).

Run 17a - Conj Use 2a: Hist Proj Acres (Pre-Comp M&I)
Monthly Net RHG Diversions
Run 17a v. Run 1
ILRG Model
1940 - 2017 (acre-feet)
EPCWID Total

Note: EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

Run 17a - Conj Use 2a: Hist Proj Acres (Pre-Comp M&I)
Monthly Net RHG Diversions
Run 17a v. Run 1
ILRG Model
1940 - 2017 (acre-feet)
HCCRD Total



Note: HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

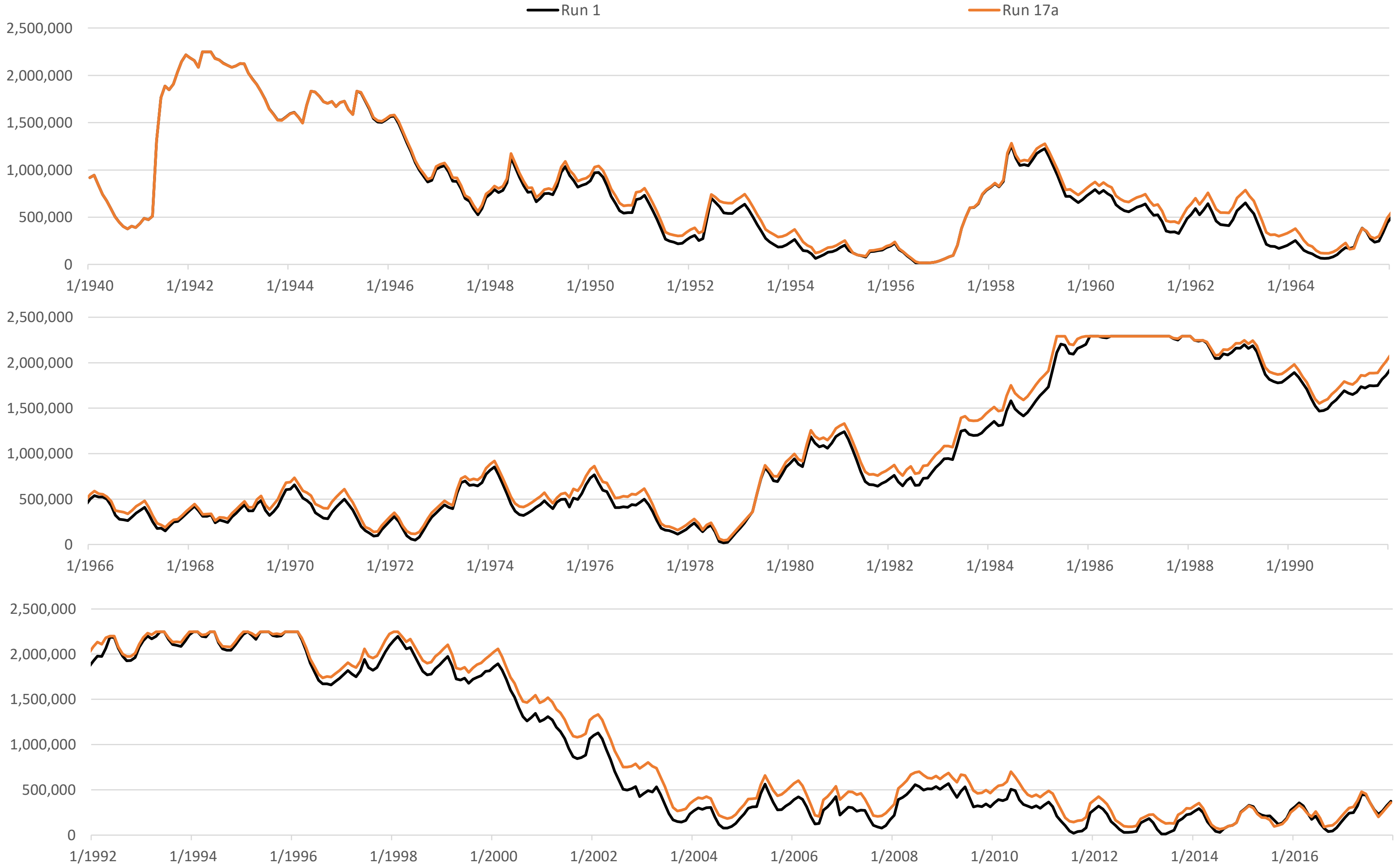
Run 17a - Conj Use 2a: Hist Proj Acres (Pre-Comp M&I)

End of Month Reservoir Storage (Elephant Butte + Caballo)

Run 17a v. Run 1

ILRG Model

1940 - 2017 (acre-feet)



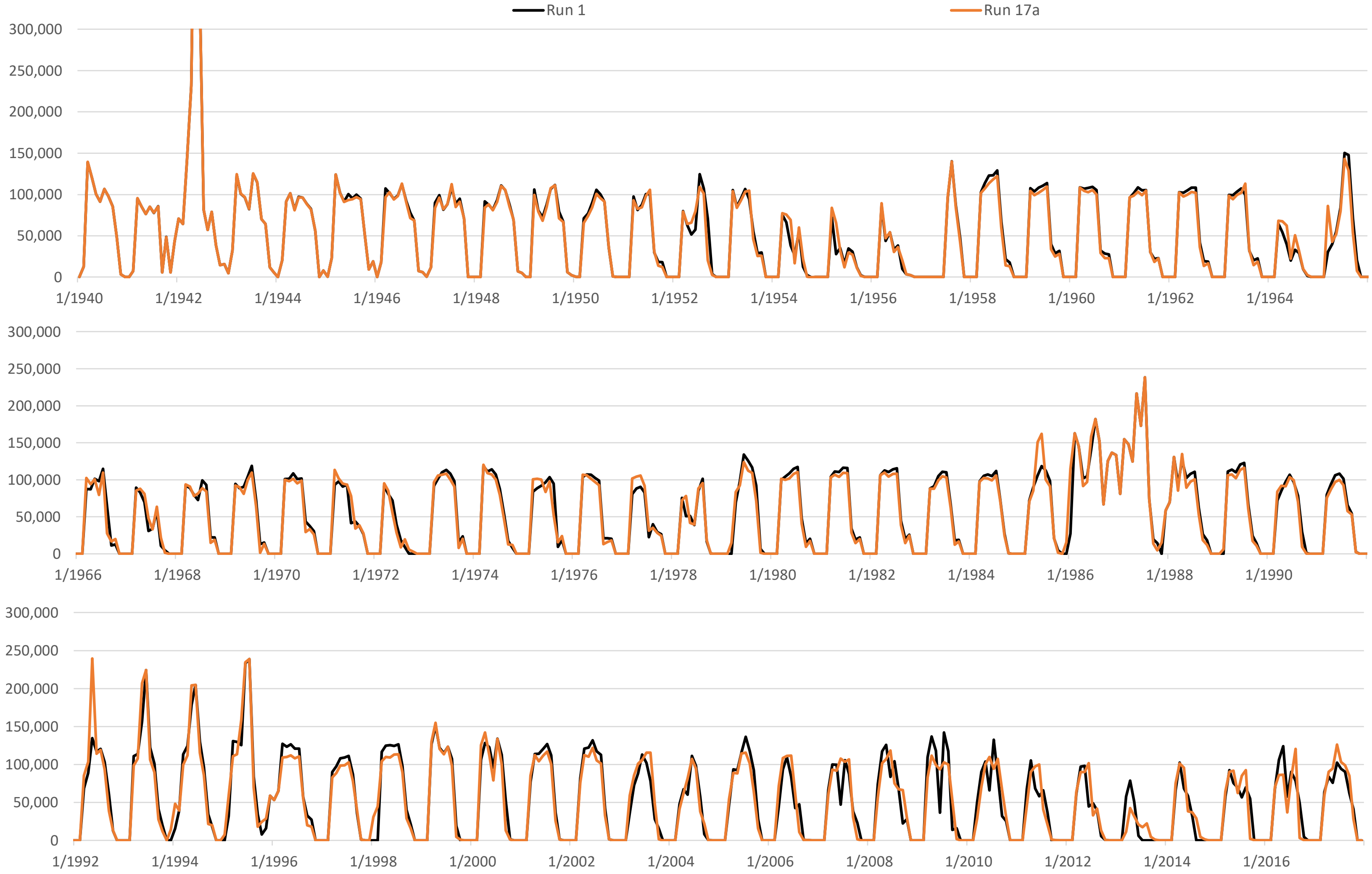
Run 17a - Conj Use 2a: Hist Proj Acres (Pre-Comp M&I)

Monthly Caballo Releases

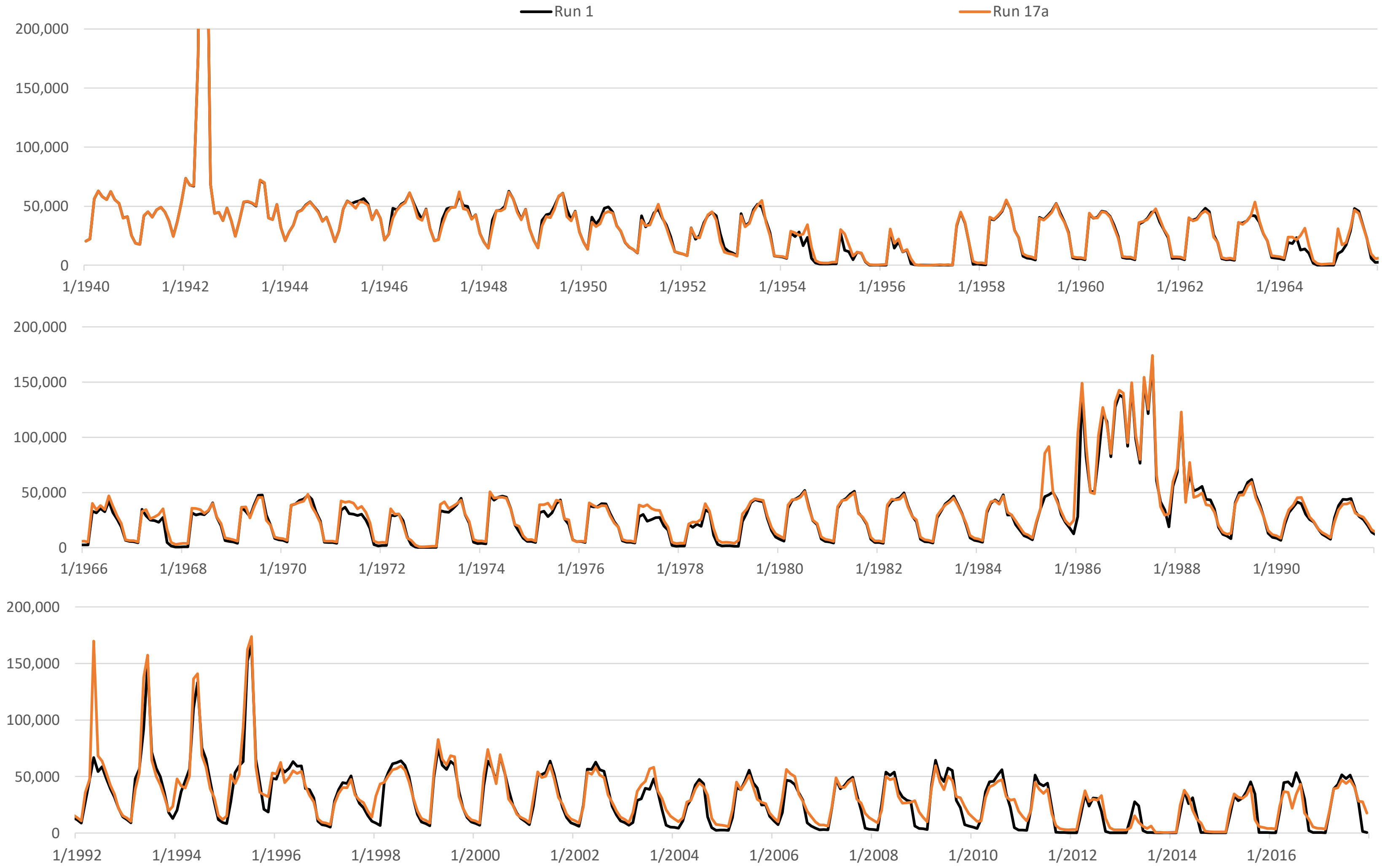
Run 17a v. Run 1

ILRG Model

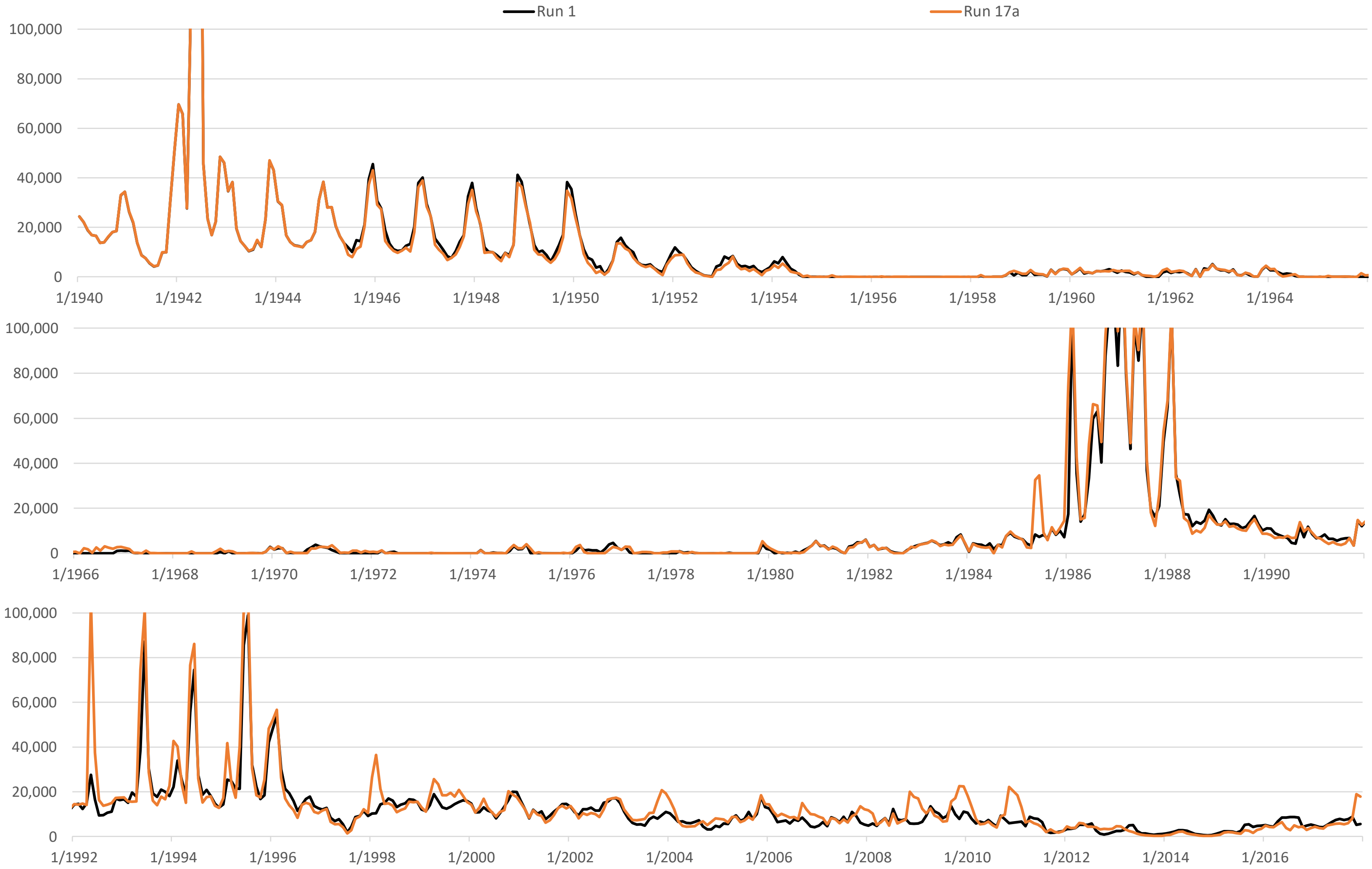
1940 - 2017 (acre-feet)



Run 17a - Conj Use 2a: Hist Proj Acres (Pre-Comp M&I)
Monthly Rio Grande at El Paso Flow
Run 17a v. Run 1
ILRG Model
1940 - 2017 (acre-feet)



Run 17a - Conj Use 2a: Hist Proj Acres (Pre-Comp M&I)
Monthly Rio Grande at Fort Quitman Flow
Run 17a v. Run 1
ILRG Model
1940 - 2017 (acre-feet)



Appendix 30AA

Comparison of ILRG Model Runs

Run 18 v. Run 1

Model Run Specifications

Model Version: LRG_v116

Name: **Run 18 - Conj Use 3: Auth Proj Acres (Pre-Comp M&I)**

Run ID: LRG_v116_Operational_Run18
Date: 8/31/2020

Name: **Run 1 - Historical Base Run (All Pumping On)**

Run ID: LRG_v116_Operational_Run1
Date: 8/23/2020

Selected Model Inputs

Pumping and Returns	**Run 18**	**Run 1**
(1) Irrigation Pumping	Conj	On
(2) Irrigated Area	Authorized	Hist
(3) Non-Irrigation Pumping	Pre-Comp	On
Non-Irrigation Pumping Returns	Pre-Comp	On
Las Cruces Jornada Pumping Returns	Off	On

Project Allocation Rules		
1950-2005	D1/D2	D1/D2
2006-2007	D1/D2	D3
2008-2017	D1/D2	D3 + CO

EPCWID Operations		
Charge EPCWID for Use of WWTP Returns	On	Off
ACE and Haskell Credits for EPCWID	Off	On
(4) Increased EPCWID Use of Fabens Drain Flows	On	Off
Charge EPCWID for Fabens Drain Flow Use	On	Off

Notes:

(1) Conjunctive use pumping on historical Project acres; no pumping on NM GW only acres.
(2) Acres set to authorized Project acres every year. HCCRD set to max historical acres.
(3) Limit M&I pumping to pre-compact levels. Reduce corresponding return flows.
(4) Starting in July 1945, use 70% of simulated Fabens drain flow up to 6,000 AF/month.

Run 18 - Conj Use 3: Auth Proj Acres (Pre-Comp M&I)

Comparison of ILRG Model Runs

Run 18 v. Run 1

1951 - 2017 Annual Average

(1,000 acre-feet)

Run No.	1	18	18 - 1	
Simulated Input or Output	**Run 1**	**Run 18**	**Run 18 minus Run 1**	
Effects of Alternate Scenario				
FHG Deliveries (Mar - Oct)				***% Diff.***
EBID	167.6	177.8	10.2	*6%*
EPCWID (incl. EPW)	139.9	144.4	4.5	*3%*
HCCRD	32.8	39.6	6.7	*20%*
Total	340.3	361.7	21.4	*6%*
FHG Deliveries (Nov - Feb)				
EBID	0.0	0.0	0.0	*83%*
EPCWID (incl. EPW)	0.2	1.1	0.9	*463%*
HCCRD	2.4	3.6	1.2	*51%*
Total	2.6	4.7	2.1	*81%*
Irrigation Pumping				
EBID	140.4	144.2	3.7	*3%*
EPCWID (Mesilla Valley)	7.4	11.9	4.6	*63%*
EPCWID (El Paso Valley)	40.1	68.0	27.9	*70%*
HCCRD	4.2	18.4	14.2	*337%*
Total	192.1	242.6	50.4	*26%*
Other Inflows/Outflows				
Net Reservoir Evaporation	125.3	119.9	-5.4	*-4%*
Riparian ET	70.9	74.0	3.1	*4%*
River Evaporation + Incidental Canal Loss	30.3	30.2	-0.2	*-1%*
Total	226.6	224.0	-2.5	*-1%*
Rio Grande at Fort Quitman				
Reservoir Spills	33.3	22.9	-10.4	*-31%*
Nov-Feb Flows	21.4	14.9	-6.5	*-30%*
Mar - Oct Flows	41.1	30.5	-10.5	*-26%*
Underflow (GW Model)	0.2	0.2	0.0	*-18%*
Total	96.0	68.6	-27.4	*-29%*

Run 18 - Conj Use 3: Auth Proj Acres (Pre-Comp M&I)

Comparison of ILRG Model Runs

Run 18 v. Run 1

1951 - 2017 Annual Average

(1,000 acre-feet)

Run No.	1	18	18 - 1	
Simulated Input or Output	**Run 1**	**Run 18**	**Run 18 minus Run 1**	
Effects of Alternate Scenario (continued)				
Change in Storage				***% Diff.***
Reservoir Storage	-4.7	-8.0	-3.4	*72%*
Alluvial GW Storage (RW Model)	-23.6	-10.0	13.6	*-58%*
Non-alluvial GW Storage (GW Models)	-96.4	-32.5	63.8	*-66%*
Soil Moisture Storage	0.6	0.2	-0.4	*-72%*
Total	-124.0	-50.3	73.7	*-59%*
Summary of Effects				
FHG Deliveries (Mar-Oct)	340.3	361.7	21.4	*6%*
FHG Deliveries (Nov-Feb)	2.6	4.7	2.1	*81%*
Irrigation Pumping	192.1	242.6	50.4	*26%*
Riparian ET + Evaporation	226.6	224.0	-2.5	*-1%*
Fort Quitman Flow	96.0	68.6	-27.4	*-29%*
Change in Storage	-124.0	-50.3	73.7	*-59%*
Total	733.6	851.2	117.6	*16%*
Other Effects of Alternate Scenario				
Rio Grande at El Paso				***% Diff.***
Reservoir Spills	49.4	35.7	-13.7	*-28%*
Nov-Feb Flows	22.8	26.0	3.2	*14%*
Mar - Oct Flows	263.8	291.6	27.8	*11%*
Total	336.0	353.2	17.3	*5%*
Rio Grande below Caballo				
Reservoir Spills	65.9	44.7	-21.2	*-32%*
Nov-Feb Flows	0.5	0.3	-0.2	*-32%*
Mar - Oct Flows	541.3	570.6	29.4	*5%*
Total	607.6	615.7	8.1	*1%*
Surface Water Diversions (Mar - Oct)				
EBID	366.5	377.9	11.4	*3%*
EPCWID (incl. EPW)	236.8	239.7	2.9	*1%*
HCCRD	67.5	65.9	-1.7	*-2%*
Total	670.8	683.5	12.7	*2%*
Surface Water Diversions (Nov - Feb)				
EBID	0.0	0.0	0.0	*0%*
EPCWID (incl. EPW)	14.3	13.5	-0.9	*-6%*
HCCRD	14.2	11.7	-2.5	*-18%*
Total	28.5	25.2	-3.4	*-12%*

Run 18 - Conj Use 3: Auth Proj Acres (Pre-Comp M&I)

Annual Differences in ILRG Model Outputs

Run 18 minus Run 1

1940 - 2017 (acre-feet)

	Net River Headgate Diversions						Farm Headgate Deliveries						Annual Flows		
	EBID		EPCWID (incl. EPW)		HCCRD		EBID		EPCWID (incl. EPW)		HCCRD				
Year	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Caballo Releases	Rio Grande at El Paso	Rio Grande at Fort Quitman
1940	28,809	28,809	21,394	23,210	1,560	2,298	19,743	19,755	13,556	13,636	2,409	8,669	54,025	32,660	-8,928
1941	19,819	19,819	15,798	17,647	1,316	2,296	14,143	14,155	10,176	10,242	1,675	6,163	-5,932	-6,320	-23,774
1942	5,018	5,018	13,183	6,642	260	-4,010	3,485	3,479	6,951	7,148	2,546	6,982	-33,419	-41,332	-89,534
1943	-1,490	-1,490	12,880	12,577	2,404	2,289	-1,066	-1,062	3,801	3,631	2,793	5,779	16,894	16,699	-15,559
1944	267	267	3,533	3,493	82	-46	192	196	-445	-568	869	4,181	7,530	7,180	-16,091
1945	-3,088	-3,088	-11,974	-1,091	1,559	812	-2,169	-2,166	-388	5,938	1,774	3,915	-3,416	-1,311	-34,102
1946	-6,406	-6,406	-6,266	-7,487	-397	-7,564	-4,498	-4,497	-2,030	1,303	293	939	-14,339	-9,533	-35,716
1947	-9,979	-9,979	-12,190	-7,381	551	-6,115	-6,645	-6,646	-44	6,159	667	504	-11,878	-5,965	-36,077
1948	-10,477	-10,477	-10,135	-7,297	0	-5,499	-6,253	-6,249	-5,856	109	1,197	1,816	-8,758	-3,608	-26,801
1949	-19,383	-19,383	-22,475	-19,040	1,310	2,342	-11,910	-11,906	-5,644	-547	1,797	1,851	-31,752	-18,398	-37,065
1950	-160	-160	-22,225	-19,575	-9,652	-11,280	529	544	-6,711	-2,466	2,096	2,502	-13,364	-10,623	-24,258
1951	933	933	-8,074	-3,242	-291	-2,573	1,640	1,653	-4,796	-309	-142	-2,445	-7,902	1,653	-16,909
1952	600	600	-8,070	-5,331	-675	-1,874	4,581	4,587	-4,027	-1,622	-2,446	619	-27,145	-4,396	-12,616
1953	-22	-22	-15,381	-12,627	-1,251	-2,488	3,398	3,404	-5,218	-2,845	-1,841	708	-19,948	-1,375	-17,867
1954	21,580	21,580	6,166	7,032	-1,671	-1,120	16,571	16,572	18,064	18,979	-1,093	-430	13,818	22,710	-14,516
1955	34,937	34,937	24,558	22,870	1,839	1,439	18,476	18,476	16,224	16,235	1,824	1,657	57,741	35,817	978
1956	-802	-802	-2,347	-4,750	1,562	1,070	-2,762	-2,762	-3,291	-3,664	1,060	635	-4,094	3,121	145
1957	-317	-317	-694	-3,601	1,995	1,535	-190	-190	-1,288	-1,365	2,459	2,053	-1,886	2,294	230
1958	826	826	36,020	35,352	5,041	4,367	2,134	2,134	18,471	18,380	8,949	11,844	37,475	60,657	-2,017
1959	425	425	19,806	20,228	632	-2,864	2,495	2,495	10,350	10,359	12,971	18,200	18,751	39,798	-17,735
1960	410	410	12,323	12,288	-1,437	-5,951	2,223	2,224	12,462	12,543	14,683	17,484	15,975	34,269	-18,706
1961	501	501	27,519	28,035	1,126	-317	2,595	2,596	20,016	20,579	4,467	12,599	31,928	48,397	-5,066
1962	-1,510	-1,510	-32,537	-32,138	-12,602	-13,680	13,082	13,084	-5,619	-5,143	2,829	13,813	-30,376	-15,596	-24,311
1963	-31,185	-31,185	11,201	12,390	-321	-1,743	-15,184	-15,184	8,527	9,131	3,832	16,008	-13,348	30,702	-11,327
1964	-18,163	-18,163	-16,827	-20,125	-1,952	-2,083	-9,781	-9,781	-5,084	-4,943	-1,201	1,647	-24,952	-5,938	-7,330
1965	-1,599	-1,599	14,596	11,878	2,401	928	-30	-30	8,085	7,795	3,059	2,011	25,954	35,957	390
1966	492	492	21,720	22,035	-3,019	-6,072	2,696	2,696	23,548	23,566	-2,908	-3,319	24,138	45,344	-944
1967	-30,577	-30,577	-28,633	-31,192	-6,058	-7,356	-5,382	-5,382	-22,031	-22,542	-6,939	-4,876	-49,011	-13,196	-1,113
1968	5,950	5,950	50,361	48,521	3,192	698	3,479	3,479	22,993	22,600	3,187	1,740	77,511	70,220	119
1969	-291	-291	13,957	14,121	-3,059	-5,203	-2,851	-2,849	18,144	18,162	-2,672	1,124	17,967	35,698	-3,069
1970	438	438	8,501	9,664	1,646	-817	2,252	2,252	15,237	15,845	9,376	17,196	7,079	30,253	-14,246
1971	-49,078	-49,078	-31,981	-36,479	-1,390	-6,156	-25,816	-25,816	-20,162	-19,738	718	1,689	-83,888	-22,743	-5,494
1972	-7,504	-7,504	-7,007	-12,129	-3,768	-7,819	-6,062	-6,062	-21,714	-21,580	-3,296	-6,600	9,919	2,435	-699
1973	218	218	59,176	57,383	9,900	7,029	2,385	2,385	25,082	24,846	11,057	8,455	78,088	88,731	828
1974	366	366	48,145	48,606	12,129	10,135	2,038	2,040	29,315	29,687	11,381	11,197	56,249	82,146	1,116
1975	-1,195	-1,195	21,124	21,548	4,229	4,251	-7,412	-7,405	21,492	22,165	5,873	4,934	35,693	48,223	4,217
1976	-123	-123	60,926	62,654	11,156	10,705	2,044	2,045	50,811	51,895	28,524	38,093	79,524	97,824	-19,321
1977	-115,180	-115,180	-65,364	-69,323	-4,747	-7,389	-59,432	-59,432	-44,364	-43,784	-2,230	-2,377	-184,587	-68,168	-971
1978	3,536	3,536	-3,286	-10,467	-796	-5,342	2,547	2,547	-25,503	-25,506	1,045	-1,338	29,015	5,890	-509

Run 18 - Conj Use 3: Auth Proj Acres (Pre-Comp M&I)

Annual Differences in ILRG Model Outputs

Run 18 minus Run 1

1940 - 2017 (acre-feet)

	Net River Headgate Diversions						Farm Headgate Deliveries						Annual Flows		
	EBID		EPCWID (incl. EPW)		HCCRD		EBID		EPCWID (incl. EPW)		HCCRD				
Year	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Mar - Oct	Annual	Caballo Releases	Rio Grande at El Paso	Rio Grande at Fort Quitman
1979	-2,129	-2,129	40,871	38,325	-254	-3,033	-273	-268	12,025	12,042	1,984	104	74,715	81,123	-265
1980	-3,354	-3,354	46,429	46,786	885	-6,856	2,567	2,570	32,317	32,323	3,375	1,646	67,361	96,084	-7,727
1981	-1,898	-1,898	38,932	38,531	-2,064	-8,561	1,538	1,539	35,305	35,578	16,351	22,139	56,591	77,844	-28,420
1982	-2,491	-2,491	33,038	32,244	-1,943	-7,399	1,827	1,828	32,865	32,868	3,968	8,156	50,912	70,963	-10,986
1983	452	452	46,554	46,024	-2,958	-8,159	3,666	3,668	45,974	46,610	29,531	36,911	94,301	92,105	-41,607
1984	636	636	41,041	41,179	4,000	-1,167	3,547	3,549	38,969	40,445	9,955	8,206	72,237	82,571	-7,454
1985	2,184	2,184	41,870	43,031	-16,215	-21,553	11,177	11,186	41,946	43,956	8,588	8,474	28,306	43,906	-27,474
1986	-542	-542	28,637	29,502	-13,887	-23,239	7,183	7,171	36,272	37,528	6,383	6,094	-328,978	-306,960	-281,384
1987	446	446	28,647	31,151	10,227	7,341	6,025	6,031	45,719	49,641	7,426	7,489	72	6,228	-191,591
1988	-95	-95	21,597	23,989	9,151	6,485	5,727	5,732	37,555	41,324	6,035	5,697	10,089	19,098	-107,832
1989	-1,594	-1,594	25,272	27,401	13,650	10,960	4,948	4,954	33,381	36,382	1,236	276	60,023	68,452	-23,683
1990	1,209	1,209	39,592	41,151	421	-2,314	5,393	5,400	42,120	44,890	12,375	12,409	60,207	74,462	-32,843
1991	1,901	1,901	3,942	5,628	-6,178	-8,484	6,447	6,459	21,694	24,201	5,461	3,727	29,131	44,780	-29,968
1992	2,525	2,525	-13,110	-12,081	-14,124	-14,527	12,214	12,222	20,026	21,555	7,358	7,393	-18,941	-5,107	-65,874
1993	509	509	-26,629	-24,179	3,182	1,844	8,074	8,086	7,490	11,379	8,708	8,722	-124,784	-110,493	-144,569
1994	-418	-418	-29,350	-27,134	3,048	1,965	3,384	3,403	7,312	11,037	8,058	7,889	6,346	14,054	-25,516
1995	326	326	-33,375	-31,262	1,924	643	4,777	4,790	6,668	10,415	6,577	6,347	14,483	25,714	-17,984
1996	274	274	-113	1,729	8,219	8,068	4,727	4,741	32,080	35,332	5,408	5,284	11,799	33,220	-18,651
1997	897	897	-5,653	-5,207	-536	-2,496	5,472	5,483	-1,359	1,017	6,530	6,711	-233	26,044	-13,363
1998	17	17	-10,173	-9,092	8,319	7,065	5,657	5,670	6,169	8,834	7,446	7,439	-1,241	20,847	-13,715
1999	-1,208	-1,208	-36,962	-38,186	2,743	2,690	13,530	13,547	-3,847	-2,513	7,021	7,053	-21,739	-3,637	-30,346
2000	-1,124	-1,124	-5,892	-8,675	9,968	10,104	7,945	7,959	463	453	11,042	11,209	58	31,914	-13,766
2001	-1,230	-1,230	32,808	29,595	15,268	15,231	4,932	4,946	34,097	34,085	10,809	10,747	48,914	69,894	2,242
2002	-838	-838	15,449	13,116	11,822	11,739	5,196	5,203	31,032	31,019	7,260	6,841	23,221	44,457	-10,012
2003	-40,935	-40,935	-8,258	-11,605	3,225	165	-20,433	-20,430	1,749	1,729	23,717	26,675	-40,244	3,154	-39,391
2004	2,588	2,588	-30,441	-34,174	-10,577	-15,927	4,206	4,206	-34,753	-34,769	12,853	15,850	-9,838	-12,084	-59,304
2005	-21,655	-21,655	52,838	49,532	-1,631	-4,902	-7,107	-7,119	11,383	11,366	35,844	38,997	41,008	65,740	-59,727
2006	-35,313	-35,313	-78,400	-81,751	-30,279	-33,850	-15,772	-15,769	-61,710	-61,724	6,698	8,511	-118,784	-83,418	-56,319
2007	129,662	129,662	-10,734	-13,865	-2,968	-6,629	83,970	83,972	-19,801	-19,796	27,892	28,616	65,982	28,955	-49,734
2008	183,233	183,233	46,189	44,043	4,111	1,886	119,499	119,532	20,529	20,609	10,754	10,598	133,747	80,397	-1,635
2009	122,595	122,595	-15,373	-16,945	-5,364	-5,284	89,210	89,240	13,426	13,514	9,573	9,437	18,554	22,282	-2,575
2010	105,688	105,688	412	-1,149	4,950	5,366	67,597	67,612	4,301	4,359	8,815	8,681	40,952	40,023	28,958
2011	-24,472	-24,472	-160,346	-162,808	-58,689	-62,884	-17,968	-17,967	-125,103	-125,084	-24,703	-24,632	-225,599	-159,881	-30,587
2012	77,330	77,330	9,961	5,800	-15,647	-22,335	33,544	33,544	-14,026	-14,030	10,002	10,094	87,052	14,648	-35,605
2013	-65,094	-65,094	-63,635	-66,964	-15,421	-18,040	-23,612	-23,612	-43,310	-43,314	-11,049	-11,197	-142,856	-58,575	-24,806
2014	98,813	98,813	32,990	29,196	1,756	-570	44,473	44,473	-14,271	-14,274	3,900	2,689	169,412	44,289	-4,637
2015	96,901	96,901	-38,936	-42,562	-11,925	-14,891	42,535	42,535	-55,442	-55,439	3,064	3,066	31,310	-42,812	-34,039
2016	76,447	76,447	-73,674	-77,162	-19,831	-24,418	34,856	34,856	-84,873	-84,864	11,738	12,597	-44,340	-77,354	-75,510
2017	251,734	251,734	-5,344	-6,808	-12,862	-18,292	160,027	160,033	-48,712	-48,684	20,022	23,320	150,829	5,337	-60,560
Averages															
1951-2017	11,427	11,427	2,934	2,083	-1,682	-4,223	10,156	10,160	4,498	5,369	6,724	7,949	8,056	17,298	-27,388
1951-1978	-6,655	-6,655	7,711	6,900	493	-1,382	-1,795	-1,794	5,562	6,062	3,662	5,797	6,060	24,669	-6,669
1979-2005	-2,428	-2,428	12,502	12,493	1,322	-1,641	4,161	4,168	21,283	22,916	10,048	10,685	7,547	24,236	-48,193
2006-2017	84,794	84,794	-29,741	-32,581	-13,514	-16,662	51,530	51,537	-35,749	-35,727	6,392	6,815	13,855	-15,509	-28,921
1985-2017	29,114	29,114	-8,066	-8,992	-3,762	-6,336	21,752	21,760	-1,570	-299	8,571	8,882	-1,396	-983	-47,024
1985-2005	-2,703	-2,703	4,319	4,487	1,810	-435	4,737	4,745	17,962	19,946	9,816	10,063	-10,111	7,318	-57,369

Notes:

EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).

EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

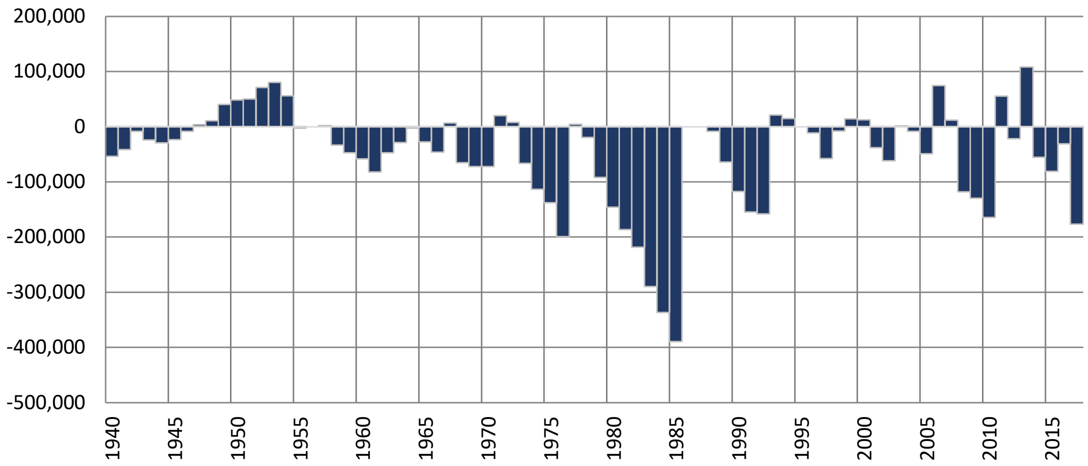
Run 18 - Conj Use 3: Auth Proj Acres (Pre-Comp M&I)

Simulated Differences in ILRG Model Outputs

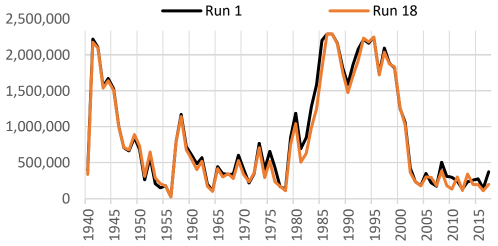
Run 18 minus Run 1

1940 - 2017 (acre-feet)

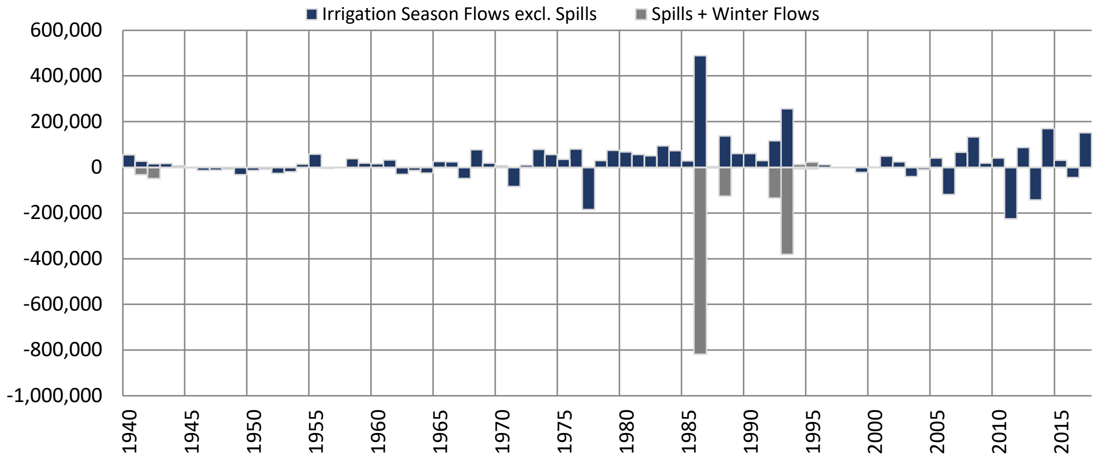
Total Project Storage (Year End)



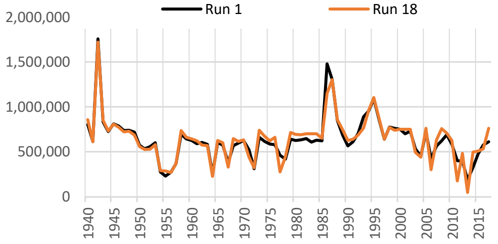
Period	Average Difference
1951-2017	-3,361
1951-1978	-2,427
1979-2005	-1,099
2006-2017	-10,631
1985-2017	4,848
1985-2005	13,693



Caballo Reservoir Outflows (Annual)



	Average Difference		
Period	Irr Season (excl. Spills)	Nov-Feb and Spills	Annual
1951-2017	29,364	-21,309	8,056
1951-1978	6,060	0	6,060
1979-2005	60,425	-52,877	7,547
2006-2017	13,855	0	13,855
1985-2017	41,867	-43,263	-1,396
1985-2005	57,874	-67,985	-10,111



Notes:

Reservoir storage does not include storage attributed to SJC, CO, or NM credit waters.

Average differences calculated as (Final Storage - Initial Storage)/(no. years).

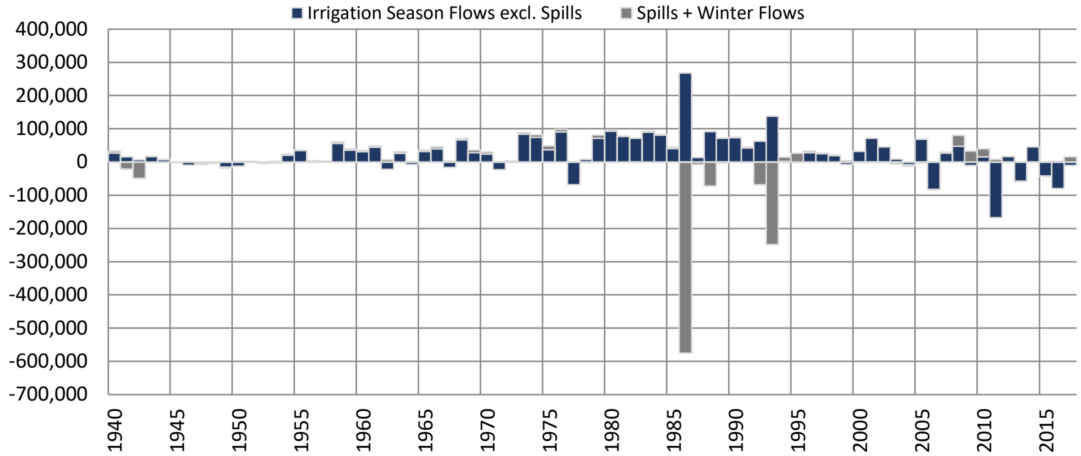
Run 18 - Conj Use 3: Auth Proj Acres (Pre-Comp M&I)

Simulated Differences in ILRG Model Outputs

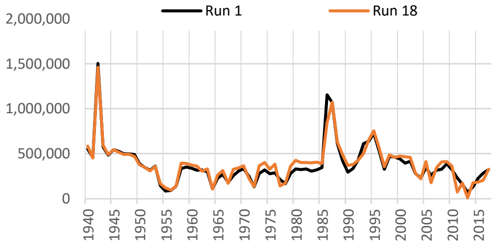
Run 18 minus Run 1

1940 - 2017 (acre-feet)

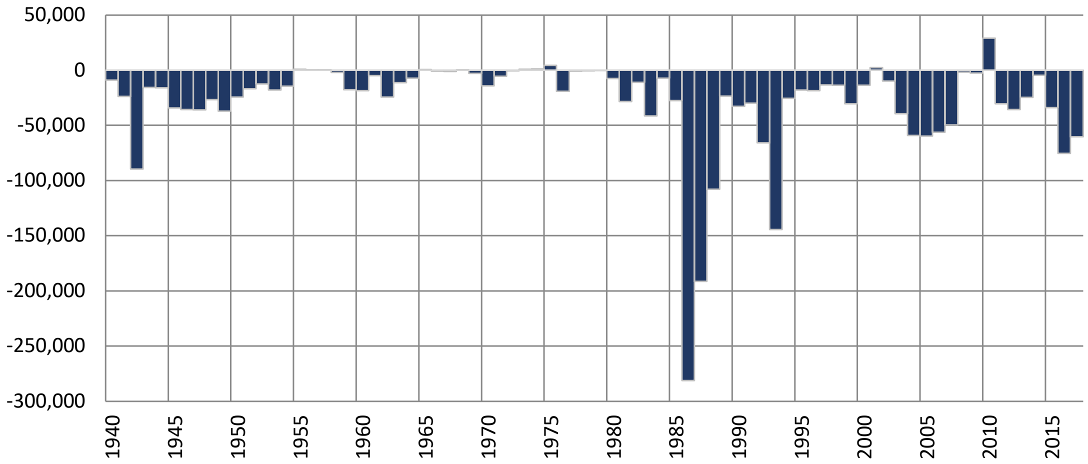
Rio Grande at El Paso (Annual)



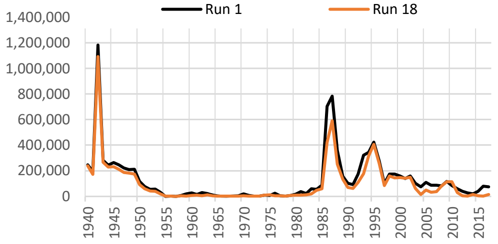
	Average Difference		
Period	Irr Season (excl. Spills)	Nov-Feb and Spills	Annual
1951-2017	27,833	-10,535	17,298
1951-1978	21,320	3,349	24,669
1979-2005	58,056	-33,819	24,236
2006-2017	-24,968	9,459	-15,509
1985-2017	23,797	-24,780	-983
1985-2005	51,663	-44,344	7,318



Rio Grande at Fort Quitman (Annual)



Period	Average Difference
1951-2017	-27,350
1951-1978	-6,633
1979-2005	-48,155
2006-2017	-28,880
1985-2017	-46,991
1985-2005	-57,341



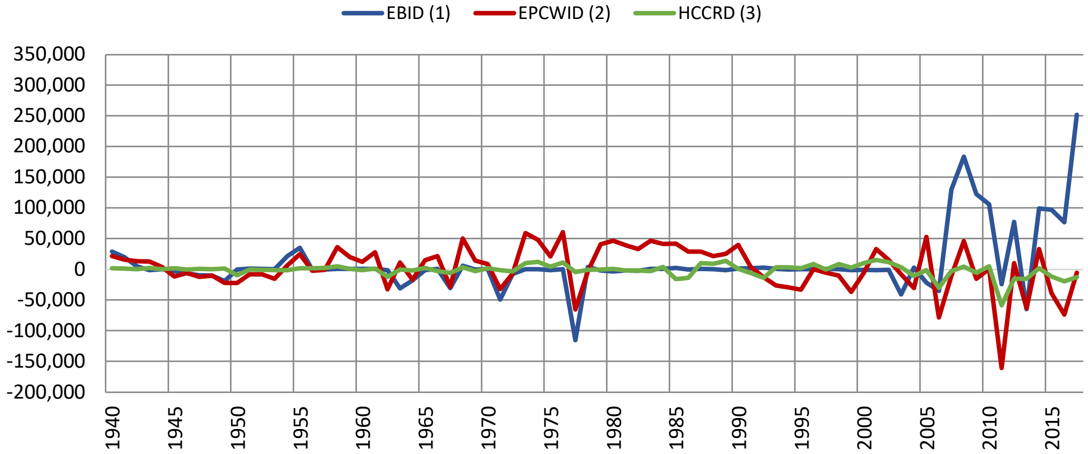
Run 18 - Conj Use 3: Auth Proj Acres (Pre-Comp M&I)

Simulated Differences in ILRG Model Outputs

Run 18 minus Run 1

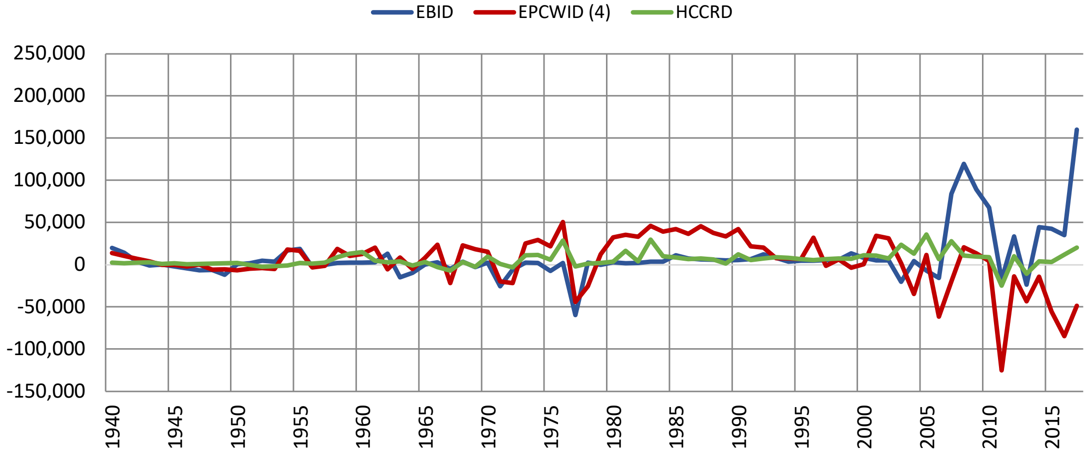
1940 - 2017 (acre-feet)

River Headgate (RHG) Diversions (Irrigation Season)



Period	Average Difference EBID	 EPCWID	 HCCRD
1951-2017	11,427	2,934	-1,682
1951-1978	-6,655	7,711	493
1979-2005	-2,428	12,502	1,322
2006-2017	84,794	-29,741	-13,514
1985-2017	29,114	-8,066	-3,762
1985-2005	-2,703	4,319	1,810

Farm Headgate (FHG) Deliveries (Irrigation Season)



Period	Average Difference EBID	 EPCWID	 HCCRD
1951-2017	10,156	4,498	6,724
1951-1978	-1,795	5,562	3,662
1979-2005	4,161	21,283	10,048
2006-2017	51,530	-35,749	6,392
1985-2017	21,752	-1,570	8,571
1985-2005	4,737	17,962	9,816

Notes:

(1) EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).

(2) EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

(3) HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

(4) EPCWID FHG values include deliveries to Rogers WTP and R/U WTP.

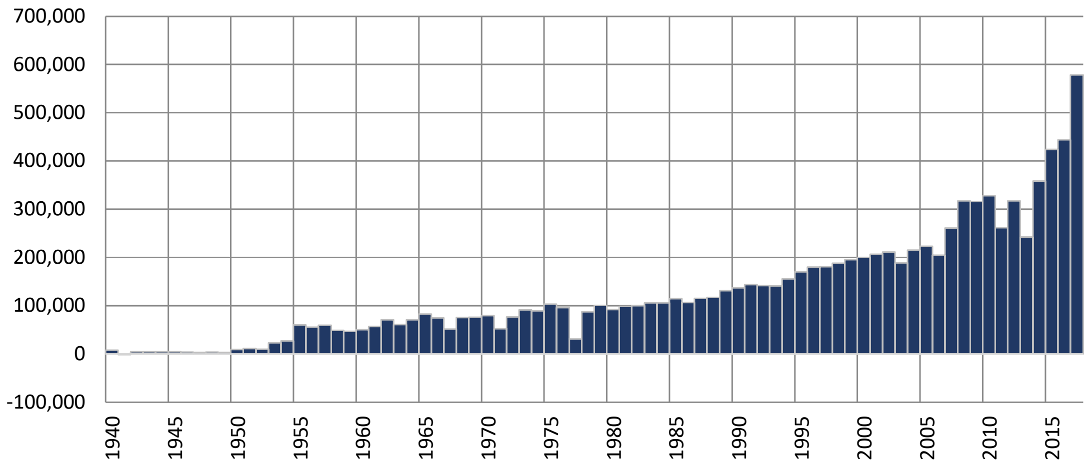
Run 18 - Conj Use 3: Auth Proj Acres (Pre-Comp M&I)

Simulated Differences in ILRG Model Outputs

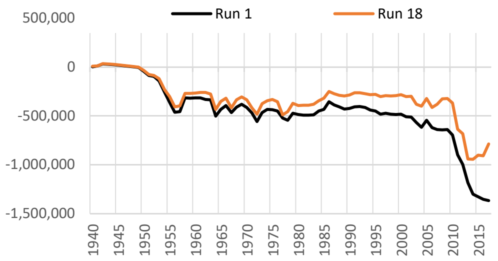
Run 18 minus Run 1

1940 - 2017 (acre-feet)

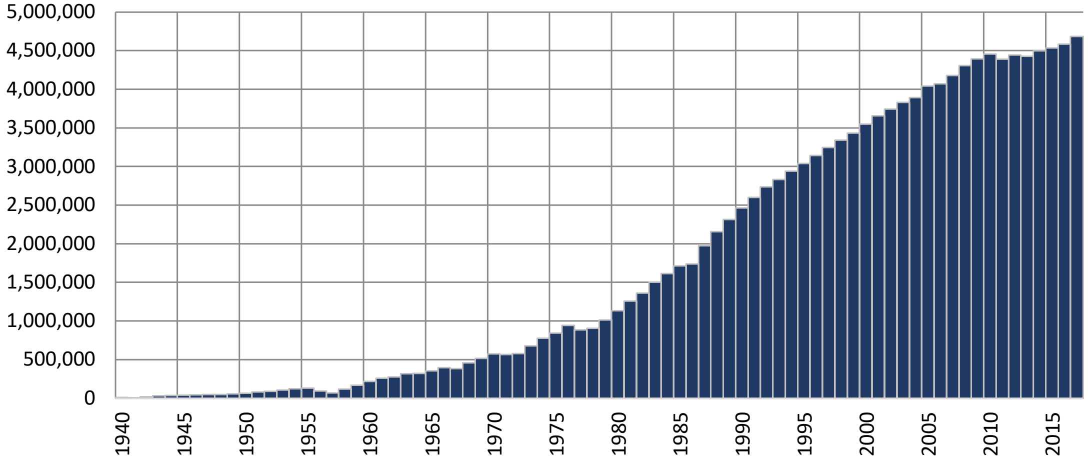
Cumulative Annual Rincon-Mesilla Groundwater Storage



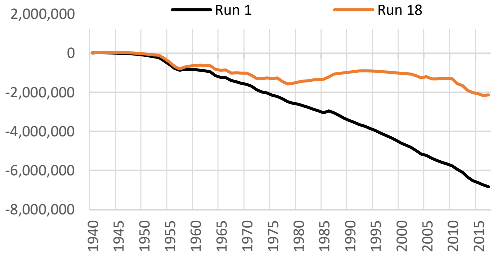
Period	Average Difference
1951-2017	8,502
1951-1978	2,799
1979-2005	5,026
2006-2017	29,633
1985-2017	14,320
1985-2005	5,570



Cumulative Annual Hueco Groundwater Storage



Period	Average Difference
1951-2017	68,950
1951-1978	29,958
1979-2005	116,180
2006-2017	53,664
1985-2017	93,028
1985-2005	115,521



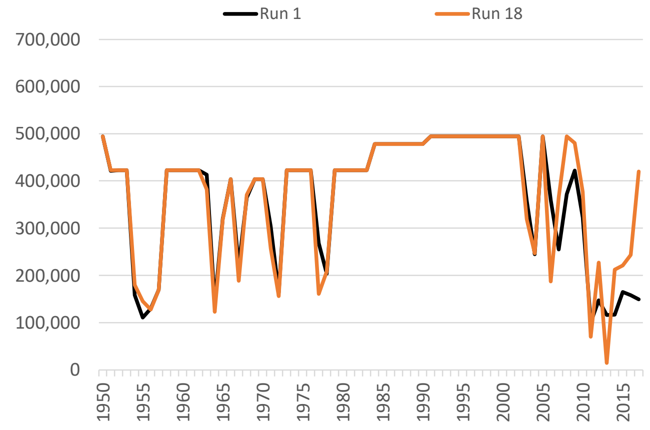
Notes:

Cumulative storage change in alluvial and non-alluvial aquifers.

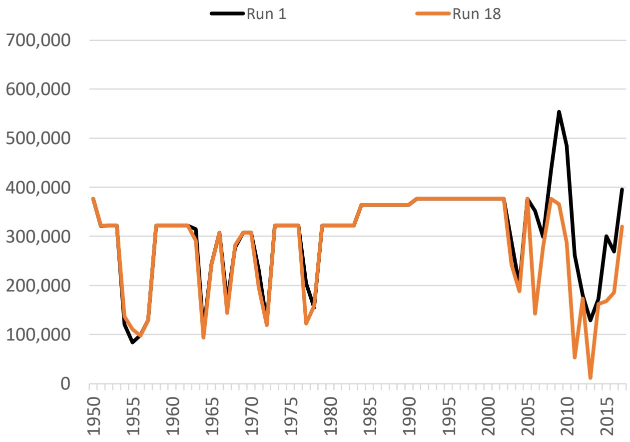
Average differences calculated as (Final Storage - Initial Storage)/(no. years).

Run 18 - Conj Use 3: Auth Proj Acres (Pre-Comp M&I)
Annual Allocation and Charges
Run 18 v. Run 1
ILRG Model
1950 - 2017 (acre-feet)

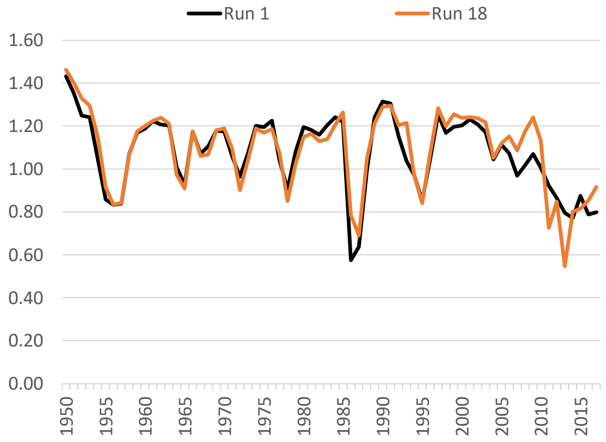
Total Allocation - EBID



Total Allocation - EPCWID



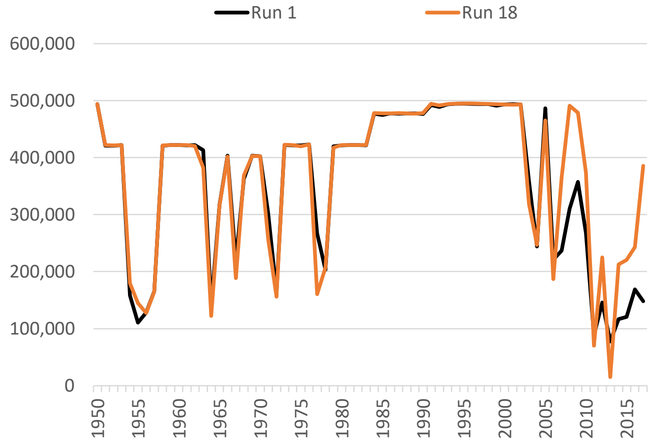
Diversion Ratio



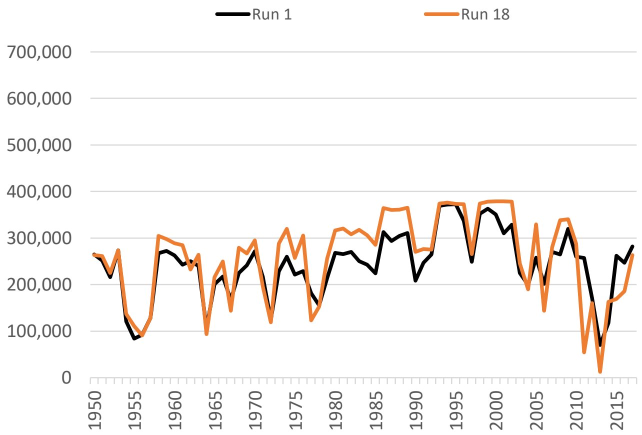
Note:

Computed as Total Charges/Caballo Release.

Annual Delivery Charges - EBID



Annual Delivery Charges - EPCWID



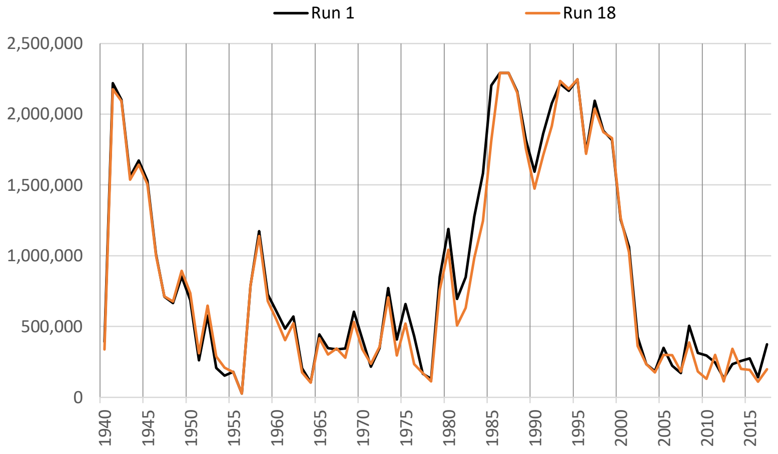
Run 18 - Conj Use 3: Auth Proj Acres (Pre-Comp M&I)

Annual Summary of Project Storage and Rio Grande Flows

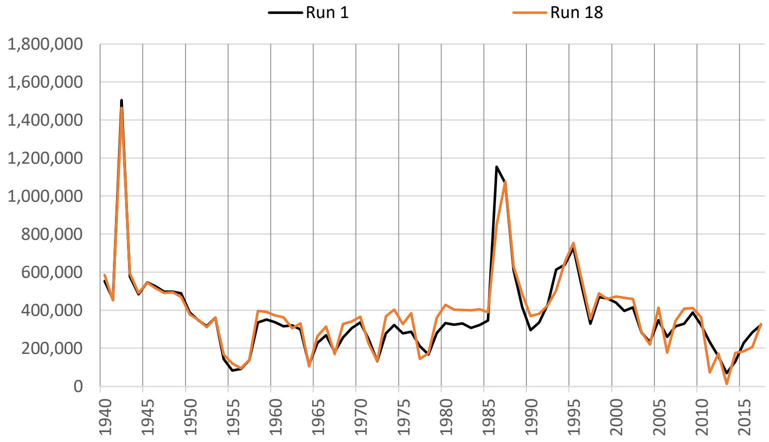
Run 18 v. Run 1

ILRG Model

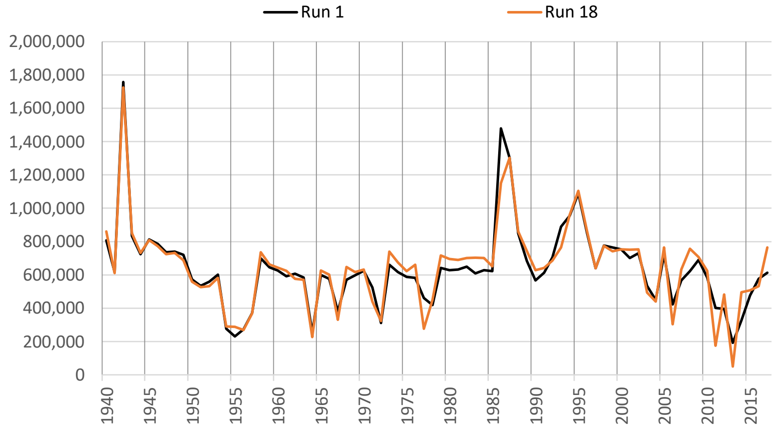
1940 - 2017 (acre-feet)



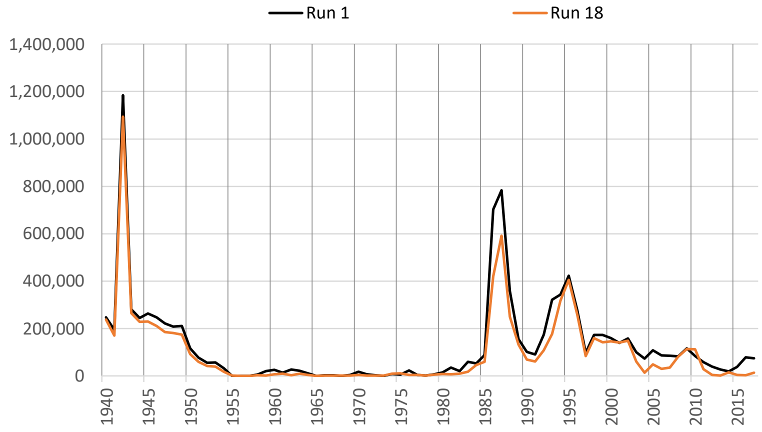
Total Year-End Project Reservoir Storage



Rio Grande at El Paso



Rio Grande Below Caballo



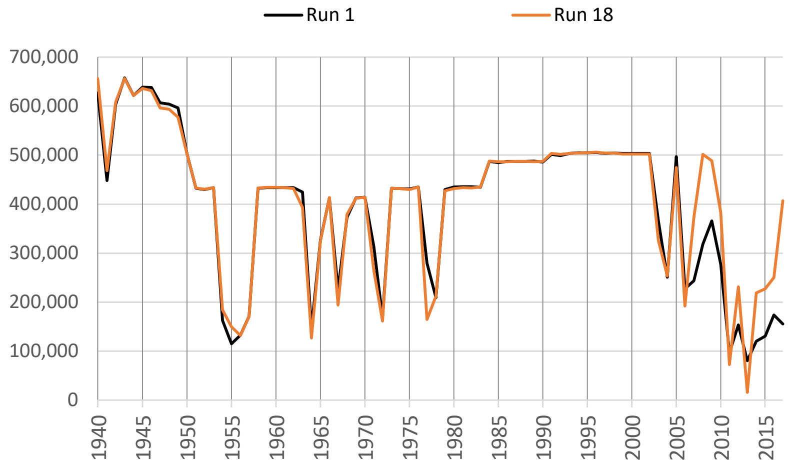
Rio Grande at Fort Quitman

***Note different scales.**

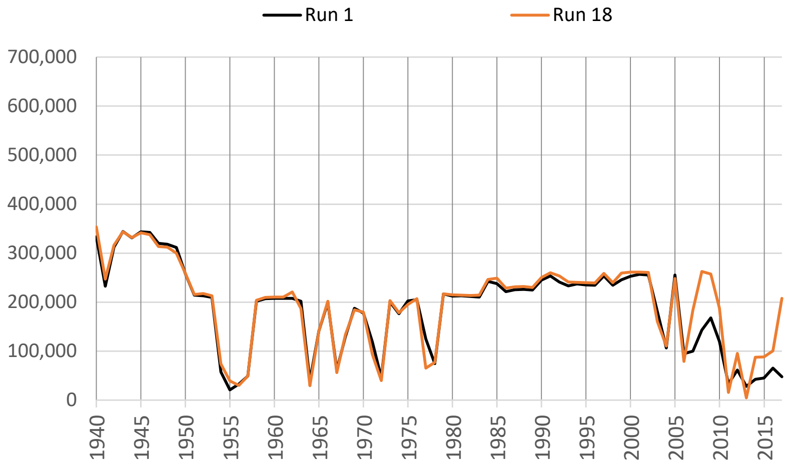
Run 18 - Conj Use 3: Auth Proj Acres (Pre-Comp M&I)
Irrigation Season Summary of Irrigation Operations
Run 18 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

EBID Total

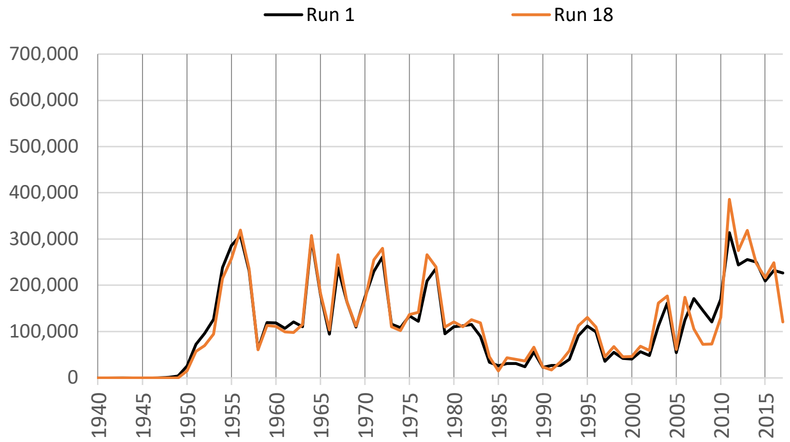
Net River Headgate Diversions



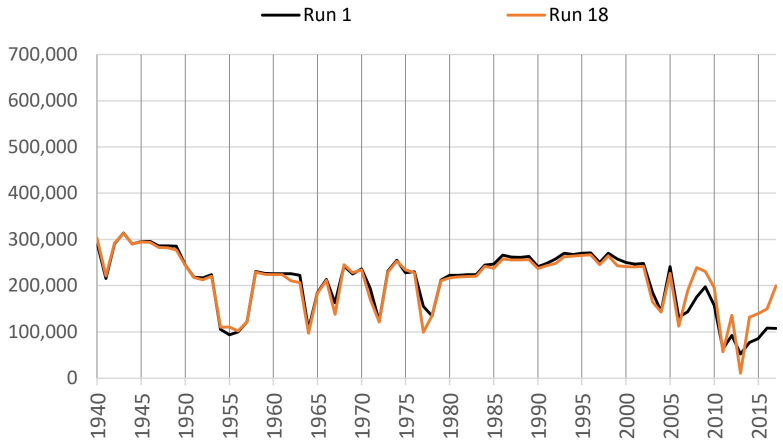
Farm Headgate Deliveries



Pumping



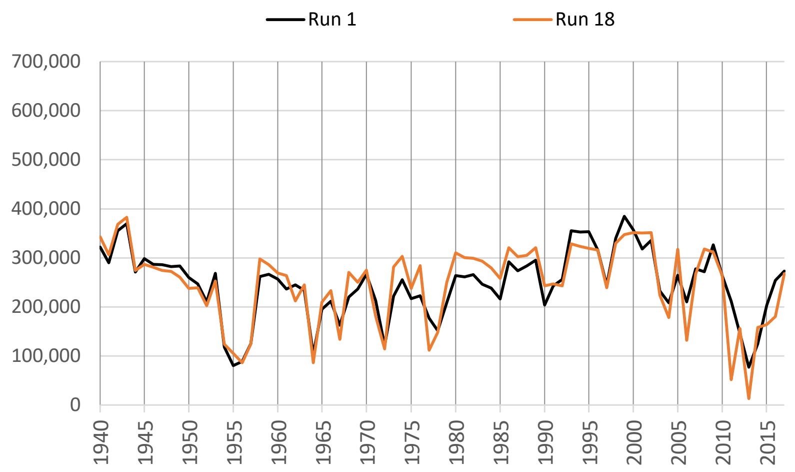
RHG Diversions - FHG Deliveries

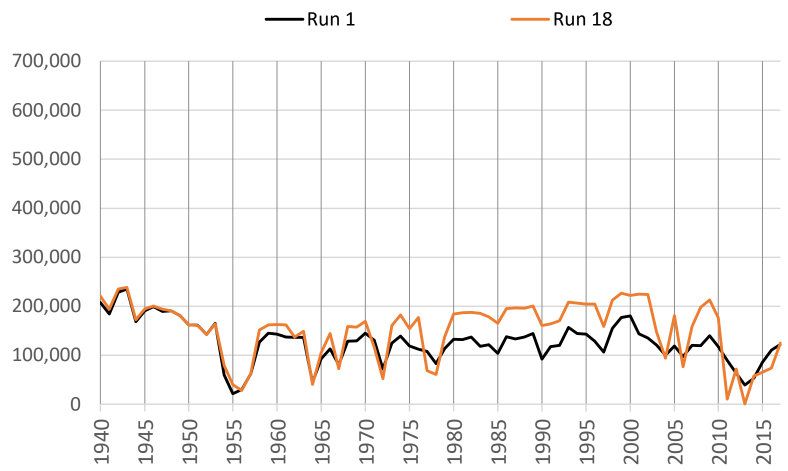


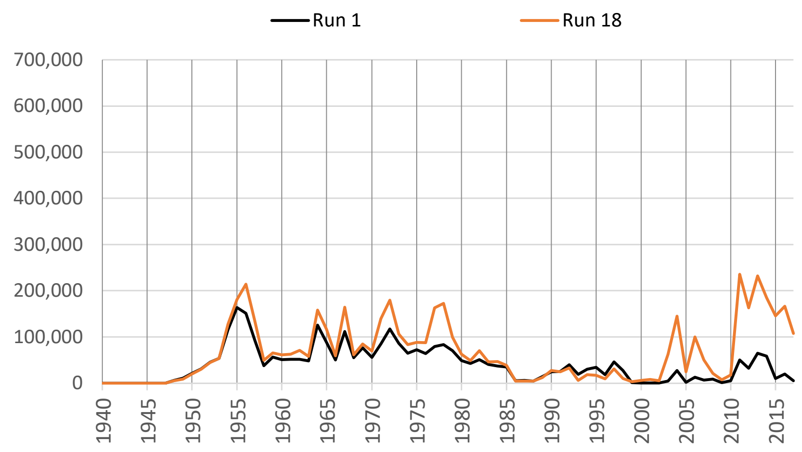
Notes: EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses). Pumping includes Supplemental and Primary groundwater pumping.

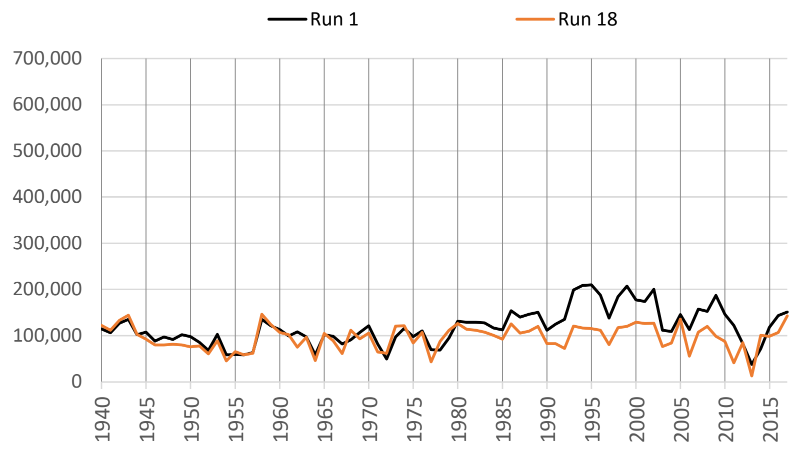
Run 18 - Conj Use 3: Auth Proj Acres (Pre-Comp M&I)
Irrigation Season Summary of Irrigation Operations
Run 18 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

EPCWID Total


Net River Headgate Diversions


Farm Headgate Deliveries


Pumping

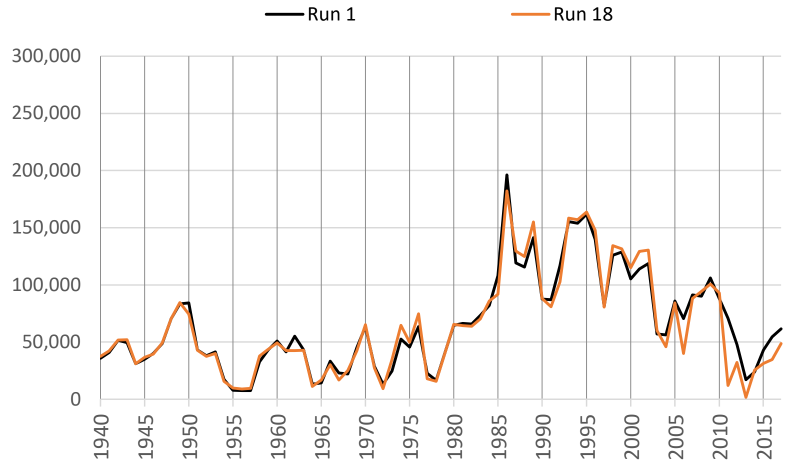

RHG Diversions - FHG Deliveries

Note: EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

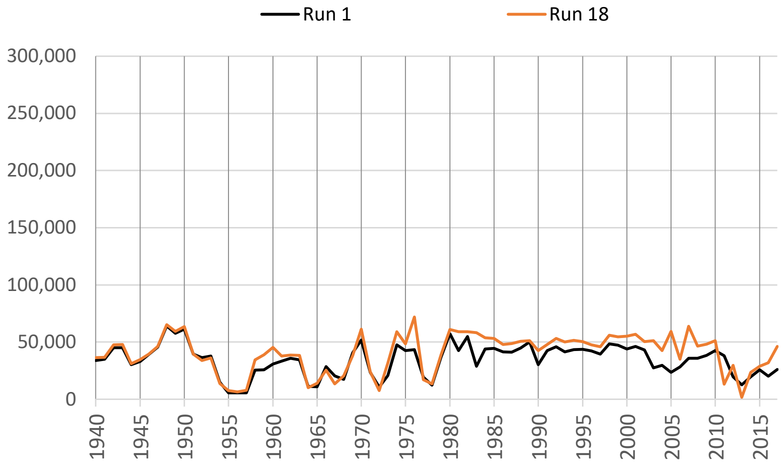
Run 18 - Conj Use 3: Auth Proj Acres (Pre-Comp M&I)
Irrigation Season Summary of Irrigation Operations
Run 18 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

HCCRD Total

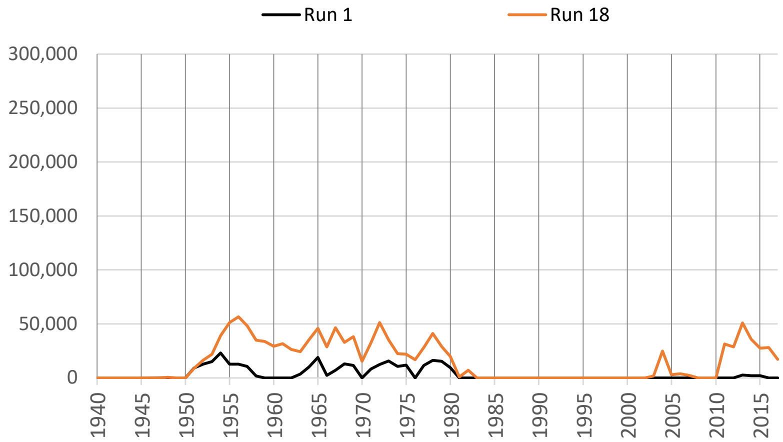
Net River Headgate Diversions



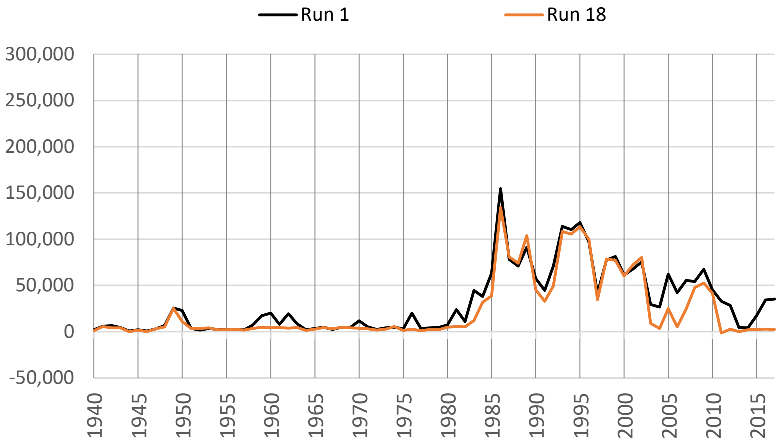
Farm Headgate Deliveries



Pumping



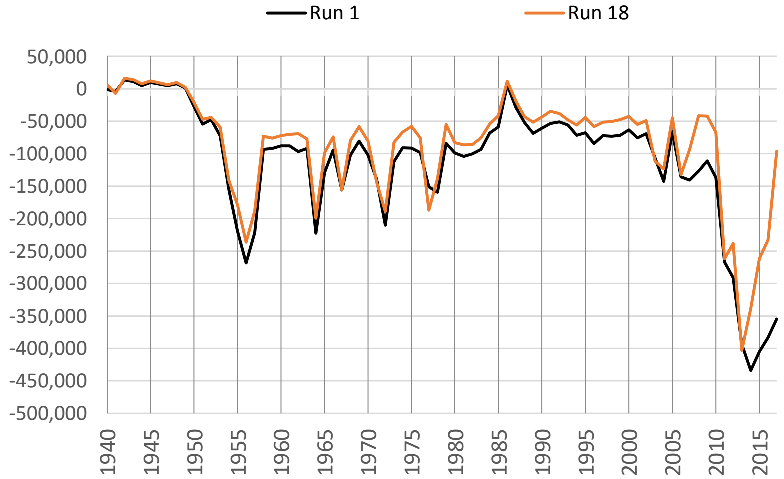
RHG Diversions - FHG Deliveries



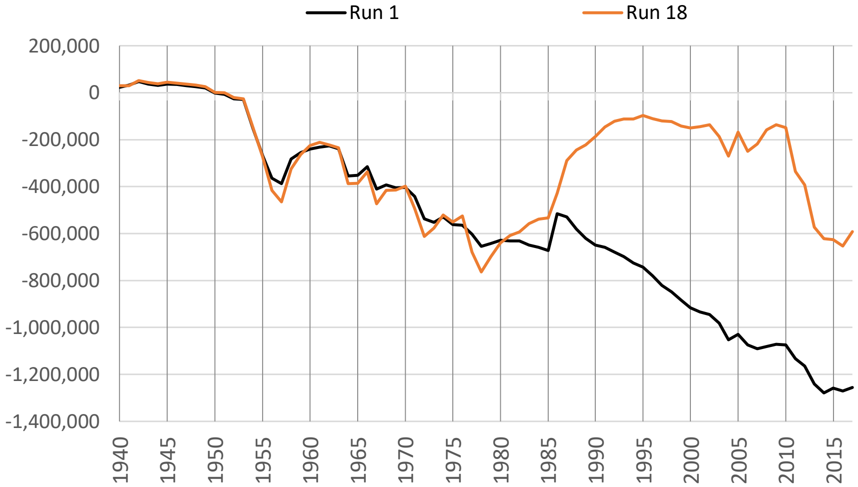
Note: HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

Run 18 - Conj Use 3: Auth Proj Acres (Pre-Comp M&I)
Cumulative Change in Ground Water Storage
Run 18 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)

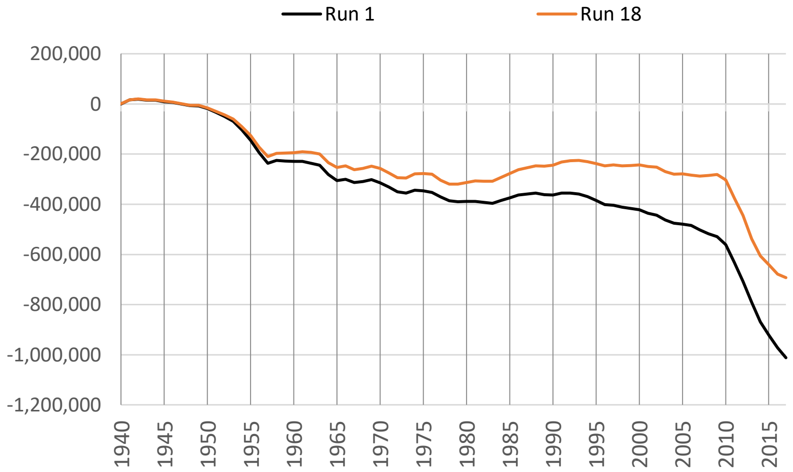
Rincon-Mesilla Alluvial Aquifer



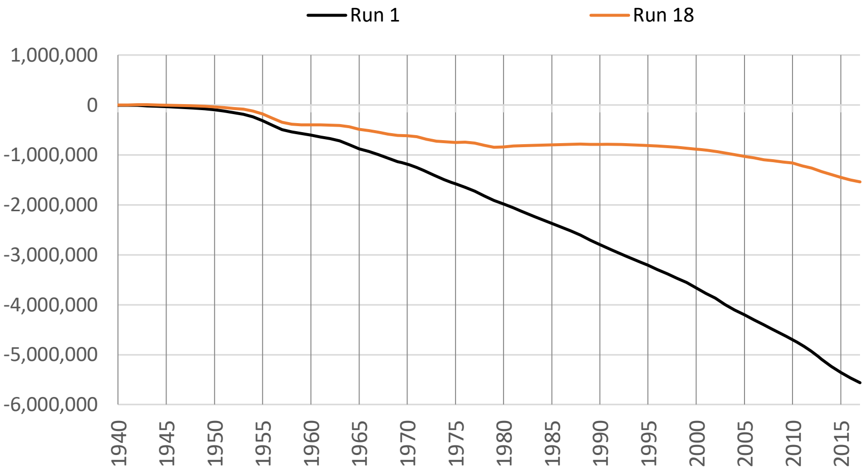
Hueco Alluvial Aquifer



Rincon-Mesilla Non-Alluvial Aquifer



Hueco Non-Alluvial Aquifer



***Note different scales.**

Run 18 - Conj Use 3: Auth Proj Acres (Pre-Comp M&I)

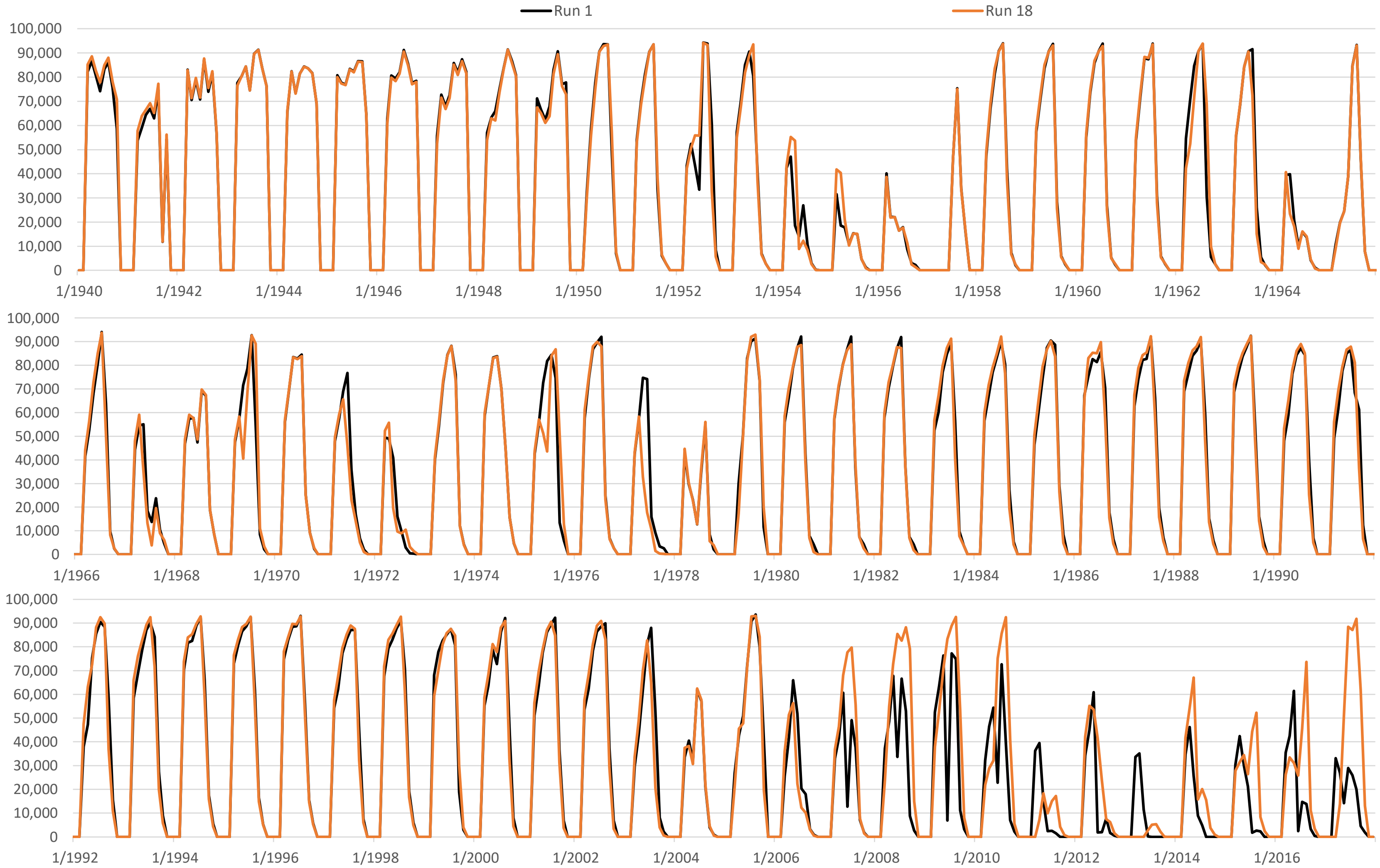
Monthly Net RHG Diversions

Run 18 v. Run 1

ILRG Model

1940 - 2017 (acre-feet)

EBID Total

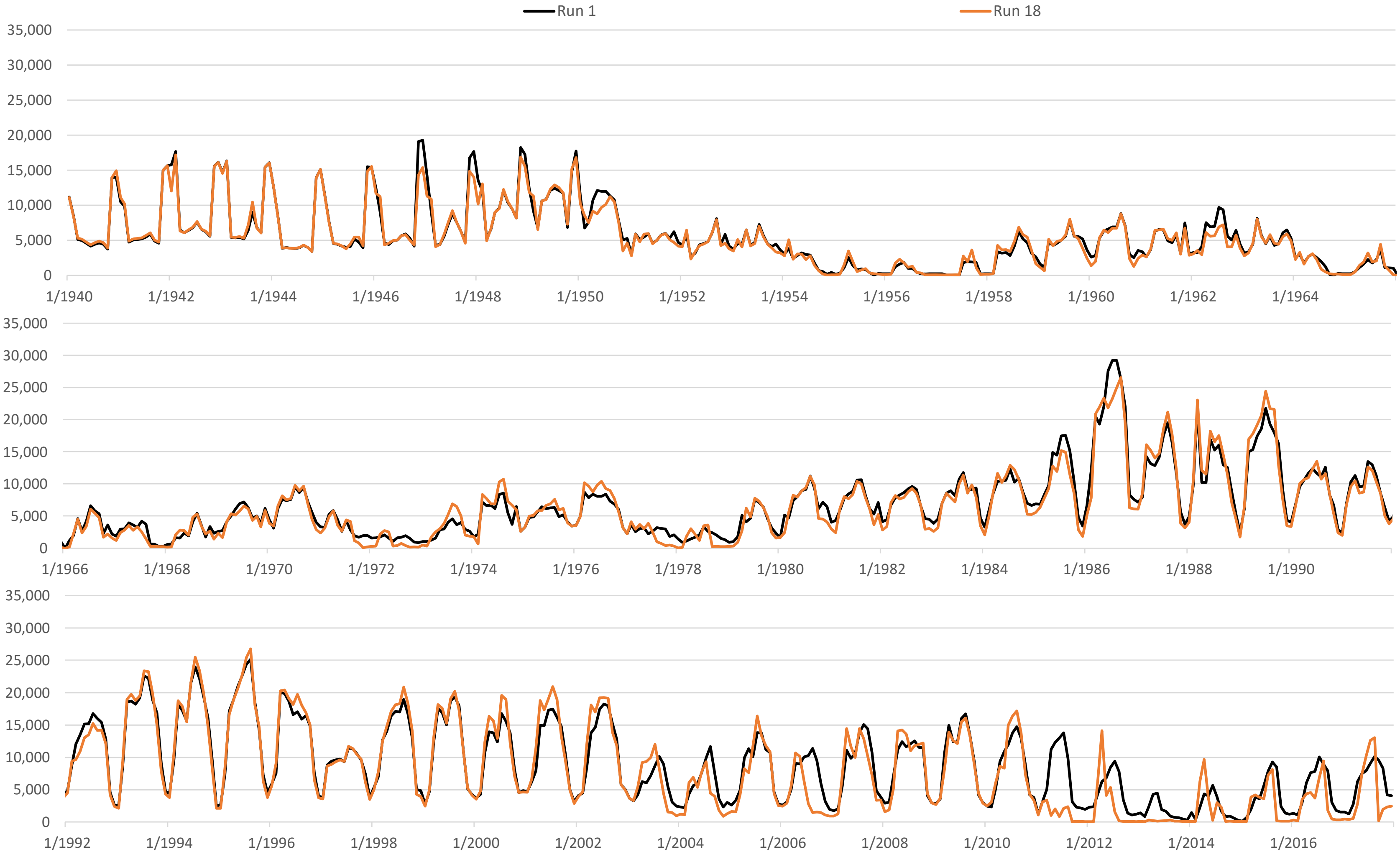


Note: EBID Net RHG Diversions are sum of Arrey, Leasburg, Eastside, and Westside minus EPV carriage, increased spill diversions, and flows to TX Mesilla (x 1.15 or 1.2 for losses).

Run 18 - Conj Use 3: Auth Proj Acres (Pre-Comp M&I)
Monthly Net RHG Diversions
Run 18 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)
EPCWID Total

Note: EPCWID Net RHG Diversions are sum of Franklin Canal gage, Riverside Canal gage, Rogers WTP, R/U WTP, TX Mesilla minus Ascarate Wasteway and increased spill diversions.

Run 18 - Conj Use 3: Auth Proj Acres (Pre-Comp M&I)
Monthly Net RHG Diversions
Run 18 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)
HCCRD Total



Note: HCCRD Net RHG diversions are sum of Hudspeth Feeder Canal, Tornillo Drain, and Tornillo Canal at Alamo Alto.

Run 18 - Conj Use 3: Auth Proj Acres (Pre-Comp M&I)

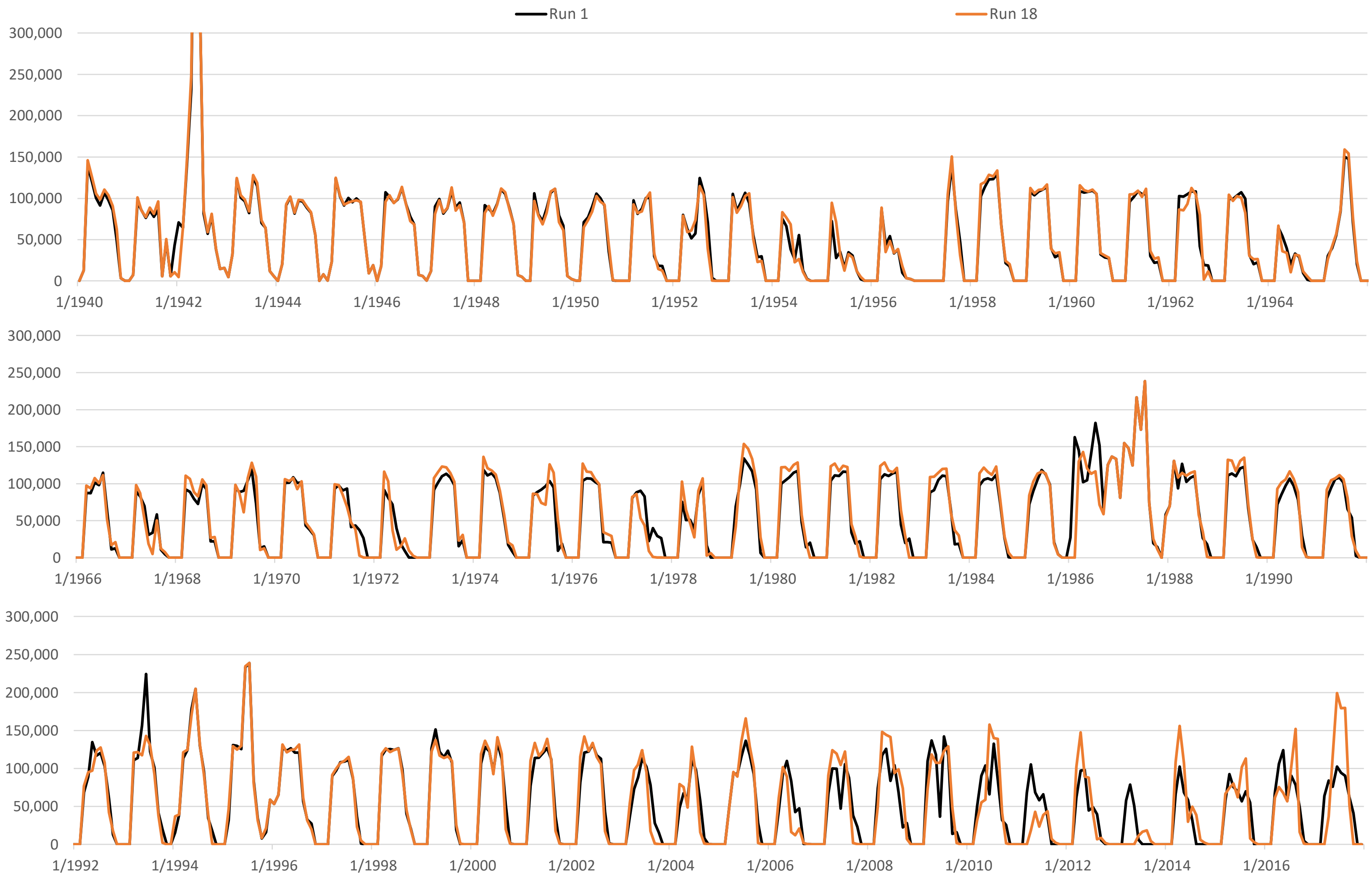
End of Month Reservoir Storage (Elephant Butte + Caballo)

Run 18 v. Run 1

ILRG Model

1940 - 2017 (acre-feet)

Run 18 - Conj Use 3: Auth Proj Acres (Pre-Comp M&I)
Monthly Caballo Releases
Run 18 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)



Run 18 - Conj Use 3: Auth Proj Acres (Pre-Comp M&I)

Monthly Rio Grande at El Paso Flow

Run 18 v. Run 1

ILRG Model

1940 - 2017 (acre-feet)

Run 18 - Conj Use 3: Auth Proj Acres (Pre-Comp M&I)
Monthly Rio Grande at Fort Quitman Flow
Run 18 v. Run 1
ILRG Model
1940 - 2017 (acre-feet)