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Exempt from filing fee pursuant to Gov't. Code Section 6103

SUPERIOR COURT OF THE STATE OF CALIFORNIA

IN AND FOR THE COUNTY OF RIVERSIDE

Coordination Proceeding Special Title (Cal. Rules of Court, rule 3.550) MOJAVE BASIN WATER CASES	CASE NO.: CIV 208568 / JCCP NO.: 5265 Dept. 1, Riverside Superior Court Hon. Craig G. Riemer, Retired
CITY OF BARSTOW, Plaintiff, vs. CITY OF ADELANTO, et al., Defendant.	**WATERMASTER'S RENEWED MOTION FOR DETERMINATION OF HYDROLOGIC BASE PERIOD FOR CALCULATION OF PRODUCTION SAFE YIELD VALUES; MEMORANDUM OF POINTS AND AUTHORITIES; SUPPORTING DECLARATION**
AND RELATED CROSS ACTIONS	Date: March 18, 2026 Time: 8:30 a.m. Dept.: 1 **Per Court Order February 20, 2026**

TO THE PARTIES ABOVE NAMED AND THEIR COUNSEL OF RECORD:

PLEASE TAKE NOTICE THAT on March 18, 2026, at 8:30 a.m. or as soon thereafter as the matter may be heard in Department 1 of the above-entitled Court, the Mojave Water Agency, as the Court-appointed Watermaster in this proceeding will move, and hereby moves that the Production Safe Yield (PSY) values calculated for Water Year 2026-2027 should be based upon the hydrologic base period from 2001-2020.[1] Watermaster's motion should be granted because the proposed 2001-2020 hydrologic base period satisfies all criteria for an appropriate base period set forth in California Department of Water Resources Bulletin No. 84 (August 1967) titled, "Mojave River Ground Water Basins Investigation" and the January 10, 1996 Judgment entered in this proceeding, and is a more appropriate hydrologic base period than any of the alternative hydrologic base periods considered.

The 2001-2020 hydrologic base period is drier than the original hydrologic base period from 1931-1990, reflecting recent prolonged drought conditions which many believe are likely to be repeated or even exacerbated in the future. For this additional reason, Watermaster believes the 2001-2020 hydrologic base period is a better representation of the long term hydrologic conditions the Basin is likely to experience in the future (compared to other hydrologic base periods considered).

The 2001-2020 drier hydrologic base period will advance the goals and objectives of the stipulated Judgment. This is so because this dryer and shorter hydrologic base period likely will result in lower Production Safe Yield values, requiring additional FPA rampdown and purchase of additional supplemental water to increase groundwater storage and ultimately achieve equilibrium between the Basin Area's limited water supply and current and expected consumptive uses.

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[1] During the August 4, 2025 hearing, the Court stated, "I see no reason why the base period cannot be resolved for the foreseeable future within the next 12 months" (Transcript, 30:10-12), and "I think it would be helpful to get that issue resolved, whether we'll stick with 1931 to 1990 or whether we're going to use the new 20-year period, I think that would be a good thing to get resolved and out of the way before we deal with PSY calculations and FPA calculations before next June or July"(Transcript, 30:22-31:1).

The motion is based upon this notice, the attached supporting declarations, the attached Memorandum of Points and Authorities, the contents of the Court's file relating to this proceeding, and such additional evidence as may be presented at the hearing on the motion.

Dated: February 24, 2026

BRUNICK, MCELHANEY & KENNEDY PLC

By: ______________________________

Leland P. McElhaney
Attorneys for the MOJAVE WATER AGENCY
(as the MOJAVE BASIN AREA WATERMASTER)

MEMORANDUM OF POINTS AND AUTHORITIES

Watermaster submits these points and authorities in support of its motion for approval of the 2001-2020 hydrologic base period for calculating Production Safe Yield for at least Water Year 2026-2027.

A. Watermaster's engagement with stakeholders regarding the selection of an appropriate base period.

On November 12, 2025, Watermaster served on all parties a copy of Watermaster Engineer's declaration which includes an extensive "Statement [and Explanation] of Reasons for Recommending 2001-2020 Base Period." A true copy thereof is attached as Exhibit 2 hereto (pages 243-672).

On December 12, 2025, Watermaster also conducted a public workshop during which Watermaster provided further explanation, and received feedback from workshop participants, regarding Watermaster's proposed selection of the new 2001-2020 hydrologic base period. Exhibit 3 hereto is a true and correct copy of Watermaster's PowerPoint presentation during the December 12, 2025 workshop (pages 673-713 hereto). As noted therein, the following alternative hydrologic base periods: 1991-2022, 1995-2024, 1998-2024, 2001-2020, 2002-2022, and 1931-2022, also were considered by Watermaster.

On January 14, 2026, Watermaster conducted a public hearing regarding the proposed 2001-2020 hydrologic base period.

Prior to and on the date of the January 14, 2026 public hearing, Watermaster received comment letters from various parties, copies of which are collectively attached as Exhibit 4 (pages 714-815 hereto). Exhibit 5 is Watermaster's written response to one of the comment letters (pages 816-821 hereto).

Prior to the January 14, 2026 public hearing, Watermaster staff also met separately with representatives of the California Department of Fish & Wildlife; Mitsubishi Cement Corporation ("Mitsubishi"), Robertson's Ready Mix, Ltd ("Robertson's"), and CalPortland Company ("CalPortland"); and Newberry Springs Recreational Lakes Association (NSRLA).

The January 14, 2026 public hearing included PowerPoint presentations from

Watermaster, counsel representing Mitsubishi, Robertson's, and CalPortland, as well as Mr. Gaastra (a representative of NSRLA). Following the presentations and extensive discussion both in favor of, and against the proposed 2001-2020 hydrologic base period, the Watermaster's Board of Directors approved the 2001-2020 hydrologic base period for PSY calculations, and directed Watermaster staff to submit same for the Court's consideration and approval.

B. Answers to the Court's questions.

In its August 5, 2025 and January 21, 2026 Orders, the Court directed that, in Watermaster's renewed motion for determination of an appropriate hydrologic base period, Watermaster is to respond to the following questions:

1. Whether the proposed base period is a more reasonable representation of long-term hydrologic conditions in the basin than the existing base period.

Answer: Yes. This is so because the cultural conditions (including land uses within the Basin) and consumptive uses of groundwater in the Basin Area have changed dramatically since 1990. This is illustrated by the USGS Annual Land Use Cover, set forth at pages 205-213 hereto (Exhibit "C"), which demonstrate a significant reduction since 1990 in large agricultural operations, along with significant increases in land use for residential and industrial development. These drastic changes are also reflected in the records of groundwater pumping and irrigated acreages set forth at pages 216-227 hereto (Exhibits E, F, G and H). All of which is discussed and explained in further detail in Robert C. Wagner's attached supporting declaration (Exhibit 1), at pages 24-29 hereto.

2. Whether the proposed base period is a better representation of those conditions than any of the possible alternative periods. [Are there "other potential base periods since 1990 that would better represent the basin than either 1931-1990 or 2001-2020."] (1/21/2026 Order, p. 2.)

Although other hydrologic base periods exist which provide better representations of "current cultural conditions" than the original 1931-1990 hydrologic base period, Watermaster continues to believe the 2001-2020 hydrologic base period is the most appropriate representation of current cultural conditions for future planning purposes, for the reasons explained herein and in Mr. Wagner's attached declaration (Exhibit 1) at pages 32-39 hereto.

In 2024, Watermaster first used the 2001-2020 hydrologic base period as the basis for calculating PSY and FPA values for Water Year 2024-2025 for all subareas; no Party then objected to the use of the new hydrologic base period.

As the Court has observed, once selected, a hydrologic base period should not be changed every year, but instead should continue to be used for an extended period of years absent significant changes in cultural conditions or consumptive uses. ["The Court: . . . I would anticipate that [changing the base period] happens with significant infrequency and certainly not more than every ten years . . . (8/4/2025 Transcript, 29:24-26.)] Accordingly, Watermaster based its 2024 PSY calculations for Water Year 2024-2025 and, also, its 2025 PSY calculations for Water Year 2025-2026 upon data extracted from the 2001-2020 hydrologic base period (except for subareas where certain data was not available or deemed unreliable).

The PSY calculation is based in part on an assumption that the hydrologic base period water supply conditions will repeat in the future. This assumption is necessary for planning purposes because it is not possible to determine with certainty future water supply conditions. Also, importation of supplemental water is necessary to arrest overdraft and achieve equilibrium. Choosing a drier hydrologic base period is more likely to result in lower PSY and FPA values, requiring the purchase of additional imported water supply. As explained in Mr. Wagner's declaration (Exhibit 1), at page 35, lines 7-10 hereto, "From a water supply perspective, when comparing two hydrologic base periods with the same cultural conditions, a larger magnitude of average water supply should yield a higher PSY value. On the contrary, a smaller magnitude of water supply should yield a lower PSY value."

Accordingly, the 2001-2020 drier hydrologic base period will advance the objectives and goals of the stipulated Judgment because it might result in lower PSY values, requiring additional rampdown of FPA and purchase of additional supplemental water to replenish groundwater depletions and ultimately achieve equilibrium between the Basin Area's water supply and consumptive uses.

Watermaster submits that the 2001-2020 base period is a better representation for planning, of the current conditions of water supply disposal and use in the Basin Area, than any of the other alternative hydrologic base periods. As required by Bulletin 84, the 2001-2020 hydrologic base period is relatively short, reasonably representative of long-term average water supply, and includes recent cultural conditions.

3. Are DWR Bulletin 84 criteria mandatory? If not are they persuasive? (1/21/2026 Order, p. 2.)

DRW Bulletin 84 is the product of a very detailed and thorough analysis of the hydrologic conditions existing in the Mojave Basin Area; the criteria set forth in Bulletin 84 for selecting an appropriate base period was relied upon to determine the original 1931-1990 hydrologic base period. While the Judgment does not mandate that Bulletin 84 criteria be utilized for subsequent determinations of appropriate hydrologic base periods, Bulletin 84 is at least persuasive as to the criteria that should be used for selecting an appropriate hydrologic base period. Its criteria are both logical and consistent with prior judicial determinations regarding the selection of hydrologic base periods for calculating Production Safe Yield (see, for example, excerpts from volume 1 of the July, 1962 State Water Rights Board "Report of Referee" in *City of Los Angeles vs. City of San Fernando, et al*., 14 Cal.3d 199 (1975), **Exhibit "B"** at pages 199-204 hereto).

For these reasons, DWR Bulletin 84 is, at a minimum, "persuasive" as to the criteria to be used for selecting an appropriate hydrologic base period for these purposes. This is explained further in Mr. Wagner's attached supporting declaration (Exhibit 1), at pages 19-40 hereto.

4. "In addressing the requirement concerning the beginning of the period, the Watermaster asserts that the beginning of the proposed base period was "preceded by a series of dry years, i.e., dry years in 1999 and 2002 [sic] precede the 2001 beginning of the base period . . ." (Mot., p. 4.) 2002 did not precede 2001. Therefore, only one dry year, 1999 preceded the beginning of the proposed period in 2001. Because a single dry year does not constitute a "series" of dry years, that criterion is not met. Thus, assuming arguendo that Bulletin 84 described the correct criteria to be used when selecting a new base period, the base period proposed does not meet those criteria. (1/21/2026 Order, p. 2.)

The confusion described above is merely the result of a fairly obvious typographical error, to wit: the base period then discussed was, as it is now, 2001-2020. The chart depicting wet and dry years at the Forks (Exhibit "I"), at pages 228-229 hereto demonstrates that **1999** and **2000** were both "dry" years. Therefore, the 2001-2020 base period satisfies Bulletin 84's criteria because the hydrologic base period from 2001-2020 is preceded by a series of dry years (1999 and 2000).

Unfortunately, Watermaster's prior motion contains an obvious typographic error where it states the 2001-2020 base period was "preceded by a series of dry years, i.e., dry years in 1999 **and 2002** [*sic*] precede the 2001 beginning of the base period . . ." (Mot., p. 4.) Obviously, 2002 did not precede 2001. Thus, the prior reference to 2002 was merely a typographical error, because Watermaster meant to then state that the 2001-2020 base period was preceded by a series of dry years, i.e., 1999 and **2000** (*not 2002*).

Accordingly, the 2001-2020 hydrologic base period does satisfy Bulletin 84's criteria for selecting a hydrologic base period, because 2001-2020 was preceded by multiple dry years in 1999 and 2000 A fuller explanation regarding the 2001-2020 hydrologic base period's compliance with all of DWR Bulletin 84's criteria for selecting an appropriate base period is set forth in Point "C" below.

5. Were "cultural conditions" in 1931-1990 significantly different than in 2001-2020? If so provide evidence demonstrating that fact. (1/21/2026 Order, p. 2.)

The maps showing USGS Annual Land Use Cover, set forth at pages 205-213 hereto (Exhibit "C") illustrate the significant changes in cultural conditions that occurred in the Basin Area after 1990, i.e., significant reduction in large agricultural operations and significant increase in residential and industrial uses between the years 1990 and 2020. As indicated in pages 216-227 hereto (Exhibits E, F, G and H), agricultural pumping declined dramatically from 1990 to 2020.

The foregoing demonstrates that cultural conditions and land uses in the Basin Area from 2001-2020 are significantly different than those that existed from 1931-1990. This is explained further in Mr. Wagner's attached supporting declaration (Exhibit 1), at pages 24-29 hereto. Therefore, the 2001-2020 hydrologic base period also satisfies DWR Bulletin 84's requirement that an appropriate hydrologic base period should include "recent cultural conditions."

6. What is Watermaster's criteria for distinguishing between normal and extreme years? (1/21/2026 Order, p. 3.)

Watermaster defines normal years as those years when the water supply is close in magnitude to the average supply during the relevant period of record. There is no definition for "extreme" years. However, the hydrologic record is dominated by years that are far above and far below normal/average years. Exhibit "I" at pages 228-229 hereto illustrates graphically the Mojave River flow at the Forks. As noted, this hydrologic record is dominated by years that are both far above and far below normal/average years; such years are characterized as being either extreme wet years, or extreme dry years.

7. What evidence does Watermaster have that "water flow at the Forks reasonably represents the water supply for the basin as a whole"?

Watermaster needs to clarify its prior statement quoted above by noting that the water flow from the Mojave River as measured at the Forks does not constitute the "entire" water supply for the Basin Area as a whole. The point Watermaster intended to make is that the annual surface supply at the Forks provides an accurate representation of both "wet years" or "dry years" in the Basin Area. Page 3 of the Court's Amended Statement of Decision notes that, "About 80 percent of the total basin recharge is from the Mojave River (Hardt, 1971.)" It states further:

> The surface flow of the Mojave River is the main source of water supply. The Mojave River channel has the ability to absorb significant amounts of the flood flows that pass through the river's various reaches. The water absorbed in the stream channel then percolates downward to the waterbearing formations. The absorption, percolation and mounding of the flood flows is the major source of replenishment to the ground water areas.

(Amended Statement of Decision, page 4.)

8. Is Watermaster's conclusion that the 2001-2020 base period "is reasonably representative of long-terms hydrologic conditions" based solely on the similarity between the average Mojave River flow during 1931-1990 (65,538 AFY) and the flow during 2001-2020 (61,635)? If not, what other factors support the conclusion that the proposed base period is reasonably representative? (8/6/2025 Order, p. 4.)

This conclusion is based solely on the similarity between the average flow during the two hydrologic base periods (see Exhibit "I", at page 228-229 hereto). Watermaster was simply pointing out the water supply at the Forks (which provides the principal surface flow to the Basin) was only 6% drier during the 2001-2020 hydrologic base period compared to the original 1931-1990 hydrologic base period; therefore, the 2001-2020 hydrologic base period is reasonably representative of the long-term average flow and, more importantly, provides a reasonable prediction of the hydrologic conditions expected to be repeated in the future. There is no other reliable measurement of the water supply to the Basin. The precipitation stations with the Forks watershed, and the Este and Oeste Subareas are short and intermittent (see Exhibit M, at pages 239-241 hereto).

9. Is a 6 percent difference de minimis? If so, how large would the difference need to be before it would be considered significant? (8/6/2025 Order, p. 4.)

Watermaster would not characterize a 6% difference as being *de minimis*. Watermaster was simply pointing out that the Mojave River surface flow at the Forks during the 2001-2020 hydrologic base period is not markedly different than the surface flow during the 1931-1990 original hydrologic base period (see, again, Exhibit "I", page 228 hereto). In that respect, the surface flow during the 2001-2020 hydrological base period is representative of the long term average flow that existed in the past and that can reasonably be expected to repeat into the future -- particularly when consideration is given (as it should be) to the effects of climate change and the prolonged drought conditions experienced after the 1990s.

Recognizing this "drier" reality, the Court suggested that Watermaster give consideration to selecting a dryer hydrologic base period.

C. The 2001-2020 hydrologic base period satisfies all criteria set forth in California Department of Water Resources Bulletin 84 and the Judgment.

Any attempt to establish PSY starts with the selection of an appropriate "hydrologic base period" for determining average water supply and outflow, consumptive uses, return flow, etc. For the Mojave Basin Area, three primary sources provide guidance for selecting an appropriate hydrologic base period. Those sources are; (1) the California Department of Water Resources Bulletin No. 84 (August 1967), titled "Mojave River Ground Water Basins Investigation" ("DWR Bulletin No. 84,"Exhibit "A" at pages 41-198 hereto); (2) the January 10, 1996 stipulated Judgment; and (3) the Court's Amended Statement of Decision entered in this proceeding.

DWR Bulletin No. 84.

Regarding the selection of an appropriate hydrologic "base period," Bulletin No. 84 (trial Exhibit 4006 in this proceeding) instructs as follows:

Base Hydrologic Period

> . . . By analysis of long-time precipitation records, it is possible to select as a "base period" *a relatively short and recent period* which represents the long-time average water supply.
>
> The base period conditions should be reasonably representative of long-time hydrologic conditions and should include both normal and extreme wet and dry years. Both the beginning and the end of the base period should be preceded by a series of wet years or a series of dry years, so that the difference between the amount of water in transit within the zone of aeration at the beginning and end of the base period would be a minimum. The base period should also be within the period of available records and should include recent cultural conditions as an aid for projections under future basin operational studies.

(DWR Bulletin No. 84, Exhibit A hereto, pp. 67-68 hereto; emphasis added.)

Relatively Short and Recent Period.

As the above quoted provisions indicate, the hydrologic base period selected should be "a relatively *short and recent period* which represents the long-time average water supply." The 2001-2020 hydrologic base period satisfies this requirement. It is "a relatively short and recent period"; as noted above, it also is representative of "the long-time average water supply" (with a differential of only 6%).

Accordingly, the 2001-2020 hydrologic base period satisfies this requirement of DWR Bulletin No. 84.

Recent Cultural Conditions.

As noted in Bulletin 84, an appropriate hydrologic base period must include "recent cultural conditions." This includes recent patterns of groundwater production, consumptive uses, and other relevant factors. As is demonstrated above, the 1931-1990 hydrologic base period which was used in the past no longer qualifies as an appropriate base period -- for the simple reason that it does not "include recent cultural conditions" (as required by DWR Bulletin No. 84). In contrast, the 2001-2020 hydrologic base period does include "recent cultural conditions." This is explained in great detail in Mr. Wagner's attached supporting declaration (Exhibit 1, at pages 24-29 and 38-39 hereto).

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Normal and Extreme Wet and Dry Years.

Under DWR Bulletin 84, the hydrologic base period also should include both normal and extreme wet and dry years. Exhibit "I" (pages 228-229 hereto) is the familiar graph recording the Mojave River Flows at The Forks from 1931 to 2024. As demonstrated therein, the proposed 2001-2020 hydrologic base period also satisfies the requirement that the selected base period include both normal and extreme wet and dry years.

The Beginning and the End of the Base Period is Preceded by a Series of Dry Years.

As noted, Bulletin No. 84 also provides that, "Both the beginning and the end of the base period should be preceded by a series of wet years or a series of dry years." As explained above, the 2001-2020 proposed hydrologic base period also satisfies this requirement because both the beginning and the end of the hydrologic base period are preceded by a series of dry years, i.e., dry years in 1999 and 2000 precede the 2001 beginning of the base period, and dry years in 2012-2019 precede the 2020 end of the base period.

Therefore, the 2001-2020 hydrologic base period satisfies *all* DWR Bulletin No. 84 criteria for an appropriate base period.

The Judgment.

Paragraph 4, subdivision "aa" of the Judgment in this proceeding defines "Production Safe Yield" as follows:

> The highest average Annual Amount of water that can be produced from a Subarea: (1) over a sequence of years that is representative of long-term average annual natural water supply to the Subarea net of long-term average annual natural outflow from the Subarea (2) under given patterns of Production, applied water, return flows and Consumptive Use, and (3)without resulting in a long-term net reduction of groundwater in storage in the Subarea.

The required elements for an appropriate hydrologic base period are described in items (1) and (2) above, to wit: in addition to net average annual natural water supply (item 1), the hydrologic base period also must include information regarding recent cultural conditions, i.e., "given patterns of Production, applied water, return flows and Consumptive Use" (item 2).

Accordingly, like Bulletin 84, the Judgment contemplates a hydrologic base period that includes a sequence of years that is representative of the net long-term average annual natural water supply and includes information regarding recent cultural conditions. As demonstrated above, the proposed 2001-2020 hydrologic base period satisfies both of these requirements because it includes a sequence of years that is representative of long-term average annual natural water supply, and information and data regarding recent cultural conditions. The 2001-2020 hydrologic base period also reflects the drier conditions (drought) experienced in the Basin Area after the 1990s.

The Court's Amended Statement of Decision.

> Production safe yield is a management tool used to determine the amount of supplemental water necessary to meet the annual deficient indicated by the safe yield calculation.

(Court's Amended Statement of Decision, page 12.)

> Production safe yield is the yield that actually can be produced by pumping water from the basin without causing an adverse effect, assuming that water actually is imported [supplemental water] to replace the deficit.

(*Id.*)

> The court has broad authority to impose assessments to bring ground water in the Basin Area within balance.

(Court's Amended Statement of Decision, page 17.)

> Supplemental water is defined as "an additional source of water that is above the natural water supply for that area. . . . While supplemental water is not the sole source of solving the problem of overdraft, to the extent it need to be used to help solve the problem, it will be found and made available.

(*Ibid.,* page 20.)

Thus, in its Amended Decision, the Court recognized that a key to achieving equilibrium in the Basin area is the purchase of supplemental water to replenish ground water lost through pumping in excess of the Production Safe Yield. The 2001-2020 hydrologic base period is 6% dryer than the original 1931-1990 base period and, because of the anticipated reductions in PSY and FPA values based thereon, will likely lead to the purchase of additional supplies of supplemental water.

D. The Alternative Hydrologic Base Period from 1995-2024

Mitsubishi, Robertson's and CalPortland offer a number of rationalizations in support of their proposed 1995-2024 hydrologic base period, e.g., it encompasses a longer hydrological record than 2001-2020. However, the question to be answered is: which of the two proposed hydrologic base periods is a better choice for "managing" the Basin to bring it into balance as soon as reasonably possible?

The Judgment's equilibrium goal will be better advanced by the 2001-2020 hydrologic base period. This is so, because the 2001-2020 base period is more reliant on Dry and Very Dry and Normal years, and less reliant on Very Wet years. Accordingly, the 2001-2020 hydrologic base period is drier than the alternative 1995-2024 base period. Relying upon "drier" water supply data from the 2001-2020 hydrologic base period should result in lower PSY values (compared to the 1995-2024 base period), and thus require additional reduction in FPA and the purchase of more imported water to replenish depleted areas of groundwater.

The Court also should consider the self-interest of the parties proposing the "wetter" 1995-2024 hydrologic base period, and whether they advocate for the 1995-2024 base period simply to avoid greater FPA rampdown. Notwithstanding the Judgment's clear mandate that FPA must be ramped down when it exceeds PSY by more than 5%, Mitsubishi, Robertson's and CalPortland have consistently argued against further FPA rampdown in the Este Subarea simply because groundwater production has been less than the FPA value without loss of storage. The Court rejected this argument:

> Mitsubishi and Robertson's argue that no reduction is justified because production is well below FPA and there has been no significant loss of storage. Their argument misses the point. The issue is not whether the current level of production results in a loss of storage, but whether production up to the current FPA – 50 percent of BAP – would result in a loss of storage.
>
> As the Court explained in 2019 regarding the Este Subarea, when a subarea's FPA exceeds the PSY, there is good reason to reduce the FPA even if the current level of production does not exceed PSY. (Order filed 7-23-2019, p. 2.) Indeed, the 7-23-2019 order expressly notified the "producers in Este that the Court intends to impose a rampdown of 5% per year until FPA is approximately equal to PSY." (*Ibid.*) That reasoning was followed in 2020 and 2021 (orders filed 6-12-2020 and 6-4-2021) and reiterated in 2022, 2023, and 2024 (orders filed 6-3-2022, 6-9-2023, and 7-3-2024).
>
> Mitsubishi and Robertson's do not explain why that reasoning does not apply

> with equal force this year. Nor do they contend that the FPA in Este is approximately equal to PSY. Indeed, it is not. At 50% of BAP, the FPA is equal to 11,568 AFY. By contrast, the PSY is only 6,582 AFY. Therefore, the fact that the current level of pumping (3,547 AFY) has not resulted in a loss of storage does not lead the Court to conclude that the FPA should remain at 50%.

(August 5, 2025 Order, p. 2.)

Mitsubishi, Robertson's and CalPortland now advocate for the 1995-2024 hydrologic base period (rather than the 2001-2020 base period) as part of their continuing efforts to avoid the possibility of further FPA ramp down – not because the 1995-2024 base period is a better management tool to achieve Basin equilibrium as soon as reasonably possible.

The alternative 1995-2024 base period is inappropriate for the following reasons: (1) it is 2% "wetter" that the 1931-1990 hydrologic base period, and 8-9% "wetter" than the 2001-2020 base period; (2) as a result, the 1995-2024 base period could result in increased PSY values, while the 2001-2020 base period should result in relatively lower PSY values; (3) the 1995-2024 base period includes a period (1995-1999) that does not represent "recent cultural conditions" because land uses and cultural conditions have changed significantly since the 1990s ; (4) contrary to Bulletin 84's criteria for selecting an appropriate hydrologic base period, the 30-year period from 1995-2024 does not constitute a "relatively short" hydrologic base period (compared to the 20-year base period from 2001-2020); and (5) from a Basin management perspective, because the 1995-2024 base period is a significantly "wetter" hydrologic base period, it would not advance the Judgment's goal of bringing the Basin Area into equilibrium as soon as reasonably possible (see Wagner Dec., Exhibit 1, pp. 36, lines 22-27 and 38, line 1-18 hereto).

E. Conclusion.

All criteria for selecting an appropriate base period set forth in both DWR Bulletin No. 84 and the Judgment are satisfied by the proposed 2001-2020 hydrologic base period. Because it is a drier hydrologic base period, the 2001-2020 hydrologic base period will advance the goals and objectives of the stipulated Judgment because it should result in relatively lower PSY and FPA values, requiring the purchase of supplemental water to replenish areas of ground water deficit. For the reasons stated herein and in Mr. Wagner's attached supporting declaration (Exhibit 1), Watermaster submits that the 2001-2020 hydrologic base period is a better predictor of future water supply and cultural conditions than any other alternative hydrologic base period that has been considered or suggested.

Accordingly, Watermaster respectfully submits the Court should grant Watermaster's renewed motion and approve the proposed 2001-2020 hydrologic base period for use in determining PSY values in the Basin Area **at least for** Water Year 2026-2027. After the ongoing modeling is completed, the Court could then determine the appropriate hydrologic base period to be used for subsequent years, without Watermaster's reliance upon the 2001-2020 base period (for calculating PSY and FPA values for Water Year 2026-2027) having any precedential value as to that subsequent determination.

In this same regard, during the October 20, 2025 hearing, the Court indicated it "would consider the possibility of granting the motion [to approve the 2001-2020 base period] on a temporary basis, i.e., authorizing the proposed base period (2001-2020) to be used in calculating the FPA recommendations for water year 2026-2027." (1/21/2026 Order, p. 1.) At the February 20, 2026 hearing, this solution also was supported by legal counsel representing the California Department of Fish & Wildlife.

Dated: February 24, 2026

BRUNICK, MCELHANEY & KENNEDY PLC

By:______________________________

Leland P. McElhaney
Attorneys for the MOJAVE WATER AGENCY
(as the MOJAVE BASIN AREA WATERMASTER)

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EXHIBIT 1

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MOJAVE WATER AGENCY

NO FEE PER GOV'T. CODE SEC. 6103

SUPERIOR COURT OF THE STATE OF CALIFORNIA

IN AND FOR THE COUNTY OF RIVERSIDE

Coordination Proceeding Special Title (Cal. Rules of Court, Rule 3.550) MOJAVE BASIN WATER CASES	CASE NO.: CIV 208568 / JCCP5265 Dept. 1. Riverside Superior Court Hon. Craig G. Riemer, Retired
CITY OF BARSTOW, et al., Plaintiff, v. CITY OF ADELANTO, et al., Defendant.	**WATERMASTER ENGINEER'S AMENDED STATEMENT OF REASONS FOR RECOMMENDING 2001-2020 BASE PERIOD** Dept.: 1 Honorable Craig G. Riemer, Retired, Judge Presiding
AND RELATED CROSS ACTIONS	

DECLARATION OF ROBERT C. WAGNER

I, Robert C. Wagner, declare and state as follows:

I am a licensed Civil Engineer in the State of California and President of the firm of Wagner and Bonsignore, Consulting Civil Engineers in Sacramento, California. I serve in the capacity of Engineer for the Mojave Basin Area Watermaster in performance of its duties. I have personal knowledge of the matters set forth herein and, if called as a witness, I could and would testify competently thereto.

DWR Bulletin 84 guidance on the selection of a hydrologic base period.

The applicable hydrologic base period to be used to implement the terms of the Judgment is not defined in the Judgment. However, in January 1996, when the Judgment was entered in *City of Barstow v. City of Adelanto,* the Watermaster, the Court, and the Parties relied upon a study published in 1967 by the California Department of Water Resources (DWR), titled DWR Bulletin 84 (trial exhibit number 4006), a copy of which is attached as **Exhibit A** (pp. 41-198) hereto. The Forward to that study states:

> *This investigation and report are the result of the recognition by the Mojave Water Agency of its need for reliable information on existing water resources, future water requirements, and sources of additional water supply to meet the needs for growth of the region it serves. Accordingly, the agency, through its legislative representatives, obtained state funds for the Department of Water Resources to undertake this investigation . . .*
>
> *To provide interested agencies and persons with information as soon as it was available, informal meetings were held and two progress reports were published by the Department of Water Resources.*
>
> *The results of this study show that additional water will be required if the Mojave region is to realize its growth potential. The meager rainfall and increasing water demands of the area indicate the need for a plan of basin operation that will take full advantage of existing and potential water resources, including ground water, imported water, and the use of the ground water basins for both storage and distribution of water.*
>
> *The information provided by this study points out the need and provides a foundation for a ground water basin model simulation and operational and economic studies, leading to the selection by local agencies of an optimum plan of water resources management.*

Bulletin 84 provides the following guidance as to precipitation serving as an index of the water supply (**Exhibit A**, p. 67 hereto):

> *In any watershed, precipitation is the original source of local water supply; therefore, the amount of precipitation to a groundwater basin and its tributary areas serve as an index of the water supply available to that basin. . . .*

Bulletin 84 also provides the following guidance regarding the criteria to be used for selecting a long-term base period (**Exhibit A**, pp. 67-68 hereto):

> *The base period conditions should be reasonably representative of long-time hydrologic conditions and should include both normal and extreme wet and dry years. Both the beginning and the end of the base period should be preceded by a series of wet years or a series of dry years, so that the difference between the amount of water in transit within the zone of aeration at the beginning and end of the base period would be a minimum. The base period should also be within the period of available records and should include recent cultural conditions as an aid for projections under future basin operational studies.*
>
> . . .
>
> *On the basis of the criteria stated in preceding paragraphs, the water years 1936-37 through 1960-61 were chosen as the base hydrologic period. This 25-year period includes the most recent pair of wet and dry cycles; has an average annual precipitation (at Squirrel Inn No. 2) of 40.7 inches, which closely approximates the estimated long-time period average of 41.7 inches; begins and ends after a series of dry years; is within the period of available data; and includes recent land use conditions.*

The Los Angeles vs. San Fernando case

Similar criteria for selecting a hydrologic base period was adopted in *City of Los Angeles vs. City of San Fernando, et al.*, 14 Cal.3d 199 (1975), which is consistent with the SGMA definition of sustainable yield (Water Code Section 10721(v)). In *City of Los Angeles v. City of San Fernando, the* State Water Rights Board approved and adopted the Report of Referee dated July 1962 pursuant to the requirements of the Court's Order of Reference. **Exhibit B** (pp. 205-213) hereto are excerpts from volume 1 of the July, 1962 State Water Rights Board "Report of Referee".

In the selection of a base study period, the Los Angeles vs. San Fernando case states the base period corresponds to the one with precipitation similar to the long-term period of record 1872-73 through 1956-57. The Report of Referee (1962) also stated the following:

> *The desirable base study period is one during which precipitation characteristics in the Upper Los Angeles River area approximate the 85-year period of record, 1872-73 through 1956-57. A further requirement of such a period is that additional hydrologic information is available sufficient to permit an evaluation of the amount, occurrence and disposal of the normal water supply* ***under recent culture conditions****. The desirable base period includes both wet and dry periods similar in magnitude and occurrence to the normal supply, and during which there are sufficient measurements and observations* ***to relate the hydrology to recent culture****.*
>
> (**Exhibit B**, p. 202; emphasis added.)

Based on the above, the 29-year base period of 1929 through 1957 was selected for the following reasons (Report of Referee, pp. 72-73, filed with the Trial Court):

1. It was a period of normal precipitation, and sufficient records were available to calculate safe yield.
2. It was a representative period of normal precipitation including a series of wet and dry years similar in magnitude and occurrence to the long-term average supply conditions of 1872-73 to 1956-57. The average annual precipitation during these 29 years closely matched the long-term average, with only minor deviations.

3. The years preceding the first and last years of this period were drier than normal, thereby reducing unaccounted water in transit toward the water table at the start or end of the period.
4. It included years with water supply and disposal patterns under cultural conditions similar to those in 1949–50, 1954–55, and 1957–58, the years used for determining safe yield.

There are several similarities between the criteria for selection of a base period described in the Report of Referee (1962) by the State Water Rights Board and the guidance from DWR Bulletin 84. The similarities in the criteria for a base period selection between DWR Bulletin 84 and *City of Los Angeles vs. City of San Fernando* are summarized as follows:

- Be representative (similar) to average long-term conditions of supply.
- Include a series of wet and dry years.
- Be based upon sufficient records depicting hydrologic conditions.
- Beginning and end of base periods are below normal (dry).
- Include periods of recent cultural conditions.

(**Exhibit B**, pp. 203-204)

Initial Hydrologic Base Period 1931-1990

Based upon DWR's guidance in Bulletin 84, the Parties and the Court in *City of Barstow* determined the initial hydrologic base period should be from 1931 to 1990, because it includes both normal and extreme wet and dry years, and meets the other requirements set forth in Bulletin 84. Therefore, after January 10, 1996 (when the Judgment was entered), the hydrologic base period from 1931 to 1990 was accepted by the Parties as the original long-term hydrologic base period for purposes of implementing the Judgment.

The hydrologic base period is important because the production safe yield (PSY) requires a finite time period for evaluation. With pertinent information from the selected hydrologic base period, Watermaster determines PSY based on an estimate of consumptive uses and production to determine the amount of water the Parties are required to purchase. The Judgment is intended as a funding mechanism so that those that pump more than their FPA will be required to purchase Replacement Water from Watermaster for recharge in a given subarea.

As indicated in Bulletin 84, the selected hydrologic base period should include recent cultural conditions, because those conditions are directly related to consumptive use and return flow which, in turn, directly impact water supply. The Court's Amended Statement of Decision in this proceeding acknowledges the importance of the cultural conditions: "Production Safe Yield is always based on a particular cultural condition." (Statement of Decision, C. 2.).

However, the "cultural conditions" for water use and disposal during the 1931-1990 hydrologic base period are not representative of recent cultural conditions. Watermaster has compiled land use data, historical pumping and irrigated acreages for the last 30 years. The following sections explain the changes in cultural conditions since 1990.

A. Changes in land uses

Changes over time are significant and must be considered. *City of Los Angeles v. City of San Fernando* notes: "The trial court found . . . that since the entry of the former judgment 'the culture of the area within the San Fernando Basin . . . has been transformed from essentially rural and agricultural to a highly developed urban society . . . .' Much of the land formerly devoted to irrigated crops has been covered by residential and commercial development." (*Id*, 14 Cal.3d at 258). A similar transformation has occurred in the Mojave Basin Area.

Exhibit C (pp. 205-213) shows the 30-year changes in land use for each subarea. The National Land Cover Database (NLCD) is a product of the U.S. Geological Survey and provides nation-wide data on land cover and land cover changes in a 30-meter resolution. The NLCD dataset provides spatial reference and descriptive data for characteristics of the land surface such as developed areas, percent of impervious surfaces, and percent of tree canopy cover. The NLCD Land Cover dataset is represented categorically by 16 different land cover class codes. For purposes of evaluating land use changes in the Basin Area, Watermaster focused on two land cover classifications: "Developed" (shown as various shades of red colors for the different levels of development) and "Cultivated Crops" (class code 82, shown with a brown color and representing agricultural land).[1]

The NLCD dataset for Alto Subarea (**Exhibit C**, p. 208) indicates a significant decrease in the land cover classified as "Cultivated Crops" from 1990 to 2020. The agricultural land use in Alto upstream of the Lower Narrows has disappeared, and agricultural land use in the Transition Zone was greatly reduced during that 30-year period. On the other hand, the developed areas in the Alto Subarea have extended and increased over that 30-year period, corresponding to the substantial growth in residential areas which are now sewered. The change in developed areas in the Alto Subarea is also evidenced by the flow patterns of the treated wastewater discharges by VVWRA into the Mojave River within the Transition Zone. **Exhibit D** (pp. 214-215) shows the measured annual discharges by VVWRA for the period 1990 to 2024. VVWRA discharges started in the 1980s. As agricultural land use changed and new developed areas were connected to the sewered system, the patterns of return flows changed. In 1990, discharges by VVWRA were nearly 7,000 acre-feet. By 2020, the annual discharges by VVWRA were 13,719 acre-feet. The long-term increase suggests population growth related to the new developed areas shown in land use changes (**Exhibit C**, p. 208).

The NLCD dataset for the Centro Subarea (**Exhibit C**, p. 209) indicates a reduction in cultivated land, particularly in the Lockhart area and areas near Hodge. Similarly, the NLCD dataset for Este and Oeste subareas (**Exhibit C**, pp. 210-211) shows a considerable reduction in agricultural land use, and an

[1] Exhibits C through M were prepared based upon data obtained from the USGS and Watermaster records of verified production and irrigated acreages, along with precipitation data provided by NOAA and San Bernardino County. This data is considered to be accurate and reliable; therefore, the data and information in Exhibits C through M are more likely than not true.

increase in the developed areas in the Oeste Subarea. It is noteworthy that Oeste agricultural land use is expected to be almost zero now.

Lastly, the NLCD dataset for the Baja Subarea (**Exhibit C**, pp. 212-213) also shows a reduction in agricultural land use in the 30-year period evaluated. For the Baja Subarea, Watermaster also included a comparison of the most recent five years (2020 to 2024). This additional comparison documents the most recent changes in agricultural land uses, indicating that cultural conditions in the Baja Subarea have continued to change.

Watermaster findings on changes in land uses are consistent with the changes in groundwater pumping and number of acres irrigated ("irrigated acreage"), as indicated below in Point "B" (to page 26, lines 18-19), all of which are more likely than not true.

B. Changes in Pumping and Irrigated Acreages

Exhibit E (pp. 216-217) shows the distribution of the total water uses in the Water Years 1990, 2020, 2022, and 2024. In 1990, Water Use was predominantly agricultural accounting for 60%, and other uses (Commercial, Municipal, Industrial, Golf Course and Recreational) accounting for 40%. Thirty years later, with the implementation of the Judgment, the water use distribution has changed. In 2020, agricultural uses in the Basin Area was about 21%, while the other users were about 79%. Continuation of the rampdown has led to a continued decline in agricultural pumping. By 2024, agricultural uses declined further to only 14% and the remaining 86% corresponds to other uses.

Exhibit F (pp. 218-219) shows the estimated total production for the Mojave Basin Area by the Type of Use from Water Year 1995 to Water Year 2024. The graphic indicates water use trends over nearly a 30-year period by five categories: Agricultural, Municipal, Industrial, Golf Course, and Recreational. During the peak Water Year 1996, total water production was close to 195,000 acre-feet. There was a remarkable downward trend in water use over time. By Water Year 2023-2024, total water use was about 111,000 acre-feet, a reduction of about 43% from the Water Year 1996 when the Judgment was implemented. In 1995, agricultural use (red bars) accounted for the largest share (nearly 88,000 acre-feet). Agricultural use dropped significantly after 1998 and continued to decline steadily. It is presently below 20,000 acre-feet indicating a major shift away from irrigated farming. Municipal use (blue bars) remains the largest component after agriculture declined. It fluctuates but generally stays between 70,000 and 100,000 acre-feet showing relative stability compared to other uses. Other use categories (Industrial, Golf Courses, Recreational) represent a small portion of the total use. In general, golf courses and recreational uses remain relatively constant, while industrial use has a slight variability.

Exhibit G (pp. 220-221) provides a graphic of the Agricultural Water Production (blue bars) and Irrigated Acreages (red line) for all subareas combined from 1995 to 2024.

Exhibit H (pp. 222-227) provides graphics of the Agricultural Water Production (blue bars) and Irrigated Acreages (red line) for each individual subarea from 1995 to 2024.

- **Alto Subarea**. For the Alto Subarea, both water production and irrigated acreage have declined consistently over time. In 1995, agricultural water production in Alto was about 14,600 acre-feet. By 2024, agricultural water production dropped to roughly 1,200 acre-feet. Watermaster's data on irrigated acreage shows a similar trend. In 2000, irrigated crops were grown on 1,452 acres. By 2024, irrigated crops were reduced to 221 acres. Irrigated acreages show a steady downward trend, with notable drops after 2002 (966 acres) and 2008 (711 acres).
- **Centro Subarea**. Agricultural water production and irrigated areas in Centro Subarea have declined over the 30-year period. In 1995, agricultural water production in Centro was about 27,400 acre-feet. By 2024, agricultural water production dropped to roughly 6,200 acre-feet. Watermaster's data on irrigated acreage shows a similar trend. In 2000, irrigated crops were grown on 2,029 acres. By 2024, irrigated crops were reduced to 1,093 acres. Irrigated acreages show some variability over time; however, a steady downward trend can be observed after 2008.

- **Baja Subarea**. In 1995, agricultural water production in Baja was about 35,200 acre-feet. By 2024, agricultural water production dropped to roughly 5,500 acre-feet. Watermaster's data on irrigated acreage shows some variability; however, irrigated areas show a steady downward trend during recent years. In 2000, irrigated crops were grown on 5,296 acres. By 2024, irrigated acreages were reduced to 1,779 acres. Watermaster concludes that agricultural pumping patterns and irrigated areas have changed during the last five years. This is consistent with the evidence of land use changes observed in Baja during the 2020 to 2024 period (**Exhibit C**, pp. 212-213).
- **Este Subarea.** Both agricultural water production and irrigated acreage have declined significantly over time. In 1995, agricultural water production was about 6,900 acre-feet. By 2024, agricultural water production dropped to roughly 2,200 acre-feet. Watermaster's data on irrigated acreage shows a similar trend. In 2000, irrigated acreage was 956 acres. By 2024, irrigated acreage had been reduced to 496 acres. After 1996, with the implementation of the Judgment, agricultural water production and simultaneously irrigated land in the Este Subarea have been in continuous decline.
- **Oeste Subarea**. The graphic for Oeste Subarea shows a clear long-term decline in both agricultural water production and irrigated acreage from 1995 to 2024, with some notable fluctuations. In 1995, agricultural water production was about 3,600 acre-feet. By 2024, agricultural water production reached zero acre-feet. Watermaster's data on irrigated acreage shows fluctuations, with a rise in farmed acreages between 2004 and 2012, peaking at 612 acres in 2012, even as agricultural water production remained relatively stable. After 2013, irrigated acreage declined rapidly, falling below 200 acres by 2020 and reaching zero by 2022. By 2022, agricultural water production had dropped to about 100 acre-feet and by 2024, water production reached zero acre-feet indicating a complete cessation of agricultural pumping and irrigation. The complete drop to zero in both agricultural water production and irrigated acreages suggests

a transition out of agricultural use in the Oeste Subarea, likely due to the implementation of the Judgment. This is consistent with the evidence of land use changes observed in Oeste during the 1990 to 2020 period (**Exhibit C,** p.211).

The foregoing demonstrates that the previously utilized hydrologic base period from 1931 to 1990 does not represent "recent cultural conditions" and, therefore, does not meet the Bulletin 84 criteria for selection of a hydrologic base period to be used for calculating PSY. Accordingly, it is necessary to select a hydrologic base period that fairly represents, among other required elements, recent cultural conditions.

Water Supply to the Basin Area

Water supply to the Basin Area includes gaged and ungagged inflow, subsurface flow, deep percolation of precipitation, and certain imports.

Surface water inflow to the Alto Subarea is measured flow of the Mojave River at the Forks and is the sum of reported values from USGS gage stations at West Fork Mojave River near Hesperia, CA and Deep Creek near Hesperia, CA. This measured USGS gage data provides the best available information regarding the surface water inflow to the Basin Area, and is more likely than not true. There are very few records of surface water inflow to the Este and Oeste Subareas.

Watermaster reviewed records of precipitation. Although there are several precipitation stations located within the Forks' watershed, the reliability of this data is questionable. The precipitation records are short, inconsistent, and intermittent (see **Exhibit M,** pp. 239-241). For these reasons, Watermaster believes the measured flow of the Mojave River at the Forks continues to be the record indicative of the long-term surface water supply to the Basin Area. Additionally, the flow record at the Forks provides a clear indication of wet and dry periods in the Basin Area, and is more likely than not true.

New Proposed Hydrologic Base Period 2001-2020

The 2001-2020 hydrologic base period, which was proposed by Watermaster in 2024 and 2025 meets the guidance set forth in Bulletin 84 as evaluated at the Forks. It is reasonably representative of long-term hydrologic conditions for inflow at the Forks, contains normal, extreme wet and dry years, and begins and ends with dry years. It also is within the period of record and includes recent cultural conditions. The 2001-2020 hydrologic base period, while similar, is drier by about 6%, compared to the 1931-1990 period as measured at the Forks. **Exhibit I** (pp. 228-229) is a hydrograph of the Mojave River at the Forks, showing the initial 60-year hydrologic base period of 1931-1990, and the proposed new hydrologic base period of 2001-2020.

Once the hydrologic base period is set, there is no reason to reset it every year, or at any other time unless the conditions upon which it is based change significantly.

Hydrologic Base Period vs. Pumping and Consumptive Uses for purposes of PSY determination

The purpose of this section is to provide an explanation of the differentiation between the selection of the hydrologic base period, and the selection of a year representative of pumping and consumptive uses for determination of PSY. For water supply, the hydrologic base period is used to determine the average water supply to the Basin Area, and it is assumed that this pattern will repeat itself in the future for planning purposes.

Watermaster needs to clarify that when calculating PSY, **the year representative of pumping and consumptive uses does not necessarily need to be strictly contained within the time frame of the hydrologic base period**. In 1996, when the Judgment was entered, the initial hydrologic base period was 1931-1990, and the PSY determination used the pumping and consumptive uses from the year 1990 (Table C-1 from the Judgment).

However, in 2000, Albert A. Webb Associates on behalf of Watermaster re-evaluated PSY using the base period for streamflow data of 1931-1990, and the pumping and consumptive uses from the Water Year 1997 (Webb, 2000). More recently, in 2019, Watermaster re-determined PSY using the water supply from the initial hydrologic base period of 1931-1990, and the pumping and consumptive uses from the Water Year 2018. Mr. Ernest Webber, one of the Bulletin 84 authors, contributed to the Webb 2000 study.

For purposes of planning, Watermaster operates under the assumption that the patterns of water supply will repeat in the future, since we do not know the future water supply. For PSY determination, we expect that pumping in the near future approximates the current pumping patterns. This allows Watermaster to calculate the amount of imported water that needs to be purchased by the Parties so that the Basin remains balanced.

In 2024, Watermaster prepared a report with an update to PSY titled "Production Safe Yield and Consumptive Use Update". In the 2024 PSY Update, Watermaster stated that "The Court previously asked that we consider a drier and more recent hydrologic planning period." Consequently, Watermaster updated the hydrologic base period and recommended 2001-2020 for purposes of re-determination of PSY. The 2024 PSY Update by Watermaster determined that for PSY calculations, the pumping and consumptive use data from the Water Year 2022 were representative because "Water year 2022, the most recent year that data is available is assumed to represent pumping and consumptive uses on a forward-looking basis."

As noted previously by Watermaster, patterns of production, applied water and consumptive uses are subject to change as land uses change, however they are not expected to change significantly from one year to the next (this has been largely true except in the Baja Subarea). Per the July 2025 Watermaster Motion, the pumping patterns and land use in the Baja Subarea have greatly changed in the recent five years. This was evidenced by the changes in agricultural pumping (**Exhibit H**, pp. 222-227) and changes in land use (**Exhibit C**, pp. 205-213).

Even though the hydrologic base period of 2001-2020 was recommended by Watermaster for all Subareas, Watermaster recognizes that for the Baja Subarea, special circumstances may warrant PSY determination based on limited data. For the Baja Subarea, the only reliable data available is pumping and water level measurements (which show recent recovery). This is true for the Este Subarea and the Oeste Subarea as well.

In 2024, Watermaster recommended Baja PSY of 12,749 acre-feet, which was determined by interpretation of water levels compared to the total pumping. Total pumping in the Baja Subarea during the representative Water Year 2022 was 12,749 acre-feet. Again, for planning purposes, this is assumed to be representative of the recent cultural conditions in the Baja Subarea.

Watermaster justification for the new hydrologic base period 2001-2020

The 60-year hydrologic base period of 1931-1990 was based on the guidance from DWR Bulletin 84 (1967), as is the 2001-2020 proposed 20-year hydrologic base period.

In September of 2022, the Court asked Watermaster to consider a drier and more recent hydrologic base period. The average water supply measured at The Forks for the hydrologic base period (1931-1990) was 65,538 acre-feet per year, while the average water supply for the proposed hydrologic base period (2001-2020) was 61,635 acre-feet per year, which is 6-percent drier than the 1931-1990 hydrologic base period.

In addition to the water supply measured at The Forks, Watermaster also evaluated precipitation in the Basin Area to determine if the new hydrologic base period is consistent with the selection criteria from the *Los Angeles vs. San Fernando* case in that the base period "was a representative period of normal precipitation including wet and dry periods of magnitude and occurrence similar to long-time mean supply conditions..." (**Exhibit B**, p. 203) To evaluate precipitation patterns in the Mojave Basin

Area, the Watermaster reviewed precipitation stations located within the watershed tributary to The Forks (see **Exhibit J**, pp. 230-232), as well as stations in or near the Oeste subarea (see **Exhibit K**, pp. 233-235) and within the Este subarea (see **Exhibit L**, pp. 236-238) that have long-term records. **Exhibit M** (pp. 239-241) shows the location of the precipitation stations with available record data, the period of record for each station, and the watershed in which each station is located. Watermaster noted that only one precipitation station covers the period of record of 1931-1990, this station is "Lake Arrowhead Fire Station #1". The average precipitation during the initial hydrologic base period of 1931-1990 was 41.36 inches, as measured at the Lake Arrowhead Fire Station #1. **Table 1** shows the results of this comparison, including the percentage of change from the 1931-1990 base period average.

Table 1. Average precipitation during the alternative hydrologic base periods and their comparison with the average precipitation during the initial 1931-1990 base period.

Alternative Hydrologic Base	Precipitation Average (inches)	Change Relative to 1931-1990 Average (41.36 inches)	Criteria
1991-2022	39.3	-4.9%	Start and end years are dry and are preceded by a series of dry years.
1995-2024	42.0	1.5%	Start and end years are wet and are preceded by a wet year/series of wet years.*
1998-2024	41.3	-0.1%	Start and end years are wet and are preceded by a wet year/series of wet years.
2001-2020	37.2	-10.1%	Start and end years are dry and are preceded by a series of dry years.
2002-2022	39.0	-5.8%	Start and end years are severe dry and are preceded by a series of severe dry years.

Note: As mentioned by Watermaster, precipitation stations within the Fork's watershed provide precipitation records that are short, inconsistent, and intermittent.

*The water supply at the Forks during the Water Years 1992 through 1995 was about three times the long-term average supply.

Evaluation of Alternative Hydrologic Base Periods

Watermaster evaluated a series of potential/alternative hydrologic base periods in addition to the 2001 to 2020 base period. These potential base periods also meet the definition of a base period set forth in Bulletin 84. Table 2 is a summary of the alternative hydrologic base periods that were evaluated by Watermaster. Table 2 shows the average Mojave River flow at the Forks and the percentage of change relative to the initial hydrologic base period 1931-1990. Watermaster noted that the average water supply to the basin during each alternative base period was similar in magnitude to the average conditions during the initial base period of 1931-1990.

Table 2. Average water supply during the alternative hydrologic base periods and their comparison with the initial 1931-1990 base period.

Alternative Hydrologic Base Periods	Mojave River at the Forks Average (a.f.)	Change relative to the 1931-1990 average (65,538 a.f.)	Criteria
1991-2022	71,344	8%	Start and end years are dry and are preceded by a series of dry years.
1995-2024	67,057	2%	Start and end years are wet and are preceded by a wet year/series of wet years.*
1998-2024	65,090	-1%	Start and end years are wet and are preceded by a wet year/series of wet years.
2001-2020	61,635	-6%	Start and end years are dry and are preceded by a series of dry years.
2002-2022	59,009	-11%	Start and end years are severe dry and are preceded by a series of severe dry years.

Notes: The PSY Update prepared by Watermaster in February of 2024 updated the hydrologic base period to be 2001-2020 for purposes of establishing PSY. This selection was based on the information that was available and reliable for Watermaster at the time of the analysis (i.e., flow data up to the year 2023).

Also, the PSY Update by Watermaster evaluated the 2001-2020 hydrologic base period also because the Upper Mojave Basin Model was calibrated through the Water Year 2020.

*The water supply at the Forks during the Water Years 1992 through 1995 was about three times the long-term average supply.

The selection of the new hydrologic base period was based on the following criteria: land use changes and recent cultural conditions, availability of the records and satisfying the request from the Court to evaluate a dryer and more recent time period.

The hydrologic base period of 1991-2022 shows an average water supply about 8-percent higher than the average of the initial base period 1931-1990. The hydrologic base period of 1995-2024 shows an average water supply about 2-percent higher/wetter than the average of the initial base period 1931-1990. From a water supply perspective, when comparing two hydrologic base periods with the same cultural conditions, a larger magnitude of average water supply should yield a higher PSY value. On the contrary, a smaller magnitude of water supply should yield a lower PSY value. However, as noted above, the Court previously asked Watermaster to consider a drier and more recent hydrologic base period. Watermaster does not recommend the two alternative hydrologic base periods of 1991-2022 and 1995-2024 because the water supply during those hydrologic base periods were of greater magnitude than during the 1931-1990 hydrologic base period.

The alternative base period 2002-2022 starts and ends on a dry year and is preceded by a series of dry years. However, because the UMBM is calibrated through the year 2020 only, Watermaster does not consider this to be an appropriate selection. Additionally, this alternative is about 11% drier than the 1931-1990 base period. Because the alternative 2002-2022 base period is outside the period of the UMBM calibration, and the magnitude of water supply in the alternative 2002-2022 base period does not "closely approximate" the magnitude of the long-term water supply during the 1931-1990 base period (as indicated by DWR Bulletin 84), Watermaster believes the alternative 2002-2022 base period is not as appropriate as the recommended 2001-2020 base period.

The alternative base periods evaluated by Watermaster were Water Years 1995-2024 and 1998-2024. As noted in Table 2, the PSY Update prepared by Watermaster in February of 2024 evaluated a new hydrologic base period based on the information available at that time (up to the end of Water Year

2023). For that reason, Watermaster did not include a base period ending in 2024. Importantly, **the Judgment does not require the hydrologic base period to be revised or updated each year as new information becomes available.**

The average water supply during the base period of 1995-2024 was 67,057 acre-feet, which is about 2-percent higher and wetter than the initial base period 1931-1990. The average water supply during the base period of 1998-2024 was 65,090 acre-feet, which is only 1-percent drier than the initial base period. Although these two potential base periods are similar in magnitude to the long-term average, they include years that are not representative of recent land uses, for the following reason. According to the evidence shown in **Exhibit C** (pp. 205-213), the land uses have greatly changed since the 1990s to present time, particularly due to Mojave Basin Area experiencing a major shift away from agricultural pumping and agricultural land use. The agricultural water use data suggest that pumping during the mid-1990s was in the order of 87,000 to 89,000 acre-feet per year (see **Exhibit G**, pp. 220-221). By 2022, agricultural water use was reduced to less than 20,000 acre-feet. As explained above, Watermaster's data on irrigated acreages show a similar trend of a constant reduction in irrigated land, particularly during recent years. Because the new hydrologic base period should meet the criteria of the DWR Bulletin 84 and include recent cultural conditions, Watermaster determined that the alternative hydrologic base periods that begin in the 1990s do not meet the representation of recent cultural conditions, and therefore, they should not be considered appropriate hydrologic base periods for PSY redetermination.

The 1995-2024 base period also is 50% (10 years) longer than the 2001-2020 base period and, therefore, would fail as "relatively short" (compared to 2001-2020) as guided by Bulletin 84 (DWR Bulletin No. 84 pp. 12-13, Exhibit A pp. 67-68). As noted, it also is approximately 2% wetter than the original 1931-1990 hydrologic base period, and 9% wetter than Watermaster's proposed 2001-2020 hydrologic base period. In addition, as explained above, the hydrologic base period 1995-2024 includes years that are not representative of recent cultural conditions.

The Judgment has been characterized, by way of the "production safe yield" calculation, as a "funding mechanism" to pay for imported water. This characterization can be found in the Court's Amended Statement of Decision, on page 12, which states, *"To the extent imported water is used to satisfy water uses, the Production Safe Yield is greater than that solely attributable to the natural supply. Production safe yield is a* ***management tool*** *used to determine the amount of supplemental water necessary to meet the annual deficit indicated by the safe yield calculation*" (emphasis added).

A shorter, more recent hydrologic base period is a better selection for arid environments due to the large variability in the water supply. Inspection of Exhibit I, pages 228-229 hereto, shows this variability during the 95-year period of record (1931-2025). 59 of the 95 years (62%) fall below 50,000 acre-feet per year (less than 75% of long-term average), as measured at the Forks. Nine of the 95 years (9.47%) produce more than 200,000 acre-feet per year.

Although there is not a Judgment definition for what a wet or dry year means, it is a common practice to divide hydrologic data into Quintiles for analysis. This division can be characterized as "Very Dry", "Dry", "Normal", "Wet", and "Very Wet". The division of the data would be the 20th, 40th, 60th and 80th percentiles. "Very Dry" is less than or equal to the 20th percentile, "Dry" is greater than 20 but less than 40, "Normal" is between 40 and 60, "Wet" is between 60 and 80, and "Very Wet" is greater than the 80th percentile. I divided the surface flow data at the Forks accordingly for four periods, 1931-1990 (original base period), 1931-2025 (entire period of record), 1995-2004 (base period proposed by Mitsubishi, Robertson's and CalPortland), and 2001-2020 (base period proposed by Watermaster). The results are provided in Table 3.

Table 3. Total volume of surface water at the Forks and its characterization based on quintiles, for five alternative hydrologic base period.

Alternative Hydrologic Base Periods	Total Volume at the Forks (a.f.)	Very Dry	Dry	Normal	Wet	Very Wet
1931–1990	3,932,267	2.4%	5.8%	8.1%	20.6%	63.0%
1931–2025	6,534,324	2.4%	5.2%	8.5%	20.4%	63.5%
1995–2024	2,011,723	3.1%	4.7%	8.1%	22.3%	61.8%
2001–2020	1,232,694	4.0%	2.7%	10.7%	28.0%	54.5%
1931–1990	3,932,267	2.4%	5.8%	8.1%	20.6%	63.0%

Given the above distribution, the four periods are similar with some important differences. In the 2001-2020 period the percentage volume that comes from "Very Wet" years is 54.5% of the total volume. The three other periods produce greater than 60% total volume from "Very Wet" years. The 2001-2020 shows a greater volume from "Very Dry" years than the others. This evidences the drought conditions experienced in the Basin Area during recent years. The period 2001-2020 also has the highest percentage of "Normal" years. Notably, the "Normal" condition in the arid Mojave region is dry or very dry. We conclude from this that selecting a drier period that is more like "normal" in terms of volume, but also acknowledges wet and very wet events, is a better "management tool" for the Basin Area.

Based upon the foregoing, Watermaster concludes the average water supply during the proposed 20-year hydrologic base period from 2001 to 2020 is similar in magnitude to the average supply during the 1931-1990 hydrologic base period. However, as explained herein, the cultural conditions in the Basin have changed from those present from 1931-1990 and from those observed during the 1990s. Accordingly, a relatively short and recent base period (based on DWR Bulletin 84) representative of current cultural conditions is more appropriate and warranted – which is one reason Watermaster recommends using the 2001 to 2020 hydrologic base period for the PSY re-calculations.

Watermaster justification for recommending a new hydrologic base period

As noted, the 60-year hydrologic base period of 1931-1990 was based on guidance from DWR Bulletin 84 (1967), which explains:

> *The base period conditions should be reasonably representative of long-time hydrologic conditions and should include both normal and extreme wet and dry years. Both the beginning and the end of the base period should be preceded by a series of wet years or a series of dry years, so that the difference between the amount of water in transit within the zone of aeration at the beginning and end of the base period would be a minimum. The base period should also be within the period of available records and should include recent cultural conditions as an aid for projections under future basin operational studies.*

For water supply, Watermaster has proposed a new and more recent hydrologic base period of 2001-2020, which is consistent with DWR Bulletin 84 because: it starts and ends in a series of dry years, contains both normal and extreme wet and dry years, has a minimum difference in the amount of water at the beginning and the end, and **includes recent cultural conditions** (i.e., pumping, patterns of water use, land uses). Today's cultural conditions are represented by the new recent hydrologic base period of 2001-2020; cultural conditions are expected to change only slightly year to year in the near future (except for the Baja Subarea). Watermaster's reason for proposing a new and more recent hydrologic base period is because the original 60-year hydrologic base period of 1931-1990 does not reflect the recent cultural conditions. The total pumping, the patterns of pumping, water uses, and land uses have greatly changed since 1931-1990. Moreover, the water supply observed in 2001- 2020 is expected to repeat itself in the future for planning purposes. As mentioned above, Watermaster's analysis demonstrates the water supply for the 1931-1990 and 2001-2020 differed by only 6-percent; however, the cultural conditions from 1931-1990 are no longer representative of present and future cultural conditions.

I declare under penalty of perjury, under the laws of the State of California, that the foregoing is true and correct.

Dated: February 24, 2026

[signature]

INDEX OF EXHIBITS

EXHIBIT A

STATE OF CALIFORNIA
The Resources Agency
Department of Water Resources

BULLETIN No. 84

MOJAVE RIVER GROUND WATER BASINS INVESTIGATION

AUGUST 1967

RONALD REAGAN
Governor
State of California

WILLIAM R. GIANELLI
Director
Department of Water Resources

FOREWORD

This investigation and report are the result of the recognition by the Mojave Water Agency of its need for reliable information on existing water resources, future water requirements, and sources of additional water supply to meet the needs for growth of the region it serves. Accordingly, the agency, through its legislative representatives, obtained state funds for the Department of Water Resources to undertake this investigation. Appropriation of funds was made under Budget Item 263.2, A. B. No. 1, 1962 Second Extraordinary Session.

To provide interested agencies and persons with information as soon as it was available, informal meetings were held and two progress reports were published by the Department of Water Resources.

The results of this study show that additional water will be required if the Mojave region is to realize its growth potential. The meager rainfall and increasing water demands of the area indicate the need for a plan of basin operation that will take full advantage of existing and potential water resources, including ground water, imported water, and the use of the ground water basins for both storage and distribution of water.

The information provided by this study points out the need and provides a foundation for a ground water basin model simulation and operational and economic studies, leading to the selection by local agencies of an optimum plan of water resources management.

William R. Gianelli

William R. Gianelli, Director
Department of Water Resources
The Resources Agency
State of California

June 12, 1967

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State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES
RONALD REAGAN, Governor
WILLIAM R. GIANELLI, Director, Department of Water Resources
JOHN R. TEERINK, Deputy Director

SOUTHERN DISTRICT

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Vernon E. Valantine . . . . Chief, Operations Branch
William X. Madden . . . . Chief, Desalination Unit, Operations Branch
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State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES

ENGINEERING CERTIFICATION

This report has been prepared under my direction as the professional engineer in direct responsible charge of the work, in accordance with the provisions of the Civil and Professional Engineers' Act of the State of California.

Harvey L. Chan
Registered Civil Engineer

Registration No. 16783

Date May 16, 1967

ATTEST:

J J Doody
District Engineer
Southern District

Registration No. 6500

Date [illegible] 1967

ABSTRACT

This bulletin presents data on the water resources and water requirements of a part of the Mojave Desert area, consisting of about 3,700 square miles located primarily in San Bernardino County. The study was authorized by the Legislature in 1962 for the purpose of providing fundamental geologic and hydrologic information to the State of California and to local water agencies in the Mojave area as the basis for planning for optimum use of water supplies and facilities. In this desert region, annual water supply from precipitation is not sufficient to meet the needs of existing agricultural and urban developments. The water deficiency that has existed in the area since about 1945 has been met by extraction of ground water. However, with the anticipated continuation--or acceleration--of the urban growth pattern of recent years, additional water will be required. These future water needs could be met by a combination of ground water and imported water. Control of non-beneficial riparian vegetation offers a potential secondary source of increased water supply. The bulletin describes geology, water supply, water quality, and water requirements in the study area. Tables give detailed information on resources and requirements. Figures and plates show the area of investigation, geology and geologic sections, precipitation patterns, hydrographic units, land use, and changes in ground water levels.

CHAPTER I. INTRODUCTION

Recently, residences and industry have grown up over much of the land along the Mojave River in San Bernardino County that formerly supported only agriculture. This development, which has increased the water uses, has caused concern among water agencies over the adequacy of the local supply. Although large amounts of water are known to be stored underground, the scanty rainfall in the vast desert areas surrounding the river raises a question as to the long-term reliability of local supplies and suggests the need for imported water. In addition, the quality of the local supplies is a matter of concern, particularly the possible changes in quality resulting from increased urban development and water use. As one means of relieving the problem, the Mojave Water Agency on June 22, 1963, signed a contract to take delivery of 50,000 acre-feet from the State Water Facility.

In recognition of the need for an analysis of the water resources along the Mojave River, the California Legislature requested the Department of Water Resources to make such an investigation. Studies were started in July 1962.

To provide interested agencies and persons with information as soon as it was available, informal meetings were held and two progress reports were published. This final report summarizes the results of the investigation.

Objectives of Investigation

The major objective of this study is to provide geologic and hydrologic information that can be used by local agencies in managing the surface and ground water resources of the area in the most productive and economic manner.

The specific objectives of this investigation are to:

1. Develop information on boundary conditions of the ground water resources, structures affecting ground water movement, transmissive and storage characteristics of the water-bearing material, and subsurface flow and change in ground water storage.

2. Increase the detail and extent of the knowledge pertaining to the amounts of annual water supply, use, and disposal for each subdivision of the study area for a selected base period. From this information, evaluate the character and amount of deep percolation, determine the average annual water supply surplus or deficiency, estimate the average annual safe yield and overdraft and determine where future imported water supplies must be delivered, by identifying the areas of water supply surplus and deficiency.

Scope of Investigation

The investigation consisted of a comprehensive and detailed geologic and hydrologic study of the area along the Mojave River. The hydrologic study concentrated on the 25-year period of 1936-37 through 1960-61, which was selected as the study base period. The hydrologic study included investigation of the mineral quality of both the surface and ground water supplies.

The geologic investigation consisted of the review of all available geologic data, detailed field mapping, and field transmissibility tests. Basin boundaries and physical properties of the area were then determined.

In the hydrologic investigation, the available reports on the study area were reviewed and data were compiled from reports published by the United States Geological Survey, United States Weather Bureau, and Department of Water Resources. Numerous contacts were made with individual agencies to gather the necessary data regarding the various items of water supply, use and disposal. This information was developed on an annual basis.

The water quality investigation consisted of review and evaluation of existing data and of new data obtained from a limited water sampling program. Areas in which the water quality is relatively consistent were delineated to show the mineral character and total dissolved solids content of the water. A limited salt balance analysis was made.

Conduct of Investigation

Geologic, hydrologic, and water quality studies were conducted to meet the objectives of this investigation. Standard engineering concepts were used to develop hydrologic information and, where necessary, simplifying assumptions were made to facilitate the geologic, hydrologic, and water quality analyses. The major steps in the conduct of this investigation are summarized below:

1. The geologic properties of the study area were determined, the study area was subdivided into convenient workable units, transmissibility and storage factors of the water-bearing sediments were estimated, and historical water level elevations were determined.

2. The annual amounts of water supply, use, and disposal were estimated; water use and disposal were subtracted from the water supply to obtain annual water supply surplus or deficiency for the base period.

3. The change in the amount of ground water in storage during the base period was estimated by the specific yield method.

4. The mineral quality of the water in the area was determined.

5. The total annual amount of water supply or deficiency was compared with the total annual change in the amount of ground water in storage during the base period.

During the first year of the investigation, activities were directed toward establishing, on a preliminary basis, the extent of the local water resources of the area; this information was used by the Mojave Water Agency and the State of California as the basis for a contract to import a supplemental water supply through the California Aqueduct. These activities were summarized in the first progress report.

During the second year of the investigation, the geologic studies of the area were expanded to identify and delineate the extent of the water-bearing materials, to establish the location of structures affecting ground water movement, and to determine the hydraulic characteristics of the water-bearing materials. The refinement of the preliminary estimates of water supply, use, and disposal was commenced; the seasonal amounts of the major components of both surface and subsurface flows within the area were determined; also, a study of the mineral characteristics of both the ground water and surface water was initiated. These activities were summarized in the second progress report.

During the third year of the investigation, the studies to achieve the specific objectives of the program were completed. These studies included a determination of the annual amount of supply, use, and disposal of water during the base period; the annual amount of water supply surplus or deficiency; and estimates of the present and future uses of water in the study area. The local water supplies and future water requirements were compared to ascertain the time, magnitude, and location of delivery of imported supplies. Ground water storage capacities estimates from the preliminary studies were revised, using an electronic digital computer. Change in the amount of ground water in storage during the base period was calculated and compared with water supply surplus or deficiency for the same period. This bulletin summarizes the activities and results of the entire investigation.

Related Investigations and Reports

Previous hydrologic investigations of the Mojave River region have been made and reported on by the Department of Water Resources and its predecessor agencies and by other federal, state, county, and private agencies. Reports of previous major investigations are listed below. Other reports utilized in preparing this bulletin are summarized in Appendix A, Bibliography.

1. Blaney, Harry F., and Ewing, Paul A. "Utilization of the Waters of Mojave River, California." United States Department of Agriculture, Division of Irrigation. August 1935.

2. California State Department of Public Works, Division of Water Resources. "Mojave River Investigation." Bulletin No. 47. 1934.

3. Frye, Arthur H., Jr. "Report on Survey for Flood Control, Mojave River, San Bernardino County, California." United States Corps of Engineers. December 28, 1956.

4. Koebig and Koebig, Incorporated. "Mojave Water Agency-Supplemental Water Report." Volume 1. March 1962.

5. ----. "Mojave Water Agency-Supplemental Water Report." Volume 1, Appendixes A, B, C, and D. March 1962.

6. Thompson, David G. "The Mojave Desert Region, California." United States Geological Survey Water-Supply Paper No. 578. 1929

7. United States Department of the Interior, Bureau of Reclamation. "Report on Victor Project, California." April 1952.

Area of Investigation

The area of investigation, which is outlined in Figures 1 and 2, is located almost entirely in San Bernardino County, with only

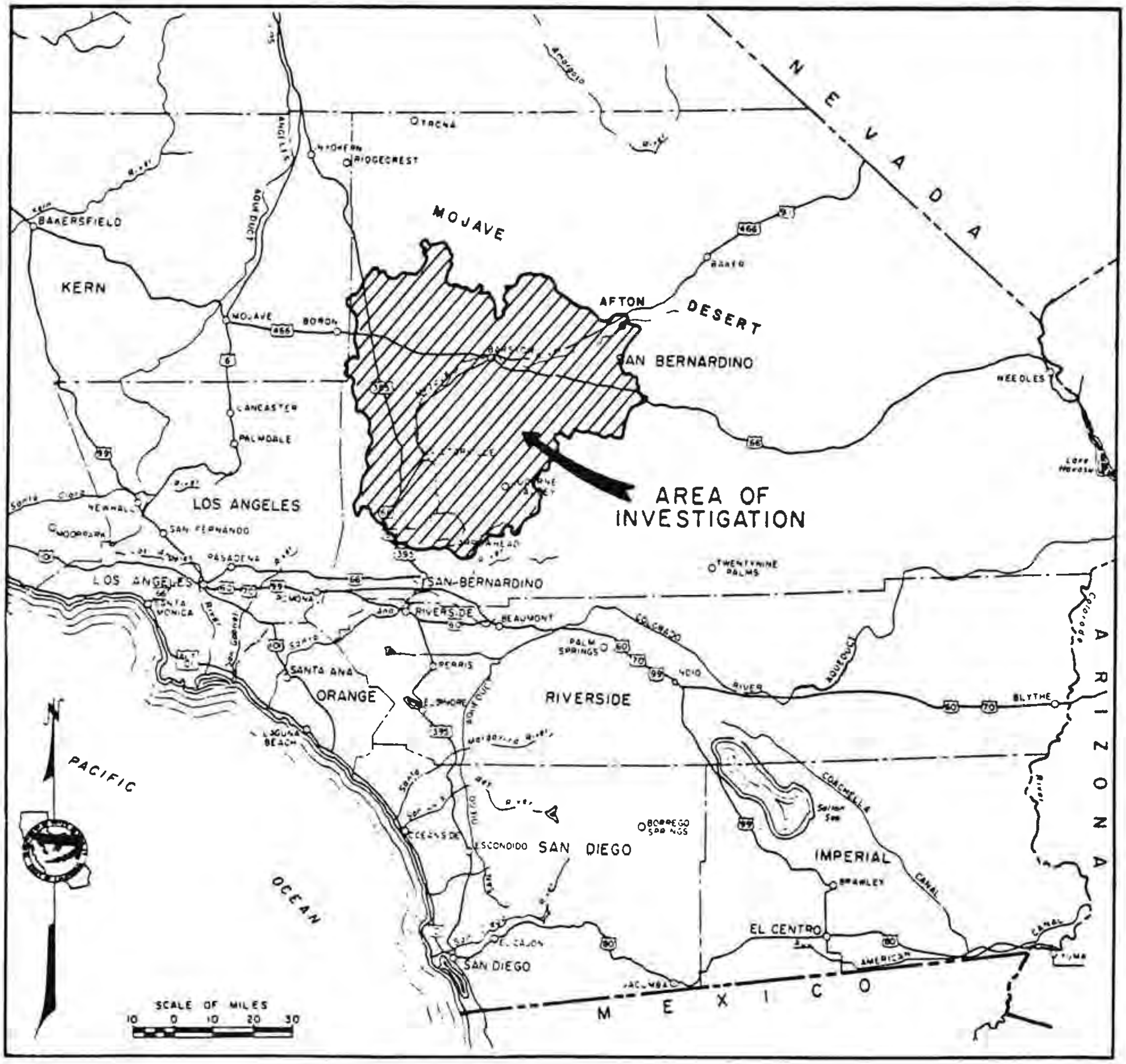

Figure I. LOCATION MAP

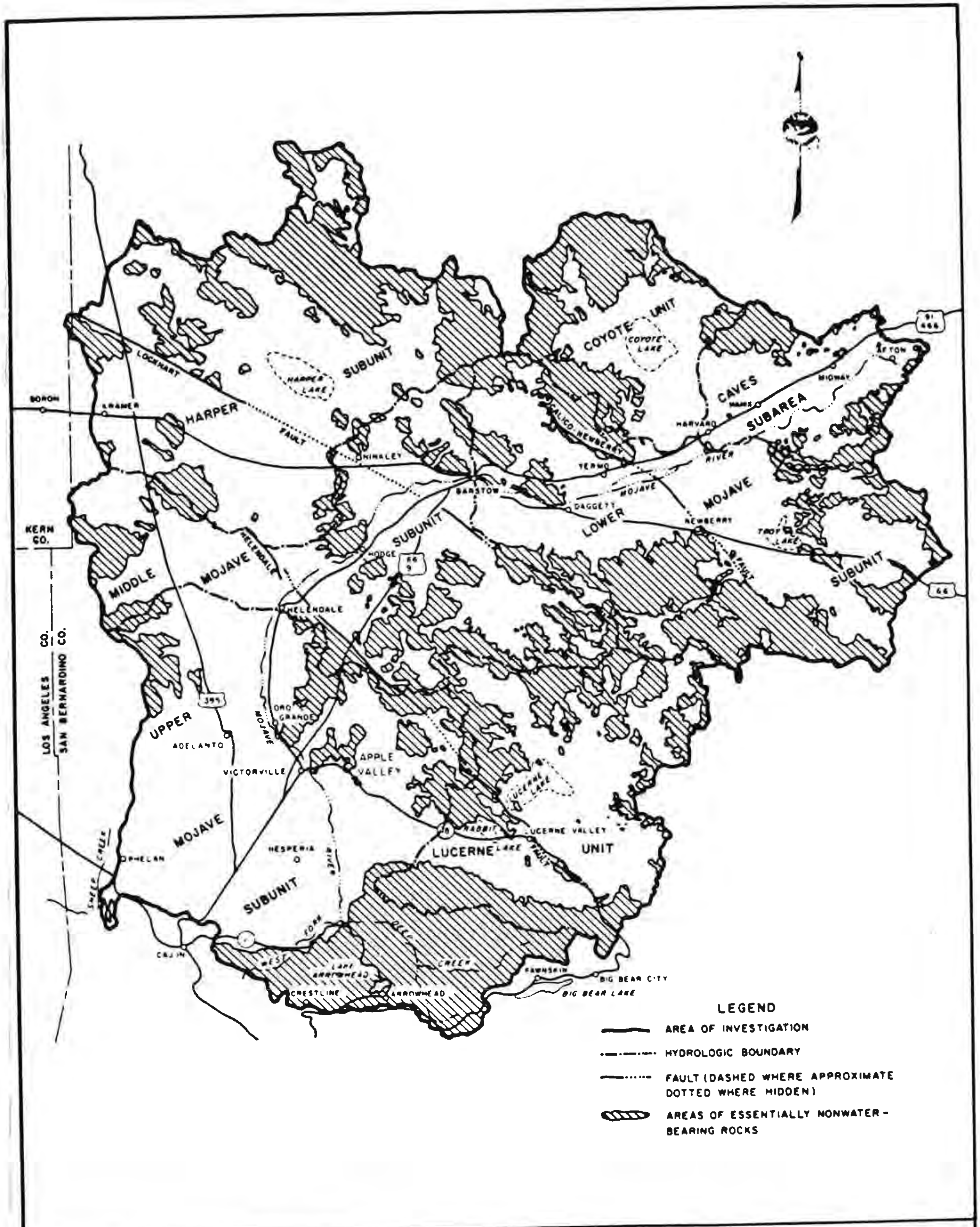

Figure 2 — AREA OF INVESTIGATION

DEPARTMENT OF WATER RESOURCES, SOUTHERN DISTRICT, 1967

a small portion in Kern County. The study area is part of the Mojave Desert, which covers vast areas of east-central Southern California.

The study area is irregularly shaped and covers about 3,700 square miles in the south-central part of the Mojave Desert. The area extends about 60 miles northerly and easterly along and adjacent to the Mojave River from its source in the San Bernardino Mountains, along the southern border of the study area, to the desert floor near Afton. Although the Mojave River extends beyond Afton, the area downstream from Afton was not included in the study because the use of water there is considered minor in quantity and economic importance to the total study area.

The study area is essentially a plain sloping gently northward and eastward. The plain is made up of small, broad valleys, or closed basins, separated by isolated hills, groups of hills, and low mountains. The bottoms of the closed basins are playas which contain water only following heavy rainfall. The largest playas in the study area are Lucerne Lake, Harper Lake, Coyote Lake, and Troy Lake.

Elevations in the study area range from more than 8,500 feet near Crestline in the San Bernardino Mountains to 2,715 feet at Victorville and 1,408 feet at Afton.

The Mojave River is the major stream traversing the study area. The river originates in the foothills of the San Bernardino Mountains at the junction of the West Fork and Deep Creek and flows north 12 miles to Victorville, then continues 18 miles adjacent to Highway 91 to Helendale. It then turns northeast and continues adjacent to Highway 91 past Barstow to Afton, the study area limit, approximately 90 miles from its beginning.

The river then flows to its terminus in Silver Lake. Flood waters in the Mojave River occasionally reach Silver Lake but soon evaporate. Perennial flow occurs only in the mountains and near Victorville, Harvard, and Afton.

Annual precipitation averages less than 4 inches in the desert area but exceeds 40 inches in the upper regions of the Mojave River watershed. Sixty percent of the precipitation occurs from December through March. The growing period between killing frosts averages about 245 days. The area is also noted for its high summer temperatures and low humidity; temperatures of more than 100° F and relative humidity below 20 percent are not uncommon.

The greater portion of the region is undeveloped. Historically, the development of irrigable lands and centers of population have been primarily along the Mojave River and the adjacent valleys where there has been an easily available supply of surface and/or ground water. Alfalfa and permanent pasture are the chief crops. The larger centers of urban development are the Cities of Barstow and Victorville, with 1960 populations of about 11,500 and 8,000. Other communities include Hesperia, Apple Valley, Lucerne Valley, Adelanto, and Yermo. Mining and the manufacture of cement are the chief industries. Several military installations are located in the study area, with George Air Force Base near Victorville being the largest.

Subdivisions of the Study Area

Because of the size and complexity of the study area and the need for localized information, the area was subdivided for this investigation. The subdivision was based mainly on information in the office report published by the Department, "Names and Areal Code Numbers of Hydrologic Areas in the Southern District", April 1964. The information in the publication is the basis for compiling, filing, and retrieving geologic and hydrologic data with high-speed electronic data processing machines in the Department.

It was found convenient for this study to adopt the names and areal code numbers used in that publication. However, some significant boundary changes were made, which are used in this study. The 1964 report will be updated to reflect these changes. The revised boundaries are a result of analysis of recent topographic and geologic maps of the United States Geological Survey and the Department of Water Resources. These changes are described later in this report. The names and areal code numbers of study area subdivisions are presented in Table 1. The subdivisions are shown on Figure 2, "Area of Investigation".

TABLE 1

NAMES AND AREAL CODE NUMBERS OF
HYDROLOGIC AREAS

Areal Code	Designation
W-18.00	Coyote Hydrologic Unit
W-28.00	Mojave Hydrologic Unit
W-28.BO	Upper Mojave Hydrologic Subunit
W-28.CO	Middle Mojave Hydrologic Subunit
W-28.DO	Harper Hydrologic Subunit
W-28.EO	Lower Mojave Hydrologic Subunit*
W-28.G1	Caves Hydrologic Subarea
X-01.00	Lucerne Hydrologic Unit

*Troy Hydrologic Subunit has been combined with Lower Mojave Hydrologic Subunit for this study.

Each subdivision in Table 1 could be further segregated into a nonwater-bearing hill and mountain area and a ground water-bearing valley area. In this report the ground water-bearing valley area is referred to as the "ground water basin" or "basin" to distinguish it from the entire subdivision, which includes portions of the surrounding hills and mountains.

In most locations in this region, water-bearing areas are separated from each other by nonwater-bearing materials of hill and mountain areas and by bedrock highs, which created conditions of alluvial constriction. In some locations, the water-bearing areas are separated by surface drainage divides. The boundary conditions between the water-bearing areas, or basins, of the hydrologic subdivisions are presented in Table 2.

TABLE 2

BOUNDARY CONDITIONS BETWEEN BASINS

Basins	Physical conditions at boundary
Upper Mojave-Lucerne	Drainage divide and alluvial constriction
Lower Mojave-Middle Mojave	Drainage divide and alluvial constriction
Lower Mojave-Caves	Drainage divide
Caves-Coyote	Drainage divide
Caves Basin at study area boundary	Alluvial constriction
Harper-Middle Mojave	Drainage divide
Middle Mojave-Upper Mojave	Drainage divide

The most significant changes in boundaries which resulted from the recent topographic coverage were made to boundaries of the Lower Mojave Basin and Lucerne Basin. Previously, the boundary between the Lower Mojave Basin and Troy Basin was represented by a low relief surface drainage divide. Because there is no restriction to ground water movement across this divide, and because restrictions do occur elsewhere in these two divisions, Troy Basin has been included as part of the Lower Mojave Basin for this study. The boundaries of the Caves Basin, Coyote Basin, and Lower Mojave Basin were also revised considerably on the basis of the recent detailed topographic mapping, although the hydraulic characteristics which determine these divisions remain basically the same. The boundary between the Lucerne Basin and the Upper Mojave Basin was also revised on the basis of topographic criteria; the boundary now follows the surface drainage between Apple Valley and Rabbit Lake.

Base Hydrologic Period

In any watershed, precipitation is the original source of local water supply; therefore, the amount of precipitation to a ground water basin and its tributary areas serves as an index of the water supply available to that basin. By analysis of long-time precipitation records, it is possible to select as a "base period" a relatively short and recent period which represents the long-time average water supply. Such a period is needed for study purposes because long-time hydrologic data, other than rainfall records, are generally unavailable.

The base period conditions should be reasonably representative of long-time hydrologic conditions and should include both normal and extreme wet and dry years. Both the beginning and the end of the base period should be preceded by a series of wet years or a series of dry years, so that the difference between the amount of water in transit within the zone of aeration at the beginning and end of the base period would be a minimum. The base period should also be within the period of available records and should include recent cultural conditions as an aid for projections under future basin operational studies.

For this study, the base hydrologic period was determined from analysis of records of a precipitation station in the San Bernardino Mountains, the major area of water supply to the basin. The accumulated departure from the mean precipitation at this recording station appears to start during a dry period (1893-94), and it continues through 1960-61. It includes the 57-year period from 1904-05 through 1960-61, which covers two cycles of wet and dry periods. This 57-year period was selected as that which best represents the long-time hydrologic conditions in the Mojave River region.

On the basis of the criteria stated in preceding paragraphs, the water years 1936-37 through 1960-61 were chosen as the base hydrologic period. This 25-year period includes the most recent pair of wet and dry cycles; has an average annual precipitation (at Squirrel Inn No. 2) of 40.7 inches, which closely approximates the estimated long-time period average of 41.7 inches; begins and ends after a series of dry years; is within the period of available data; and includes recent land use conditions. The precipitation characteristics at the Squirrel Inn No. 2 Station are shown on Figure 3. Because of the similarity of hydrologic conditions (dry trends) preceding 1936-37 and 1960-61 and because valley precipitation averaged less than 6 inches annually, the assumption could be made that there was no significant change in the amount of water in transit at the beginning and end of the base period. In view of this, the difference in the amount of water percolating downward through the

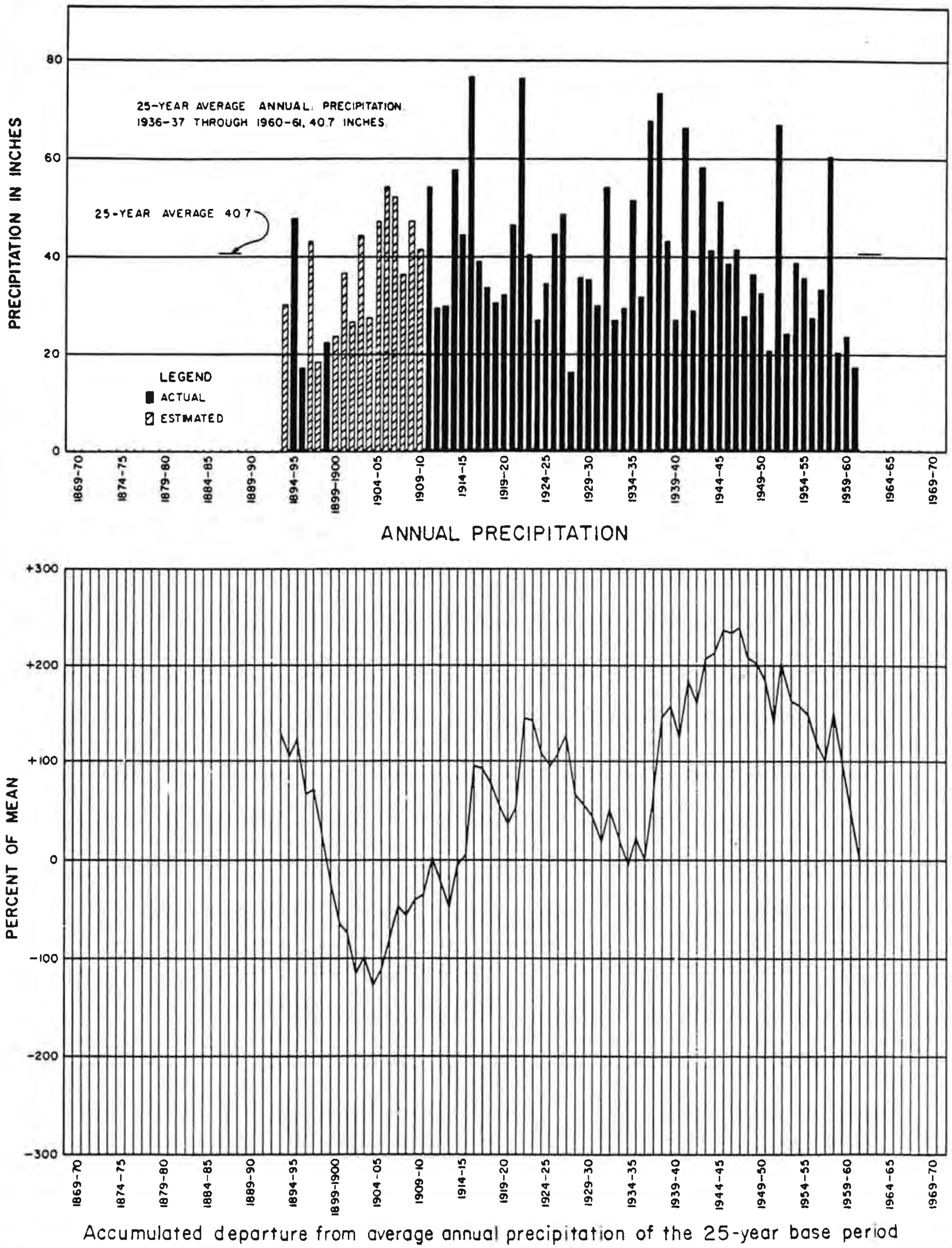

Figure 3. PRECIPITATION CHARACTERISTICS AT SQUIRREL INN NO. 2

DEPARTMENT OF WATER RESOURCES, SOUTHERN DISTRICT, 1967

zone of aeration to the zone of saturation was considered to be negligible for both periods. This assumption facilitated computation of changes in the amount of ground water storage during the base period.

CHAPTER II. GEOLOGY

In this investigation, the geology studies included a detailed examination of the physiography, stratigraphy, and structure of the area. The primary objective of these studies was to develop a better understanding of the water-bearing formations of the area and to determine the occurrence, movement, and quality of ground water within the formations. To meet this objective, geologic formations and structures were inspected and were correlated with geologic units delineated by previous studies. An areal geology map of the study area was then prepared and lithologic units were grouped according to general water-yielding characteristics. Water well logs, water quality data, water level data, and aquifer test information were evaluated, along with data obtained from interviews with local water well drillers. The results of these studies are summarized and discussed in the following paragraphs.

Physiography

The Mojave study area is an alluviated plain that slopes gently northward and eastward. Bordering the plain are the San Bernardino Mountains on the south; the Fry, Rodman, and Cady Mountains on the east; the Alvord Mountains, the Paradise Range, the Calico Mountains, the Rainbow Hills, and the Gravel Hills on the north; and the Kramer Hills and the Shadow Mountains on the west.

The high San Bernardino Mountains are essentially nonwater-bearing crystalline and metamorphic rock. These mountains contribute the major amount of runoff to the ground water basin; they also are the source of the bulk of the alluvial debris deposited in the valley areas. Minor amounts of both runnoff and alluvial debris are contributed by the low mountains and hills interspersed throughout and bordering the basin.

The principal stream traversing the study area is the Mojave River, which originates in the San Bernardino Mountains, and flows north and east about 110 miles, terminating in Silver Lake, about 20 miles outside the study area.

Other important features of the study area are the Upper and Lower Narrows of the Mojave River, where rising ground water occurs as the result of constrictions in the cross-sectional area of the water-bearing materials. Physiographic features are shown on Plate 1, "Physiographic Features and Lines of Equal Average Annual Precipitation"; detailed areal geology is shown on Plate 2, "Areal Geology".

The Mojave River ground water basin is the subsurface reservoir which yields water to wells drilled in the area. The ground water basin area, or valley fill area, contains shallow, permeable alluvial deposits, and is underlain and surrounded by relatively impermeable rock. These features are shown on Plate 3, "Geologic Sections".

Stratigraphy

Geologic units of the region are grouped under two broad categories according to their water-yielding characteristics: water-bearing and nonwater-bearing. A crystalline complex of pre-Tertiary igneous and metamorphic rocks that characteristically yields little water to wells forms the major portion of the mountain and hill areas surrounding the water-bearing portions of the study area. These formations, which are considered nonwater bearing, underlie water-bearing sediments. The water-bearing sediments are unconsolidated to semiconsolidated alluvial deposits that are Quaternary in age, continental in origin, and made up primarily of materials ranging in size from coarse gravel to clay. These sediments are generally more consolidated with depth, and commonly exhibit cementation in the older formations. Interspersed within, and overlying these sediments, in local areas are nonwater-bearing volcanic deposits.

Water-Bearing Formations

The water-bearing deposits of the area result primarily from deposition of alluvial material eroded from the adjacent highlands. The streams carry debris onto the valley floor during flood flows, forming alluvial fans at the base of the mountains by dropping the coarse particles first. As the distance from the mountains becomes greater, the sediment-carrying capacity of the stream becomes less, resulting in deposition of finer grained sediments. Usually only the silts and clays reach the central or lowest portions of the basins. Generally, the coarser alluvial fan deposits and deposits within the streambed are more permeable and result in higher yield to wells, whereas the fine-grained deposits do not yield water readily. The older deposits have undergone chemical weathering and compaction and have been cemented to some degree, all of which tends to reduce the permeability of the materials.

The Mojave River has interrupted this general deposition pattern by traversing the study area, cutting a channel through both coarse-and fine-grained materials, and then backfilling with coarse-grained river channel deposits. These latter deposits are highly permeable and contain the major source of the water supply used at present in the study area.

Within the study area, the water-bearing materials include 11 lithologic units that range in age from Recent to Pleistocene; these units include: river deposits, playa deposits, dune sand, younger alluvium, younger fan deposits, old lake and lakeshore deposits, older alluvium, older fan deposits, landslide breccia, Shoemaker gravel, and the Harold Formation. Figure 4, "Generalized Stratigraphic Column of Water-Bearing Sequence, Mojave River Area" shows the stratigraphic sequence of the water-bearing formations or units, their lithology, and the maximum thickness of each formation or unit. The major characteristics of these water-bearing lithologic units are discussed in the following paragraphs.

River Deposits. Boulders, gravel, sand, and silt, with some interbeds of clay and sandy clay, occupy the channel of the Mojave River. The deposits are unconsolidated, unweathered, and range up to 90 feet in thickness. The river deposits form the most important aquifer in the study area. A majority of the irrigation and municipal water wells in the region draw water from this aquifer. These wells yield water at an average rate of 500 gallons per minute, although some wells yield as much as 1,600 gallons per minute. In addition, ground water in the river deposits is a major source of replenishment to the other ground water areas, through subsurface flow.

Playa Deposits. Playa deposits underlie the surfaces of the dry lakes in the study area. The deposits are fine sand, silts, and clays, which range in thickness from a few feet to about 25 feet. These fine-grained materials generally have a low permeability and, even when saturated, will yield only small quantities of water to wells. These materials generally

SYSTEM	SERIES	GEOLOGIC FORMATION	LITHOLOGY	MAXIMUM THICKNESS (FEET)
QUATERNARY	RECENT	RIVER DEPOSITS	Qra	90±
		PLAYA DEPOSITS	Qp	25±
		DUNE SAND	Qds	35±
		YOUNGER ALLUVIUM	Qal	100±
		YOUNGER FAN DEPOSITS	Qyf	75±
	PLEISTOCENE	OLD LAKE & LAKESHORE DEPOSITS	Qol	75±
		OLDER ALLUVIUM	Qoa	1000±
		OLDER FAN DEPOSITS	Qof	1000±
		LANDSLIDE BRECCIA	Qls	100±
		SHOEMAKER GRAVEL	Qs	300±
		HAROLD FORMATION	Qh	1300±

LEGEND

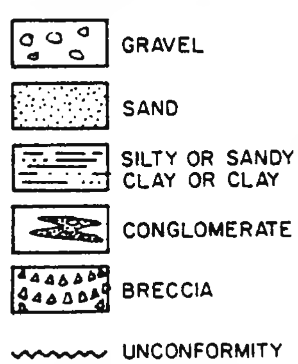

Fig. 4. GENERALIZED STRATIGRAPHIC COLUMN OF WATER-BEARING SEQUENCE, MOJAVE RIVER AREA

exhibit high concentrations of total dissolved solids, ranging from 380 to 5,300 parts per million.

Dune Sand. Sand dunes are present in all of the basins, commonly near the playas and adjacent to the Mojave River. Typical deposits are found downstream of Hodge and in Hinkley Valley. These deposits range in thickness from a few feet to as much as 35 feet. The dunes are porous and permeable and suitable for storage of ground water; however, they are above the existing water table.

Younger Alluvium. Younger alluvium occurs as a veneer overlying large portions of the older materials, and occupies small stream channels tributary to the Mojave River. The deposits are made up of material ranging in size from very small to large and are usually unweathered sands and silts, plus some gravel and clay. The younger alluvium ranges in thickness from a few inches to about 100 feet. Not only are the deposits less prolific water producers than the river deposits but yields are usually less than 300 gallons per minute. Large portions of the younger alluvium are above the water table, or only partially saturated.

Younger Fan Deposits. Unconsolidated younger fan deposits are located at the base of the highland areas, usually above the water table. These deposits are poorly-sorted gravel and sand with some silt and clay. The younger fan deposits range in thickness from a few inches to about 75 feet. They occur extensively as a thin veneer at the base of the desert mountain ranges, overlying bedrock. Reworked older material has been deposited as alluvial fans at the base of the bluffs adjacent to the Mojave River.

These are partially saturated, and wells penetrating them vary in yield from a few gallons per minute to about 1,200 gallons per minute.

Old Lake and Lakeshore Deposits. Old lake deposits of well-bedded silts, clays, and sands, interbedded with thin fresh-water limestones are exposed at four separate areas along the Mojave River: (1) in the bluffs at Victorville, (2) along the river northwest of Helendale, (3) in the low hills south of Barstow, and (4) in the bluffs of the Mojave River at the Caves Basin near Manix. Water well logs indicate the presence of blue and green clays which suggests that lake deposits underlie Hinkley and Harper Valleys. The Old Lake and Lakeshore deposits range in thickness from a few inches to about 75 feet. Lake deposits yield little water to wells, but may act as confining layers for deeper water-bearing materials.

Lakeshore deposits are remnants of sand and gravel bars of late Pleistocene lakes. These deposits, which are found south and east of Coyote Lake and near Manix, are above the water table.

Older Alluvium. Older alluvium underlies most of the study area. The unconsolidated to moderately consolidated deposits are interbedded gravel, sand, silt, and clay. The deposits are weathered, and some cementation has developed, usually in the form of caliche.

The older alluvium ranges in thickness from a few inches to about 1,000 feet and contains the major portion of ground water in storage in the area. Generally, the alluvium yields water freely to wells; however, in some areas the materials are poor in their water-yielding characteristics. A few wells in the vicinity of Hesperia and near Daggett produce more than 2,000 gallons per minute from older alluvium; in contrast, water wells in older alluvium north of Adelanto characteristically yield 30 gallons per minute or less.

Older Fan Deposits. Deposits of older fans are exposed irregularly throughout the region, but generally occur near the flanks of the highland areas. The deposits include gravels, sands, and silts, which in some areas, are cemented with caliche deposits. The materials are moderately consolidated, and in some places, deeply weathered. Maximum thickness is estimated to be 1,000 feet. Records of the few wells known to penetrate older fan material indicate that the yield varies considerably, but is generally low.

Landslide Breccia. In the southeasterly portion of the Lucerne Basin, on the flank of the San Bernardino Mountains, is a large slide deposit which apparently occurred during Pleistocene time. This area, known as the Blackhawk slide, contains primarily poorly-sorted and partially cemented blocks of limestone. Maximum thickness is estimated to be 100 feet. There are no known water wells in the landslide. If saturated, the breccia would probably have low water-yielding capacity.

Shoemaker Gravel. The Shoemaker gravel is a deposit of poorly-sorted, subangular gravel with lenses of sand and silt that underlies older alluvium and overlies the Harold Formation in depths of as much as 300 feet. Although some unused water wells penetrate the Shoemaker gravel, it generally lies above the water table and there are no known wells extracting from it. However, if it were saturated it probably would yield water freely.

Harold Formation. The Harold Formation is exposed in the bluffs facing south near the crest of Cajon Pass as a series of discontinuous beds of grayish silty sandstone with lenses of conglomerate, and occasional thin beds of clayey silt; it is approximately 1,300 feet thick.

The Harold Formation apparently yields little water to wells, as indicated by two known wells that produce less than 20 gallons per minute.

Nonwater-Bearing Formations

Pre-Tertiary crystalline rocks enclose the entire study area and comprise the major portions of the mountain and hill areas; the area also includes consolidated Tertiary sedimentary and volcanic rocks and Quaternary basalt. The crystalline complex and the Tertiary deposits also underlie the valley areas, but are buried by the unconsolidated Quaternary alluvial deposits that comprise the water-bearing formations.

In the mountain and hill areas, the rocks may be the only source of water; however, because the yield from wells is typically less than 50 gallons per minute, these formations are considered to be essentially nonwater-bearing. In addition to being poor storage reservoirs, these formations also act as impediments to ground water movement. The nonwater-bearing units, listed generally from younger to older, include: Quaternary basalt, Tertiary sedimentary rocks, Tertiary volcanic rocks, and the basement complex. The major characteristics of these nonwater-bearing lithologic units are discussed in the following paragraphs:

Quaternary Basalt. Abundant outcrops of Quaternary volcanic rocks with thicknesses ranging from a few inches to about 265 feet are located in the Black Mountain area north of Harper Lake, in a long belt extending south of Troy Lake, and in the Rodman Mountains. The dominant rock type is basalt, which occurs as vesicular to dense basalt dikes and flows, associated with some cinders, and local deposits of scoriaceous tuff. In the study area, all of these deposits occur above the regional water table. They are not tapped by any known wells, and therefore are not a significant source of ground water. However, water is yielded freely from basalt deposits in other localities through springs.

Tertiary Sedimentary Rocks. The Tertiary continental sedimentary deposits identified in the study area range in age from Miocene to Pliocene and range in thickness from a few inches to about 4,800 feet. Major outcrops occur in the mountain and hill areas northeast of the Lockhart fault and some isolated exposures occur in the Kramer Hills.

These consolidated rocks consist of water-deposited conglomerates, sandstone, siltstone, mudstone, limestone, agglomerates, and volcanic tuffs. In the study area, these formations do include pervious layers, but the water they contain is generally of poor quality and yields from wells are low. Because of their fine grain size and low porosity, the limited recharge they receive in outcrop areas, and the great depths at which they occur in the valleys, these deposits are considered to be nonwater-bearing.

Tertiary Volcanic Rocks. Tertiary volcanic rocks consist of extrusive and intrusive rock of various compositions, interbedded with Tertiary continental sedimentary rocks. These formations occur in large and small outcrop areas in the mountain and hill region predominantly northeast of the Lockhart fault, and in small, isolated areas within the Kramer Hills. These rocks yield little water to wells and are considered to be nonwater-bearing.

Basement Complex. Basement rocks of the study area are a highly complex assemblage of pre-Tertiary crystalline and metamorphic rocks that are exposed in the mountain and hill areas, and underlie the younger deposits of the valley areas. These rocks are generally nonwater-bearing, but locally yield small-to-moderate quantities of water from springs, cracks, and from a few shallow wells in the residuum.

Structures Affecting Ground Water Movement

Geologic structural features, which affect ground water movement, include anticlines, synclines, faults, and valleys or topographic highs formed by folding or faulting. Within the area of investigation, structural features which affect ground water movement are generally obscured by alluvial cover and are not well defined on the surface. The exceptions are the San Bernardino Mountains, a high, rugged east-west trending uplifted block of the San Andreas fault system, and the other more subdued highland areas which generally form the internal and external borders of the Mojave River Ground Water Basin. The general nonlinear alignment of these highlands indicates that, in the main, the alluvial valleys owe their formation to normal erosional processes rather than to faulting, and the irregular, barren hills and mountains are stubborn, erosion resistant remnants. However, the greater depths of fill that occur in certain parts of the basin can be satisfactorily explained only by the assumption of faulting and folding.

At several places along the Mojave River channel, shallow alluvial sections underlain by near-surface, topographically-high masses of bedrock obstruct ground water underflow and serve to perpetuate conditions of rising ground water. This rising ground water condition occurs at four locations: the Upper Narrows, Lower Narrows, near Camp Cady, and at Afton.

The major faults within the study area which impede and affect the flow of ground water significantly are the Helendale fault, the Lockhart fault, and the Calico-Newberry fault. These three northwest-southeast trending faults are associated with, and subordinate to, the dominating San Andreas and Garlock fault systems. The locations of these faults are shown on Plate 2, "Areal Geology". The major characteristics and the principal structural influences of these faults are discussed in the following paragraphs:

Helendale Fault

The active Helendale fault extends northwest from the vicinity north of Baldwin Lake to the southeast flank of the Kramer Hills, a distance of over 45 miles. Directly east of the Kramer Hills and north of the northwest end of the Helendale fault trace is an unnamed fault, which extends in a general northwest direction for over 30 miles. This unnamed fault may be part of the Helendale fault system; however, due to the lack of supporting evidence, definite conclusions cannot be drawn.

Ground water levels in the vicinity of the Helendale fault indicate that it impedes the movement of ground water. This is particularly true in the Lucerne Basin where differences of 48 feet in water levels have been measured in wells 250 feet apart on either side of the fault. Table 3 includes water level data for wells on both sides of the fault.

In Lucerne Basin, the highest water levels are on the western side of the fault. These levels occur near the northwest end of the fault trace where ground water flowing northeasterly spills over the fault. Some flowing wells are in the vicinity, as indicated in Table 3.

In the Middle Mojave Basin, where the Helendale fault crosses the Mojave River, ground water levels indicate that the fault impedes ground water

TABLE 3

WATER LEVEL DATA FOR WELLS ADJACENT TO
HELENDALE FAULT IN LUCERNE BASIN

State well number	Date of observation	Depth of well, in feet	Depth to water, in feet	Elevation of water in well, in feet
Southwesterly of the Fault				
4N/1W-10A1	4-15-54	568	4	2,903
4N/1W-10H2	2- 9-54	168	8	2,902
4N/1W-10R2	2-10-54	250	0.2	2,930
4N/1W-11Q3	2-10-54	250	Flowing	Flowing
4N/1W-14B2	2- 2-54	100	10	2,930
4N/1W-14K2	2-16-54	219	Flowing	Flowing
4N/1W-14Q4	2-17-54	129	18	3,012
Northeasterly of the Fault				
4N/1W- 2P1	11-18-54	410	60	2,808
4N/1W-11B1	4-14-54	376	45	2,840
4N/1W-11J1	4-14-54	300	53	2,872
4N/1W-11Q1	3-15-55	85	51	2,882
4N/1W-13M1	11-23-54	--	112	2,803
4N/1W-14A2	2- 3-54	140	74	2,891
4N/1W-14H1	2-16-54	44	44	2,936

movement in the older alluvium, but not within the Recent channel deposits of the Mojave River. Upstream from the fault, rising water contributes to the Mojave River; downstream of the fault this condition is reversed.

Lockhart Fault

In the area of investigation, the Lockhart fault extends northwest from the southwest flank of the Fry Mountains to the extreme northwest portion of the study area, a distance of over 70 miles. The fault trace continues for another 15 miles beyond the study area. The Lockhart fault impedes the movement of ground water in the Harper Basin and in older alluvium within Hinkley Valley in the Middle Mojave Basin. Although the paucity of water wells in the Harper Basin precludes quantitative estimates of this impediment, the generally higher level of the water table southwest of the fault suggests the fault impedes ground water flow. Ground water level data for wells adjacent to the Lockhart fault in the Harper Basin are shown in Table 4.

TABLE 4

WATER LEVEL DATA FOR WELLS ADJACENT TO LOCKHART FAULT

State well number	Date of observation	Depth of well, in feet	Depth to water, in feet	Elevation of water in well, in feet
Southwesterly of the Fault				
10N/4W-8P1	1- 7-59	789	18	2,007
Northeasterly of the Fault				
10N/4W- 4C1	5-27-59	419	160	1,940
10N/4W- 6A1	5-19-59	250	250	1,870
10N/4W-10A1	5-20-59	325	187	1,933

Although there is no surface trace of the Lockhart fault in Hinkley Valley, the extension of the trace from Harper Basin coincides with the southwest flank of a deep pumping hole in Hinkley Valley. The steep gradient of that flank indicates an effective impediment to ground water flow.

Calico-Newberry Fault

The active Calico-Newberry fault trends northwest from the northeast flank of the Rodman Mountains to, and along, the southwest flank of the Calico Mountains, a distance of over 35 miles.

Water level measurements in wells indicate the Calico-Newberry fault impedes the movement of ground water in Lower Mojave Basin except along the northwestern portion of the fault, from the Mojave River to just east of the community of Yermo. In that portion of the fault area, little difference was observed in the water levels on either side of the fault. On the other hand, ground water level elevations measured in wells adjacent to either side of the fault southeast of the Mojave River indicate a marked difference in levels. In this area, the water levels south of the fault are higher than those north of the fault. Representative ground water level data are listed in Table 5.

TABLE 5

WATER LEVEL DATA FOR WELLS ADJACENT TO CALICO-NEWBERRY FAULT

State well number	Date of observation	Depth of well, in feet	Depth to water, in feet	Elevation of water in well, in feet
Southwesterly of the Fault				
9N/2E- 3C1	1-13-60	63	17.5	1,853
9N/2E-11H1	1-12-60	---	17.5	1,848
9N/2E-13Q1	12- 7-60	230	14.6	1,855
9N/3E-19P1	3-24-60	151	8.6	1,847
9N/3E-29G1	3-24-60	--	11.2	1,839
9N/3E-33E1	8- 8-61	304	Flowing	1,830
Northeasterly of the Fault				
9N/2E- 3A2	3-23-60	65	40.1	1,845
9N/3E-18M1	12-16-59	253	54	1,860
9N/3E-20Q1	6- 2-60	390	58	1,845
9N/3E-29A1	3-24-60	90	68.2	1,846
9N/3E-34N1	12-17-59	99	23.1	1,818

CHAPTER III. WATER SUPPLY, USE, AND DISPOSAL

Hydrologic studies of water supply, use, and disposal are essential in evaluating the surplus or deficiency of the water supply and in determining the overdraft and safe yield. These studies, which are discussed and summarized in this chapter, include analyses of precipitation, surface flow, subsurface flow, import-export of water, and consumptive use. For these studies, the 25-year base period from 1936-37 through 1960-61 was used. (The selection of this base period is discussed in Chapter II.)

In the study area, data sufficient for these hydrologic studies are available in areas along the Mojave River and the adjacent valleys that constitute the Upper Mojave, Middle Mojave, Lower Mojave, and Lucerne Ground Water Basins. The limited amount of data that are available on the other three basins--Harper, Coyote, and Caves--does not permit comparable analyses. Where information is available, it is included in the following text and tables as a matter of interest.

For most items of water supply, use, and disposal, the historical data on the annual amounts for each year of the base period were available for the four major basins. For some items, such as subsurface inflow and outflow across basin boundaries, the surface inflow from the desert mountain area, it was necessary to estimate the average annual amounts.

Water Supply

The ground water basins discussed in this report are equivalent to the water-bearing portions of the study area. Plate 4, "Ground Water

Basins and Effective Base of Fresh Water", shows the boundaries of each of the basins in the study area.

For this study, sources of water supply are considered to be precipitation falling on the ground water basins and surface, subsurface, and import waters flowing into the basins.

Because the basins are interrelated, a part of the surface and subsurface inflow and the imported water supply to one basin may originate as outflow or as exported water from other basins. For this reason, water supply to and within the total study area from these sources is discussed as surface flow, subsurface flow, and import-export water.

Because the amount of pumped ground water which is not consumptively used is assumed to return to the ground water basin, this amount could be considered as water supply. However, because pumped ground water cancels out as a factor in the overall hydrologic equation when surface and ground water supplies are considered together, it is not discussed here as an item of supply, but is included later in this chapter as an item of water use and disposal.

Precipitation

The average annual precipitation in the study area ranges from less than 4 inches on the desert valley floor to over 40 inches in the San Bernardino Mountains. This range in average annual precipitation is shown on Plate 1. The data utilized on this map were prepared by the U. S. Weather Bureau as part of its meteorological studies of the southwestern United States.

Records of two long-term precipitation stations in the study area indicate a similar wide range in average annual precipitation. At Barstow, on the desert valley floor, the average annual rainfall is

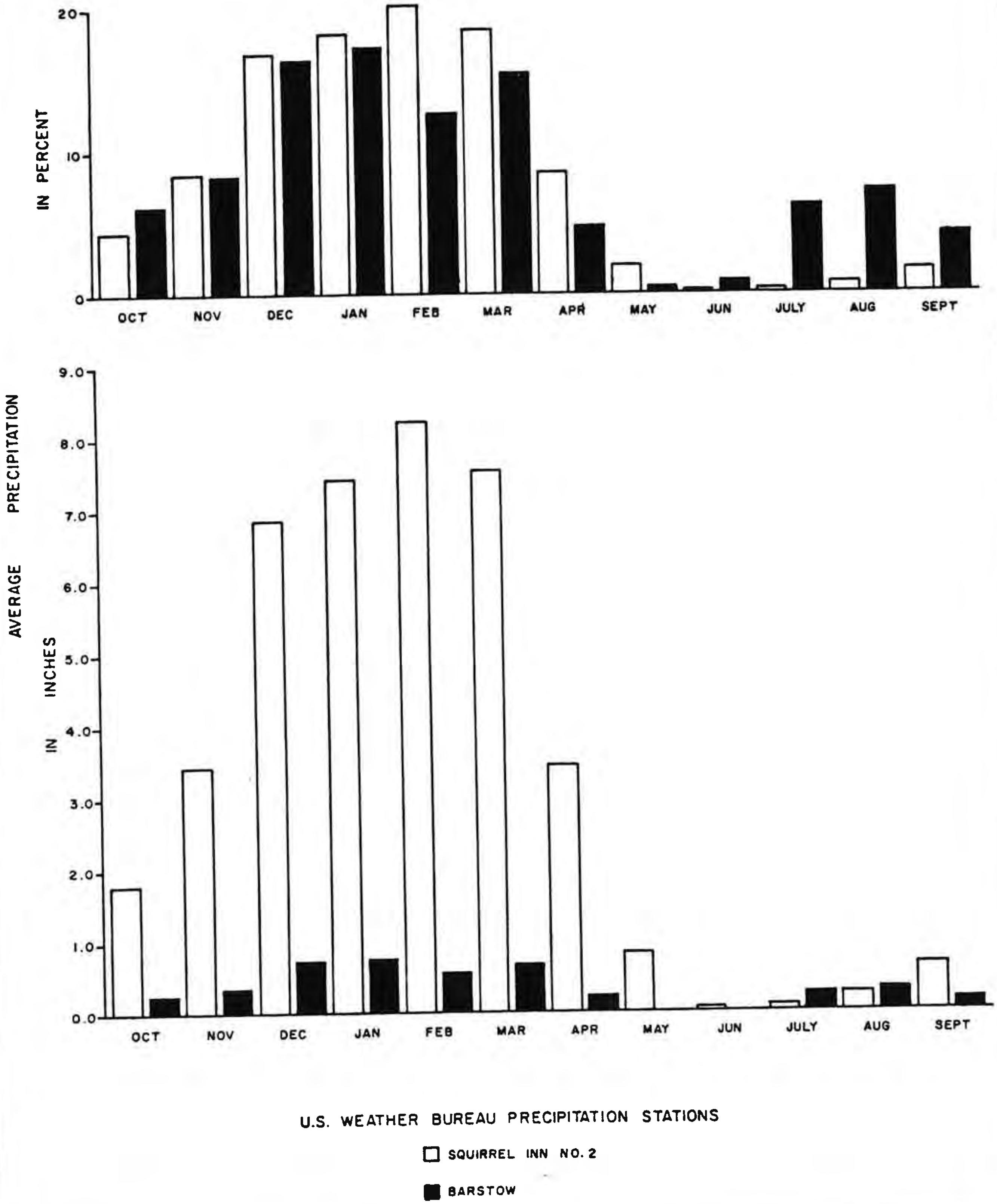

Fig. 5. AVERAGE MONTHLY DISTRIBUTION OF PRECIPITATION AT REPRESENTATIVE STATIONS–1936-37 THROUGH 1960-61

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TABLE 7

ESTIMATED AVERAGE ANNUAL PRECIPITATION BY AREA*

Location	Area, in acres	Precipitation, in inches
Mountain Areas		
San Bernardino Mountains	169,600	24.6
Desert Mountains		
Upper Mojave Basin	46,800	6.4
Middle Mojave Basin	107,500	6.1
Lower Mojave Basin	136,900	6.9
Lucerne Basin	71,600	7.6
Harper Basin	100,800	6.7
Coyote Basin	66,100	7.8
Caves Basin	34,000	5.7
Valley Areas		
Upper Mojave Basin	371,100	6.3
Middle Mojave Basin	260,500	5.0
Lower Mojave Basin	259,200	4.2
Lucerne Basin	190,100	6.4
Harper Basin	297,200	4.5
Coyote Basin	99,900	5.0
Caves Basin	94,000	4.5

*For the base period

Rainfall in the area south of the town of Hesperia is -- in some years -- in excess of 8 inches and, therefore, contributes to the ground water supply. In this area, the average annual amount of precipitation exceeding 8 inches during the base period of the study was sufficient to provide to the land surface an estimated 4,500 acre-feet of water supply annually. The average annual amount of deep percolation from precipitation to the valley floor was estimated by applying a technique used by the Department in previous investigations. This technique relates deep percolation to the amount of precipitation, the evapotranspiration requirements and soil moisture deficiency that must be satisfied above the selected 8 inch value, and the residual amount of runoff. The technique was developed from data used in studies reported in Department of Water Resources' Bulletin No. 33, "Rainfall Penetration and Consumptive Use of Water -- in Santa Ana River Valley and Coastal Plain", 1930, and in U. S. Department of Agriculture publication, "Determining Water Requirements in Irrigated Areas from Climatological and Irrigation Data", by Harry F. Blaney and Wayne D. Criddle of the Soil Conservation Service, dated August 1950.

Based on this technique, the amount of precipitation that may percolate was determined to be 3,850 acre-feet. However, to make allowances for any loss of this water as it passes from the root zone to ground water due to vapor transport, the amount of precipitation that percolates and becomes ground water was assumed to be 3,500 acre-feet.

Table 8 summarizes the estimated annual deep percolation of precipitation on the valley floor south of Hesperia during the base period. The occurrence of perched ground water in the same region confirms the occurrence of deep percolation as a source of water supply. However, the available data were not sufficient to define the magnitude and areal extent of the perched ground water body or to check the seasonal amounts of deep percolation from this source during the base period.

Surface Flow

Surface flow has two sources: base flow from the discharge of ground water to the stream channels and storm runoff from precipitation on the tributary hill and mountain areas. Base flow is found in four

TABLE 8

ESTIMATED SEASONAL DEEP PERCOLATION OF
PRECIPITATION ON THE VALLEY FLOOR
SOUTH OF HESPERIA DURING THE BASE PERIOD

In acre-feet

Water year	Deep percolation	Water year	Deep percolation
1936-37	3,500	1950-51	0
38	2,000	52	7,450
39	350	53	0
40	0	54	1,450
		55	0
1940-41	30,150	1955-56	0
42	0	57	0
43	5,600	58	5,400
44	30,550	59	0
45	1,000	60	0
1945-46 through 1948-50	0	1960-61	0
		25-year average	3,500

reaches of the Mojave River. At the point of origin of the Mojave River, the confluence of the West Fork of the Mojave River and Deep Creek, base flow results from the perennial supply available from the drainage area of Deep Creek. At Victorville, Camp Cady, and Afton, base flow, or rising water results from constrictions in the alluvial section of water-bearing materials, which force the ground water to the surface of the stream channel.

Runoff enters the study area through stream channels or as overland flow. The sources of runoff from precipitation are the San Bernardino Mountains and the desert mountains on the valley floor, shown on Table 7. In addition, as discussed earlier in the chapter, runoff from precipitation on the valley floor is a source of water supply in the area south of Hesperia.

Those stream gaging stations in the study area from which data were obtained for use in this report are presented in Table 9, by station name, length of record, and drainage area. In addition, the gaging station from the diversion site on Deep Creek to Hesperia is also listed. Although the records of the station at Beacon Creek near Helendale were not utilized in this study, it is part of the United States Geological Survey program to determine runoff characteristics for small drainage areas, which may provide valuable information in the future. Location of these stations is shown on Plate 1.

The principal surface flow in the study area is the Mojave River. The two major streams in the San Bernardino Mountains are Deep Creek and the West Fork of the Mojave River. These streams combine at the base of the mountains to form the Mojave River. This confluence is referred to as the forks. The flows in these streams are gaged by the U. S. Geological Survey about 1 mile upstream of their confluence. The records of the combined flow of the two streams and the diversion on Deep Creek are indicative of the flow of the Mojave River at the forks into the Upper Mojave Basin. The average annual flow at the forks during the base period was about 62,000 acre-feet, including diversion above the forks.

The major sources of surface inflow, or water supply to the basin, are the two forks of the Mojave River: Deep Creek and West Fork.

TABLE 9

STREAM GAGING STATIONS

Index No.*	Name[a]	Period of record: From	Period of record: To	Period of record: Incomplete or missing years	Drainage area, in square miles
Active Stations					
1[b]	Deep Creek near Hesperia	1904-05	1960-61	9	137.0
2[c]	West Fork Mojave River near Hesperia	1904-05	1960-61	9	74.8
3[d]	Mojave River at Lower Narrows, near Victorville	1898-99	1960-61	17	530.0
4	Mojave River at Barstow	1930-31	1960-61	0	f
5	Mojave River at Afton	1929-30	1960-61	21	f
6	Beacon Creek at Helendale	1959-60	1960-61	0	0.7
7	Cushenbury Creek near Lucerne Valley	1956-57	1960-61	1	6.4
Inactive Stations					
8	Deep Creek Diversion	1950-51	1958-59	0	---
9[e]	Mojave River at Point of Rocks	1908-09	1910-11	2	f
10	Mojave River at Hodge	1930-31	1931-32	0	f

a. USGS gaging station unless otherwise noted.
b. Lake Arrowhead Company records as East Fork of Mojave River from 1904-05 through 1921-22; USGS records from 1929-30 through 1960-61.
c. Lake Arrowhead Company records from 1904-05 through 1960-61; USGS records from 1929-30 through 1960-61.
d. Lake Arrowhead Company records from 1904-05 through 1914-15; USGS records from 1898-99 through 1905-06 and from 1930-31 through 1960-61.
e. Lake Arrowhead Company records.
f. Not available.
* These index numbers are as shown on Plate 1.

The flows in these forks are gaged about 1 mile upstream of their confluence at the forks, and the records of the combined flow of the two streams and the diversion on Deep Creek are considered indicative of the flow of the Mojave River at the forks. The flow at the forks essentially occurs at the boundary of the water-bearing material, although a portion of the area above the gage on the West Fork is underlain with water-bearing material. Consequently, some of the runoff from the San Bernardino Mountains has an opportunity to infiltrate and percolate to the ground water reservoir before it reaches the gage.

The average annual runoff at the forks during the base period was computed to be 62,000 acre-feet. The amount is about 16 percent less than the average annual amount for the entire period of record, which begins in 1904, and about 26 percent less than for the period 1904-05 through 1936-37 that includes one wet and one dry period. This shows that the runoff during the earlier time was more than during the base period. However, in previous studies of the selection of the base period, the average annual precipitation for these same periods was determined to be about equal. Because of this condition, it is reasonable to expect that the average annual runoff for the base period and the longer time would be about equal.

To determine whether or not the streamflow records should be adjusted to account for the difference in runoff, the records of the gaged stations at the forks were checked against records of other streams by applying a double mass curve technique commonly used by hydrologists.

The results showed that the data plot is a straight line and that the amounts of runoff at the forks are proportional to the amounts occurring in other streams. Therefore, two conclusions were arrived at: first, the runoff records of the Mojave River at the forks are accurate over the entire period of record; second, the difference in the amounts of runoff from comparable amounts of precipitation is apparently due to the changing physical conditions and precipitation characteristics affecting the precipitation runoff relationship of the drainage area above the forks. Accordingly, the average annual runoff at the forks during the base period is considered representative of the amount of water supply to the basin under present physical conditions and precipitation characteristics.

Because a small portion of the water-bearing material is above the gage on the West Fork of the Mojave River, some of the runoff from the San Bernardino Mountains percolates and becomes ground water before it reaches the gage. The amount that becomes ground water is considered as part of the surface flow of the Mojave River in this study. During the year, the average annual amount of ungaged runoff above the gage contributing to the water supply of the basin was estimated to be 1,150 acre-feet. This amount was determined by comparing the estimate of runoff for the West Fork drainage area with the gaged record at the forks. The estimate of runoff was based on the precipitation-runoff relationship discussed hereinafter and the amount of precipitation over the drainage area which was obtained from the isohyetal map.

For the balance of the ungaged portion of the San Bernardino Mountains, the average annual surface inflow from runoff was estimated to be 50 acre-feet to the Upper Mojave Basin and 600 acre-feet to the

Lucerne Basin. These estimates were determined by applying precipitation-runoff relationships discussed later in this chapter.

Although there is a gage on a 6.4 square mile drainage area of Cushenbury Creek, which is tributary to Lucerne Basin, the average annual amount of runoff in this area during the base period could not be determined from the short period of record. Therefore, the estimate of runoff from the San Bernardino Mountains to Lucerne Basin includes the amount from the Cushenbury Creek drainage area.

From the San Bernardino Mountains to Afton, the Mojave River crosses the boundaries between ground water basins, which are identified and discussed in Chapter II. At the basin boundaries, the flow of the Mojave River is surface outflow from the upstream basin or surface inflow to the downstream basin. There are four of these boundaries along the river: Helendale, Barstow, Camp Cady site, and Afton. Except at Barstow, the flow is a combination of storm flow and base flow. At Barstow, the flow is entirely storm flow from runoff originating in the San Bernardino Mountains.

There is no record of a stream-gaging station at the boundary between the Upper and Middle Mojave Basins which is near Helendale. However, flow data are available for stations at two nearby locations: less than three years of record at Point of the Rocks, about 1½ miles downstream from the boundary, and two years of record at Hodge. These data were used to check the estimates of flow at the boundary.

The estimates of flow at the basin boundary near Helendale were based on: (1) a correlation developed from the flow data of the

Lower Narrows station and the Barstow station to be discussed next; (2) the criteria that, for the same amounts of annual flow entering the initial reach, the total amount of annual riverbed percolation in any number of reaches must equal the amount of riverbed percolation in the entire reach; and (3) the assumption that there is no change in the amount of storm flow in the reach between Victorville and Helendale because the majority of the storm flow occurs when there is base flow at Helendale. This correlation shows the relationship between the annual amounts of riverbed percolation and the annual amounts of flow at the Lower Narrows station, with riverbed percolation being computed as the difference in the annual amounts of gaged flow at the two stations. Therefore, knowing the annual flows at the Lower Narrows station, the annual amounts of riverbed percolation in the reach between the station and the boundary were determined. The annual amounts of flow at the boundary were determined by deducting percolation from flows at the Lower Narrows station. The average annual flow at the basin boundary during the base period was estimated to be 35,500 acre-feet.

The flow of the Mojave River is gaged at Barstow, about one-half mile downstream of the boundary between the Middle and Lower Mojave Basins. For study purposes, the flow at the gage is considered representative of flow at the boundary. The flow of the Mojave River at Barstow consists entirely of storm flow, 96 percent of which occurs from January through April. This storm flow originates as storm runoff in the San Bernardino Mountains above the forks and occurs when the storm runoff is of sufficient magnitude to reach Barstow. During the base period, the record of the gage at Barstow indicates no flow occurred at the station during 13 of the 25 years of the base period.

Based on these records, the average annual flow of the Mojave River at Barstow was computed to be 21,450 acre-feet during the base period. The seasonal flow ranged from zero to 130,000 acre-feet in 1937-38. In addition, the records at the station were used for estimating the flow of the Mojave River at the basin boundary near Helendale, previously discussed, and at the basin boundary at the Camp Cady site, to be discussed next.

The Mojave River crosses the boundary between the Lower Mojave and Caves Basins near the abandoned Camp Cady which is approximately 5 miles southeast of Harvard. The flow in the river at this point comprises base flow (rising water at the constriction in the alluvial section) and storm flow. During the base period, the average annual flow at the boundary was estimated to be 12,200 acre-feet and comprised 11,300 acre-feet storm flow and 900 acre-feet base flow.

In determining the average annual flow, it was first necessary to estimate the average annual storm flow by applying the same technique used in analyzing the flow of the Mojave River near Helendale. Where, (1) knowing the annual flows at the Barstow station, (2) based on a correlation developed from the flow data of the Barstow station and Afton station to be discussed next, and (3) based on the same criteria presented in analyzing the flow of the Mojave River near Helendale, the annual amounts of storm flow were estimated and the average annual storm flow determined to be 11,300 acre-feet.

The paucity of data precludes an analysis to determine the base flow at the boundary and, therefore, the average seasonal amount of base flow was assumed to be the same amount as at the Afton gage.

The flow of the Mojave River is gaged at the basin boundary at Afton. The flow at the station is the amount leaving the study area and comprises base flow (rising ground water at the constriction in the cross-sectional area of water-bearing materials at Afton Canyon) and storm flow. The storm flow at the station is a combination of runoff originating in the San Bernardino Mountains and runoff from local summer storms. The major portion of the storm flow originates in the San Bernardino Mountains. During the base period, flow at Afton was recorded only for the years 1952-53 through 1960-61; therefore, it was necessary to estimate the flow for the other 16 years of the base period. Flow data prior to the base period, from January 1930 through September 1932, and ground water level data during the missing 16 years of record between the Barstow and Afton stations aided in estimating the annual flow during the base period. Based on these data, the annual amounts for the 16 years of missing record were determined, and the average annual storm flow at Afton from the runoff originating in the San Bernardino Mountains was estimated to be 8,650 acre-feet. In addition, the average annual storm flow at Afton due to local summer storms was determined by a study of the magnitude and frequency of the amounts found in the 9 years of record at the station. From this study, the average annual storm flow from local summer storms was determined to be 50 acre-feet.

The annual base flow during the missing years of record was estimated by establishing a relationship between the base flow for the years of record and ground water level data at nearby wells. Based on this relationship, the base flow for the 16 years of missing record was determined, and the average annual base flow was estimated to be 900 acre-feet. Combined with the storm flow at the station, the average annual flow at the boundary where the Mojave River leaves the study area was estimated to be 9,600 acre-feet.

The average annual flows of the Mojave River at the various basin boundaries are shown in Table 10.

TABLE 10

AVERAGE ANNUAL FLOWS AT THE BASIN BOUNDARIES

Basin boundary	In acre-feet
At the Forks	62,000
Near Helendale	35,500
At Barstow*	21,450
Camp Cady Site	12,200
At Afton*	9,600

*Stream-gaging station.

The ungaged desert mountains on the valley floor contribute runoff to the water supply of the basins. This runoff constitutes about five percent of the total water supply of the study area. However, it is an important source of water supply to the basins that do not border the Mojave River. Estimated average annual runoff to these three basins -- Lucerne, Harper, and Coyote -- amounted to 450 acre-feet, 550 acre-feet, and 450 acre-feet during the base period. This is the only source of surface inflow to Harper and Coyote Basins; Lucerne receives additional runoff from the San Bernardino Mountains.

The amount of runoff from the ungaged desert mountains to the basins was estimated from an average seasonal precipitation-runoff relationship which was developed by adjusting a curve of the relationship for various streams in Southern California to reflect local conditions in the Mojave Desert region. The adjustment was made by creating a curve parallel to the original curve. The amount of offset from the original curve was based on the relationship of the average annual precipitation and runoff of the Deep Creek drainage area to the average of various streams in Southern California. Values of percent runoff for different depths of average annual precipitation used in estimating the runoff from ungaged drainage areas in the current studies and in the preliminary studies are presented in Table 11. By applying these values to the average annual precipitation on the various ungaged areas, the average annual surface inflow to the basins could be determined.

TABLE 11

AVERAGE PRECIPITATION-PERCENT RUNOFF VALUES

Average annual precipitation, in inches	Average annual runoff, in percent of precipitation
10	3.1
9	2.6
8	2.1
7	1.7
6 or less	1.0

As discussed earlier in the chapter, runoff from precipitation on the valley floor south of Hesperia percolates and becomes ground water. This is a source of water supply and, for this study, is considered surface inflow to the Upper Mojave Basin. The estimate of the average annual amount was based on the precipitation-runoff relationship discussed previously, modified for slope and soil conditions. The area of the valley floor south of Hesperia is flatter and composed of more permeable older alluvium than the steep and crystalline rock drainage areas used in originally developing the curve; therefore, it is reasonable to expect less runoff to occur in this area for equal amounts of precipitation. Analysis of limited data suggests that the amount of runoff is about half the amount determined from the precipitation-runoff relationship. On this basis, the average annual runoff from precipitation on the valley floor south of Hesperia during the base period was estimated to be 1,350 acre-feet. Most of this amount percolates in the many natural channels and becomes ground water in the area. However, because small amounts may be consumptively used by native vegetation, the amount of this runoff that becomes water supply to the Upper Mojave Ground Water Basin was assumed to be 1,000 acre-feet.

The flow of the Mojave River at the basin boundaries, the runoff from desert mountains on the valley floor, and runoff from precipitation on the basin as surface inflow to the Upper Mojave, Middle Mojave, Lower Mojave, and Lucerne Basins are summarized in Table 12.

TABLE 12

ESTIMATED SURFACE INFLOW DURING THE BASE PERIOD

In acre-feet

Water year	To Upper Mojave Basin: From: San Bernardino Mountains: At the forks	Above West Fork	Other areas	From: Desert Mountains	Valley Area	Total	To Middle Mojave Basin: From: Mojave River	Desert Mountains	Total	To Lower Mojave Basin: From: Mojave River	Desert Mountains	Total	To Lucerne Basin: From: San Bernardino Mountains	Desert Mountains	Total
1936-37	169,250	1,150	50	250	2,800	173,500	125,200	550	125,750	103,900	800	104,700	600	450	1,050
38	218,900	1,150	50	250	3,700	224,050	159,150	550	159,700	138,100	800	138,900	600	450	1,050
39	40,600	1,150	50	250	500	42,550	17,250	550	17,800	550	800	1,350	600	450	1,050
40	31,250	1,150	50	250	350	33,050	15,350	550	15,900	0	800	800	600	450	1,050
1940-41	161,200	1,150	50	250	2,800	165,450	118,950	550	119,500	96,000	800	96,800	600	450	1,050
42	26,100	1,150	50	250	400	27,950	13,700	550	14,250	100	800	900	600	450	1,050
43	150,000	1,150	50	250	2,800	154,250	104,700	550	105,250	91,000	800	91,800	600	450	1,050
44	86,850	1,150	50	250	1,900	90,200	60,300	550	60,850	36,250	800	37,050	600	450	1,050
45	70,850	1,150	50	250	1,150	73,450	39,500	550	40,050	22,100	800	22,900	600	450	1,050
1945-46	54,550	1,150	50	250	700	56,700	29,350	550	29,900	12,550	800	13,350	600	450	1,050
47	50,350	1,150	50	250	1,150	52,950	17,150	550	17,700	2,900	800	3,700	600	450	1,050
48	16,750	1,150	50	250	150	18,350	10,550	550	11,100	0	800	800	600	450	1,050
49	26,150	1,150	50	250	400	28,000	8,350	550	8,900	0	800	800	600	450	1,050
50	15,550	1,150	50	250	250	17,250	7,650	550	8,200	0	800	800	600	250	1,050
1950-51	4,350	1,150	50	250	0	5,800	7,200	550	7,750	0	800	800	600	450	1,050
52	106,450	1,150	50	250	2,150	110,050	35,200	550	35,750	12,550	800	13,350	600	450	1,050
53	13,000	1,150	50	250	100	14,550	7,850	550	8,400	0	800	800	600	450	1,050
54	57,400	1,150	50	250	850	59,700	13,500	550	14,050	0	800	800	600	450	1,050
55	21,050	1,150	50	250	200	22,700	8,150	550	8,700	0	800	800	600	450	1,050
1955-56	19,100	1,150	50	250	100	20,650	7,750	550	8,300	0	800	800	600	450	1,050
57	23,750	1,150	50	250	150	25,350	7,100	550	7,650	0	800	800	600	450	1,050
58	151,950	1,150	50	250	2,200	155,600	54,150	550	54,700	20,050	800	20,850	600	450	1,050
59	20,850	1,150	50	250	200	22,500	6,800	550	7,350	0	800	800	600	450	1,050
60	8,750	1,150	50	250	0	10,200	6,350	550	6,900	0	800	800	600	450	1,050
1960-61	4,500	1,150	50	250	0	5,950	6,300	550	6,850	0	800	800	600	450	1,050
25-year average	61,980	1,150	50	250	1,000	64,430	35,500	550	36,050	21,442	800	22,242	600	450	1,050

Estimated average annual inflow to: Harper Basin -- 550 acre-feet. (desert mountains)
Coyote Basin -- 450 acre-feet. (desert mountains)
Caves Basin -- 12,350 acre-feet. (12,200 acre-feet from Mojave River; 150 acre-feet from desert mountains)

Subsurface Flow

Primarily, ground water movement within the study area occurs parallel and adjacent to the Mojave River in a south to north direction. Minor subsurface movement occurs in alluvium adjacent to the hills and mountains. The prevailing ground water gradients generally conform to the regional slope of the land surface; however, in portions of the study area, the gradients are reversed. This reversed gradient is caused by pumping from ground water in storage.

Ground water can move across the boundaries of the basins within the study area and its subdivisions when the permeability of the subsurface materials, the hydraulic gradient, and the cross-sectional area are sufficient for movement to occur and provided there is no subsurface barrier. At some of the boundaries, data on the permeability, hydraulic gradient, and cross-sectional area were not available for computing the amount of subsurface flow. However, it is believed the limited extent of alluvial materials at these boundaries prohibits the movement of significant quantities of water.

There is no subsurface outflow from the study area. However, subsurface inflow into the study area apparently occurs at the southwest boundary of the study area, which is also the west boundary of the Upper Mojave Basin. Because information on the depth and nature of the alluvial materials and the hydraulic gradient at this location is lacking, no direct determination of the amount of this flow was possible. However, on the basis of analysis of the natural recharge to the ground water basin west of the Upper Mojave Basin (primarily from Sheep Creek which is outside the study area), it appears reasonable that some ground water moves into the study area across this boundary. For this study, it was assumed that one-third of the estimated average seasonal runoff of Sheep Creek, less the average seasonal diversion to Phelan, percolated and moved easterly into the study area and the Upper Mojave Basin.

The amounts of underflow across the basin boundaries were determined from estimates of the factors in the equation, Q=TIW, which is based on Darcy's Law. In this equation, the subsurface flow (Q) is equal to the transmissibility (permeability times saturated aquifer depth) (T) of the subsurface materials, multiplied by the width of the cross-sectional area (W) through which the flow passes, and the slope, or the hydraulic gradient, (I) of the ground water at the cross-sectional area.

The estimates of underflow for each of the selected boundaries are listed in Table 13.

TABLE 13

ESTIMATED AVERAGE ANNUAL SUBSURFACE INFLOW

In acre-feet

Basin	Average annual amount during the base period	
Upper Mojave from:		
West Boundary	850	
Lucerne	100	
TOTAL		950
Middle Mojave from Upper Mojave		2,000
Lower Mojave from Middle Mojave		2,000
Harper from Middle Mojave		1,000
Coyote from Lower Mojave		1,000
Caves from Lower Mojave		1,000

Import-Export of Water

A small amount of water is imported from outside the study area to the town of Phelan, in the Upper Mojave Basin. Some water supply, as well as sewage, crosses the boundary from the Middle to Lower Mojave Basins within the City of Barstow.

The water supply for Phelan is imported by pipeline from the Sheep Creek drainage area which is in the San Gabriel Mountains just outside the study area. Although the major purpose of the imported water is for urban and suburban use, a portion may overflow into another pipeline for agricultural use when there is no available storage in the tank.

Records of the amount of water imported are fragmentary until late 1963, when a meter was installed. From this recent information, the average annual amount of imported water to Phelan during the base period was estimated to be 250 acre-feet.

The boundary between the Middle and Lower Mojave Basins passes through the City of Barstow, which is supplied with water pumped from wells in the two basins. The water is distributed by the Southern California Water Company. Based on information on the amounts pumped and the demand by population in each basin, it was established that some of the water extracted in the Middle Mojave Basin is transported across the basin boundary to service areas in the Lower Mojave Basin. The estimate of the average annual amount of water supply transported across the basin boundary during the base period was 700 acre-feet.

A second source of water exported from the Middle Mojave Basin is sewage that originated from the City of Barstow and was transported across the boundary to a treatment plant in the Lower Mojave Basin. The smaller portion of the City is in the Middle Mojave Basin. The average annual amount of sewage exported from the basin is estimated to be 100 acre-feet. This estimate is based on the amount of applied water and its consumptive use, the population in the two basins, and the amount of flow through the treatment plant in 1961.

Table 14 summarizes the amounts of water imported to the Upper Mojave Basin from outside the study area and to the Lower Mojave Basin from Middle Mojave Basin.

TABLE 14

ESTIMATED AVERAGE ANNUAL AMOUNTS OF WATER IMPORTED TO THE UPPER AND LOWER MOJAVE BASINS

In acre-feet

Basin	Average annual amount during the base period	
Upper Mojave		250
Lower Mojave from Middle Mojave:		
Water	(700)	
Sewage	(100)	
TOTAL		800

In Table 15 is shown the annual supply and the 25-year average annual supply from each source of supply to each of the four main basins: Upper Mojave, Middle Mojave, Lower Mojave, and Lucerne. The estimated annual supply to each of the other three basins -- Harper, Coyote, and Caves -- is also indicated by footnote. Although there is insufficient hydrologic data available in these last three basins to make definite determinations of the amounts of water supply, estimates were made to provide an indication of existing conditions.

TABLE 15

ESTIMATED WATER SUPPLY DURING THE BASE PERIOD

In acre-feet

Water year	Upper Mojave Basin					Middle Mojave Basin				Lower Mojave Basin					Lucerne Basin		
	Precipitation*	Surface inflow	Subsurface inflow	Imported water	Total	Precipitation*	Surface inflow	Subsurface inflow	Total	Precipitation*	Surface inflow	Subsurface inflow	Imported water	Total	Precipitation*	Surface inflow	Total
1936-37	8,600	173,500	950	250	183,300	1,250	125,750	2,000	129,000	900	104,700	2,000	800	108,400	150	1,050	1,200
38	6,850	224,050	950	250	232,100	1,350	159,700	2,000	163,050	950	138,900	2,000	800	142,650	150	1,050	1,200
39	4,800	42,550	950	250	48,550	1,500	17,800	2,000	21,300	1,250	1,350	2,000	800	5,400	150	1,050	1,200
40	4,000	33,050	950	250	38,250	1,350	15,900	2,000	19,250	950	800	2,000	800	4,550	150	1,050	1,200
1940-41	36,950	165,450	950	250	203,600	2,000	119,500	2,000	123,500	1,850	96,800	2,000	800	101,450	150	1,050	1,200
42	4,100	27,950	950	250	33,250	1,650	14,250	2,000	17,900	1,400	900	2,000	800	5,100	150	1,050	1,200
43	11,650	154,250	950	250	167,100	1,500	105,250	2,000	108,750	1,100	91,800	2,000	800	95,700	150	1,050	1,200
44	36,850	90,200	950	250	128,250	1,350	60,850	2,000	64,200	850	37,050	2,000	800	40,700	150	1,050	1,200
45	6,350	73,450	950	250	81,000	1,700	40,050	2,000	43,750	1,300	22,900	2,000	800	27,000	150	1,050	1,200
1945-46	4,250	56,700	950	250	62,150	1,150	29,900	2,000	33,050	450	13,350	2,000	800	16,600	150	1,050	1,200
47	4,850	52,950	950	250	59,000	1,250	17,700	2,000	20,950	500	3,700	2,000	800	7,000	350	1,050	1,400
48	4,800	18,350	950	250	24,350	1,500	11,100	2,000	14,600	700	800	2,000	800	4,300	550	1,050	1,600
49	6,150	28,000	950	250	35,350	2,050	8,900	2,000	12,950	1,450	800	2,000	800	5,050	700	1,050	1,750
50	4,550	17,250	950	250	23,000	2,050	8,200	2,000	12,250	1,300	800	2,000	800	4,900	850	1,050	1,900
1950-51	5,300	5,800	950	250	12,300	2,100	7,750	2,000	11,850	1,250	800	2,000	800	4,850	1,000	1,050	2,050
52	15,150	110,050	950	250	126,400	2,300	35,750	2,000	40,050	2,450	13,350	2,000	800	18,600	1,200	1,050	2,250
53	5,850	14,550	950	250	21,600	2,300	8,400	2,000	12,700	1,650	800	2,000	800	5,250	1,250	1,050	2,300
54	7,300	59,700	950	250	68,200	2,400	14,050	2,000	18,450	1,800	800	2,000	800	5,400	1,250	1,050	2,300
55	7,500	22,700	950	250	31,400	2,450	8,700	2,000	13,150	1,750	800	2,000	800	5,350	1,250	1,050	2,300
1955-56	5,300	20,650	950	250	27,150	2,350	8,300	2,000	12,650	1,500	800	2,000	800	5,100	1,300	1,050	2,350
57	5,250	25,350	950	250	31,800	2,000	7,650	2,000	11,650	900	800	2,000	800	4,500	1,300	1,050	2,350
58	11,900	155,600	950	250	168,700	2,850	54,700	2,000	59,550	2,050	20,850	2,000	800	25,700	1,250	1,050	2,300
59	4,500	22,500	950	250	28,200	2,250	7,350	2,000	11,600	1,050	800	2,000	800	4,650	1,250	1,050	2,300
60	4,900	10,200	950	250	16,300	2,500	6,900	2,000	11,400	1,400	800	2,000	800	5,000	1,200	1,050	2,250
1960-61	4,700	5,950	950	250	11,850	2,250	6,850	2,000	11,100	1,050	800	2,000	800	4,650	1,150	1,050	2,200
25-year average	8,896	64,430	950	250	74,526	1,896	36,050	2,000	39,946	1,272	22,242	2,000	800	26,314	694	1,050	1,744

Estimated average annual supply to: Harper Basin -- 1,550 acre-feet.
Coyote Basin -- 1,450 acre-feet.
Caves Basin -- 13,350 acre-feet.

*The amount of precipitation on the basin consumptively used by native vegetation is not included.

Water Use and Disposal

The use and disposal of water during the base period, 1936-37 through 1960-61, are discussed here under the headings of surface outflow, subsurface outflow, exported water, and consumptive use.

The figures shown below for surface outflow, subsurface outflow, and exported water were arrived at by the methods described in the previous section for determining the flows at basin boundaries within the study area.

Surface Outflow

Surface outflow from the study area takes place only at the northeast boundary near Afton. The average annual amount of surface outflow during the base period was estimated to be 9,600 acre-feet.

Amounts of average annual surface outflow from each of the basins within the study area during the 25-year base period are given below.

Basins	Average annual surface outflow in acre-feet
Upper Mojave to Middle Mojave	35,500
Middle Mojave to Lower Mojave	21,450
Lower Mojave to Caves	12,200

There is no surface outflow from the Lucerne Basin.

Subsurface Outflow

There is no subsurface outflow from the study area. The amount of average annual subsurface outflow from basins during the 25-year base period was:

Basins	Average annual subsurface outflow in acre-feet
Upper Mojave to Middle Mojave	2,000
Middle Mojave to Lower Mojave	2,000
Middle Mojave to Harper	1,000
Lower Mojave to Caves	1,000
Lower Mojave to Coyote	1,000

Exported Water

The only export of water is from the Middle Mojave Basin to the Lower Mojave Basin, an estimated average annual amount of 700 acre-feet.

Consumptive Use

Water is consumptively used by vegetation and by man and his associated activities. Water is consumed by vegetation through the transpiration processes and building of plant tissues and by evaporation from the soil, from free water surfaces, and from foliage. Water consumptively used by man and his activities includes water used for agriculture, domestic uses, industrial purposes, and water evaporated by urban and nonvegetative types of land use. Water for consumptive use is obtained from natural sources and from man-made facilities.

Applied water from man-made sources meets the consumptive use requirements not supplied through natural sources and is usually in excess of the consumptive use requirements. The portion of the applied water that is not consumed replenishes the basin by becoming ground water through deep percolation.

In the following discussion of beneficial and nonbeneficial uses of water in the study area, the land use data was obtained from a comprehensive survey of the Mojave River region, conducted by the Department of Water Resources in 1961. The results of this survey are shown on Plate 5, "Land Use, 1961".

The three kinds of plant growth in the study area are: native vegetation, which covers much of the desert; riparian native vegetation, which grows in and near streams; and agricultural crops. Consumptive use of both precipitation and ground water by agriculture is a beneficial use. In addition, consumptive use of water by man in urban or suburban developments and industry is a beneficial use. Consumption of precipitation by native vegetation and consumption of both precipitation and ground water by riparian native vegetation are nonbeneficial uses.

The studies of beneficial consumptive use include determining the total amount of water used by the various crops and the amounts of water used by the population of the study area and its associated commerce and industry.

Agriculture. Estimates of consumptive use of precipitation and applied water by agriculture during the base period were based on the mean annual unit consumptive use values and acreages of the various types of crops. The unit use values for the Mojave River region are presented in State Water Resources Board Bulletin No. 2, "Water Utilization and Requirements of California", 1955. These unit use values are derived by the "Blaney-Criddle Method". Briefly, this method uses an empirical consumptive use coefficient, the average monthly temperature, the monthly percent of daylight hours, and the length of growing season to arrive at the unit use values.

In applying these unit use values to the base period, the values were modified to reflect the average monthly temperature in the Upper Mojave Basin as recorded at the climatological station at Victorville, and the temperature in the Middle and Lower Mojave Basins based on temperature data at the station at Barstow. The modified, or average, annual unit consumptive use values of precipitation and applied water for various types of crops are shown in Table 16.

As shown in Table 16, the amount of precipitation consumptively used by crops is equal to the small amount of precipitation that occurs during the nongrowing season. This is based on precipitation observed at stations in Victorville and Barstow. These records confirm that the average annual precipitation during the nongrowing season is too small to permit runoff from the tilled area. This amount of rainfall is also well within the moisture-holding capacity of the soil, where it is retained until the growing season. During the growing season, this water is consumptively used; thus, the moisture-holding capacity of the soil was assumed to be depleted at the beginning of the water year.

A description of the various classifications of crops used in this study is presented in Appendix C. These groupings are similar to those used in State Water Resources Board Bulletin No. 2.

TABLE 16

ESTIMATED AVERAGE SEASONAL UNIT CONSUMPTIVE USE VALUES FOR AGRICULTURAL CROPS DURING THE BASE PERIOD

In acre-feet per acre

Agricultural crop	Unit consumptive use values					
	Upper Mojave and Lucerne Basins			Middle and Lower Mojave Basin		
	Precipi-tation	Ground water*	Total	Precipi-tation	Ground water*	Total
Alfalfa	0.5	3.0	3.5	0.4	3.3	3.7
Pasture	0.5	2.8	3.3	0.4	3.1	3.5
Truck crops	0.5	1.6	2.1	0.4	1.7	2.1
Field crops	0.5	1.6	2.1	0.4	1.7	2.1
Deciduous fruits and nuts	0.5	2.3	2.8	0.4	2.5	2.9
Small grains	0.5	1.0	1.5	0.4	1.2	1.6
Vineyards	0.5	2.5	3.0	0.4	2.7	3.1

*Pumped ground water that is applied to crops.

The total acreage and the acreages of the various types of crops in the study area were obtained from federal, state, and county land and water use surveys. These included Department of Water Resources surveys in 1929, 1950, 1957, and 1961, a United States Bureau of Reclamation survey in 1946, and United States Bureau of Census surveys in 1934, 1939, and 1949. County crop reports for the Mojave Desert portion of the San Bernardino County were also available for 15 years of the base period, beginning with 1946.

The data for only two of the surveys -- those conducted by the Department in 1957 and 1961 -- included acreages of all the various crops in each basin. Data from the balance of the surveys are of lesser detail, and crop acreage by basin was partially estimated. Based on the data from these surveys, the total acreage and the acreage of the various types of crops in each basin during each year of the base period were determined. Total acreage for each was interpolated from a curve of the plotted data that shows the variation of the acreage of agriculture from 1929 through 1961. Acreages of the various types of crops were assumed to follow the percentage distribution of the three distinct periods of agricultural development in the study area, for which data on the types of crops are available. The three distinct periods of agricultural development are from 1936-37 to 1946-47, 1946-47 to 1959-60, and 1959-60 to end of the base period 1960-61. The estimated land use in 1961 in each basin is shown in Table 17.

TABLE 17

ESTIMATED LAND USE IN THE BASINS IN 1961

In acres

Nature and class of land use[a]	Mojave Basins			Lucerne Basin	Harper Basin	Coyote Basin	Caves Basin
	Upper	Middle	Lower				
WATER SERVICE AREA							
Urban and Suburban							
Residential	5,850	800	1,200	b	0	0	0
Recreational residential	3,250	0	0	b	0	0	0
Commercial	550	100	250	b	0	0	0
Industrial	100	0	50	b	0	0	0
Unsegregated urban and suburban area	1,850	700	650	b	150	0	50
Subtotal	11,600	1,600	2,100	b	150	0	50
Included Nonwater Service Area	29,050	2,550	3,200	b	250	0	0
Gross Urban and Suburban Area	40,650	4,150	5,300	b	400	0	50
Irrigated Agriculture							
Alfalfa	4,050	3,100	1,750	850[c]	300	400	650
Pasture	1,300	900	300	800[c]	200	0	0
Truck crops	200	0	0	0[c]	0	0	0
Field crops	400	200	150	0[c]	0	50	0
Deciduous fruits and nuts	50	0	150	0	0	0	0
Small grains	900	1,350	50	300[c]	0	0	0
Subtotal	6,900	5,550	2,400	1,950[c]	500	450	650
Fallow	150	50	0	0[c]	50	0	0
Included Nonwater Service Area	350	300	100	100[c]	50	50	50
Gross Irrigated Agriculture	7,400	5,900	2,500	2,050[c]	600	500	700

a. Described in Appendix C.
b. Data not available.
c. Estimated.

Estimates of the annual and average annual amounts of consumptive use of precipitation and applied water during the base period for the Upper Mojave, Middle Mojave, Lower Mojave, and Lucerne Basins are presented in Table 18.

TABLE 18

CONSUMPTIVE USE OF WATER BY AGRICULTURE DURING THE BASE PERIOD

In acre-feet

Water year	Upper Mojave Basin			Middle Mojave Basin			Lower Mojave Basin			Lucerne Basin		
	Precipitation	Ground water*	Total	Precipitation	Ground water*	Total	Precipitation	Ground water*	Total	Precipitation	Ground water*	Total
1936-37	1,950	9,300	11,250	750	5,200	5,950	150	1,050	1,200	150	900	1,050
38	1,950	9,250	11,200	750	5,200	5,950	150	1,050	1,200	150	900	1,050
39	1,950	9,250	11,200	750	5,150	5,900	150	1,050	1,200	150	900	1,050
40	2,000	9,450	11,450	750	5,300	6,050	150	1,100	1,250	150	900	1,050
1940-41	2,050	9,750	11,800	800	5,450	6,250	150	1,100	1,250	150	900	1,050
42	2,150	10,100	12,250	800	5,600	6,400	150	1,150	1,300	150	900	1,050
43	2,200	10,400	12,600	850	5,800	6,650	150	1,200	1,350	150	900	1,050
44	2,300	10,750	13,050	850	6,000	6,850	150	1,250	1,400	150	900	1,050
45	2,400	11,300	13,700	900	6,300	7,200	200	1,300	1,500	150	900	1,050
1945-46	2,500	11,850	14,350	950	6,600	7,550	200	1,350	1,550	150	900	1,050
47	2,800	14,200	17,000	1,150	8,400	9,550	350	2,700	3,050	350	1,800	2,150
48	3,050	15,550	18,600	1,350	9,950	11,300	550	4,100	4,650	550	2,700	3,250
49	3,300	16,750	20,050	1,550	11,500	13,050	750	5,450	6,200	700	3,600	4,300
50	3,550	18,150	21,700	1,750	12,900	14,650	900	6,900	7,800	850	4,500	5,350
1950-51	3,800	19,450	23,250	1,950	14,450	16,400	1,100	8,200	9,300	1,000	5,400	6,400
52	4,050	20,750	24,800	1,950	14,300	16,250	1,250	9,600	10,850	1,200	6,300	7,500
53	3,950	20,150	24,100	1,950	14,300	16,250	1,200	9,200	10,400	1,250	6,550	7,800
54	3,800	19,500	23,300	1,900	14,150	16,050	1,100	8,300	9,400	1,250	6,600	7,850
55	3,700	19,850	23,550	1,900	14,150	16,050	950	7,350	8,300	1,250	6,750	8,000
1955-56	3,600	19,350	22,950	1,900	14,000	15,900	850	6,450	7,300	1,300	6,800	8,100
57	3,550	18,850	22,400	1,850	13,750	15,600	700	5,450	6,150	1,300	6,900	8,200
58	3,500	18,750	22,250	1,950	14,450	16,400	750	5,600	6,350	1,250	6,750	8,000
59	3,500	18,750	22,250	2,050	15,100	17,150	800	6,100	6,900	1,250	6,550	7,800
60	3,500	18,200	21,700	2,150	14,300	16,450	900	6,650	7,550	1,200	6,300	7,500
1960-61	3,500	18,200	21,700	2,200	14,950	17,150	950	7,200	8,150	1,150	6,150	7,300
25-year average	2,984	15,114	18,098	1,428	10,290	11,718	588	4,434	5,022	694	3,706	4,400

Estimated (1961 land use conditions):	Precipitation	Ground water	Total
Harper Basin	200	1,600	1,800 acre-feet
Coyote Basin	200	1,400	1,600 acre-feet
Caves Basin	250	2,150	2,400 acre-feet

*Pumped ground water that is applied to crops.

<u>Urban-Suburban and Industry</u>. In the study area, because of the lack of historic urban and suburban land use surveys and the minor amounts of heavy industry in the basins, it was appropriate to estimate urban-suburban water use on the basis of a per capita use of water and population data.

The population of the study area is concentrated in the four major basins. Estimates of population in these basins from 1930 through 1960 are presented in Table 19 and are based on federal census surveys of 1950 and 1960, supplemented by information from earlier state reports. Detailed estimates of the population of the other three basins, Harper, Caves, and Coyote, are not available; however, they are sparsely settled areas and constitute approximately 2 percent of the total study area population.

TABLE 19

ESTIMATED POPULATION
1930 TO 1960

Year	Population				
	Mojave Basin			Lucerne Basin	Total
	Upper	Middle	Lower		
1930	2,650	2,300	1,100	150	6,200
40	3,250	1,550	3,800	200	8,800
50	8,400	4,100	9,750	450	22,700
60	25,000	8,100	18,300	1,600	53,000

The amount of applied, or delivered, water that is consumptively used by the population in the study area was determined from data in Department of Water Resources Bulletin No. 78, "Investigation of Alternative Aqueduct Systems to Serve Southern California", Appendix D, "Economic Demand for Imported Water", 1960. Based on information in the report, the average per capita applied water in the study area was estimated to have increased from about 130 gallons per capita per day at the start of the base period (1936-37) to 200 gallons per capita per day at the end (1960-61). The information in the report was also the basis for the assumption that 50 percent of the applied water is consumptively used.

The annual and average annual amounts of consumptive use of water during the base period by urban and suburban areas in the Upper Mojave, Middle Mojave, Lower Mojave, and Lucerne Basins are presented in Table 20.

Industrial use of water in the study area is by a railway maintenance yard, a steam power generating plant, and three cement plants.

TABLE 20

CONSUMPTIVE USE OF WATER BY URBAN AND SUBURBAN AREAS DURING THE BASE PERIOD

In acre-feet

Water year	Mojave River			Lucerne Basin
	Upper	Middle	Lower	
1936-37	200	100	250	--
38	200	100	250	--
39	250	100	250	--
40	250	100	300	50[a]
1940-41	300	150	350	--
42	350	150	400	--
43	400	200	450	--
44	450	200	500	--
45	500	250	550	100[b]
1945-46	550	250	650	--
47	600	300	700	--
48	650	300	750	--
49	700	350	850	--
50	800	400	900	200[b]
1950-51	850	400	950	50
52	950	450	1,050	50
53	1,050	450	1,100	50
54	1,150	500	1,150	50
55	1,250	500	1,200	100
1955-56	1,400	550	1,200	100
57	1,500	550	1,250	100
58	1,850	600	1,500	100
59	2,300	750	1,750	150
60	2,750	900	2,000	200
1960-61	2,950	900	2,050	200
25-year average	968	384	894	60

a. Four-year total.
b. Five-year total.

Water consumption by these industries was computed from records of metered pumping of wells and records of the amounts used in the industrial process. Where these records were not complete, additional data on water purchases and plant production (computed in terms of use of water per product) were also used for estimating the water consumption. Table 21 shows the amounts of consumptive use of water by industry.

Nonbeneficial Consumptive Use

Throughout most of the undeveloped portions of the study area, the consumptive use of water by native vegetation is assumed equal to the precipitation. However, vegetation along the banks of the Mojave River derives only a small part of its water supply from precipitation, but consumes large quantities of ground water that might be beneficially used by man if the vegetation were eliminated and controlled. Estimates of nonbeneficial consumptive use of water by this riparian native vegetation were based on the "Blaney-Criddle Method" applied to the acreages of the four classifications of riparian native vegetation considered in this study. These classifications are based on the Department's 1961 land use survey modified by field correlation. The classifications provide a direct means of determining an individual consumptive use value for each type of riparian native vegetation, as shown in Table 22.

As shown in Table 23, the acreages of riparian native vegetation were classified according to areal (surface) density and kind of plants, taking into account the areas of high ground water and minor areas of free water surfaces. The amounts in each basin were determined from aerial photos of the Mojave River area taken in 1929, 1939, and 1959.

TABLE 21

CONSUMPTIVE USE OF WATER BY INDUSTRY DURING THE BASE PERIOD

In acre-feet

Water Year	Upper Mojave Basin	Lower Mojave Basin	Lucerne Basin
1936-37	250	200	0
38	200	200	0
39	200	200	0
40	200	200	0
1940-41	300	200	0
42	350	200	0
43	250	200	0
44	250	200	0
45	250	200	0
1945-46	350	200	0
47	350	200	0
48	350	200	0
49	350	200	0
50	450	200	0
1950-51	500	200	0
52	550	200	0
53	550	200	0
54	650	200	0
55	1,250	200	0
1955-56	1,450	200	0
57	1,500	200	250
58	1,450	200	400
59	1,450	200	400
60	1,300	200	450
1960-61	1,400	700	500
25-year average	646	220	80

The 1929 photos were used for coverage along the river from the forks to the Lower Narrows near Victorville where 1939 photos were not available. The 1959 survey was considered to approximate conditions in 1961, the end of the base period for this study.

TABLE 22

AVERAGE ANNUAL UNIT CONSUMPTIVE USE VALUE OF RIPARIAN NATIVE VEGATATION

In acre-feet per acre

Classification of riparian native vegetation	Unit consumptive use value					
	Upper Mojave Basin			Middle and Lower Mojave Basin		
	Precipitation	Ground water	Total	Precipitation	Ground water	Total
Trees, 80 percent areal density or greater	0.4	4.7	5.1	0.3	5.1	5.4
Trees, 79 percent areal density or less	0.4	4.2	4.6	0.3	4.6	4.9
Brush and meadowland	0.4	2.9	3.3	0.3	3.2	3.5
Swamp	0.4	6.8	7.2	0.3	7.3	7.6

Table 23 shows the classifications of riparian native vegetation and the acreages of each in the Upper, Middle, and Lower Mojave Basins in 1960-61.

TABLE 23

AREAS DEVOTED TO
RIPARIAN NATIVE VEGETATION IN 1960-61

In acres

Classification of riparian native vegetation	Mojave Basin		
	Upper	Middle	Lower
Trees, 80 percent areal density or greater	1,790	170	1,010
Trees, 79 percent areal density or less	1,350	1,110	680
Brush and meadowland	1,320	70	180
Swamp	600	0	0

Utilizing the Blaney-Criddle method and the estimated acreage and assigned consumptive use coefficient for each classification of riparian native vegetation, the unit water use values and the amounts of consumptive use were determined for each year of the base period.

The annual and average annual amounts of consumptive use of precipitation and ground water by riparian native vegetation in the Upper, Middle, and Lower Mojave Basins during the base period, is shown on Table 24.

Estimated amounts of water use and disposal during the base period are presented in Table 25 for each of the main basins: Upper Mojave, Middle Mojave, Lower Mojave, and Lucerne. Estimates for the other three basins -- Harper, Coyote, and Caves -- are also indicated by footnote.

TABLE 24

CONSUMPTIVE USE OF WATER BY RIPARIAN NATIVE VEGETATION DURING THE BASE PERIOD

In acre-feet

Water year	Upper Mojave Basin			Middle Mojave Basin			Lower Mojave Basin		
	Precipitation	Ground water	Total	Precipitation	Ground water	Total	Precipitation	Ground water	Total
1936-37	3,100	20,450	23,550	500	7,300	7,800	750	11,250	12,000
38	2,900	20,850	23,750	600	7,300	7,900	800	11,200	12,000
39	2,500	21,500	24,000	750	7,200	7,950	1,100	10,900	12,000
40	2,000	22,200	24,200	600	7,400	8,000	800	11,200	12,000
1940-41	4,750	19,650	24,400	1,200	6,850	8,050	1,700	10,300	12,000
42	1,950	22,650	24,600	850	7,250	8,100	1,250	10,750	12,000
43	3,850	20,950	24,800	650	7,500	8,150	950	11,050	12,000
44	4,000	19,700	23,700	500	7,550	8,050	700	11,050	11,750
45	2,950	21,800	24,750	800	7,650	8,450	1,100	11,100	12,200
1945-46	1,750	23,350	25,100	200	8,550	8,750	250	12,300	12,550
47	2,050	23,100	25,150	100	8,500	8,600	150	12,100	12,250
48	1,750	22,600	24,350	150	8,050	8,200	150	11,500	11,650
49	2,850	21,500	24,350	500	7,400	7,900	700	10,450	11,150
50	1,000	24,100	25,100	300	7,850	8,150	400	11,250	11,650
1950-51	1,500	23,950	25,450	150	8,000	8,150	150	11,450	11,600
52	3,650	20,750	24,400	350	7,400	7,750	1,200	9,850	11,050
53	1,900	22,600	24,500	350	7,300	7,650	450	10,500	10,950
54	2,050	22,750	24,800	500	7,150	7,650	700	10,300	11,000
55	3,800	20,250	24,050	550	6,750	7,300	800	9,700	10,500
1955-56	1,700	22,750	24,450	450	6,800	7,250	650	9,800	10,450
57	1,700	23,200	24,900	150	7,000	7,150	200	10,100	10,300
58	3,000	21,250	24,250	900	6,100	7,000	1,300	8,800	10,100
59	1,000	23,950	24,950	200	6,850	7,050	250	9,950	10,200
60	1,400	23,500	24,900	350	6,550	6,900	500	9,450	9,950
1960-61	1,200	23,150	24,350	50	6,700	6,750	100	9,600	9,700
25-year average	2,412	22,100	24,512	468	7,318	7,786	684	10,636	11,320

Estimated (1961 land use conditions):	Precipitation	Ground water	Total
Caves Basin	negligible	1,150	1,150 acre-feet

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TABLE 25

ESTIMATED WATER USE AND DISPOSAL DURING THE BASE PERIOD

In acre-feet

Water year	Upper Mojave Basin				Middle Mojave Basin					Lower Mojave Basin				Lucerne Basin		
	Surface outflow	Subsurface outflow[a]	Consumptive use	Total	Surface outflow	Subsurface outflow[a]	Exported water	Consumptive use	Total	Surface outflow	Subsurface outflow[a]	Consumptive use	Total	Subsurface outflow[a]	Consumptive use	Total
1936-37	125,200	2,000	35,250	162,450	103,900	3,000	800	13,850	121,550	54,950	2,000	13,650	70,600	100	1,050	1,150
38	159,150	2,000	35,350	196,500	138,100	3,000	800	13,950	155,850	109,050	2,000	13,650	124,700	100	1,050	1,150
39	17,250	2,000	35,650	54,900	590	3,000	800	13,950	18,300	1,050	2,000	13,650	16,700	100	1,050	1,150
40	15,350	2,000	36,100	53,450	0	3,000	800	14,150	17,950	1,050	2,000	13,750	16,800	100	1,100	1,200
1940-41	118,950	2,000	36,800	157,750	96,000	3,000	800	14,450	114,250	50,550	2,000	13,800	66,350	100	1,050	1,150
42	13,700	2,000	37,550	53,250	100	3,000	800	14,650	18,550	1,050	2,000	13,900	16,950	100	1,050	1,150
43	104,700	2,000	38,050	144,750	91,000	3,000	800	15,000	109,800	48,050	2,000	14,000	64,050	100	1,050	1,150
44	60,300	2,000	37,450	99,750	36,250	3,000	800	15,100	55,150	8,800	2,000	13,850	24,650	100	1,050	1,150
45	39,500	2,000	39,200	80,700	22,100	3,000	800	15,900	41,800	5,650	2,000	14,450	22,100	100	1,150	1,250
1945-46	29,350	2,000	40,350	71,700	12,550	3,000	800	16,550	32,900	3,600	2,000	14,950	20,550	100	1,050	1,150
47	17,150	2,000	43,100	62,250	2,900	3,000	800	18,450	25,150	1,950	2,000	16,200	20,150	100	2,150	2,250
48	10,550	2,000	43,950	56,500	0	3,000	800	19,800	23,600	1,050	2,000	17,250	20,300	100	3,250	3,350
49	8,350	2,000	45,450	55,800	0	3,000	800	21,300	25,100	1,050	2,000	18,400	21,450	100	4,300	4,400
50	7,650	2,000	48,050	57,700	0	3,000	800	23,200	27,000	1,050	2,000	20,550	23,600	100	5,550	5,650
1950-51	7,200	2,000	50,050	59,250	0	3,000	800	24,950	28,750	1,050	2,000	22,050	25,100	100	6,450	6,550
52	35,200	2,000	50,700	87,900	12,550	3,000	800	24,450	40,800	3,600	2,000	23,150	28,750	100	7,550	7,650
53	7,850	2,000	50,200	60,050	0	3,000	800	24,350	28,150	1,000	2,000	22,650	25,650	100	7,850	7,950
54	13,500	2,000	49,900	65,400	0	3,000	800	24,200	28,000	950	2,000	21,750	24,700	100	7,900	8,000
55	8,150	2,000	50,100	60,250	0	3,000	800	23,850	27,650	900	2,000	20,200	23,100	100	8,100	8,200
1955-56	7,750	2,000	50,250	60,000	0	3,000	800	23,700	27,500	900	2,000	19,150	22,050	100	8,200	8,300
57	7,100	2,000	50,300	59,400	0	3,000	800	23,300	27,100	750	2,000	17,900	20,650	100	8,550	8,650
58	54,150	2,000	49,800	105,950	20,050	3,000	800	24,000	47,850	4,900	2,000	18,150	25,050	100	8,500	8,600
59	6,800	2,000	50,950	59,750	0	3,000	800	24,950	28,750	600	2,000	19,050	21,650	100	8,350	8,450
60	6,350	2,000	50,650	59,000	0	3,000	800	24,250	28,050	700	2,000	19,700	22,400	100	8,150	8,250
1960-61	6,300	2,000	50,400	58,700	0	3,000	800	24,800	28,600	650	2,000	20,600	23,250	100	8,000	8,100
25-year average	35,500	2,000	44,224	81,724	21,442	3,000	800	19,884	45,126	12,196	2,000	17,456	31,652	100	4,540	4,640

a. Estimated average annual outflow.

Estimated total use and disposal:
Harper Basin 1,800 acre-feet -- 1961 land use conditions.
Coyote Basin 1,600 acre-feet -- 1961 land use conditions.
Caves Basin 13,150 acre-feet (3,550 acre-feet -- 1961 land use conditions and 9,600 acre-feet, estimated average annual surface outflow at Afton)

Water Supply Surplus or Deficiency

A balance must exist between the sum of water entering and leaving the water-bearing portion of the study area and change in storage within that portion. A quantitative statement of this balance for any increment of time is provided by the equation of hydrologic equilibrium which, expressed in its general form, is:

$$\text{Inflow-Outflow} = \pm \text{ Change in Storage.}$$

In this report, the water-bearing area, from the base of the alluvium to and including the ground surface, is considered as the free body, as shown in Figure 6, and the equation of hydrologic equilibrium is expressed as:

Water Supply - Water Use and Disposal =
Water Supply Surplus or Deficiency.

Based on the water year as the increment of time, the annual water supply surplus or deficiency for each year of the 25-year base period was determined, using this equation.

In each of the four main basins, Upper Mojave, Middle Mojave, Lower Mojave, and Lucerne Basins, the total water supply during the base period was less than the total water use and disposal. In each basin, this resulted in a water supply deficiency which was met by using ground water in storage.

The amount of annual water supply, annual water use and disposal, and the resulting annual and accumulated deficiency during the base period for each basin is presented in Table 26. The accumulated deficiencies -- 179,950 acre-feet, 129,500 acre-feet, 133,450 acre-feet, and 72,400 acre-feet for the Upper Mojave, Middle Mojave, Lower Mojave, and Lucerne Basins -- represent the reduction in ground water in storage during the base period in each of these basins. The total water supply, use and disposal, and deficiency is shown in the following tabulation:

Basin	In acre-feet		
	Water Supply	Water Use and Disposal	Deficiency
Upper Mojave Basin	1,863,150	2,043,100	179,950
Middle Mojave Basin	998,650	1,128,150	129,500
Lower Mojave Basin	657,850	791,300	133,450
Lucerne Basin	43,600	116,000	72,400
Totals	3,563,250	4,078,550	515,300

Due to lack of complete data, it is not possible to compute comparable water supply, use and disposal amounts for the other three basins -- Harper, Coyote, and Caves. However, it is apparent from the limited information available that a water deficiency also existed in these basins during the base period, and that future development of these areas will require supplemental water.

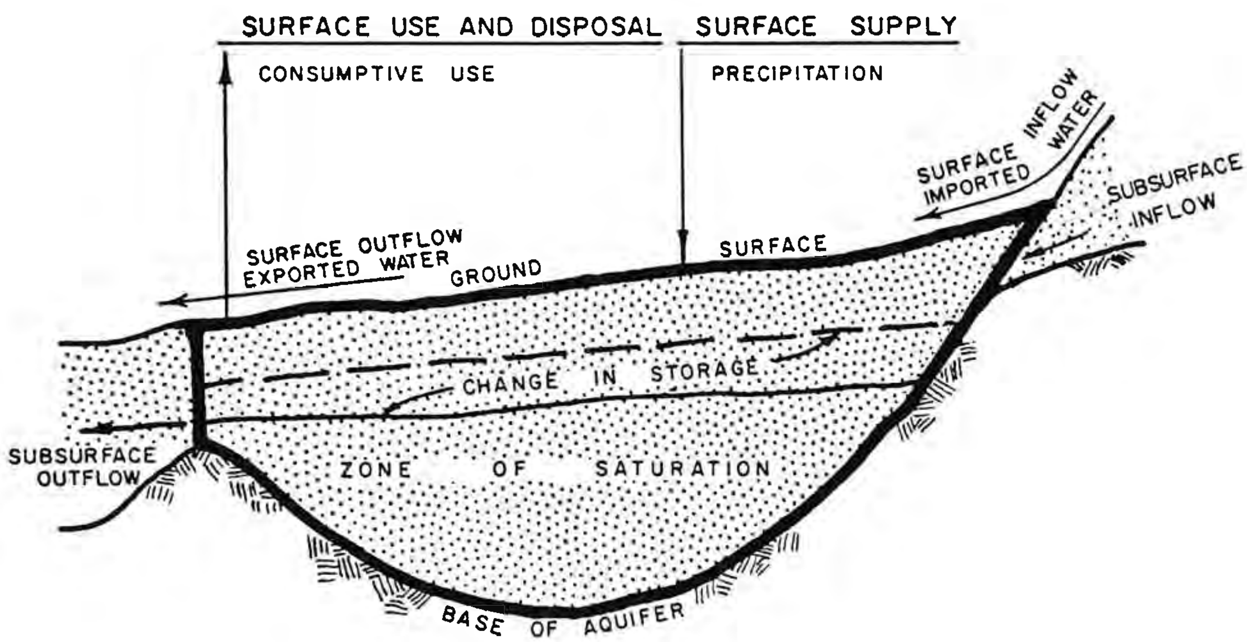

Fig. 6. THE GROUND WATER BASIN AS A FREE BODY

TABLE 26

ESTIMATED WATER SUPPLY, USE AND DISPOSAL, AND WATER SUPPLY SURPLUS OR DEFICIENCY DURING THE BASE PERIOD

In acre-feet

Water year	Upper Mojave Basin				Middle Mojave Basin				Lower Mojave Basin				Lucerne Basin			
	Water supply	Water use and disposal	Surplus or deficiency		Water supply	Water use and disposal	Surplus or deficiency		Water supply	Water use and disposal	Surplus or deficiency		Water supply	Water use and disposal	Surplus or deficiency	
			Annual	Accumulated			Annual	Accumulated			Annual	Accumulated			Annual	Accumulated
1936-37	183,300	162,450	20,850	20,850	129,000	121,550	7,450	7,450	108,400	70,600	37,800	37,800	1,200	1,150	50	50
38	232,100	196,500	35,600	56,450	163,050	155,850	7,200	14,650	142,650	124,700	17,950	55,750	1,200	1,150	50	100
39	48,550	54,900	- 6,350	50,100	21,300	18,300	3,000	17,650	5,400	16,700	-11,300	44,450	1,200	1,150	50	150
40	38,250	53,450	-15,200	34,900	19,250	17,950	1,300	18,950	4,550	16,800	-12,250	32,200	1,200	1,200		150
1940-41	203,600	157,750	45,850	80,750	123,500	114,250	9,250	28,200	101,450	66,350	35,100	67,300	1,200	1,150	50	200
42	,33,250	53,250	-20,000	60,750	17,900	18,550	- 650	27,550	5,100	16,950	-11,850	55,450	1,200	1,150	50	250
43	167,100	144,750	22,350	83,100	108,750	109,800	- 1,050	26,500	95,700	64,050	31,650	87,100	1,200	1,150	50	300
44	128,250	99,750	28,500	111,600	64,200	55,150	9,050	35,550	40,700	24,650	16,050	103,150	1,200	1,150	50	350
45	81,000	80,700	300	111,900	43,750	41,800	1,950	37,500	27,000	22,100	4,900	108,050	1,200	1,250	- 50	300
1945-46	62,150	71,700	- 9,550	102,350	33,050	32,900	150	37,650	16,600	20,550	- 3,950	104,100	1,200	1,150	50	350
47	59,000	62,250	- 3,250	99,100	20,950	25,150	- 4,200	33,450	7,000	20,150	-13,150	90,950	1,400	2,250	- 850	- 500
48	24,350	56,500	-32,150	66,950	14,600	23,600	- 9,000	24,450	4,300	20,300	-16,000	74,950	1,600	3,350	-1,750	- 2,250
49	35,350	55,800	-20,450	46,500	12,950	25,100	-12,150	12,300	5,050	21,450	-16,400	58,550	1,750	4,400	-2,650	- 4,900
50	23,000	57,700	-34,700	11,800	12,250	27,000	-14,750	- 2,450	4,900	23,600	-18,700	39,850	1,900	5,650	-3,750	- 8,650
1950-51	12,300	59,250	-46,950	- 35,150	11,850	28,750	-16,900	- 19,350	4,850	25,100	-20,250	19,600	2,050	6,550	-4,500	-13,150
52	126,400	87,900	38,500	3,350	40,050	40,800	- 750	- 20,100	18,600	28,750	-10,150	9,450	2,250	7,650	-5,400	-18,550
53	21,600	60,050	-38,450	- 35,100	12,700	28,150	-15,450	- 35,550	5,250	25,650	-20,400	- 10,950	2,300	7,950	-5,650	-24,200
54	68,200	65,400	2,800	- 32,300	18,450	28,000	- 9,550	- 45,100	5,400	24,700	-19,300	- 30,250	2,300	8,000	-5,700	-29,900
55	31,400	60,250	-28,850	- 61,150	13,150	27,650	-14,500	- 59,600	5,350	23,100	-17,750	- 48,000	2,300	8,200	-5,900	-35,800
1955-56	27,150	60,000	-32,850	- 94,000	12,650	27,500	-14,850	- 74,450	5,100	22,050	-16,950	- 64,950	2,350	8,300	-5,950	-41,750
57	31,800	59,400	-27,600	-121,600	11,650	27,100	-15,450	- 89,900	4,500	20,650	-16,150	- 81,100	2,350	8,650	-6,300	-48,050
58	168,700	105,950	62,750	- 58,850	59,550	47,850	11,700	- 78,200	25,700	25,050	650	- 80,450	2,300	8,600	-6,300	-54,350
59	28,200	59,750	-31,550	- 90,400	11,600	28,750	-17,150	- 95,350	4,650	21,650	-17,000	- 97,450	2,300	8,450	-6,150	-60,500
60	16,300	59,000	-42,700	-133,100	11,400	28,050	-16,650	-112,000	5,000	22,400	-17,400	-114,850	2,250	8,250	-6,000	-66,500
1960-61	11,850	58,700	-46,850	-179,950	11,100	28,600	-17,500	-129,500	4,650	23,250	-18,600	-133,450	2,200	8,100	-5,900	-72,400
25-year average	74,526	81,724			39,946	45,126			26,314	31,652			1,744	4,640		

CHAPTER IV. WATER QUALITY

Surface and ground waters contain dissolved minerals that vary in amount and composition. Surface water character is primarily dependent upon mineral composition of rocks within the upper source areas of a stream. As the stream proceeds to lower levels, the basic water character continues to be influenced by mineral characteristics of materials through which it flows and by secondary contributions of other water types from tributaries and rising ground water.

Concentrations of mineral constituents in ground water are influenced primarily by the quality and quantity of water which percolates to the ground water basin. The sources of this replenishment by percolation include surface flow, precipitation, sewage and industrial waste waters, and irrigation waters. Ground water quality is also influenced by the lithologic type and relative age of water-bearing materials; the hydrologic and geologic conditions that govern rates of ground water movement; well construction and destruction techniques; the season of the year; changes in water level elevations; and duration and rate of pumping prior to sampling of the ground water.

Regional and local correlation of the quality of extracted ground water is, therefore, dependent on the knowledge of geology, hydrology, well drilling practices, duration, and rates of ground water extractions and drawdowns, and water use. Such information is vital to the identification and comprehension of factors that produce water of dissimilar qualities from closely spaced wells, or water of similar quality from wells in widely separated regions within the study area.

In the vast and remote Mojave region, however, collection of adequate data is a major problem. Wells are scarce--in some areas, non-existent. There are few records of well construction or water production rates; for this reason, interpretation of conditions which produce waters of varying qualitites in the area can only be based on approximations.

From such records as are available, it is apparent that there is a wide variation in the mineral character and quality of ground water within the individual basins of the Mojave study area. The existence of marked differences of water quality in certain basins necessitated the grouping of individual water types into broader more general categories to facilitate description and discussion. This procedure resulted in the identification of some relatively consistent and distinct ground water quality characteristics within each basin. Moreover, these characteristics made it possible to identify those basin areas that were influenced by flows from the Mojave River and to locate restrictions to ground water movement.

As a general guide on the acceptability and use of various water supplies in the Mojave River region, water quality criteria are presented in Appendix D.

Sampling and Analyses

A regular water quality monitoring program in the area of investigation has been conducted by the Department since 1952 in cooperation with the San Bernardino County Flood Control District. Additional samples were taken during this investigation to confirm previous data. Samples

TABLE 27

MINERAL ANALYSES OF REPRESENTATIVE SURFACE WATERS

Constituent	Heath Canyon-tributary to Sheep Creek Sec.9 T3N/R7W		Mojave River: West Fork (floodflow) Sec.32 T3N/R4W		The Forks Sec.18 T3N/R3W		Victorville Sec.29 T6N/R4W		Helendale Sec.31 T8N/R4W		Barstow (floodflow) Sec.31 T10N/R1W		Barstow Sec.31 T10N/R1W		Harvard Crossing (floodflow) Sec.34 T10N/R3E		Afton Canyon Sec.18 T11N/R6E	
	epm[a]	ppm[b]	epm	ppm	epm	ppm	epm	ppm	epm	ppm	epm	ppm	epm	ppm	epm	ppm	epm	ppm
Ca	2.37	47	1.00	20	1.05	21	2.15	43	2.30	46	1.24	25	1.63	33	2.19	44	1.20	24
Mg	0.47	6.0	0.41	5	0.33	4	0.75	9	0.74	9	0.44	5	0.34	4	0.77	9	0.30	4
Na	0.15	3.0	0.39	9	1.22	28	1.83	42	2.39	55	0.64	15	2.93	68	4.26	98	12.65	291
K	0.16	6.4	0.08	3	0.05	2	0.08	3	0.118	4.6	0.046	1.9	0.25	9.6	0.02	0.8	0.26	10.2
CO_3	0	0	0	0	0	0	0	0	0.32	10	0	0	0	0	0	0	0.80	24
HCO_3	1.45	88	1.19	73	1.69	103	3.18	194	3.24	198	1.30	79	3.48	212	4.59	280	6.60	403
Cl	0	0	0.17	6	0.37	13	0.79	28	0.87	31	0.28	10	0.73	26	1.30	46	4.65	165
SO_4	1.68	81	0.32	15	0.55	26	0.83	40	1.02	49	0.70	33.6	0.94	45	1.42	68	2.55	122
NO_3	0	0	0.13	8	0.02	1	0.05	3	0.029	1.8	0.03	1.63	0.04	1.54	0.032	2.0	0.09	5.6
F	0.02	0.4	0.02	0.4	0.09	1.8	0.03	0.6	0.041	0.78			0.021	0.40		0.16	0.04	0.8
Boron		0		0.07						0.145		0.20		0.40				1.12
Silica		4.0										26		5				64
TDS[c] by Evaporation	262		132		171		283		310		139		293		455		916	
Percent Na	48		21		46		38		43		27		57		59		88	
Total hardness	142		71		68		145		153		84		99		148		75	
Sampled by[d]	DWR		DWR		DWR		DWR		SBCFCD		DWR		DWR		SBCFCD		DWR	
Data sampled	3/28/63		4/2/65		2/5/65		2/5/65		2/4/64		4/4/58		8/28/58		3/27/58		10/25/61	
Discharge (cfs)	3		135		18		31				1500		40				1.5	
Temperature	45° F.		46° F.		50° F.		51° F.				50° F.						57° F.	
pH	7.5		7.2		7.6		8.0		8.1		7.6		7.1		7.6		8.5	
$EC \times 10^6$	320		194		272		476		493		216		484		700		1520	

a. Chemical equivalents per million.
b. Parts per million by weight.
c. Total dissolved solids.
d. SBCFCD-San Bernardino County Flood Control District; DWR-Department of Water Resources

were also drawn from wells in areas not previously covered by the monitoring program. Another major source of water quality data was information compiled by the United States Geological Survey, and published by the Department of Water Resources in the Bulletin 91 series. In addition, useful information was obtained from the Department's Bulletin No. 106-1, "Ground Water, Occurrence and Quality, Lahontan Region", June 1964.

Representative analyses of surface water within the individual basins are presented in Table 27. Ground water analyses are presented in Table 28.

Mineral Character and Quality of Surface and Ground Water

The mineral character and quality of water in the study area depends upon the geologic composition of the study area, the movement and occurrence of surface and ground waters, and the use of these waters. Surface and ground waters exhibit several distinct types of mineral character and ranges of total dissolved solids.

Surface Water

Available mineral analyses depicting surface water character and quality within the study area are primarily confined to the flows of the Mojave River, the main source of water supply to the region. Average of all data shows that storm flow of the Mojave River is primarily calcium bicarbonate in character and has less than

TABLE 28

MINERAL ANALYSES OF REPRESENTATIVE GROUND WATERS FROM WELLS

Constituent	Lucerne Basin						Upper Mojave Basin						Middle Mojave Basin					
	South of Lucerne Lake 4N,1W-1P		Lucerne Valley 5N/1W-29R2		Near Fifteenmile Valley 4N/2W-20K1		Near Apple Valley 4N/3W-23D1		Apple Valley 5N/3W-33R1		Near Adelanto 6N/5W-9B1		Stoddard Valley 7N/1W-9E1		Near Helendale 8N/4W-30E1		Hinkley Valley 10N/3W-23H4	
	epm[a]	ppm[b]	epm	ppm	epm	ppm	epm	ppm	epm	ppm	epm	ppm	epm	ppm	epm	ppm	epm	ppm
Ca	3.52	70	2.77	55	2.40	48	6.14	123	2.54	51	0.41	8.2	1.59	32	4.20	84	0.66	13
Mg	4.82	59	1.22	15	1.34	16	1.00	12	1.24	15	0.18	2.2	0.59	7.2	0.52	6.3	0.06	0.7
Na	2.05	47	27.43	631	1.87	43	8.44	194	2.83	65	5.00	115	1.95	45	10.43	240	5.20	120
K	0.06	2.3	0.10	4.0	0.06	2.5	0.14	5.4	0.06	2.4	0.02	0.8	0.05	1.9	0.09	3.5	0.03	1.3
CO_3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HCO_3	2.50	152	3.20	195	2.36	144	0.66	40	2.35	143	2.83	173	2.28	139	2.81	172	4.50	274
SO_4	4.73	227	11.60	557	1.87	90	13.93	668	2.82	135	2.36	113	0.86	41	4.85	233	0.71	34
Cl	3.01	106	16.00	567	1.16	41	1.18	42	1.32	47	0.19	6.8	0.77	27	7.57	269	0.70	25
NO_3	0.39	24	0.16	10	0.06	3.8	0.02	1.2	0.06	3.6	0.02	1.3	0.12	7.3	0.01	0.5	0.02	1.4
F	0.01	0.2	0.20	4.0	0.13	2.4	0.17	3.3	0.04	0.8	0.06	1.2	0.06	1.2	0.02	0.4	0.08	1.6
Boron		0.08		1.2		0.09		1.90		0.46		0.27		0.20		0.52		1.62
Silica		18		32		31		30		23		15		24		24		25
TDS[c] by Evaporation	732		1,934		305		1,105		412		342		252		924		346	
Percent Na	20		87		33		54		42		89		47		69		88	
Total hareness	417		200		187		357		189		30		109		236		36	
Sampled by[d]	DWR		DWR		DWR		DWR		DWR		DWR		DWR		DWR		DWR	
Date sampled	8/23/63		7/17/63		6/13/63		6/14/63		3/28/63		1/10/64		4/27/64		1/22/64		1/8/64	
Temperature	68° F.										68° F.				74° F.		68° F.	
pH	7.6		7.6		7.8		8.1		7.9		7.9		8.0		7.6		8.2	
EC x 10^6	990		3,000		557		1,529		650		550		400		1,460		570	

a. Chemical equivalents per million.
b. Parts per million by weight.
c. Total dissolved solids.
d. DWR-Department of Water Resources.

MINERAL ANALYSES OF REPRESENTATIVE GROUND WATERS FROM WELLS
(continued)

Constituent	Harper Basin						Lower Mojave Basin						Coyote Basin		Caves Basin	
	South of Harper Lake 11N/4W-33G1		Northwest of Harper Lake 32S/43E-28K1		Near Lockhart 11N/4W-30N2		West of Yermo 10N/1E-33P1		Near Toomey 10N/2E-25P1		South of Troy Lake 8N/4E-7E1		near Coyote Lake 12N/2E-32G1		near Harvard 10N/3E-14J1	
	epm[a]	ppm[b]	epm	ppm	epm	ppm	epm	ppm	epm	ppm	epm	ppm	epm	ppm	epm	ppm
Ca	1.30	26	1.70	34	3.49	70	1.75	35	1.13	23	0.49	9.9	1.88	38	2.62	52
Mg	0.20	2	0.60	7	0.83	10	0.43	5	0.80	10	0.53	6.4	0.46	5.6	0.68	9
Na	10.70	246	8.75	201	15.60	359	2.97	68	3.17	73	5.35	123	10.65	245	3.60	83
K	0.12	5	0.13	5	0.20	8	0.06	2	0.03	1	0.11	4.4	0.06	2.5	0.03	1
CO_3	0	0	0	0	0	0	0	0	0.32	10	0.40	12	0	0	0	0
HCO_3	2.45	211	1.15	70	3.36	205	2.48	151	2.92	178	3.15	192	1.86	114	2.44	148
SO_4	3.74	180	6.89	331	5.60	269	1.19	57	0.97	46	1.19	57	5.47	262	1.57	75
Cl	6.00	213	3.00	106	10.69	379	1.41	50	0.90	32	1.35	48	5.73	203	2.71	96
NO_3	0.18	11	0.09	5.6	0.06	4	0.02	1	0	0	0.01	0.7	0	0	0.03	2
F	0.043	0.8	0.060	1.1		1.8	0.03	0.5	0.01	0.2	0.10	1.90	0.10	2.0	0.03	0.6
Boron		0.32		1.73				1.4		0.29		1.0		0.82		0.46
Silica		60		24										28		
TDS[c] by Evaporation		804		763		1,221		301		296		426		848		402

	South of Harper Lake	Northwest of Harper Lake	Near Lockhart	West of Yermo	Near Toomey	South of Troy Lake	near Coyote Lake	near Harvard
Percent Na	87	79	78	57	62	82.6	82	52
Total hardness	75	115	216	109	96	51	117	165
Sampled by[d]	DWR	DWR	DWR	DWR	DWR	SBCFCD	DWR	DWR
Date sampled	7/25/61	7/25/61	4/7/65	4/6/65	6/24/64	4/22/64	4/29/64	6/24/64
Temperature	78° F.	78° F.					67° F.	78° F.
pH	7.7	8.0	7.7	8.0	8.5	8.3	8.0	7.9
EC x 10^6	1,315	1,205	2,076	533	475	61.35	1,220	670

a. Chemical equivalents per million.
b. Parts per million by weight.
c. Total dissolved solids
d. DWR-Department of Water Resources; SBCFCD-San Bernardino County Flood Control District.

400 parts per million (ppm) total dissolved solids (TDS) before it percolates into the ground water basins of the region. Mineral analyses of samples of ground water rising to the stream channel at Victorville indicate that the rising water is higher in TDS, about 300 ppm, and has a larger percent of sodium than its source of replenishment, the storm flow of the Mojave River. At Afton, where rising water maintains a perennial stream, the water character is primarily sodium bicarbonate-chloride and is significantly poorer in quality than the rising water at Victorville. At Afton, the total dissolved solids were about 900 ppm in 1962.

Ground Water

The classification of ground water quality is based upon water samples obtained from pumped wells. For study purposes, the quality of ground water in the study area was grouped into four broad, general water types. The first type is generally relatively low in total dissolved solids, with calcium, sodium, or a combination of the two being the major dissolved cation, and bicarbonate the major dissolved anion constituent. A second general type contains a relatively high total dissolved solids content that is either sodium, calcium sulfate, or sodium or calcium sulfate-chloride in character. A third distinct type is high in total dissolved solids and is either sodium chloride or sodium-calcium chloride in character. A fourth general type has a relatively high total dissolved solid content and consists of a mixture of bicarbonate-sulfate water or bicarbonate-chloride water with either sodium, calcium, or a combination of both as the predominant cation.

For illustrative purposes, and for more detail, 13 distinct ground water types have been identified and are shown on Plate 6, "**Water Quality Conditions". These are the results of selective data reduction** and condensation of the wide range of water type variations which are present in the study area. Each of these 13 types, however, falls into at least one of the four broad categories previously outlined, which are discussed in detail in the following paragraphs:

Bicarbonate Ground Water. Ground water within the area influenced by surface waters of the Mojave River is predominantly bicarbonate in character, with the dominant cations being either sodium, calcium, or a mixture of sodium and calcium. The bicarbonate characteristic of the ground water is believed to be derived from runoff from the bordering granitic rocks that occur in the San Bernardino Mountains to the south. Ion exchange within the area influenced by percolating stream waters is indicated by the change from a predominantly calcium bicarbonate character in the Upper Mojave Basin to a predominantly sodium bicarbonate character downstream in the Middle and Lower Mojave Basins. This ion exchange phenomena is believed to occur between water and clay within the water-bearing materials.

A magnesium bicarbonate type water occurs in the southern portion of Lucerne Basin adjacent to the Helendale fault. The magnesium cation is derived principally from dolomitic limestone outcrops that occur in the mountains to the south and from dolomitic limestone detritus that is contained in the sediments.

Mineral analyses indicate that for the study area as a whole, the average total dissolved solids (TDS) content of the bicarbonate type ground water is approximately 300 parts per million (ppm), although the range of TDS is from 90 to 2,000 ppm. Fluoride concentrations found in bicarbonate type ground water throughout the study area are commonly less than 1 ppm; however, a few isolated wells at scattered locations in the Middle Mojave Basin have revealed fluoride concentrations up to 4.0 ppm. Mineral analyses also indicate that the boron content in the area as a whole is commonly less than 1 ppm; however, excessive boron concentrations have been recorded in a few isolated wells, predominately in areas where wells have penetrated older sediments. This penetration allows a mixing between poorer quality water from the older sediments and better quality water from the younger sediments.

Sulfate and Sulfate-Chloride Ground Water. In areas where there is a predominance of older alluvium (particularly older alluvium whose source rocks include the Tertiary sedimentary deposits) or where portions of the ground water basin receive very little recharge and have only a slight amount of ground water movement, ground water typically has a sulfate or sulfate-chloride anion content. The dominant cation is usually sodium, although calcium occurs occasionally as the dominant cation constituent. In addition, where the ground water basins are intersected by or closely related to faults, ground water is dominantly sodium-calcium sulfate in character and usually has a relatively high total dissolved solids concentration. Total dissolved solids content in the area's sulfate or sulfate-chloride type water ranges from 200 to more than 3,000 parts per million (ppm), although it is typically 700 to 1,000 ppm.

Mineral analysis of ground water extracted from one well in the extreme southwest portion of Harper Basin, in a structural wedge southwest of the Lockhart fault and northeast of the Helendale fault, revealed a TDS concentration of nearly 15,000 ppm and a water character of sodium sulfate-chloride. This concentration and water type, together with the proximity to the Helendale fault and the evidence of very little recharge and ground water movement in the immediate area, lend credence to the assumption that ground water in this particular locale is connate water and has probably been virtually static since entrapment. However, this condition could also result from meteoric water that has been concentrated by evaporation. Phenomenon of this sort presumably exists in other areas within the basins; however, the lack of adequate well data renders it impossible to determine the extent and frequency of the condition.

Analyses also indicate that the concentration of fluoride in the sulfate or sulfate-chloride type ground water ranges from less than 1 part per million to almost 4.0 ppm; the average fluoride content ranges between 1 and 2 ppm. Boron concentrations are typically between 1 and 2 ppm in Upper Mojave and Lucerne Basins; however, the downstream basins contain water that has a boron content that is commonly greater than 2 ppm. In one particular area in Harper Basin, it ranges from 0 up to 35 ppm.

Sodium Chloride Ground Water. The third general ground water type present in the area of investigation contains sodium as the dominant cation and chloride as the dominant anion. Calcium occasionally occurs with sodium in nearly equal concentrations; however, predominance of this condition is limited to the Lower Mojave Basin in an area directly northwest of Troy Dry Lake. Examples of modifications in water type resulting from significant amounts of the sulfate ion are also found in the study area. Such modifications are rare and are prevalent in only one small area of Lucerne Basin.

Sodium chloride type ground water occurs consistently in the study area, being typically present in the fine-grained playa deposits found at lower elevations of the basins and in the older lake deposits. The total dissolved solids content ranges from 380 ppm to more than 5,300 ppm; the average is approximately 1,200 ppm.

Fluoride and boron concentrations are commonly between 1 and 2 ppm. However, in the Middle Mojave Basin, fluoride content frequently ranges from 4 to 8 ppm; boron, from 4.9 to 10 ppm. In the Harper Basin these ranges are: fluoride, 0.5 to 1.6 ppm; and boron, 0.32 to 8.7 ppm.

Ground Water of More Than One Type. Ground water, in which two or more of the four major water types are present, is pumped in some isolated places in the study area. This condition, which has also been observed during investigations of other regions, indicates that ground water quality types may be related to the formations in which they occur, rather than to areal distribution. In the Mojave region, for example, where older alluvium is overlain by channel deposits of the Mojave River, a well penetrating both of these formations would yield a combination of bicarbonate water from the channel deposits and sulfate water from the underlying alluvium. This appears to be one explanation for the combinations of water types that are pumped in some areas.

Total dissolved solids concentrations of these combined water types tend to be moderately high, in the 600 to 900 ppm range, while the fluoride and boron content varies from 0 to 1 ppm from basin to basin. There are very few instances where fluoride and boron reach a high level of concentration in these waters. In the Barstow-Daggett area, however, well log data indicate that some water wells penetrate volcanic material, which is known to contribute significant amounts of boron and increased mineral content to the water.

Changes in Ground Water Character and Quality. It is difficult to trace any distinct trend in ground water character and quality because of the lack of historical data in the major portion of the study area. In general, available data indicate that the character and quality of water in and adjacent to the downstream reaches of the Mojave River have declined. At Afton, the total dissolved solids content has increased from about 650 ppm in 1950 to about 900 ppm in 1962. The mineral character of ground water has also changed in various areas of the basins. In some of these areas, domestic and agricultural uses have increased the total dissolved solids content by 300 to 1,000 ppm. Along the Mojave River, ground water impairment may be attributed to waste waters derived from man's agricultural, urban and suburban, and industrial activities. The natural recycling of these "used" waters to and from the ground water basin reservoir, slowly but continually increases the total dissolved solids concentration, thereby decreasing the water quality. The change in ground water characteristics may also reflect types of water encountered in the various water-bearing formations as the ground water levels throughout the basins declined.

In addition, the sources of water supply are continually adding salts to the basins that far exceed the amounts removed by water disposal. A limited study of the amount of salts added to the water-bearing portion of the study area shows that water supply contributed an average of 21,000 tons of salts during the base period, 1936-37 through 1960-61, and that water disposal by surface outflow removed an average of 3,000 tons of salts. With man's activities in the basins contributing an additional average of 4,000 tons of salt during the base period, an adverse salt balance, or accumulation of salts, at the rate of 22,000 tons per year exists in the basin.

At present, there are only scattered areas in the basin where water quality is a problem because of the undesirable character and high TDS of the water. A more comprehensive study may be needed in the future to provide specific information on the water quality conditions in the Mojave River area.

CHAPTER V. GROUND WATER STORAGE, OVERDRAFT, AND SAFE YIELD

The ground water basins, or water-bearing portions, of the study area contain millions of acre-feet of storage space. These provide for natural regulation of the water supply, use, and disposal. During periods of heavy precipitation, when there is a surplus of water supply, water levels rise and ground water in storage increases. However, in dry periods, the deficiency in water supply is met by extraction and use of ground water, which in time lowers water levels and decreases the amount of ground water in storage.

Ground Water Storage

The ground water in storage in each basin of the study area is many times greater than the average annual water supply to the basin. These natural reservoirs are the primary water resource in the study area. Most of the wells that pump ground water are located along the river and in adjacent valleys where, historically, there has been a readily available supply of ground water. Generally, as the distance from the river increases, the depth at which ground water occurs also increases. Thus, although there are vast amounts of ground water in storage, only limited use has been made of this water resource.

For studies on ground water storage, some of the ground water basins were subdivided into smaller units, on the basis that geologic faults and alluvial constrictions limit the movement of ground water from one portion of the basin to another. These limited areas of the basins are referred to as storage units. These storage units were used in computing the ground water storage capacity and the change in storage for each basin discussed here. The storage units are shown on Figure 7.

Storage Capacity

For the basins in the study area, the storage capacity is defined as the amount of storage space between the ground surface and the 1961 water levels. The ground water in storage is considered to be the amount contained in the zone between the 1961 water levels and the base of the water-bearing materials. Plate 7, "Ground Water Level Contours, 1961", shows the ground water levels at the end of the base period. The most recent water levels for this study are shown on Plate 8, "Ground Water Level Contours, Spring 1964".

Although the base of the water-bearing materials in the study area was not well known, estimates were made, based primarily on well logs that extend to the nonwater-bearing materials, and on gravity surveys conducted by the United States Geological Survey. Materials were considered to be water-bearing if they produced a minimum yield of 50 gallons per minute. This limit was assumed to provide a reasonable estimate of the base of the water-bearing materials, which lie at great depths and are generally considered to be too consolidated to yield water readily. Estimates of the elevation of the base of the water-bearing materials are shown on Plate 4.

The total thickness of the water-bearing materials from the ground surface to the base of these materials ranges from a foot at its contact with nonwater-bearing crystalline rock to over 1,000 feet near Phelan, with an average total thickness of about 300 feet for the

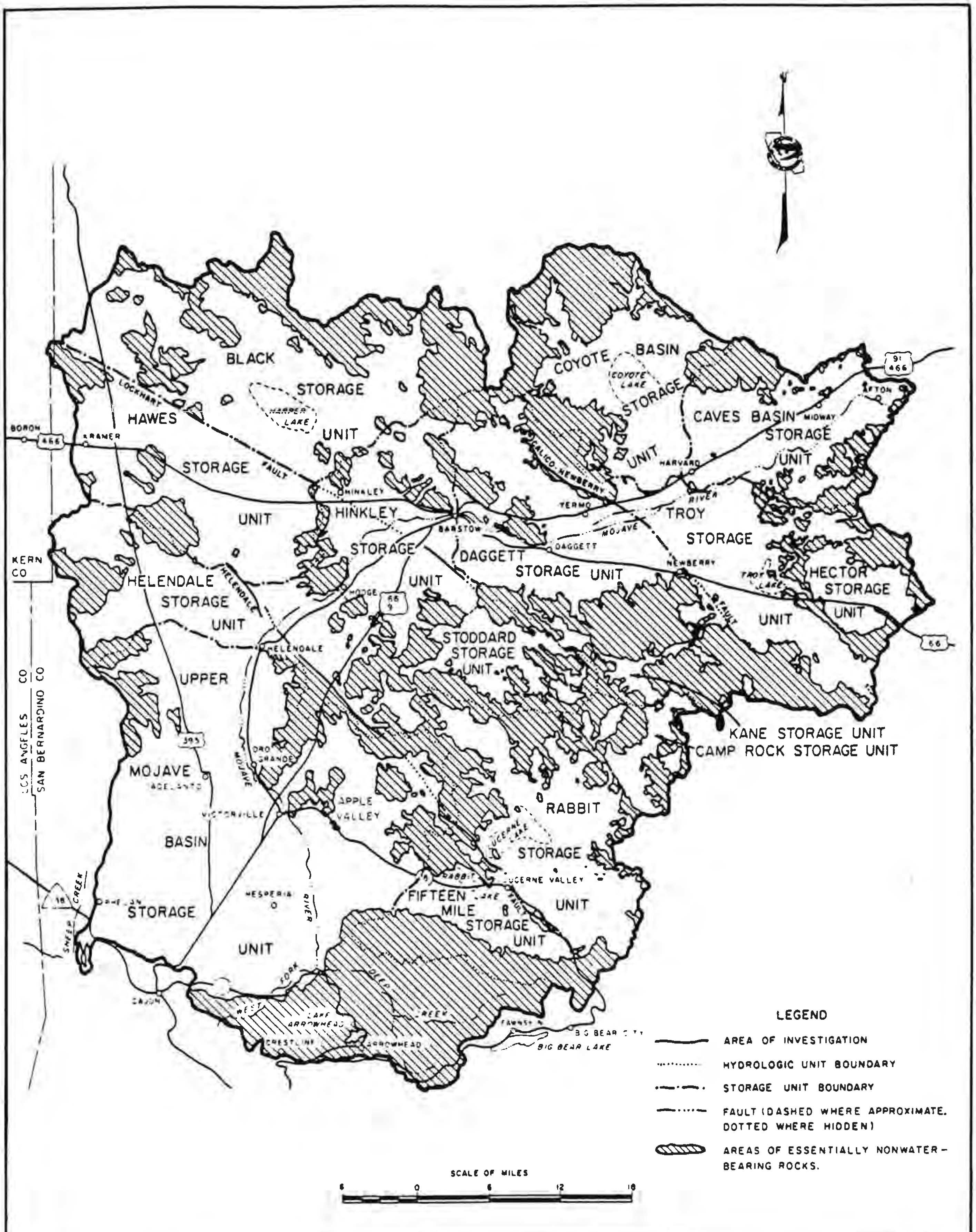

FIGURE 7 - GROUND WATER STORAGE UNITS

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alluviated portion of the study area. Overall, the average saturated thickness, based on the 1961 water levels, is approximately 230 feet. For the portion of the basins that receive surface and/or subsurface inflow from the Mojave River, the average saturated thickness, based on the 1961 water levels, is approximately 275 feet, in an average total thickness of 360 feet. In general, as the distance from the river increases the average saturated thickness becomes smaller in proportion to the total thickness of the water-bearing materials.

To estimate the volume of water stored in the interstices within the water-bearing sediments, the volume of sediments is multiplied by its specific yield value. The specific yield of water-bearing materials is defined as the ratio of the volume of water that saturated materials will yield by gravity drainage over a period of time to the total volume of the saturated materials, prior to draining; it is usually expressed as a percent. Specific yield values of these materials, as described in water well driller's logs, were determined in a cooperative study by the Department and the United States Geologic Survey. Specific yield values and representative driller's terms are presented in Appendix E. These values range from 3 to 35 percent.

The average specific yield from the ground surface to the base of the water-bearing materials varies according to the lithologic composition of the materials, resulting in a wide range (4 to 25 percent) and wide distribution of the average specific yield values in the study area. In those portions of the basins in which surface and/or subsurface inflow from the Mojave River constitutes the most important source of ground water supply, the average specific yield was found to be 14 percent.

The average specific yield for the other areas was estimated to be about 10 percent.

The storage capacity of each basin and storage unit is shown in Table 29. As presented in the table, total storage capacity consists of available storage space and the ground water in storage, in relation to the 1961 water levels.

TABLE 29

ESTIMATED GROUND WATER STORAGE CAPACITY, AVAILABLE STORAGE, AND GROUND WATER IN STORAGE

In acre-feet

Basin	Total storage capacity		Available storage space, above 1961 water levels		Ground water in storage, below 1961 water levels	
Upper Mojave		26,532,000		8,212,000		18,320,000
Middle Mojave						
Helendale storage unit	5,649,000		1,907,000		3,742,000	
Hinkley storage unit	1,792,000		936,000		856,000	
Stoddard storage unit	607,000	8,048,000	174,000	3,017,000	433,000	5,031,000
Lower Mojave						
Daggett storage unit	3,919,000		1,465,000		2,454,000	
Troy storage unit	4,035,000		973,000		3,062,000	
Hector storage unit	643,000		575,000		68,000	
Kane storage unit	105,000	8,702,000	53,000	3,066,000	52,000	5,636,000
Lucerne						
Fifteen Mile storage unit	1,307,000		792,000		515,000	
Rabbit storage unit	2,861,000		1,463,000		1,398,000	
Camp Rock storage unit	568,000	4,736,000	328,000	2,583,000	240,000	2,153,000
TOTAL		48,018,000		16,878,000		31,140,000
Harper						
Black storage unit	3,791,000					
Hawes storage unit	3,184,000	6,975,000		*		*
Coyote		7,530,000		*		*
Caves		4,152,000		*		*

* Data not available.

Change in Storage

Change in the amount of ground water in storage over a specified period is reflected by the change in ground water levels. One method to compute changes in storage is by use of the equation of hydrologic equilibrium (Inflow-Outflow = ± change in storage). Storage changes during the base period using this method are shown in Table 26 as water supply surplus or deficiency.

The change in storage during the base period was also determined by use of the Specific Yield Method:

(Specific yield value) x (thickness of saturated water-bearing materials) x (area) = ground water in storage.

The results of this computation substantiate the results obtained by the use of the hydrologic equation. The amounts of surplus and deficiency computed by the Specific Yield Method are shown in Table 30.

TABLE 30

ESTIMATED CHANGE IN AMOUNTS OF GROUND WATER IN STORAGE DURING THE BASE PERIOD

In acre-feet

Basin	Ground water in storage					
	Below 1936 water levels		Below 1961 water levels		Change in 25-years	
Upper Mojave		18,506,000		18,320,000		-186,000
Middle Mojave						
Helendale storage unit	3,772,000		3,742,000		30,000	
Hinkley storage unit	952,000		856,000		96,000	
Stoddard storage unit	433,000		433,000		0	
		5,157,000		5,031,000		-126,000
Lower Mojave						
Daggett storage unit	2,522,000		2,454,000		68,000	
Troy storage unit	3,124,000		3,062,000		62,000	
Hector storage unit	68,000		68,000		0	
Kane storage unit	52,000		52,000		0	
		5,766,000		5,636,000		-130,000
Lucerne						
Fifteen Mile storage unit	516,000		515,000		1,000	
Rabbit storage unit	1,477,000		1,398,000		79,000	
Camp Rock storage unit	240,000		240,000		0	
		2,233,000		2,153,000		- 80,000

When the annual amounts of water supply surplus or deficiency from Table 26 are accumulated and plotted, as shown on Figure 8, "Cumulative Water Supply Surplus or Deficiency", the general trend corresponds to the hydrographs of the wells numbers 4N/3W-18E1, 10N/2W-19P1, and 9N/1E-13E2 shown on Figure 9, "Hydrographs of Ground Water at Representative Wells". These wells are in areas where substantial changes in storage have occurred. Figure 9 also shows hydrographs of wells in outlying areas, where a smaller reduction in storage occurred during the base period.

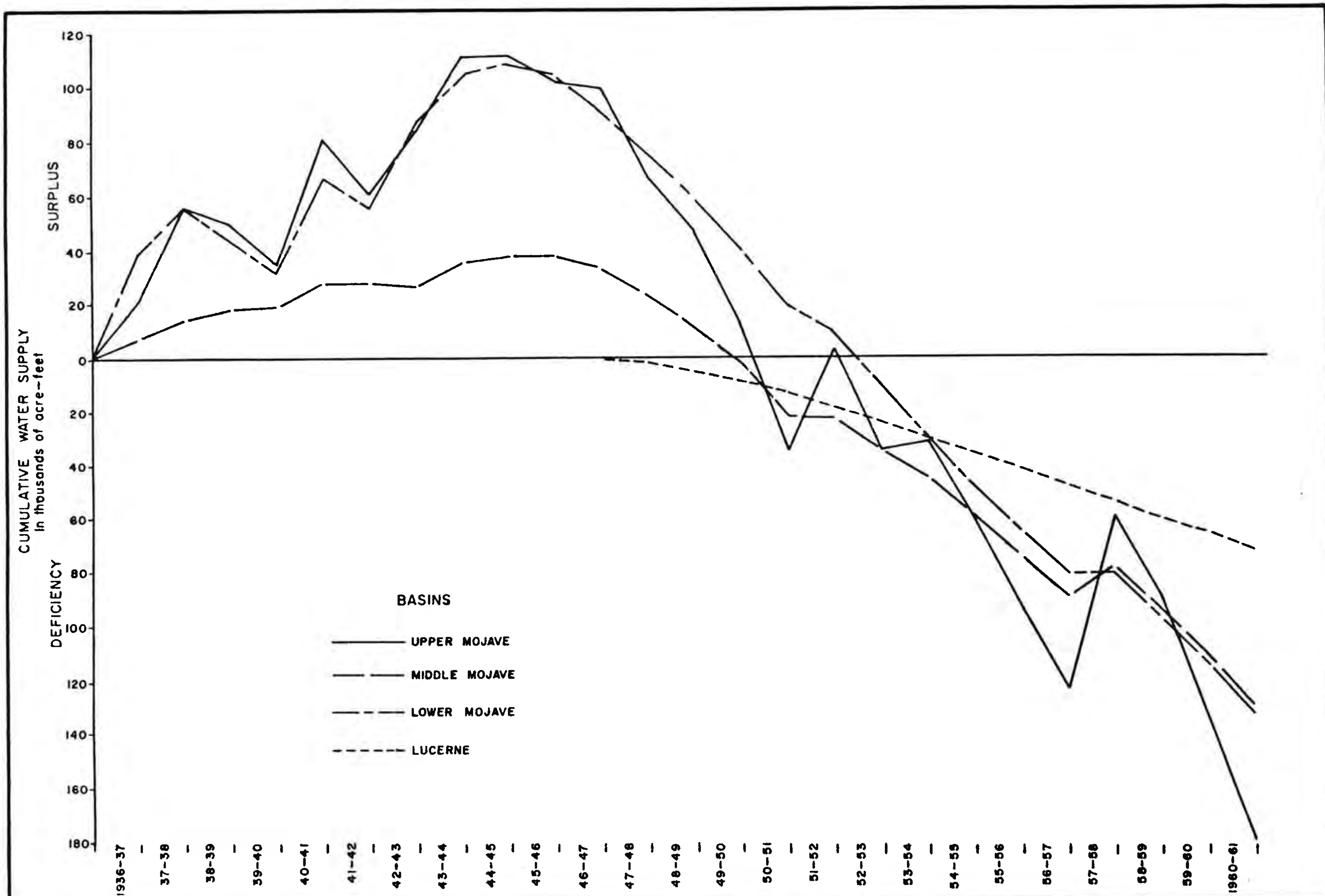

Fig. 8. CUMULATIVE WATER SUPPLY SURPLUS OR DEFICIENCY

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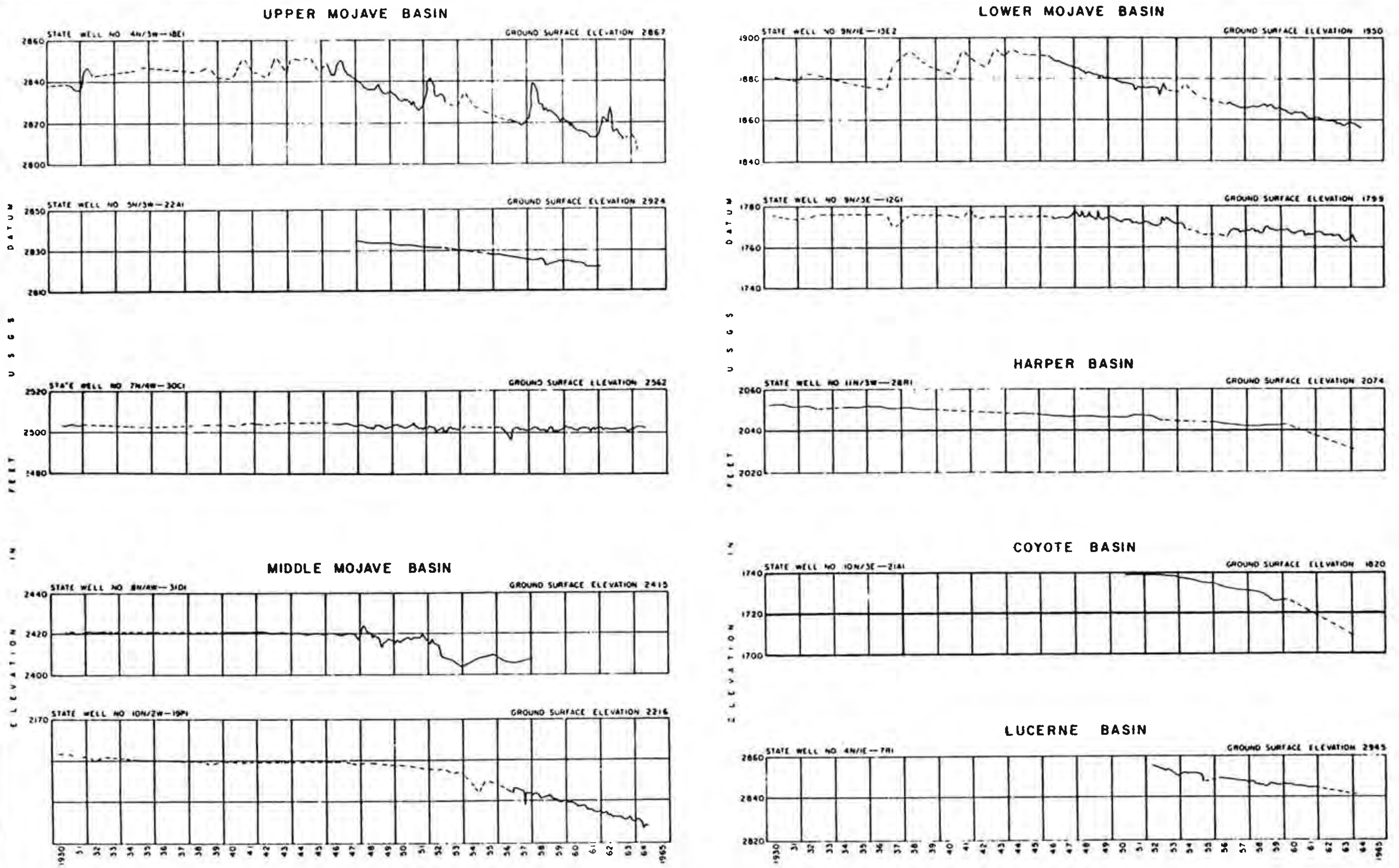

Figure 9. HYDROGRAPHS OF GROUND WATER AT REPRESENTATIVE WELLS

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Comparison of the two figures shows that, in general, water levels in the study area increased from 1936-37 to about 1945, but decreased from 1945 to 1961, the end of the study base period. This trend has continued to 1966. The distribution and amounts of pumping in the basins in 1961 is shown in Table 31.

TABLE 31

PUMPAGE OF GROUND WATER IN 1961*

In acre-feet

Basin	Pumpage	
Upper Mojave		
San Bernardino Mountains to Upper Narrows	33,737	
Upper to Lower Narrows	4,291	
Lower Narrows to Helendale	14,173	
		52,201
Middle Mojave		
Helendale to Hodge	9,111	
Hodge to Barstow	17,264	
		26,375
Lower Mojave		
Barstow to Daggett	4,698	
Daggett to Calico-Newberry fault	9,208	
East of Calico-Newberry fault	5,963	
		19,869
Lucerne		
Southwest of Helendale fault	667	
Northeast of Helendale fault	9,876	
		10,543
TOTAL		108,988

Estimated:	Harper	1
	Coyote	5,601
	Caves	2,861

*The amounts of pumpage were estimated from State Water Rights Board's records. However, currently a detailed verification of pumpage is being made by the Mojave Water Agency. Preliminary figures from this determination indicate the pumpage within the area served by the Agency in 1961 to be on the order to 180,000 acre-feet.

Because, after use, a substantial portion of water extracted from wells returns by deep percolation to the zone of saturation, amounts pumped from wells should not be construed as reduction in ground water sotrage.

Plate 9 depicts the amounts of change in water levels in wells in the study area during the base period, 1936-37 to 1960-61.

Ground Water Overdraft and Safe Yield

In this report, the value assigned to ground water overdraft is equal to the mean annual decrease in the amount of ground water in storage over a longtime period, under a particular set of physical conditions affecting the supply, use, and disposal of water.[1/] The value assigned to ground water safe yield is equal to the mean annual amount of ground water that can be pumped from the ground water basin, under the same specific physical conditions, without causing a longtime net change in the amount of ground water in storage.

As was pointed out earlier, the water supply and climatic conditions during the 25-year base period were considered to be equivalent to those conditions during the longtime period.

The set of physical conditions used in the determination of overdraft and safe yield were those that existed in the study area in 1960-61, the last year of the base period. These physical conditions were assumed fixed throughout the base period. In other words, this assumption established the annual amount of water supply, use, and disposal to sustain the 1960-61 physical conditions under mean water supply and climate the entire base period; it also established the places and ways in which the fixed amounts of water supply were applied, used, and disposed.

[1/] See Chapter III for specific items on water supply, use, and disposal.

Ground water overdraft was computed to be the average annual water supply deficiency under actual conditions plus the difference between the average annual consumptive use during the base period and the mean annual consumptive use under 1960-61 physical conditions. This is true because the mean annual amounts of water supply, use, and disposal were found to be the same as the average amounts of the corresponding hydrologic items, except the amount of consumptive use which increased significantly.

The values of ground water basin overdraft for each of the four major basins are derived in Table 32.

TABLE 32

ESTIMATED ANNUAL OVERDRAFT UNDER
1960-61 LAND USE CONDITIONS AND PUMPAGE

In acre-feet per year

Basin	Average annual water supply deficiency under actual conditions	Consumptive Use			Ground water overdraft
		Average annual under actual conditions	Mean annual under 1960-61 conditions	Increase	
Upper Mojave	7,200	44,200	50,400	6,200	13,400
Middle Mojave	5,200	19,900	24,800	4,900	10,100
Lower Mojave	5,350	17,450	20,600	3,150	8,500
Lucerne	2,900	4,550	8,000	3,450	6,350
Totals	20,650	86,100	103,800	17,700	38,350

Estimates of annual safe yield were obtained by subtracting the estimates of annual overdraft from estimates of the annual amounts of ground water pumpage that would have been necessary to sustain the

1960-61 physical conditions under mean water supply and climate over a longtime period. Values of safe yield for the four major basins are presented in Table 33.

TABLE 33

ESTIMATED MEAN ANNUAL SAFE YIELD
UNDER 1960-61 LAND USE CONDITIONS AND PUMPAGE*

In acre-feet per year

Basin	Estimated annual pumpage under 1960-61 conditions	Ground water	
		Overdraft	Safe yield
Upper Mojave	57,000	13,400	43,600
Middle Mojave	32,000	10,100	21,900
Lower Mojave	22,000	8,500	13,500
Lucerne	12,000	6,350	5,650
Totals	123,000	38,350	84,650

*The amounts of pumpage were estimated from State Water Rights Board's records. However, currently a detailed verification of pumpage is being made by the Mojave Water Agency. Preliminary figures from this determination indicate the pumpage within the area served by the Agency in 1961 to be on the order of 180,000 acre-feet. Using this figure, the estimated mean annual safe yield would be on the order of 140,000 acre-feet.

It should be pointed out again that two basic assumptions were made in the determination of overdraft and safe yield in this study: (1) a particular set of physical conditions affecting the supply, use, and disposal (including pumpage) of water in the ground water basin was assumed, and (2) it was further assumed that these conditions remained constant at the 1960-61 level throughout the 25-year base period. These assumptions then fixed the amounts of the items of supply, use, and disposal of water at one level for the entire base period; they also held constant the place and manner in which the fixed amount of water supply was applied, used, and disposed. These assumptions were hypothetical, of course, since this situation did not occur in the past and will probably not occur in the future.

In the management of ground water basins in the Mojave area, an understanding of these assumptions and the manner in which they are used is necessary, if the estimates of safe yield and overdraft obtained by this method are to be used as guides in controlling the amounts of pumpage from the ground water basins and in estimating the needs for imports to the area. For example, should it be deemed necessary to reduce the amounts of pumpage by the amount of the overdraft in order to achieve safe yield, the amount of such reduction would have to be made up by an equal amount of supplemental water, such as water obtained by removal of riparian native vegetation or by importing water. This supplemental water would have to be applied in the same place and manner as the extracted water for which it is being substituted, if the estimates of safe yield of the basin determined under constant conditions are to remain unchanged.

The amounts of annual overdraft and safe yield would be different for different sets of physical conditions. Sufficient changes could be made to eliminate overdraft and maintain safe yield. Man has control over, and could change, such physical conditions as (a) urban, suburban, industrial, agricultural land use; (b) intensity of native vegetation, especially riparian native vegetation; and (c) water conservation featues such as reclamation of waste water and artificial recharge of water. In turn, these will change the amounts of water supply, use, and disposal.

An example by which the amount of annual overdraft could be reduced and the annual amount of safe yield could be increased significantly would be by economically removing and controlling the amount of riparian native vegetation. Assuming that the set of physical conditions previously used would have been the same, except that 50 percent of the riparian native vegetational use would have been removed, the annual amount of overdraft would have decreased from about 38,000 acre-feet to 19,000 acre-feet and the annual amount of safe yield would have correspondingly increased from 79,000 acre-feet to 98,000 acre-feet.

There are major flood control and water supply features under way that could affect the physical conditions of the basin. The U. S. Army Corps of Engineers is currently designing the federally authorized flood control dam at the fork site, at the confluence of Deep Creek and the West Fork of the Mojave River. Also, the U. S. Bureau of Reclamation has investigated a multiple-purpose dam and reservoir project at the same site. Principally, it would reduce peak floodflows, decreasing the amount of surface outflow from the study area. In turn, the annual overdraft would decrease and the annual safe yield would increase.

The amounts of ground water overdraft and safe yield are dependent upon the set physical conditions used in their determination, one of which is pumpage. Accordingly, the amounts of ground water overdraft and safe yield are subject to redetermination whenever major changes occur in these conditions. Such a reevaluation may be necessary periodically in the future to provide a continuing guide to the use of ground water in storage.

CHAPTER VI. FUTURE SUPPLEMENTAL WATER REQUIREMENTS AND SOURCES

The San Bernardino Mountains separate the Mojave River desert region from the coastal metropolitan area of Southern California but the region is affected by the social and economic trends of the coastal area. The future expansion in the developed coastal area will tend to spill over into the inland Mojave desert and should have a profound effect on the economy of the study area.

Although the major portion is undeveloped, the study area is strategically located in relation to the great Southern California market with its center in Los Angeles. It is traversed by major transcontinental rail and highway routes, and a dependable supply of electricity and natural gas. Land is available at much lower prices than in coastal Southern California and in its present relatively undeveloped state, the study area could easily accommodate additional agricultural, urban and suburban, and industrial development.

The development of the study area will be limited by the local, social and economic factors affecting agriculture, urban and suburban areas, and industry. Agriculture is influenced by the economic feasibility of producing particular crops under certain market conditions, the availability of land, the pressure for land for other developments, and the availability of low-cost water. In general, farming is marginal and is affected by the late spring and early fall frosts which, in contrast to other more productive and desirable areas, limit production of most crops to the summer months when market prices are lowest. The number of crops that can be produced annually is also limited. In addition, any significant increase in the cost of water would make it uneconomical for the farmer to continue. Therefore, assuming that future agricultural water costs will remain close to the current levels and that the cost of imported water to the Mojave Water Agency would be recovered by increased urban and sub-urban water rates and by ad valorem taxation, the total gross agricultural acreage is expected to decrease only slightly -- to 16,800 acres in 1970, 15,600 acres in 1980, and 14,500 acres in 1990.

The present urban-suburban areas will continue to be the center for most of the future social and economic activity. Under the influence of the current trend toward development of recreational and retirement areas in the desert regions and the closely associated growth in commercial activity to support these areas, the population of the Mojave region is expected to increase. However, the magnitude of growth will probably not be as great as the growth anticipated in other regions of Southern California.

Population projections to the year 1990 are given in the Department's Bulletin 119-12, "Feasibility of Serving the Mojave Water Agency from the State Water Project", printed in December 1965. This bulletin updates the population figures given in Bulletin 78, "Investigation of Alternative Aqueduct Systems to Serve Southern California", Appendix D, "Economic Demand for Imported Water", published in March 1960.

The current estimates of future population of the Mojave Water Agency (which is essentially the population of the study area) are: 90,000 in 1970, 211,000 in 1980, and 393,000 in 1990. The per capita population demand is estimated to increase from the 200 gallons per capita per day in 1960-61 to 213 gpcd in 1970, 222 gpcd in 1980, and 228 gpcd in 1990.

Industrial activity is not expected to increase in the same proportions as the population. Although the area has the potential for industrial development, the initial investment required to install utilities and other services may deter industries from locating in the area. Furthermore, the study area will be competing with other areas of Southern California for industry. However, the growth of cement production can be expected to continue. The basic raw materials are in abundant supply and the demand will continue to grow and be stimulated by the projected growth of California, generally, and Southern California, specifically. Cement production, however, is not a labor-intensive industry and it has become increasingly mechanized in recent years. For this reason, the expected further expansion of the capacity of the present plants and the probable construction of new plants will not necessarily lead to a proportionate increase in employment within the industry and in demand for water. On this basis, industrial use of water was assumed to increase from 2,600 acre-feet in 1960-61 to 5,000 acre-feet in 1970.

Amounts of water use and disposal, water supply, and water deficiency under 1960-61 land use conditions, and projected amounts for the years 1970, 1980, and 1990 are presented in Table 34.

The water deficiency of 1960-61 and earlier years was met by use of ground water in storage. However, the anticipated growth of the area will result in increased need for supplemental water in future years. To meet these needs, the Mojave Water Agency has contracted with the State of California Department of Water Resources for importation of Northern California water through the State Water Project. These deliveries are to begin in 1972.

TABLE 34

WATER REQUIREMENTS AND SOURCES OF SUPPLY
(Total Study Area)

In acre-feet

Study area	1960-61	1970	1980	1990
Water Use and Disposal:				
Surface Outflow[a]	9,600	9,600	9,600	9,600
Consumptive use				
Agriculture	60,100	51,000	48,000	44,000
Riparian Native Vegetation[b]	41,950	41,950	41,950	41,950
Urban and Suburban	6,200	11,000	26,000	50,000
Industry	2,600	3,000	4,000	5,000
TOTAL	120,450	116,550	129,550	150,550
Existing Sources of Water Supply:				
Precipitation	12,750	12,750	12,750	12,750
Surface inflow	68,000	68,000	68,000	68,000
Subsurface inflow	850	850	850	850
Imported water	250	250	250	250
TOTAL	81,850	81,850	81,850	81,850
Water Supply Deficiency	38,600	34,700	47,700	68,700
Supplemental Sources of Water Supply:				
State Water Project Annual Entitlement[c]			27,200	50,800
Water Deficiency[d]	38,600	34,700	20,500	17,900

a. May be reduced if a proposed dam is constructed at the Forks site.
b. Water salvage could result from a program of elimination and control of riparian native vegetation.
c. Delivery scheduled to begin in 1972 with importation of 8,400 acre-feet.
d. To be met by use of ground water. Amount could be reduced under conditions a and b above.

Consideration was also given to the possibility of additional inflow occurring in future years as the result of importation of water into the mountain area by the Crestline-Lake Arrowhead Water Agency, which has contracted for 5,800 acre-feet of water annually from the State Water Project. Deliveries are scheduled to begin in 1972.

The Crestline-Lake Arrowhead region is primarily a recreation and resort area. Small streams, springs, and shallow wells are the current sources of water. Currently, about 30 percent of the total area within the water agency service area is sewered and this treated sewage is disposed of through evaporation ponds. The remaining portion of the sewage is disposed of through individual septic tank cesspool systems.

About 85 percent of the consumptive use of water by man occurs during the summer months, when consumptive use of water by vegetation and evaporation is also highest. Assuming that the current rate of development continues and that present weather cycles also continue, the amount of imported water supply from the State Water Project will be sufficient only to meet the future additional water demands; there will be no increase in inflow to the study area due to the application of imported water in the mountain area.

As shown in Table 34, a significant possible source of supplemental water is water salvaged as a result of a program of elimination and control of riparian native vegetation. Based on the limited amount of available information, the approximate cost of such a program would be about $50 per acre for clearing, plus about $10 per acre for control by spraying or burning. These amounts include the direct cost of equipment, operating expenses, and salaries and wages.

Because these areas are along the river, where free water surface and high ground water conditions may exist, it may be necessary to collect and distribute the recovered water to other areas to prevent loss by evaporation. If collection and distribution facilities are included in the program, there would be additional cost. Management costs should also be included in determining the total cost of a program to eliminate and control areas of riparian native vegetation to provide a source of supplemental water.

In meeting the future water demands by identifying the above mentioned sources of supplemental water supplies, consideration could be given to a planned reduction of ground water in storage since approximately 30,000,000 acre-feet of ground water exists within the basins and the average annual deficiency is in the order of 38,000 acre-feet.

CHAPTER VII. SUMMARY OF FINDINGS AND CONCLUDING STATEMENTS

In this chapter, the results of the geologic, hydrologic, and water quality studies are summarized as findings. The concluding statements evaluate the objectives achieved and indicate the further application of the findings.

Summary of Findings

Geology

The area of investigation is irregularly shaped, covers about 3,700 square miles, and contains about 2,500 square miles of water-bearing area. It is essentially an alluviated plain made up of small, broad valleys, separated by hills, groups of hills, and low mountains.

Structurally, the study area is dissected by three major northwest-southeast trending faults, which have an important influence on ground water flow: the Helendale, Lockhart, and Calico-Newberry faults. These faults exhibit very little surface expression, primarily because of burial by alluvium. Ground water levels are higher on the southwest side of each of these faults than on the northeast side. Water level differences range from a few feet to about 60 feet.

The water-bearing portion of the study area comprises seven ground water basins: Upper, Middle, and Lower Mojave Basins, and Harper, Coyote, Caves, and Lucerne

Basins. All except Lucerne Basin receive the major portion of their water supply from the Mojave River. The major source of water supply to the Lucerne Basin is from surface inflow from the mountain area.

The heterogeneous, water-bearing alluvial deposits that constitute the ground water basins are primarily the result of stream erosion of the adjacent highlands. These alluvial deposits average about 300 feet in thickness, within a range of a few feet to over 1,000 feet. The saturated portion of these deposits, over the entire study area, averages about 230 feet in depth. However, in those portions of the area that receive inflow from the Mojave River, the average saturated thickness is 275 feet, in an average total thickness of 360 feet.

The specific yield of the water-bearing alluvial deposits varies throughout the basins. The average specific yield for areas influenced by inflow from the Mojave River is approximately 14 percent. For the entire water-bearing portion of the study area, the specific yield ranges from 3 to 25 percent; for the other areas, the average is 10 percent.

Hydrology

Historical Conditions.

The amounts of annual water supply, water use and disposal, and water supply deficiency during the 25-year base period

(1936-37 through 1960-61) were determined for the Upper, Middle, and Lower Mojave Basins, and Lucerne Basin, where adequate geologic and hydrologic data were available. Data for the other three basins -- Harper, Coyote, and Caves -- were limited; however, the findings in the four major areas of record are indicative of conditions throughout the study area.

Water supply sources consist of precipitation, surface inflow, subsurface inflow, and imported water. Precipitation on the valley floor is not sufficient to contribute to the water supply of the basins, except in a portion of the Upper Mojave Basin, south of the town of Hesperia, where the average annual precipitation is greater than eight inches. The average annual amount of water from this source that percolates to the ground water body is about 4,500 acre-feet. The existence of perched ground water in the same general area confirms the addition of water to the ground water body in this area.

Surface inflow to the study area from the surrounding hills and mountains averaged about 68,000 acre-feet annually during the base period. Subsurface inflow to the study area from bordering regions occurs only at the southwest boundary, where inflow to the Upper Mojave Basin contributes about 900 acre-feet annually to the water supply.

During the study base period, imported water was a minor source of supply. About 300 acre-feet of domestic water was imported annually from outside the study area to the town of Phelan.

Surface or subsurface flow between basins within the study area and water piped across these basin boundaries are items of inflow or imported water supply to the receiving basin. However, because this water originates as outflow or exported water from adjacent basins within the study area, these amounts balance out and do not increase the overall water supply.

Water use and disposal is by surface outflow, subsurface outflow, exported water, and consumptive use. Surface outflow from the study area occurs at the northeast boundary, an average annual amount of 9,600 acre-feet from Caves Basin at Afton.

There is no subsurface outflow or water export from the study area to the outlying regions.

The average annual amounts of consumptive use in the study area could only be determined for the four major basins. These amounts were about 44,000 acre-feet for the Upper Mojave Basin, 20,000 acre-feet for the Middle Mojave Basin, 17,000 acre-feet for the Lower Mojave Basin, and 4,500 acre-feet for Lucerne Basin.

The average annual water supply, disposal, and deficiency are as follows:

AVERAGE ANNUAL AMOUNTS

In acre-feet

Basin	Supply	Disposal	Deficiency
Upper Mojave	74,500	81,700	7,200
Middle Mojave	39,900	45,100	5,200
Lower Mojave	26,300	31,600	5,300
Lucerne	1,700	4,600	2,900

The average annual deficiency in water supply, about 21,000 acre-feet, was met by use of pumped ground water.

The deficiency in water supply was the result of increased urbanization and development of the area and the prolonged drought conditions that have prevailed in southwestern United States since about 1945.

If 1961 physical conditions had prevailed throughout the 25-year base period, the average annual overdraft would have been about 38,000 acre-feet and the corresponding average annual safe yield would have been about 85,000 acre-feet for these four basins.

The principal regions where quantitative estimates of ground water storage could be made are the Upper Mojave, Middle Mojave, Lower Mojave, and Lucerne Basins. These basins have a total storage capacity, between the ground surface and the base of the water-bearing materials, of about 48,000,000 acre-feet. There was a net decrease of 522,000 acre-feet in the amount of ground water in storage between the beginning and the end of the 25-year base period. At the close of the base period, in 1961, about 31,100,000 acre-feet of ground water remained in storage in these four basins.

Future Conditions

The study area is primarily desert, and development of farms and communities has been limited to areas along the Mojave River and the adjacent valleys where water has been readily available. However, the study area is strategically located in relation to the expanding Southern California market and will be influenced by the social and economic trends of the region, in general, and of Los Angeles, in particular.

The population of the study area is expected to increase from 55,300 in 1960-61 to 393,000 in 1990. Urban and suburban water use will rise from 6,200 acre-feet in 1960-61 to 50,000 acre-feet in 1990. Agricultural land use is expected to decline during this period, from 18,650 acres to 14,500 acres, resulting in a decrease in agricultural water use, from 60,100 acre-feet to 44,000 acre-feet annually. Conversely, water use and disposal by industry will require 5,000 acre-feet annually by 1990 -- almost double the 2,600 acre-feet needed by industry in 1960-61. These changes in population and occupation will result in a net increase in water use from about 120,000 acre-feet in 1960-61 to about 151,000 acre-feet in 1990.

Historical climatic and hydrologic conditions are assumed to continue in the future; thus, water supply from natural sources will remain at about the same level as it was during the 25-year base study period. In view of the anticipated increase in water needs under future conditions of growth and development in the study area, water supply deficiency will amount to about 68,700 acre-feet annually by 1990, as compared to the 1960-61 deficiency of 38,600 acre-feet.

In order to provide supplemental water to meet the future needs, the Mojave Water Agency has entered into a contract with the State of California for water from the State Water Project. Deliveries of imported water are scheduled to begin in 1972. Use of this water will reduce the 1990 water deficiency from 68,700 acre-feet to 17,900 acre-feet. The remaining water supply deficiency can be met by use of pumped ground water.

Consideration was also given to possible future sources of supplemental water supply. In the event that a dam is constructed at the forks site, as proposed by the U. S. Army Corps of Engineers and studied by the U. S. Bureau of Reclamation, outflow at Afton could be reduced. The water thus conserved would be available for use in the study area. An additional potential supply of supplemental water could be developed by elimination and control of riparian native vegetation or by introduction of a planned program of reduction of ground water storage.

Water Quality

There is a wide variation in the quality and mineral character of the water in the study area. This variation is related to the source of replenishment, the geological formation in which the ground water is found, and use of water by man. Ground water influenced by the Mojave River is typically bicarbonate, with an average total dissolved solids content of about 300 parts per million. Ion exchange is indicated by a change in the character of the water from predominately calcium bicarbonate in the Upper Mojave Basin to predominately sodium bicarbonate in the downstream Middle and Lower Mojave Basins. The other most common type of ground water found in the study area is related to older alluvium. This water is typically sulfate or sulfate-chloride in character with a total dissolved solids range from 700 to 1,000 ppm.

Sodium chloride type ground water is consistently present in the fine-grained playa deposits found at lower elevations of the basins and in the older lake deposits. The total dissolved solids content ranges from 380 ppm to more than 5,300 ppm. The average is approximately 1,200 ppm.

Inflow of salts to the study area exceeds the outflow of salts at the rate of 22,000 tons per year. However, there are only a few areas in which problems due to the accumulation of salts occur. These are in the vicinity of dry lakes and near Afton.

Concluding Statements

Studies leading to this report were conducted to determine the location, amount and quality of local water supply in the basins along the Mojave River, to evaluate the adequacy of the local water supply to meet present and future water requirements, and to indicate potential sources of supplemental water.

The geologic and hydrologic information provided by this study can be used by local agencies in planning for effective use of existing surface and ground water resources of the study area and in developing supplemental sources of water. The information provided by this study points out the need and provides a foundation for a ground water basin model simulation and operational economics studies, leading to the selection by local agencies of an optimum plan of water resources management.

APPENDIX A

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also includes water similarly consumed and evaporated by urban and nonvegetative types of land use.

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P = gallons per day square foot

I = feet per foot

A = square feet

Q = gallons per day

Deep Percolation - See Percolation, Deep.

Ground Water - Subsurface water occurring in the zone of saturation and moving under control of the water table slope or piezometric gradient.

Ground Water Basin - As used in this report, an area underlain by water-bearing sediments capable of storing and yielding a ground water supply.

Ground Water Overdraft - For this study, the value is equal to average annual decrease in the amount of ground water in storage that occurs during a longtime period, under a particular set of physical conditions affecting the supply, use, and disposal (including pumpage) of water in the ground water basin.[1]

[1] See Chapter III for specific items of water supply, use, and disposal.

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APPENDIX B

DEFINITION OF TERMS

DEFINITION OF TERMS

Acre-foot - The volume of water required to cover one acre one foot in depth (43,560 cubic feet or 325,829 gallons).

Applied Water - The water delivered to a farmer's headgate or to an urban individual's meter, or its equivalent. Excludes precipitation.

Blaney-Criddle Method - Based on an empirical formula developed by Harry F. Blaney and Wayne D. Criddle for the U.S. Department of Agriculture. Used to obtain estimates of evapotranspiration. (For a detailed description, see California State Water Resources Board Bulletin No. 2 and U.S. Department of Agriculture Technical Bulletin No. 1275.)

Character of Water - A classification of water based on predominant anion and/or cation in equivalents per million (epm). Identified by the name of the ion which constitutes one-half or more of the total ions for that water group.

Connate Water - Water entrapped in the interstices of a sedimentary rock at the time it was deposited. These waters may be fresh, brackish or saline in character. Because of the dynamic geologic and hydrologic conditions in California, this definition has been altered in practice to apply to water in older formations, even though in these the water may have been altered in quality since the rock was originally deposited.

Consumptive Use of Water - Water consumed by vegetative growth in transpiration and building plant tissue, and water evaporated from adjacent soil, from water surfaces, and from foliage. It

also includes water similarly consumed and evaporated by urban and nonvegetative types of land use.

Darcy's Equation - An equation applied to ground water studies, based on Darcy's Law (the flow rate through porous media is proportional to the head loss and inversely proportional to the length of the flow path). Expressed as Q = PIA, where the subsurface flow (Q) is equal to the permeability (P) of the subsurface materials, times the cross-sectional area (A) and the slope or the hydraulic gradient (I) of the ground water at the cross-sectional area.

P = gallons per day square foot

I = feet per foot

A = square feet

Q = gallons per day

Deep Percolation - See Percolation, Deep.

Ground Water - Subsurface water occurring in the zone of saturation and moving under control of the water table slope or piezometric gradient.

Ground Water Basin - As used in this report, an area underlain by water-bearing sediments capable of storing and yielding a ground water supply.

Ground Water Overdraft - For this study, the value is equal to average annual decrease in the amount of ground water in storage that occurs during a longtime period, under a particular set of physical conditions affecting the supply, use, and disposal (including pumpage) of water in the ground water basin.[1]

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[1] See Chapter III for specific items of water supply, use, and disposal.

Ground Water Safe Yield - For this study, the value is equal to average annual amount of ground water that could be pumped from a ground water basin over a long-time period without causing a long-time net change in storage of ground water. The extractions must occur under a particular set of physical conditions affecting the supply, use, and disposal of water in the ground water basin.[1/]

Ground Water Storage - That stage of the hydrologic cycle during which water occurs as ground water in the zone of saturation.

Ground Water Table - See Water Table.

Hydraulic Gradient - Under unconfined ground water conditions, the slope of the profile of the water table. Under confined ground water conditions, the line joining the elevations to which the water would rise in wells if they were perforated in the aquifer.

Hydrology - The applied science concerned with the waters of the earth, their occurrences, distribution, use, and circulation through the unending hydrologic cycle of precipitation; consequent runoff, infiltration, storage, use, and disposal; eventual evaporation; and reprecipitation. It is concerned with the physical and chemical reaction of water with the rest of the earth, and its relation to the life of the earth.

Hydrology, Ground Water - The branch of hydrology that treats of subsurface water -- its occurrence, movement, and storage and its replenishment and depletion -- also, of the properties of unconsolidated materials and rocks that control the occurrence, movement,

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[1/] See Chapter III for specific items of water supply, use, and disposal.

and storage of subsurface water and of the method of investigation and utilization of subsurface water.

Impermeable - Impervious; having a texture that does not permit water to move through it perceptibly under the head differences ordinarily found in subsurface water.

Infiltration - The flow, or movement, of water through the soil surface into the ground.

Overdraft - See Ground Water Overdraft.

Perched Ground Water - Ground water occurring in a saturated zone separated from the main body of ground water by unsaturated rock or by an impervious formation.

Percolation - The movement or flow of water through the interstices, or the pores, of a soil or other porous media.

Percolation, Deep - The movement of water entering the zone of saturation, below the root zone.

Period - A specified division or portion of time.

a. Average. An arithmetical average relating to a period other than a mean period.

b. Base. A period chosen for detailed hydrologic analysis, because prevailing conditions of water supply and climate are approximately equivalent to mean conditions and because adequate data for such hydrologic analysis are available.

c. Mean. A period chosen to represent conditions of water supply and climate over a long series of years.

d. Annual. Any 12-month period other than the calendar year. In this study, annual period is synonymous with the runoff period, October 1 through September 30.

Permeability - The permeability (or perviousness) of rock is its capacity for transmitting a fluid. Degree of permeability depends upon the size and shape of the pores, the size, shape, and extent of their interconnections.

Permeable - Pervious, having a texture that permits water to move through it perceptibly under the head differences ordinarily found in subsurface water.

Physical Conditions - For this study, the state of man's activities, particularly land use -- agriculture, urban, suburban, and industrial -- and the resulting physical structures affecting the supply, use, and disposal of water.

Rising Water - Ground water from the zone of saturation which appears at the ground surface, usually to a streambed, when the ground surface is at a lower elevation than the ground water table or the piezometric surface of a confined aquifer.

Safe Yield - See Ground Water Safe Yield.

Specific Yield - The ratio of the volume of water a saturated sediment will yield by gravity drainage to the total volume of the sediment and water prior to draining, customarily expressed in percent.

Total Dissolved Solids (TDS) - The dry residue from the dissolved matter in an aliquot of a water sample remaining after evaporation of the sample at a definite temperature.

Transmissibility, Coefficient of - The rate of flow of water, expressed in gallons per day, at the prevailing water temperature through each vertical strip, 1 foot wide, having a height equal to the thickness of the aquifer, and under a unit hydraulic gradient.

Transpiration - The exhalation of water vapor from the stomata of plant leaves and other surfaces.

Unconfined Ground Water - Ground water that is not immediately overlain by impervious materials and that moves under control of the water table slope.

Unconformity - A surface or erosion or nondeposition, usually the first, that separates younger strata from older rocks.

Vapor Transport - The loss of percolating water in the zone of aeration in areas of low annual precipitation, infrequent high annual precipitation, and great depth to the zone of saturation.

Water Quality - Those physical, chemical, biological, and radiological characteristics of water which affect its suitability for beneficial uses.

Water Table - The surface of ground water at atmospheric pressure in an unconfined aquifer. This is revealed by the levels at which water stands in wells penetrating the unconfined aquifer.

Water Supply Surplus or Deficiency - For this study, the difference between the inflow to and the outflow from a ground water basin during any given period. The outflow of water includes the consumptive use of water. A water supply surplus results when the inflow is greater than the outflow; a water supply deficiency results when the inflow is less than the outflow.

APPENDIX C

CLASSIFICATION OF LAND USE

WATER SERVICE AREA

Urban and Suburban Category

Class of Land Use	Type of Land Use
Residential.	Single and multiple family houses and apartments, institutions, motels, 1- and 2-story hotels, trailer parks, and residential subdivisions under construction at time of survey.
Recreational residential . .	Weekend and summer home tracts within a primarily recreational area.
Commercial	All classes of commercial enterprises, including strip commercial, downtown commercial, and schools, but excluding 1- and 2-story hotels, motels, and institutions.
Industrial	All classes of industrial land uses involving manufacturing, processing, and packaging, but excluding extractive industries (oil, sand, and gravel), air fields, and storage, distribution, and transportation facilities.
Unsegregated urban and suburban area	Farmsteads, dairies, livestock ranches, parks, cemeteries, and golf courses.
Included nonwater service area	Oil fields, tank farms, vacant lots, quarries, gravel pits, warehouses and storage yards, railroads, public streets, landing strips of airfields, and subdivisions with streets and utilities in place but with no buildings constructed.

Irrigated Agriculture Category

Class of Land Use	Type of Land Use
Alfalfa	Alfalfa raised for hay, seed, or pasture

Class of Land Use (continued)	Type of Land Use
Pasture	Irrigated grasses and legumes other than alfalfa used for livestock forage.
Truck crops	Vegetables of all varieties, melons, flower seed, and nursery crops.
Field crops	Cotton, sorghum, sugar beets, and field corn.
Deciduous fruits and nuts	All varieties.
Small grains	Barley, wheat, and oats.
Fallow	Tilled, between crops.
Included nonwater service area	Public highways and roads, farm access roads, canals, and other inclusions not devoted to crop production, including idle and abandoned lands.

APPENDIX D

WATER QUALITY CRITERIA

WATER QUALITY CRITERIA

Criteria presented in the following sections can be utilized in evaluating mineral quality of water relative to existing or anticipated beneficial uses. It should be noted that these criteria are merely guides to the appraisal of water quality. Except for those constituents which are considered toxic to human beings, these criteria should be considered as suggested limiting values. Water which exceeds one or more of these limiting values need not be eliminated from consideration as a source of supply, but other sources of better quality water should be investigated.

Criteria for Drinking Water

Criteria for appraising the suitability of water for domestic and municipal use in connection with interstate quarantine have been promulgated by the United States Public Health Service. The limiting concentrations of chemical substances in drinking water have been abstracted from these criteria and are shown in Table 35. Other organic or mineral substances may be limited if their presence renders the water hazardous for use.

Interim standards for certain mineral constituents have been adopted by the California State Board of Public Health. Based on these standards, temporary permits may be issued for drinking water supplies failing to meet the United States Public Health Service Drinking Water Standards, provided the mineral constituents in Table 36 are not exceeded.

TABLE 35

UNITED STATES PUBLIC HEALTH SERVICE
DRINKING WATER STANDARDS
1962

Chemical Substance	Mandatory limit in ppm
Arsenic (As)	0.05
Barium (Ba)	1.0
Cadmium (Cd)	0.01
Hexavalent chromium (Cr^{+6})	0.05
Cyanide (CN)	0.2
Lead (Pb)	0.05
Salenium (Se)	0.01
Silver (Ag)	0.05
	Nonmandatory, but recommended limit in ppm
Alkyl benzene sulfonate (detergent)	0.5
Arsenic (As)	0.01
Carbon chloroform extract (exotic organic chemicals)	0.2
Chloride (Cl)	250
Copper (Cu)	1.0
Cyanide (CN)	0.01
Fluoride (F) (See Table 37)	
Iron (Fe)	0.3
Manganese (Mn)	0.05
Nitrate (NO_3)	45
Phenols	0.001
Sulfate (SO_4)	250
Total dissolved solids (TDS)	500
Zinc (Zn)	5

TABLE 36

UPPER LIMITS OF TOTAL SOLIDS AND SELECTED MINERALS IN DRINKING WATER AS DELIVERED TO THE CONSUMER

	Permit	Temporary Permit
Total solids	500 (1000)*	1500 ppm
Sulfates (SO_4)	250 (500)*	600 ppm
Chlorides (Cl)	250 (500)*	600 ppm
Magnesium (Mg)	125 (125)	150 ppm

* Numbers in parentheses are maximum permissible, to be used only where no other more suitable water is available in sufficient quantity for use in the system.

The relationship of infant methemoglobinemia (a reduction of oxygen content in the blood, constituting a form of asphyxia) to nitrates in the water supply has led to limitation of nitrates in drinking water. The California State Department of Public Health has recommended a tentative limit of 10 ppm nitrogen (44 ppm nitrates) for domestic water. Water containing higher concentrations of nitrates may be considered to be of questionable quality for domestic and municipal use.

The California State Board of Public Health has defined the maximum safe amounts of fluoride ion in drinking water in relation to mean annual temperature. These relationships are shown in Table 37.

TABLE 37

RELATIONSHIP OF TEMPERATURE TO FLUORIDE CONCENTRATION IN DRINKING WATER

Mean Annual Temperature	Mean monthly fluoride ion concentration
50°F	1.5 ppm
60°F	1.0 ppm
70°F - above	0.7 ppm

Criteria for Hardness

Even though hardness in water is not included in the foregoing standards, it is of importance in domestic and industrial uses. Excessive hardness in water used for domestic purposes causes increased consumption of soap and formation of scale in pipe and fixtures. Table 38 showing degrees of hardness in water has been suggested by the United States Geological Survey.

TABLE 38

HARDNESS CLASSIFICATION

Range of hardness, expressed as $CaCO_3$ in ppm	Relative classification
0 - 60	Soft
61 - 120	Moderately hard
121 - 200	Hard
Greater than 200	Usually requires softening

Criteria for Irrigation Water

Criteria for mineral quality of irrigation water have been developed by the Regional Salinity Laboratories of the United States Department of Agriculture in cooperation with the University of California. Because of diverse climatological conditions and the variation in crops and soils in California, only general limits of quality for irrigation waters can be suggested. The department uses three broad classifications of irrigation waters as listed below and in Table 39.

Class 1 - Regarded as safe and suitable for most plants under most conditions of soil and climate.

Class 2 - Regarded as possibly harmful for certain crops under certain conditions of soil or climate, particularly in the higher ranges of this class.

Class 3 - Regarded as probably harmful to most crops and unsatisfactory for all but the most tolerant.

TABLE 39

QUALITATIVE CLASSIFICATION OF IRRIGATION WATERS

Chemical properties	Class 1 Excellent to good	Class 2 Good to injurious	Class 3 Injurious to unsatisfactory
Total dissolved solids, in ppm	Less than 700	700 - 2000	More than 2000
Conductance, in micromhos at 25°C	Less than 1000	1000 - 3000	More than 3000
Chlorides, in ppm	Less than 175	175 - 350	More than 350
Sodium, in percent of base constituents	Less than 60	60 - 75	More than 75
Boron, in ppm	Less than 0.5	0.5 - 2.0	More than 2.0

These criteria have limitations in actual practice. In many instances, water may be wholly unsuitable for irrigation under certain conditions of use and yet be completely satisfactory under other circumstances. Consideration also should be given to soil permeability, drainage, temperature, humidity, rainfall, and other conditions that can alter the response of a crop to a particular quality of water.

Criteria for Industrial Uses

It is beyond the scope of this report to present water quality requirements for the various types of industry found in the Mojave River region or for the diverse processes within these industries, since such criteria are as varied as industry itself. In general, where a water supply meets drinking water standards, it is satisfactory for industrial use, either directly or following a limited amount of treatment or softening by the industry.

APPENDIX E

SPECIFIC YIELD VALUES

AND REPRESENTATIVE DRILLERS' TERMS

3 Percent (Clay)

Black rock
Black schist
Blue shale
Boulders, chunk rock
Boulders, hard
Caliche
Cemented boulders
Clay
Clay cobblestones
Hard pan
Hard shelf
Hillside clay conglomerate
Lime "shelves"
Rotten granite
Soft granite

Sticky clay

Tight clay
White quartz & Black shale

5 Percent (Sandy Clay)

Basalt
Basaltic sandstone
Cemented conglomerate
Clay - scattered gravel
Clay - scattered lime
Clay - with embedded rock

Crumbly clay
Crushed rock
Decomposed granite
Fractured granite
Gravelly clay
Hard lime shale
Kaolin
Limerock & Biotite clay
Muck
Nodules
Rotten Ledge rock
Sandy clay
Sandy Muck
Sandstone reefs
Silty clay
Volcanic rock
White limestone

10 Percent (Silt)

Black swamp mud & silt
Cemented gravels
Clay - embedded gravel
Coarse granulated water-bearing kaolin
Limy silt
River silt
Silt
Soft silt
Soil (Topsoil)
Talc

12 Percent (Cemented Sand)

Cemented sand
Cemented sand & gravel
Conglomerate sand
Hard cemented sand
Hard sand
Sandy clay & cobbles
Water gravel with cement reef

15 Percent (Sandy Silt)

Granulated kaolin
Kaolin with grit
Mucky sand, gravel & bits
Sandy silt

18 Percent (Coarse, Medium, or Undiff. Gravel)

Alluvial fill boulders
Brittle conglomerate - water
Brittle FM - water
Coarse, medium, or undifferentiated gravel
Cobblestone - coarse sand - some gravel
Loose "Granite" formation
Sand w/clay ribs

20 Percent (Silty Sand)

Dirty sand
Hilldrift
Silty sand
Soft sand

22 Percent (Fine Gravel)

Fine gravel
Pea gravel

26 Percent (Fine Sand)

Blow sand
Dune sand
Fine sand
Quicksand

EXHIBIT B

IN THE SUPERIOR COURT OF THE STATE OF CALIFORNIA
IN AND FOR THE COUNTY OF LOS ANGELES

THE CITY OF LOS ANGELES, a Municipal Corporation, *Plaintiff,* vs. CITY OF SAN FERNANDO, a Municipal Corporation, et al., *Defendants.*	No. 650079

REPORT OF REFEREE

Volume I
TEXT AND PLATES

By
STATE WATER RIGHTS BOARD
REFEREE

July, 1962

APPROVAL AND ADOPTION BY STATE WATER RIGHTS BOARD

The State Water Rights Board, Referee in the action entitled "The City of Los Angeles, a Municipal Corporation, Plaintiff, vs. City of San Fernando, a Municipal Corporation, et al., Defendants," before the Superior Court of the State of California in and for the County of Los Angeles, No. 650079, approves and adopts this "Report of Referee" dated July 1962, pursuant to the requirements of the "Order of Reference to State Water Rights Board to Investigate and Report Upon the Physical Facts (Section 2001, Water Code)," dated June 11, 1958, and the "Interim Order," dated November 19, 1958, entered by the Court in said action. In accordance with paragraph III of said Order of Reference dated June 11, 1958, the Board will file with the Court and retain in its office the basic data upon which it bases its findings.

Approved and adopted by the State Water Rights Board at a meeting duly called and held at Sacramento, California, on the 27th day of July, 1962.

Kent Silverthorne, Chairman

Ralph J. McGill, Member

W. A. Alexander, Member

STATE WATER RIGHTS BOARD
EUREKA
CALIFORNIA

Selection of Base Study Period

The desirable base study period is one during which precipitation characteristics in the Upper Los Angeles River area approximate the 85-year period of record, 1872-73 through 1956-57. A further requirement of such a period is that additional hydrologic information is available sufficient to permit an evaluation of the amount, occurrence and disposal of the normal water supply under recent culture conditions. The desirable base period includes both wet and dry periods similar in magnitude and occurrence to the normal supply, and during which there are sufficient measurements and observations to relate the hydrology to recent culture.

Subsequent to 1927-28, records of stream outflow, culture distribution and water utilization on the valley floor, and ground water levels at wells are fairly comprehensive and adequate. In contrast, earlier records concerning these items are available only on a limited basis. There is a paucity of earlier measurements required to determine basin-wide ground water levels and continuous stream outflow. Because of the aforementioned requirements and limitations, the selection of a base period was restricted to years subsequent to 1927-28.

To determine the regimen of occurrence of rain in the Upper Los Angeles River area, selected precipitation stations on the valley floor having long periods of record were studied for an indication of periods with an occurrence of rain equivalent to the normal period. The 85-year mean seasonal precipitation was used to compute the indices of wetness for these selected stations, and annual averages of these indices of wetness were utilized to construct the cumulative percentage deviation mass diagram for the Upper Los Angeles River area, shown on Plate 10.

Comparison of the precipitation trends in the Upper Los Angeles River area with those reflected by the longer record of precipitation at Los Angeles, Pasadena, Acton and Sawtelle Soldiers Home, also shown on Plate 10, indicates that even though the magnitude of the annual deviation varies, the cyclic trends of these four stations are generally in agreement with the trends indicated by precipitation records within the area.

The 29-year period, 1928-29 through 1956-57, was selected as the base study period for the following reasons:

1. It was a period of normal precipitation during which sufficient records were available for purposes of determining safe yield.
2. It was a representative period of normal precipitation including both wet and dry periods of magnitude and occurrence similar to long-time mean supply conditions of 1872-73 through 1956-57. A wet period occurred from 1936-37 through 1944-45, and a predominantly dry period from 1945-46 through 1956-57. The 29-year period 1928-29 through 1956-57 contains nine years when precipitation was predominantly above average, that is, 115 percent of normal or greater. These nine years comprise 31 percent of the 29-year period as compared to 29 years of similar wetness occurring during the 85-year or normal period which comprise about 34 percent of that period. The average annual amount of precipitation during the 29-year period approximates the long-time mean

having the following average annual deviation from the 85-year mean expressed as a percentage thereof:

Valley lands	+3.5 percent
Hill and mountain areas	-2.2 percent
Combined	-0.4 percent

3. The years immediately preceding the first and last years of this period were of below normal wetness, which thereby minimized the difference of unaccounted-for water in transit to the water table at the start and end of the period.
4. It includes a period of record of supply and disposal under conditions of culture which approximate those existing in 1949-50, 1954-55 and 1957-58, the years during which safe yield is to be determined.

Special Study Periods

The period 1933-34 through 1948-49 is of significance in that it can be used to check change in storage computations. During this 16-year period a substantial rise and fall of ground water levels occurred with average levels at the beginning and end of the period being approximately the same elevation.

The 29-year base study period contains periods of differing practices as to the use of water which are related to change in land use, economic conditions, living standards and technological improvements. Thus, to properly evaluate the use of water under current conditions, a study period during recent years having a rain supply equivalent to the long-time mean was desirable. The 9-year period 1949-50 through 1957-58

74

EXHIBIT C

Mojave Watermaster Land Use Changes

Wagner&Bonsignore
Consulting Civil Engineers, A Corporation

USGS Annual NLCD Land Cover Classification

- The annual NLCD (National Land Cover Database) uses a modified Anderson Level II classification system with 16 land cover classes. For example:

Developed	
21	**Developed, Open Space**- areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for less than 20% of total cover. These areas most commonly include large-lot single-family housing units, parks, golf courses, and vegetation planted in developed settings for recreation, erosion control, or aesthetic purposes.
22	**Developed, Low Intensity**- areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 20% to 49% percent of total cover. These areas most commonly include single-family housing units.
23	**Developed, Medium Intensity** -areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 50% to 79% of the total cover. These areas most commonly include single-family housing units.
24	**Developed High Intensity**-highly developed areas where people reside or work in high numbers. Examples include apartment complexes, row houses and commercial/industrial. Impervious surfaces account for 80% to 100% of the total cover.

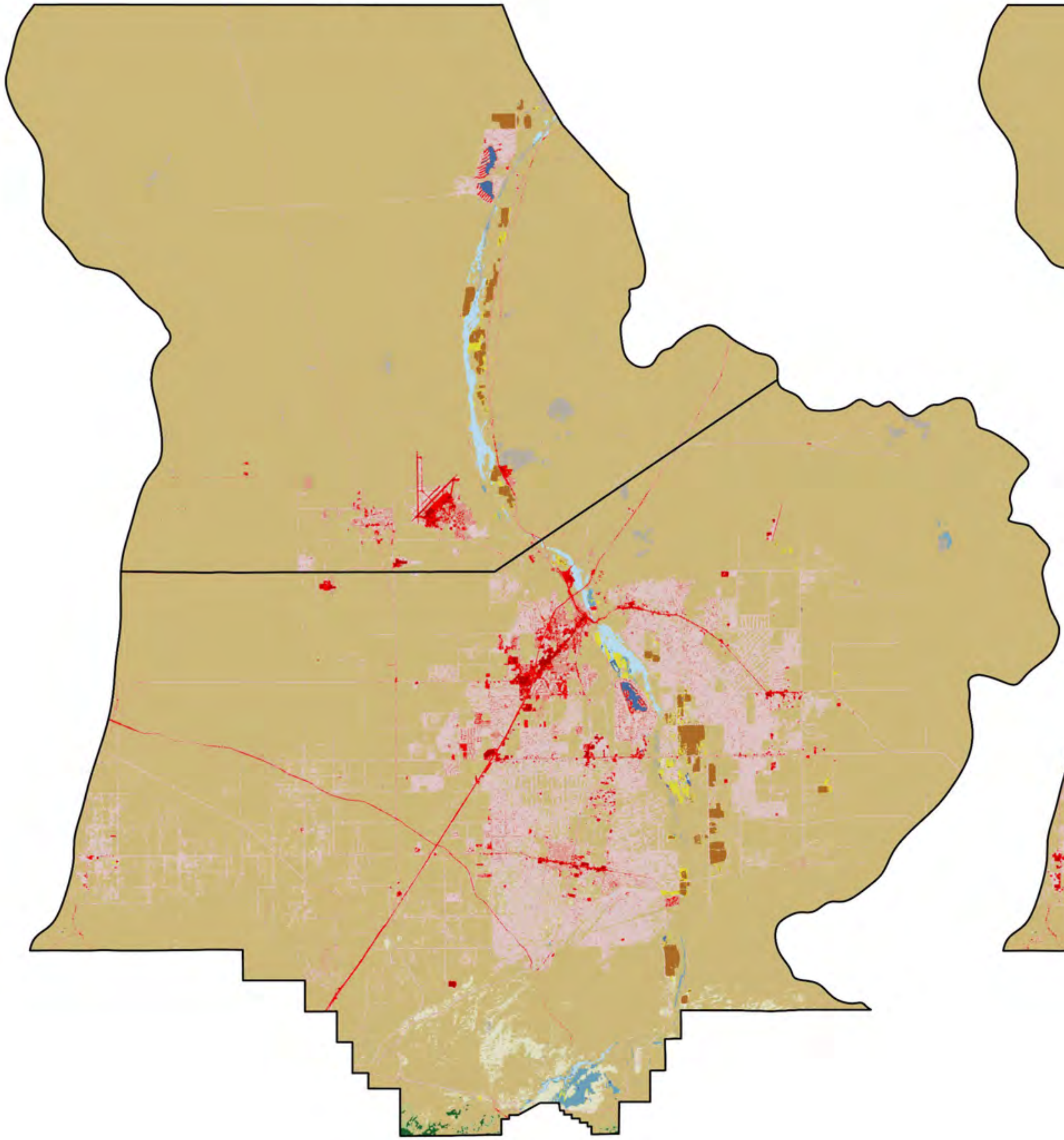
Planted/Cultivated	
81	**Pasture/Hay**-areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops, typically on a perennial cycle. Pasture/hay vegetation accounts for greater than 20% of total vegetation.
82	**Cultivated Crops** -areas used for the production of annual crops, such as corn, soybeans, vegetables, tobacco, and cotton, and also perennial woody crops such as orchards and vineyards. Crop vegetation accounts for greater than 20% of total vegetation. This class also includes all land being actively tilled.

Shrubland	
51	**Dwarf Scrub**- Alaska only areas dominated by shrubs less than 20 centimeters tall with shrub canopy typically greater than 20% of total vegetation. This type is often co-associated with grasses, sedges, herbs, and non-vascular vegetation.
52	**Shrub/Scrub**- areas dominated by shrubs; less than 5 meters tall with shrub canopy typically greater than 20% of total vegetation. This class includes true shrubs, young trees in an early successional stage or trees stunted from environmental conditions.

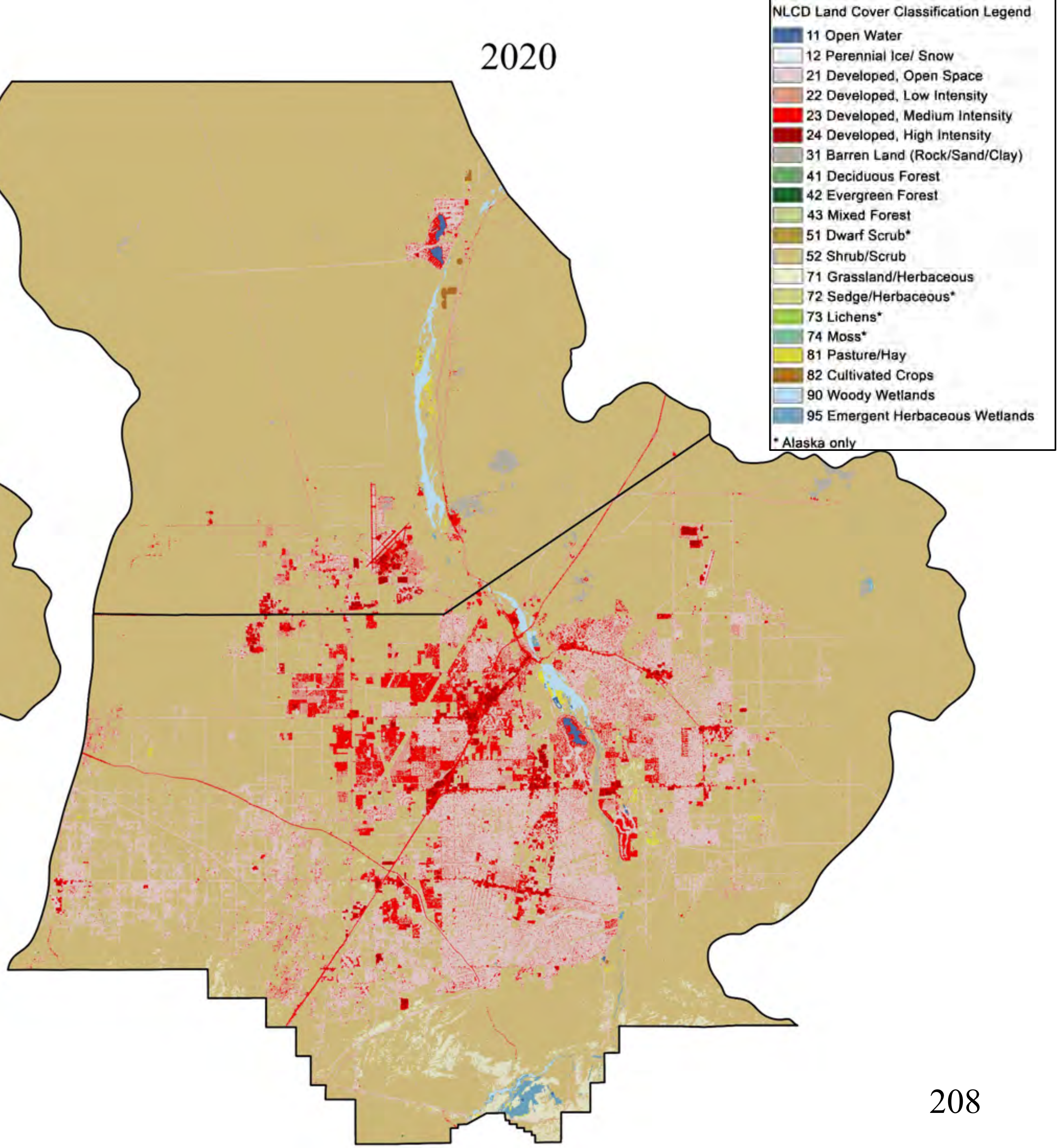
Source: Annual NLCD Land Cover Classification by the U.S. Geological Survey (USGS). Available at https://www.usgs.gov/centers/eros/science/annual-nlcd-land-cover-classification

Alto

1990

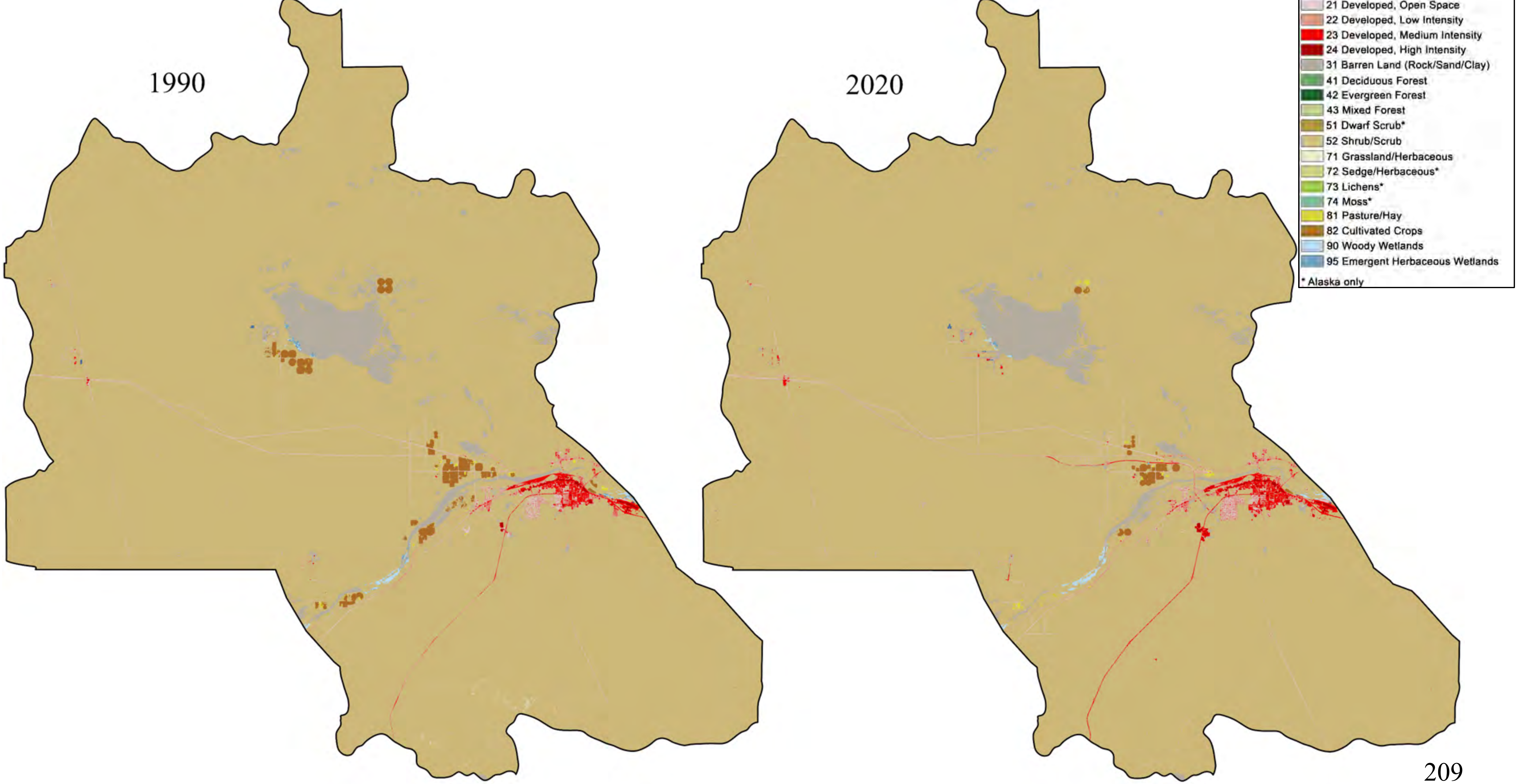


2020



Annual National Land Cover Database (NLCD) by the U.S. Geological Survey (USGS)'s Land Cover program. Annual NLCD data was downloaded from the *Multi-Resolution Land Characteristics (*MRLC) site.

Centro



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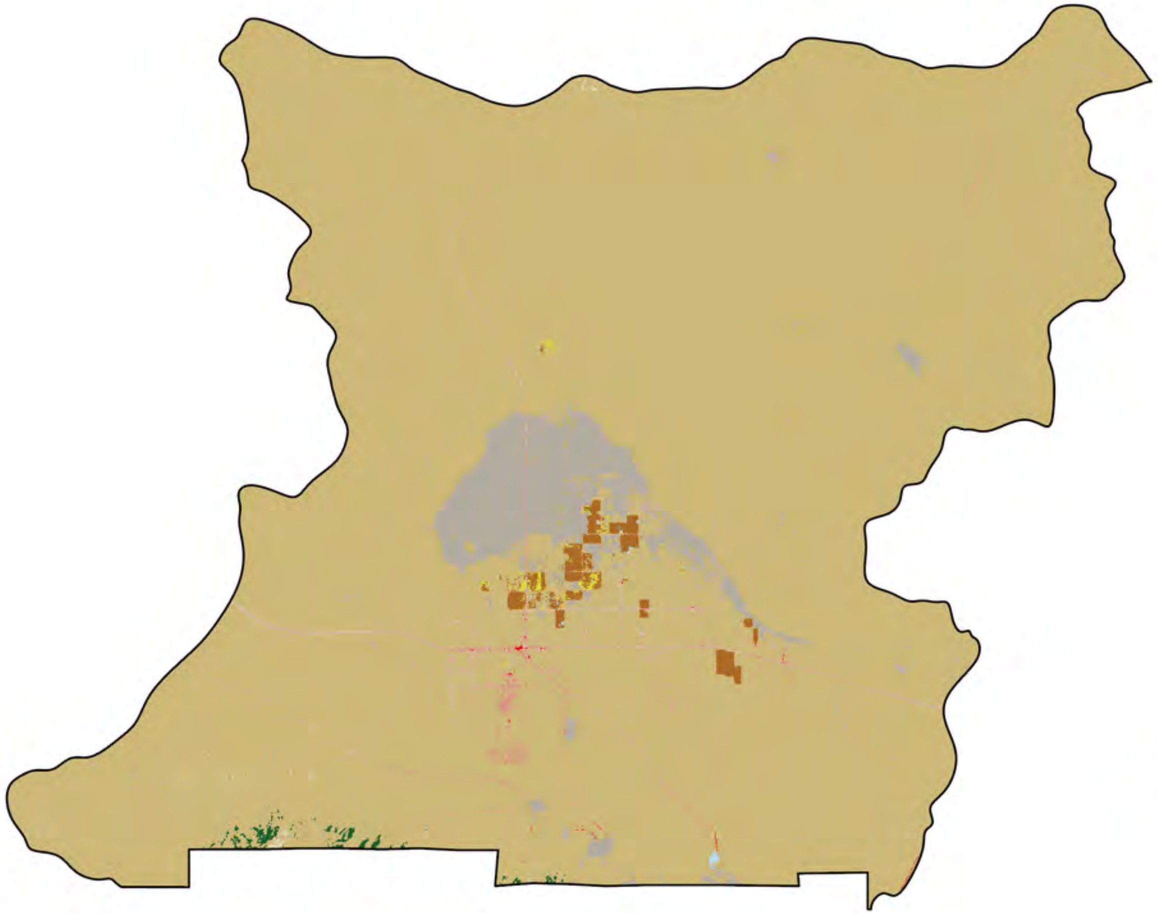
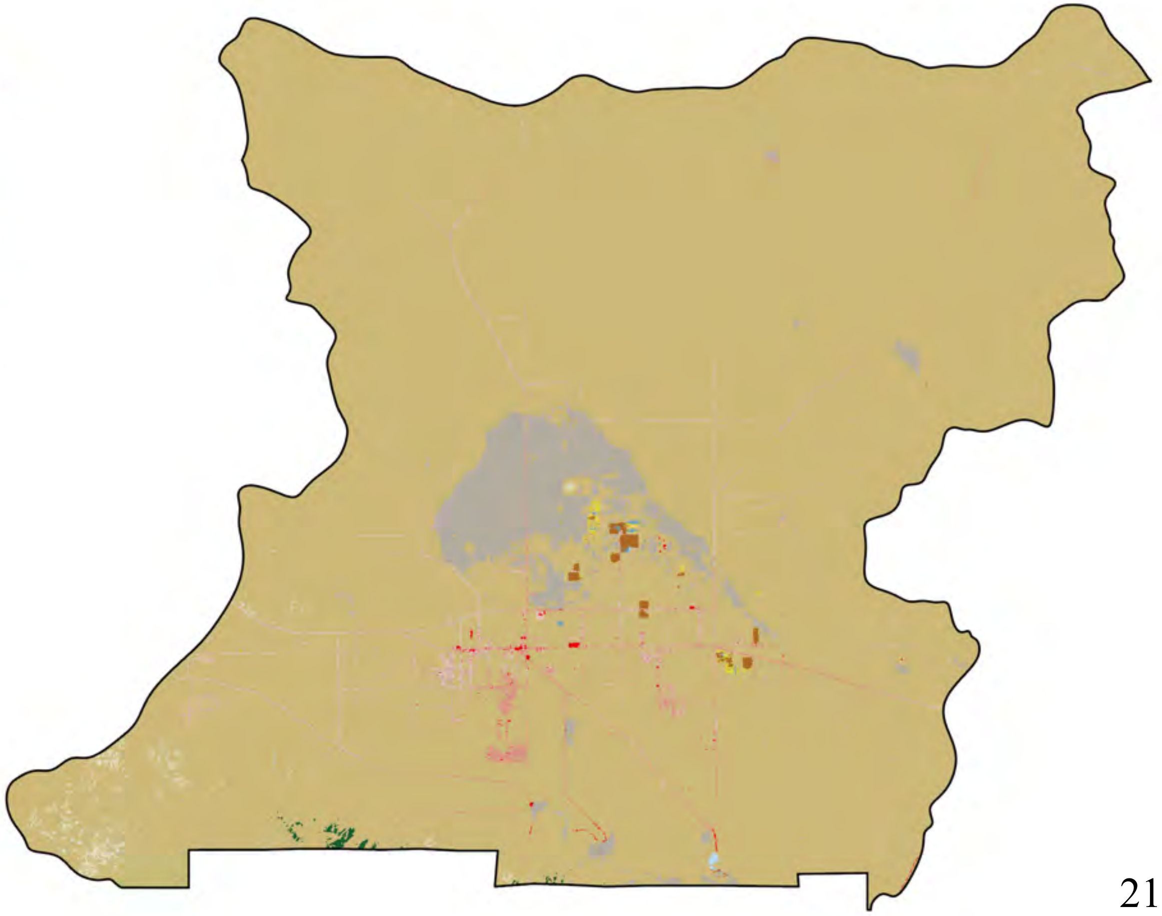


2020



Annual National Land Cover Database (NLCD) by the U.S. Geological Survey (USGS)'s Land Cover program. Annual NLCD data was downloaded from the *Multi-Resolution Land Characteristics (*MRLC) site.

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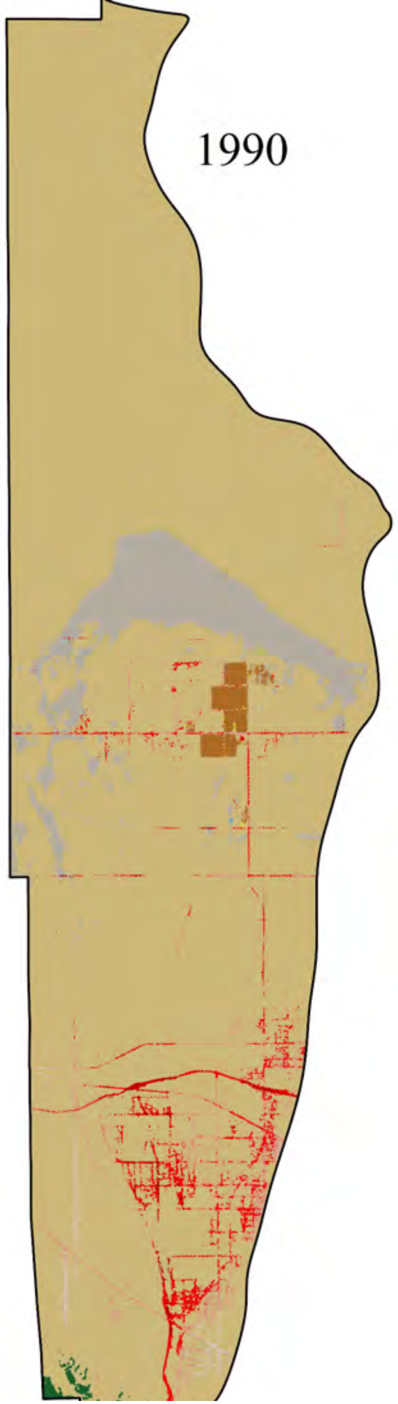
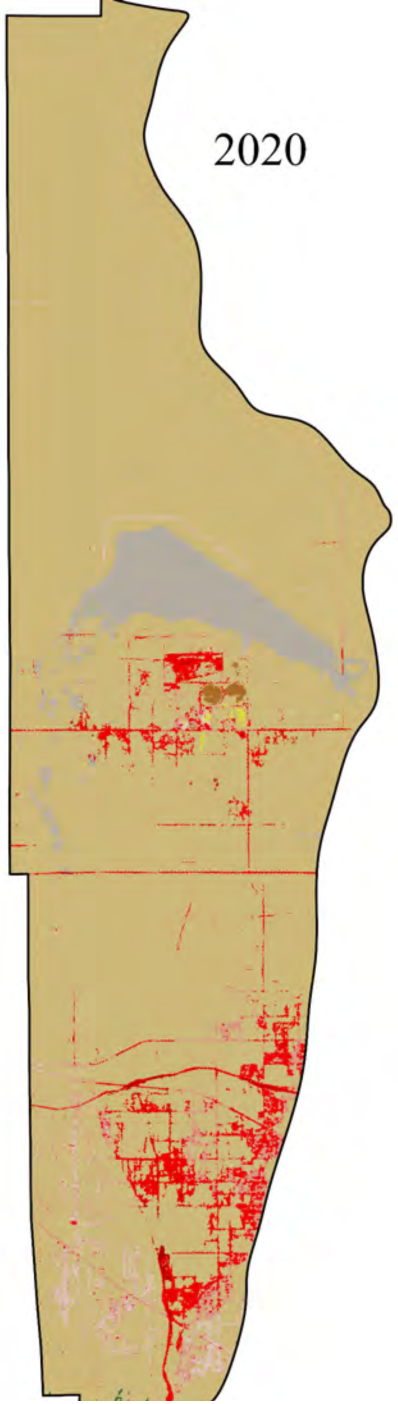
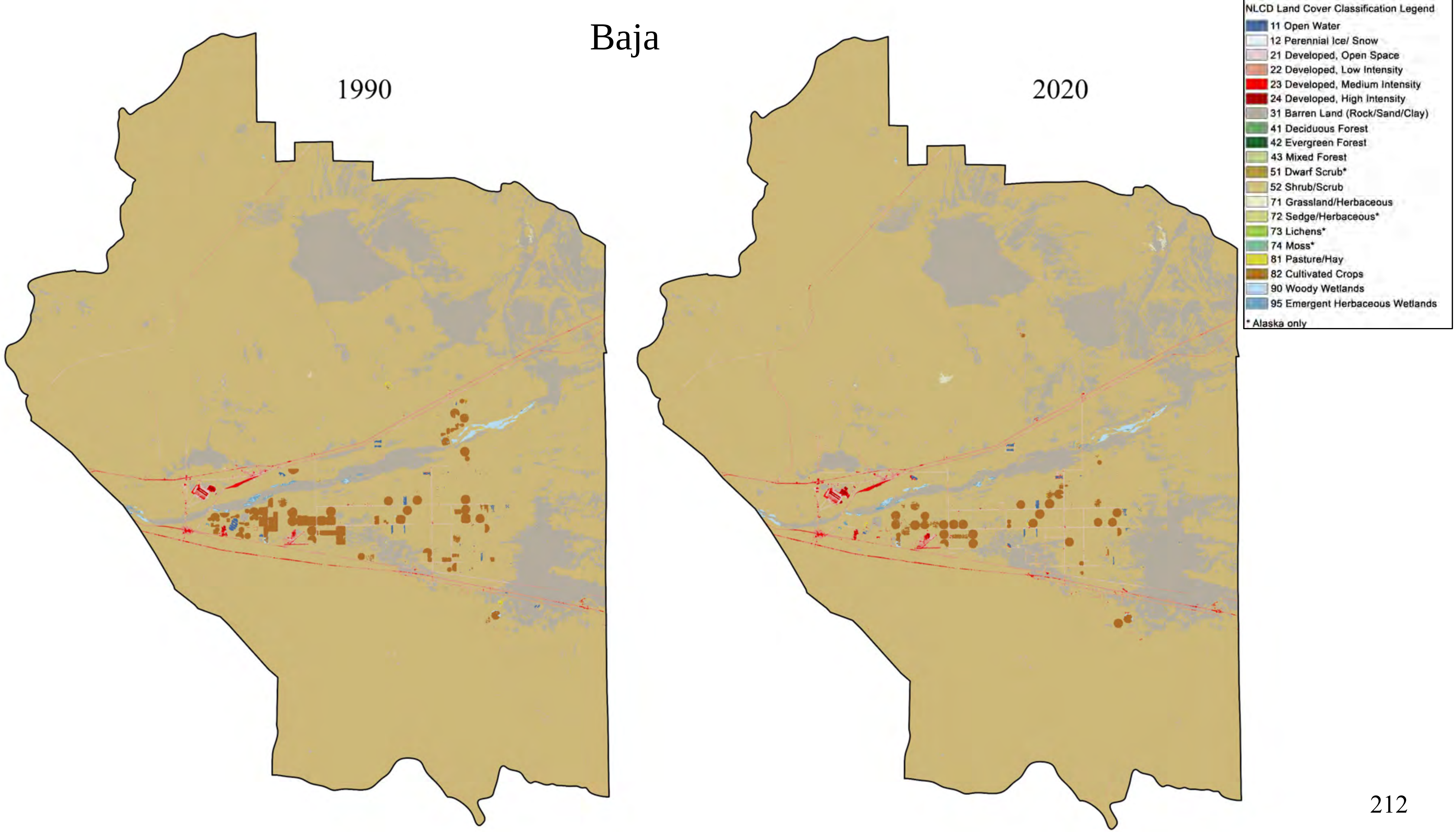




Annual National Land Cover Database (NLCD) by the U.S. Geological Survey (USGS)'s Land Cover program. Annual NLCD data was downloaded from the *Multi-Resolution Land Characteristics (*MRLC) site.

Baja



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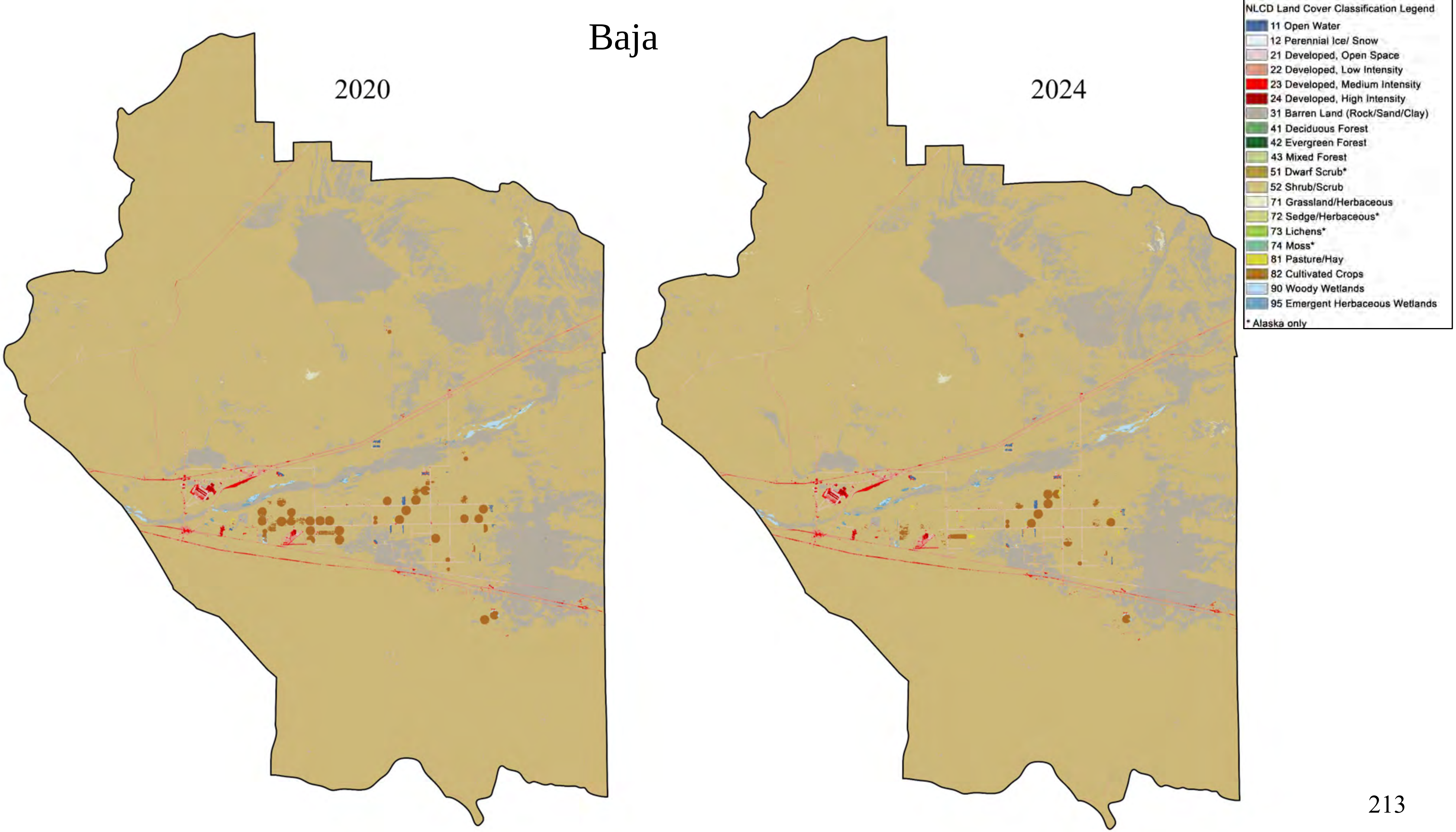
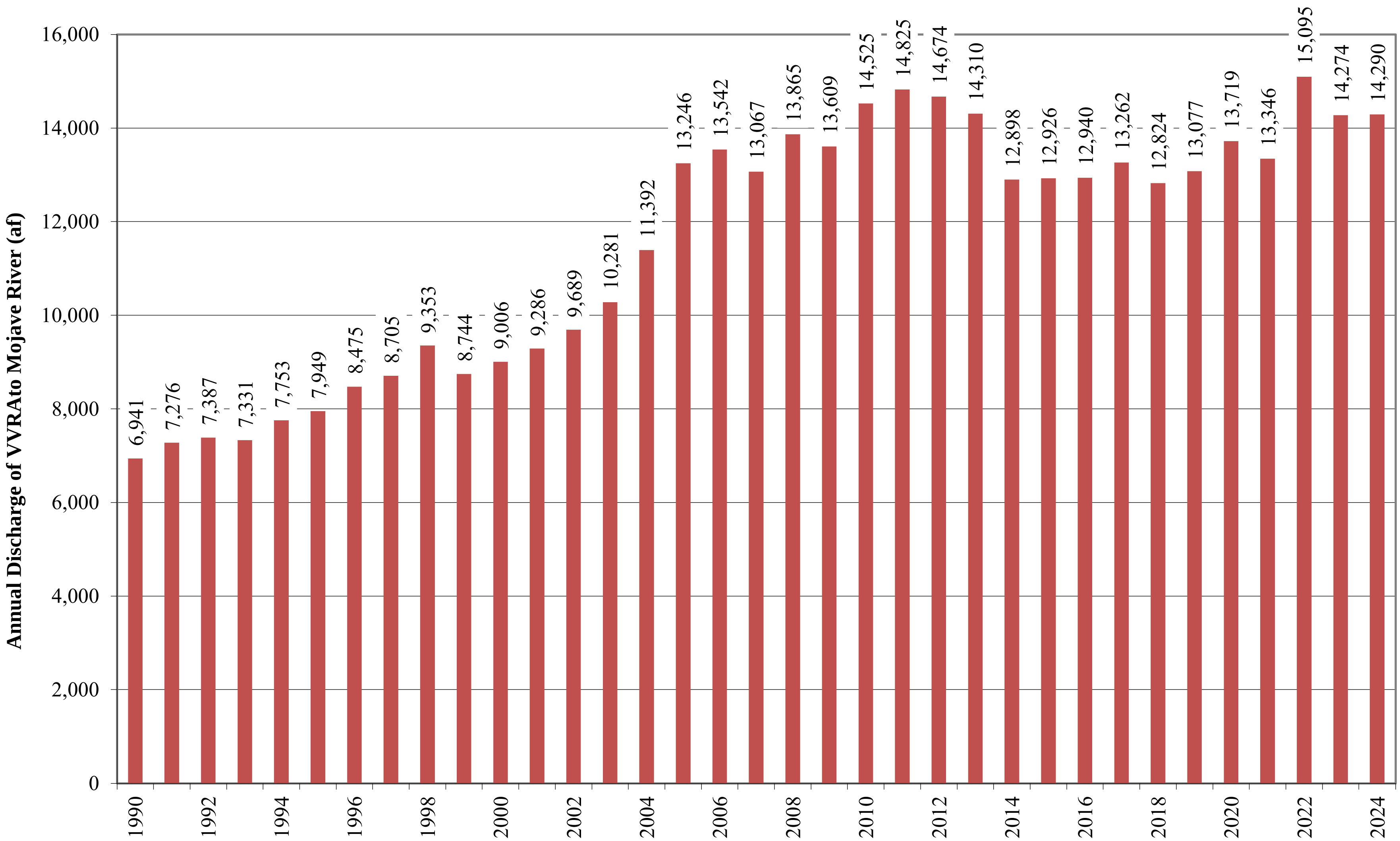
Baja



Annual National Land Cover Database (NLCD) by the U.S. Geological Survey (USGS)'s Land Cover program. Annual NLCD data was downloaded from the *Multi-Resolution Land Characteristics (*MRLC) site.

EXHIBIT D

Annual Discharge of Victor Valley Wastewater Reclamation Authority to Mojave River

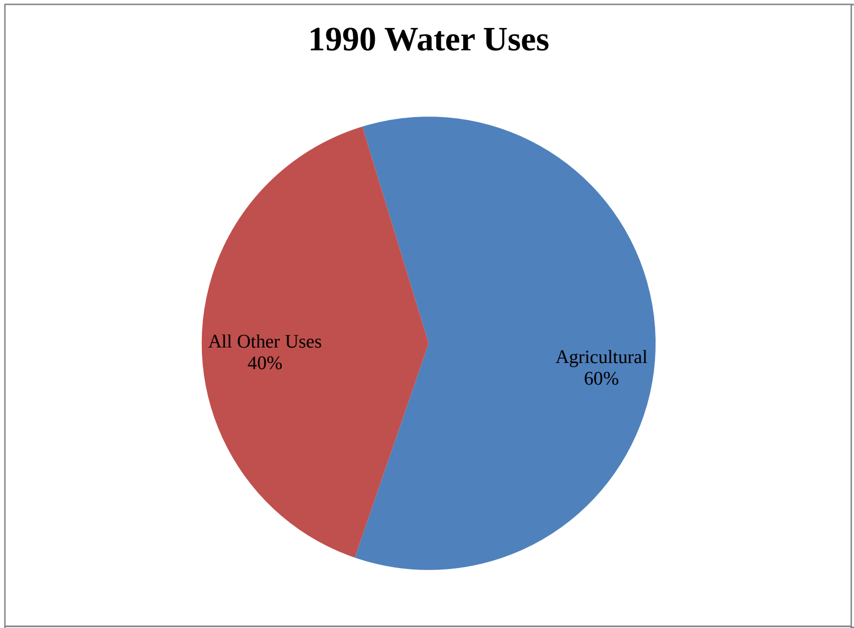


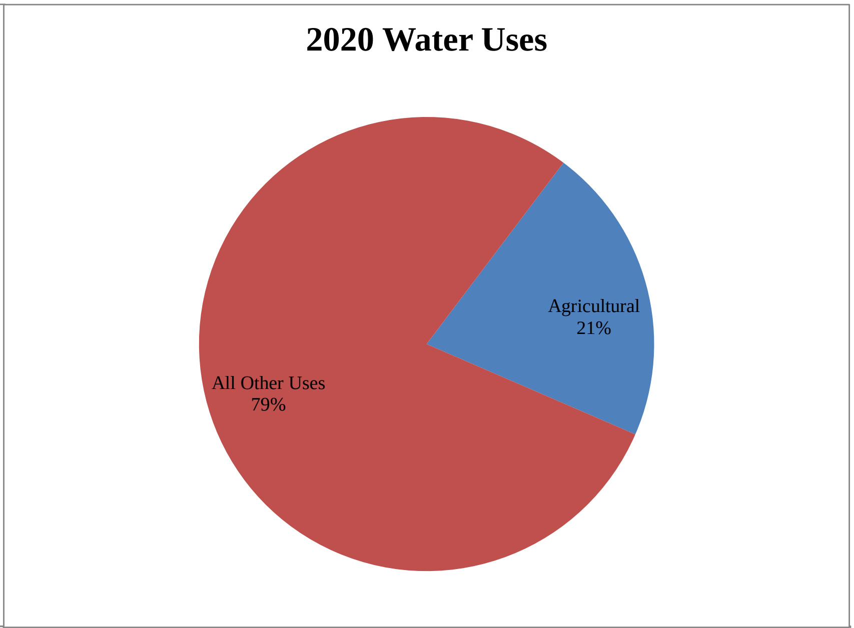
G:\MOJAVE WATERMASTER - 3040\Analysis\3040-225H-Mojave River Discharge (modified from 018x), VVWRA

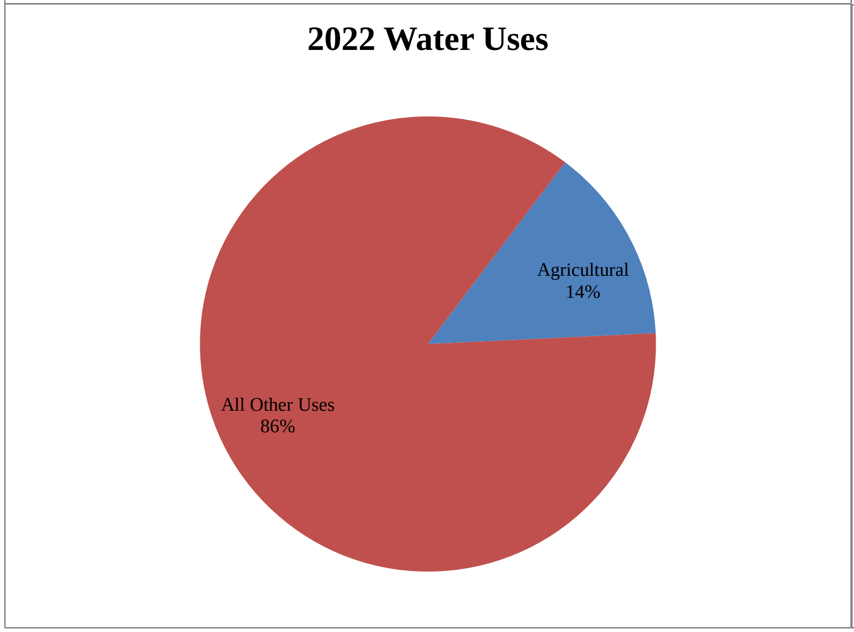
EXHIBIT E

Mojave Basin Area

Estimated Water Production by Agricultural and Other Uses







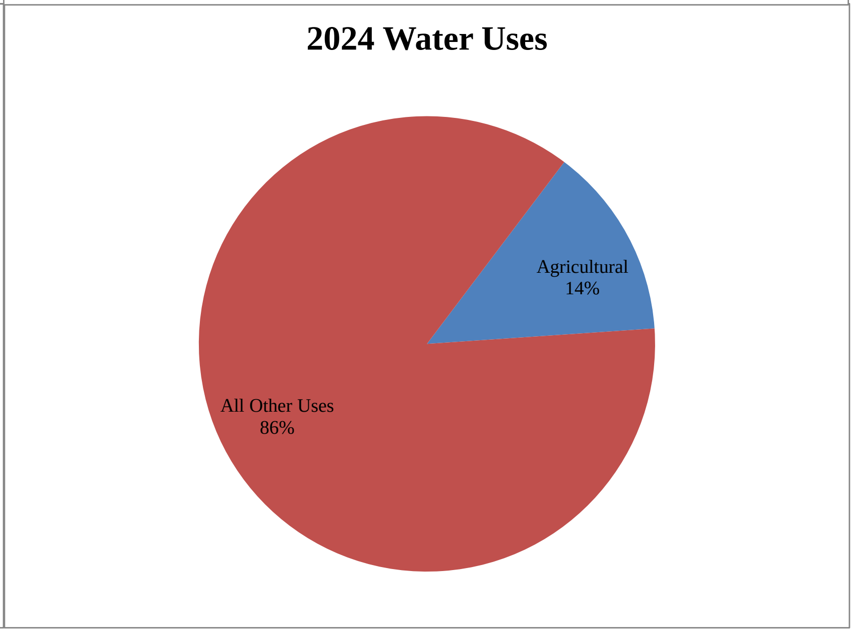


EXHIBIT F

Mojave Basin Area
Estimated Water Production by Type of Use
1994-95 Through 2023-24

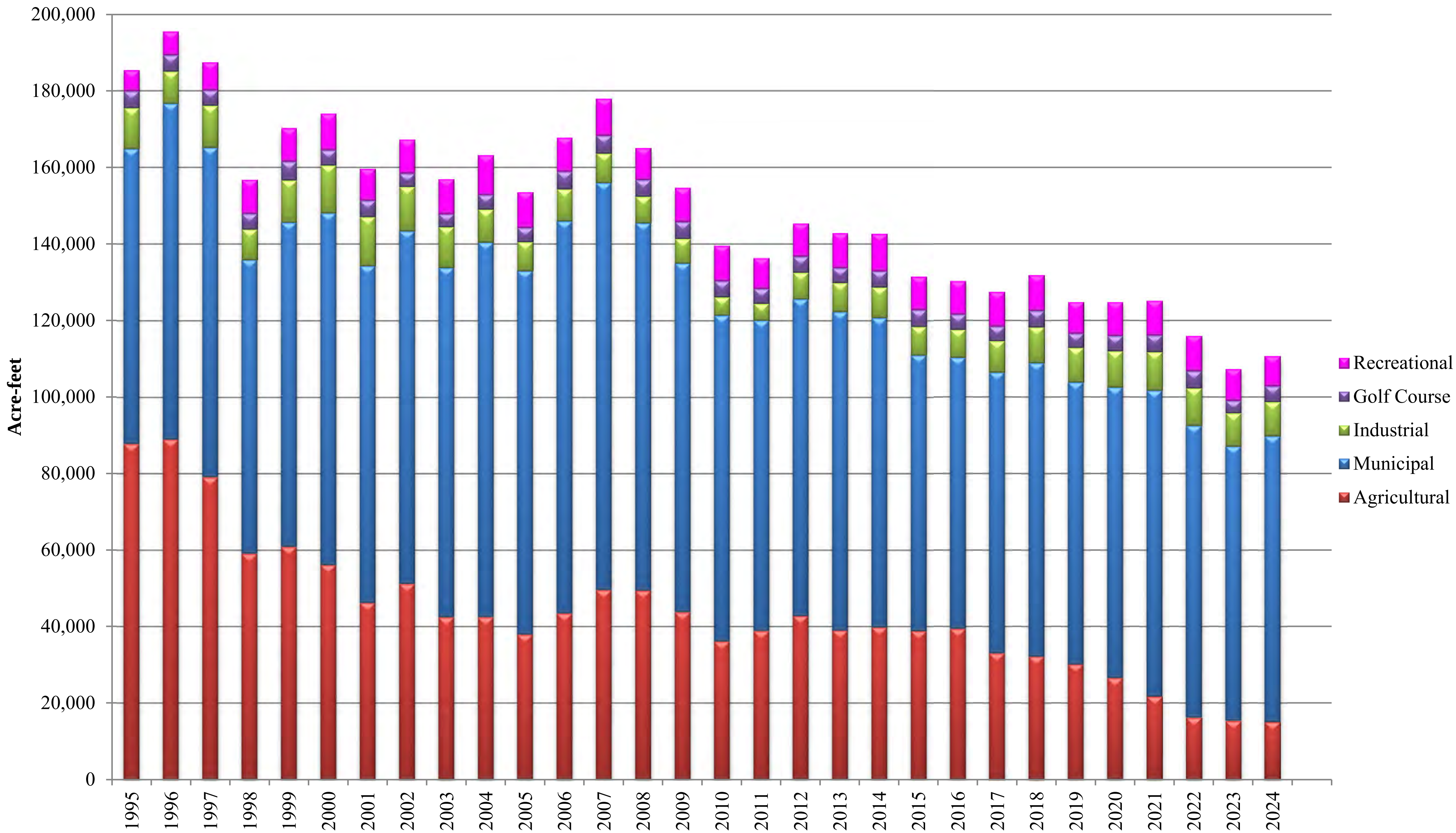


EXHIBIT G

Agricultural Water Production and Irrigated Acreage All Subareas

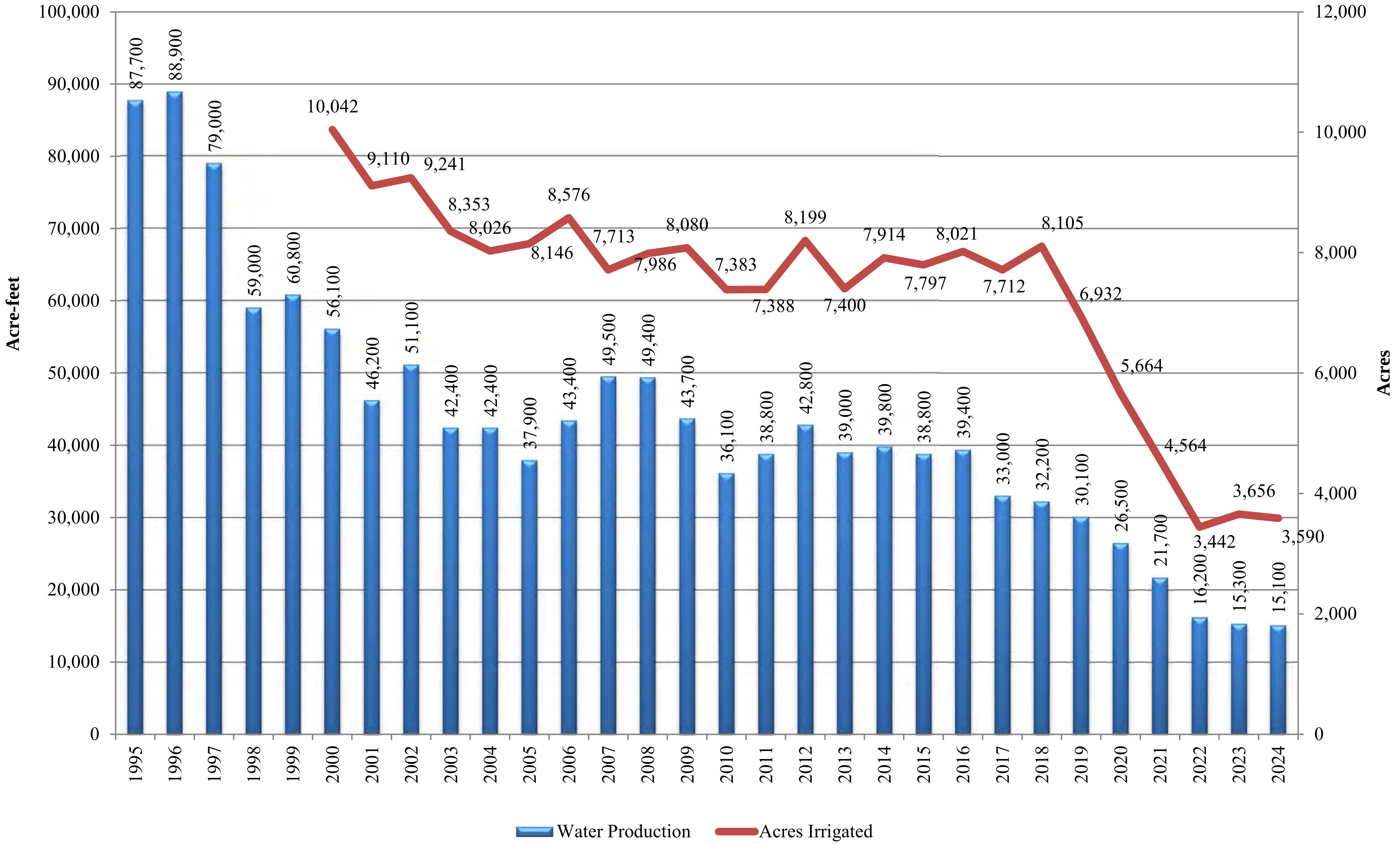
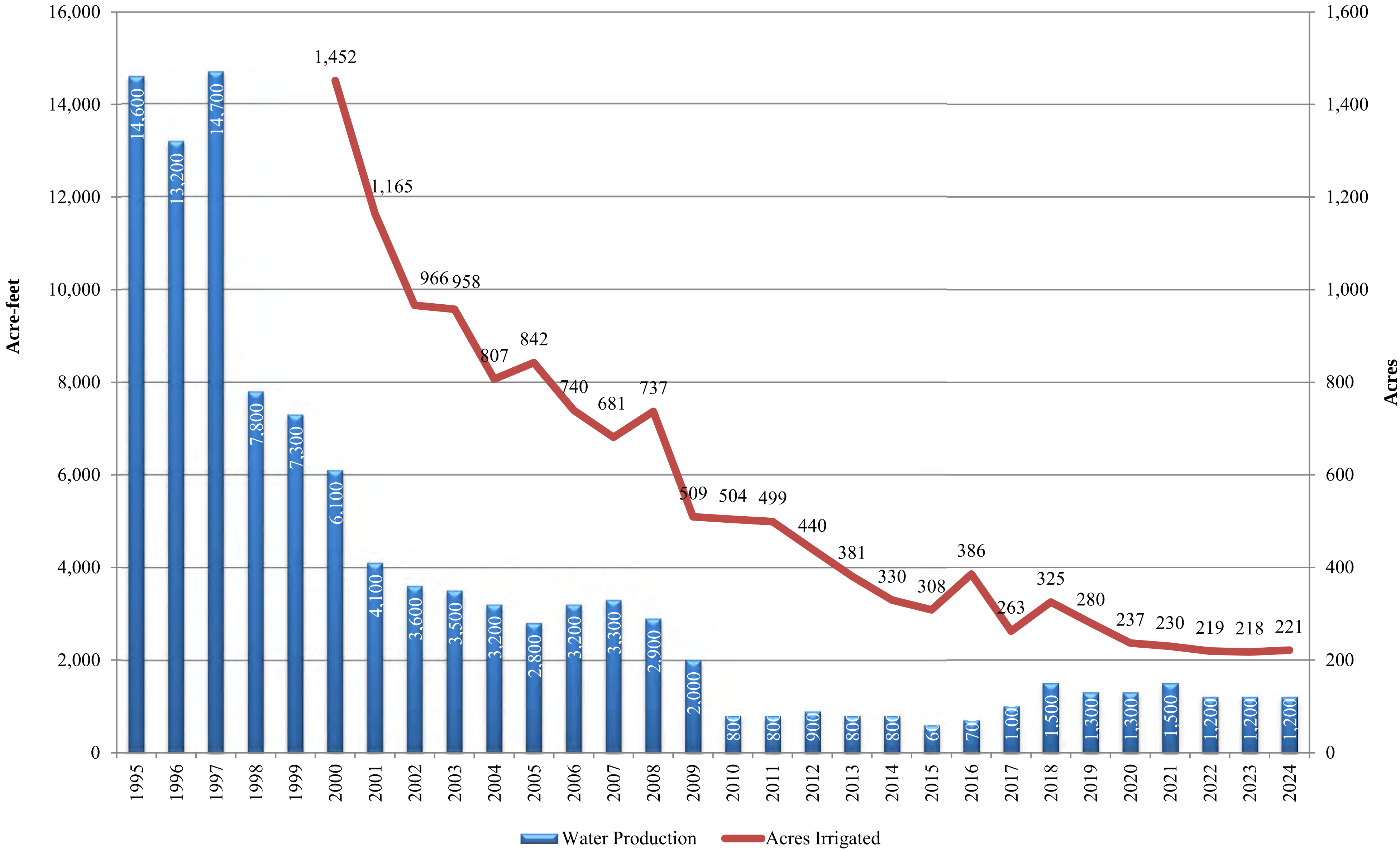
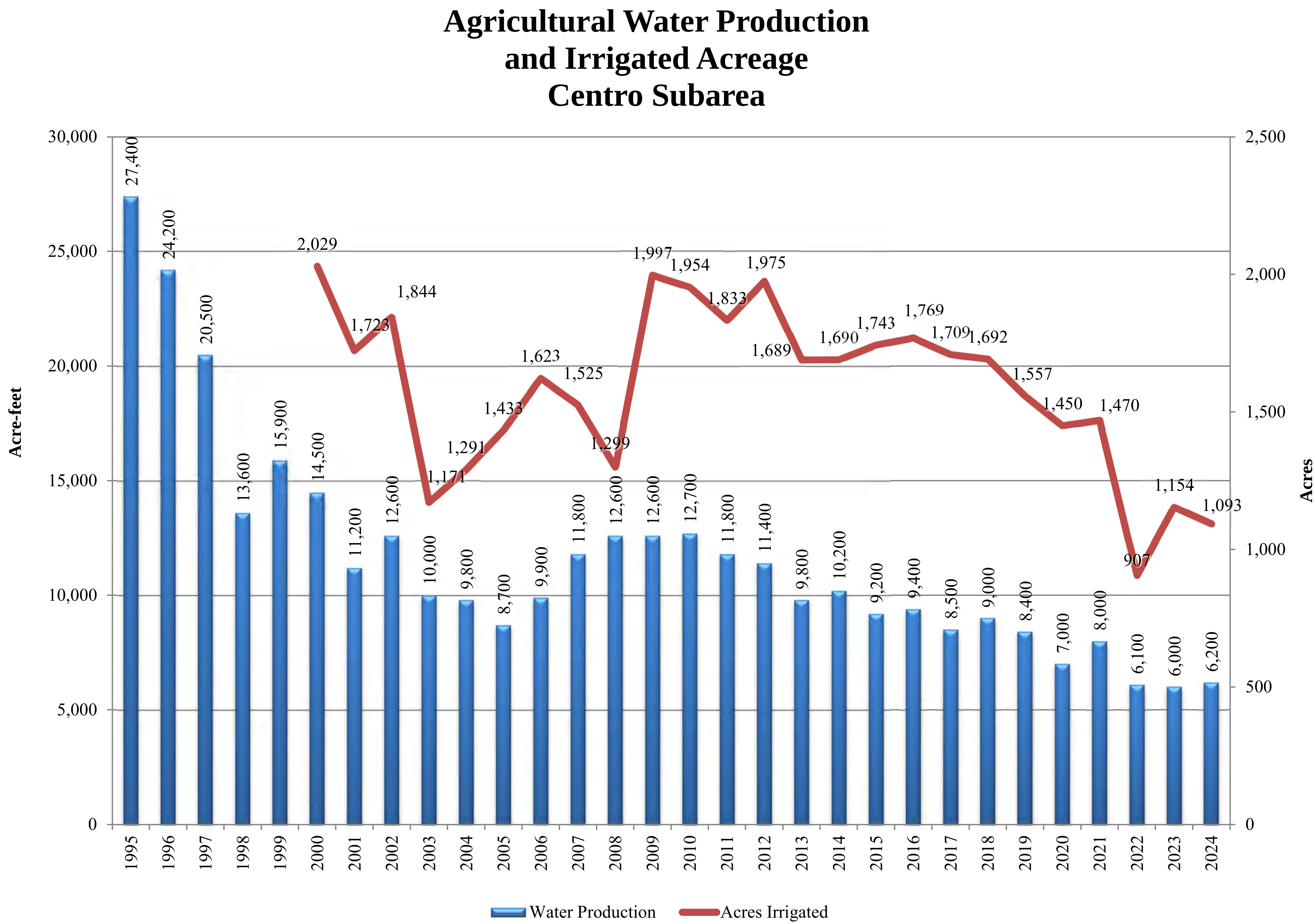


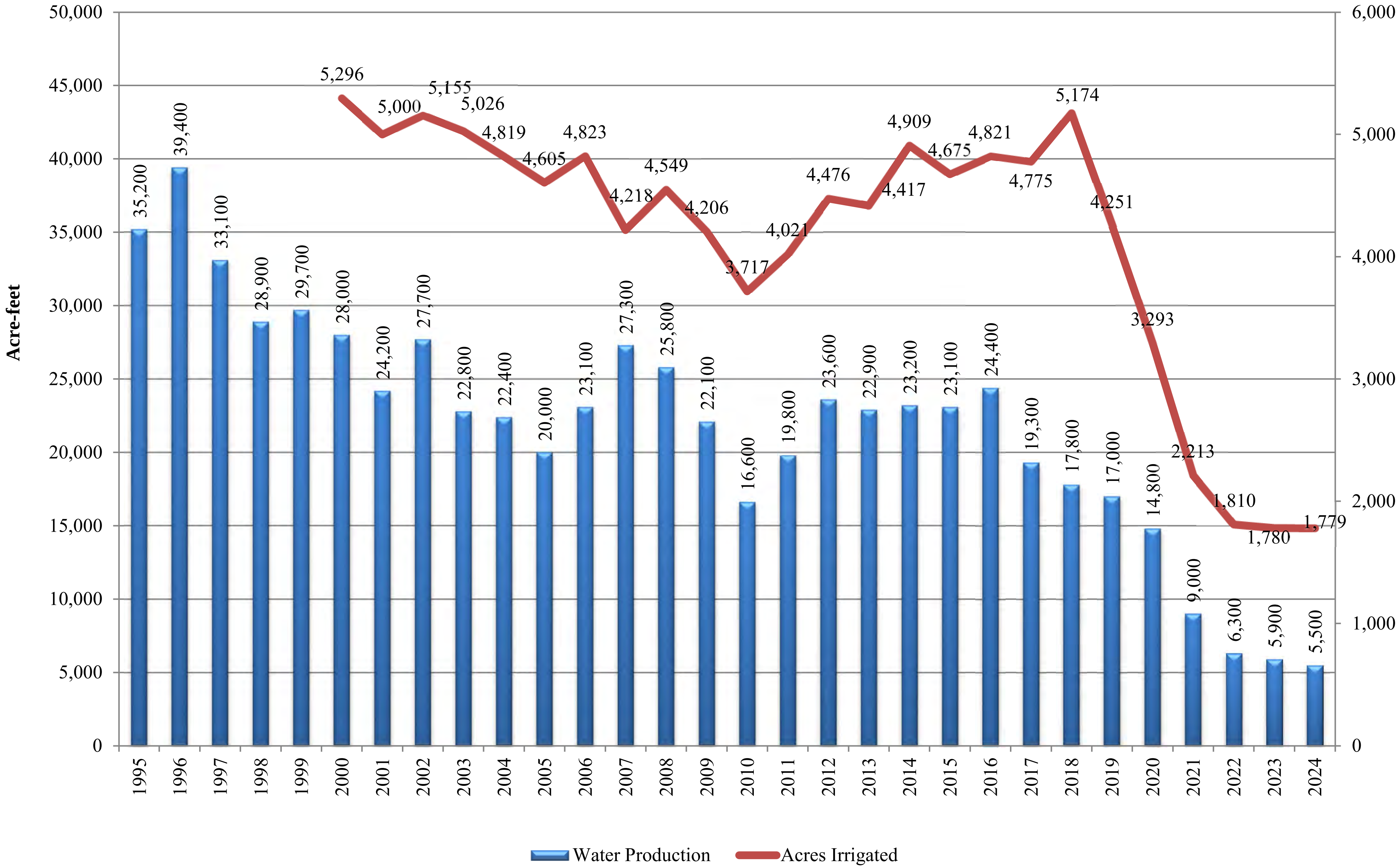
EXHIBIT H

Agricultural Water Production and Irrigated Acreage
Alto Subarea

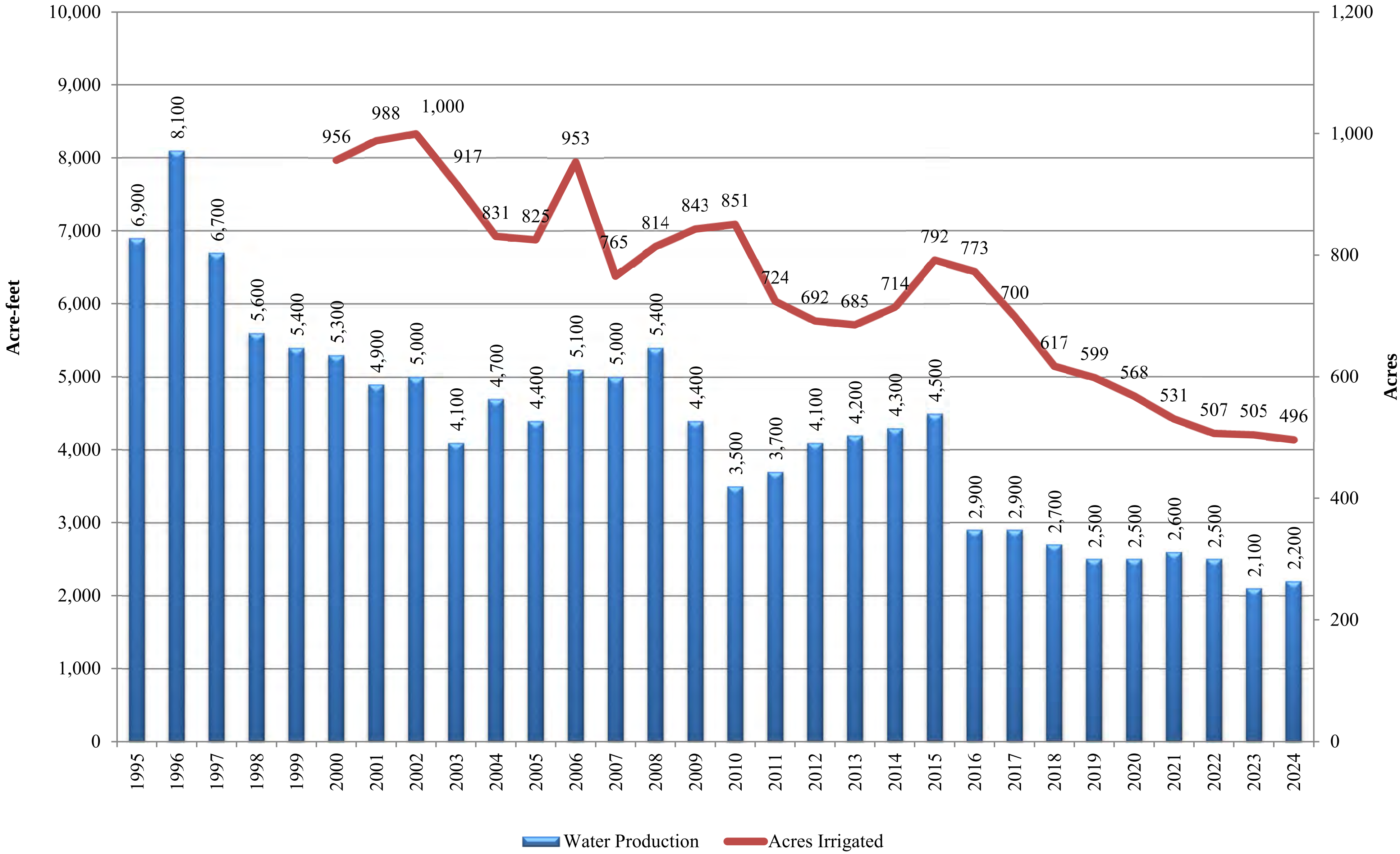


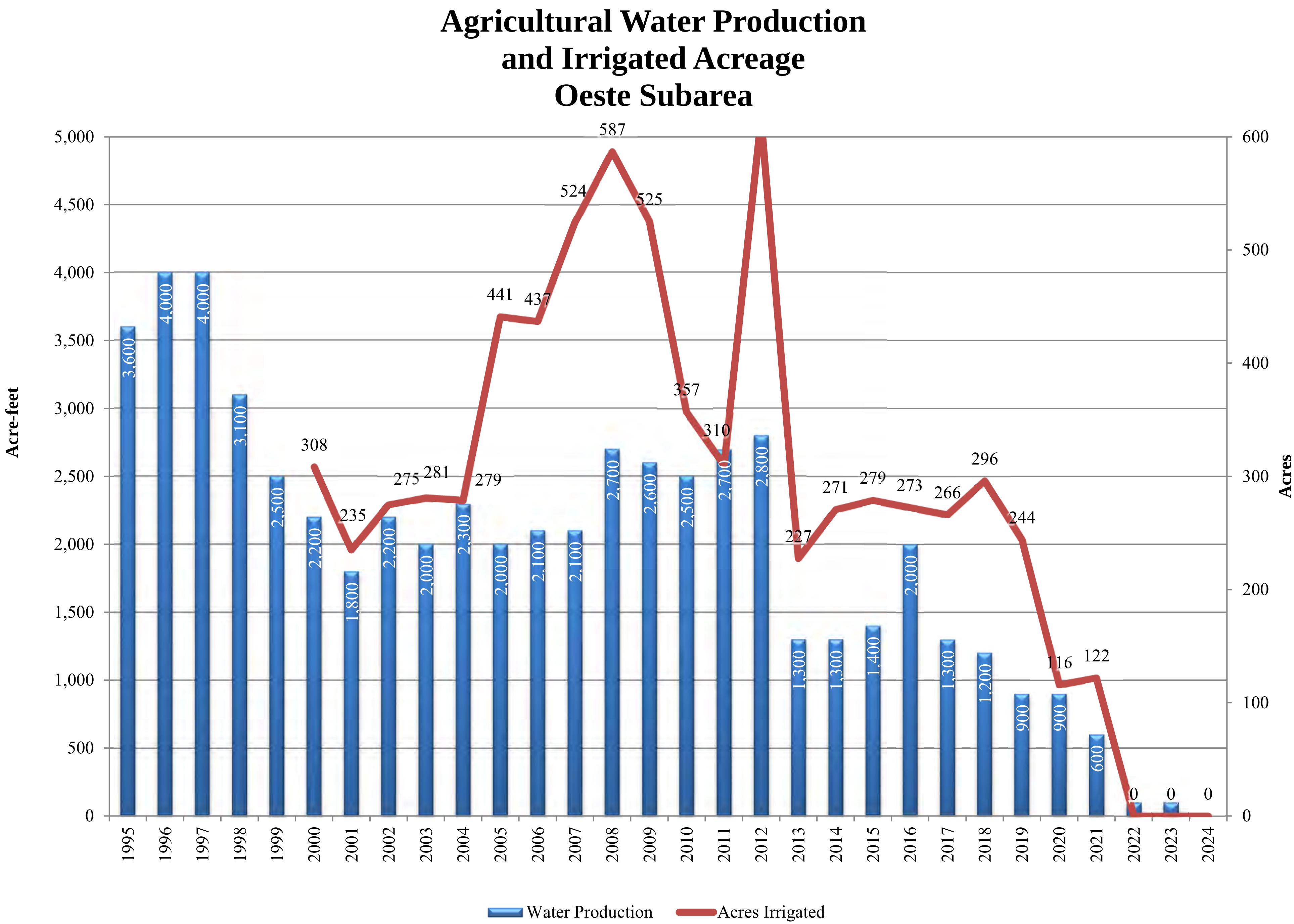

Agricultural Water Production
and Irrigated Acreage
Centro Subarea
Acre-feet
Acres
Water Production
Acres Irrigated
1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024
27,400 24,200 20,500 13,600 15,900 14,500 11,200 12,600 10,000 9,800 8,700 9,900 11,800 12,600 12,600 12,700 11,800 11,400 9,800 10,200 9,200 9,400 8,500 9,000 8,400 7,000 8,000 6,100 6,000 6,200
2,029 1,723 1,844 1,171 1,291 1,433 1,623 1,525 1,299 1,997 1,954 1,833 1,975 1,689 1,690 1,743 1,769 1,709 1,692 1,557 1,450 1,470 907 1,154 1,093

Agricultural Water Production and Irrigated Acreage
Baja Subarea



Agricultural Water Production
and Irrigated Acreage
Este Subarea





Agricultural Water Production
and Irrigated Acreage
Oeste Subarea
Acre-feet
Acres
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
600
500
400
300
200
100
0
3,600
4,000
4,000
3,100
2,500
2,200
1,800
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2,300
2,000
2,100
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2,700
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2,700
2,800
1,300
1,300
1,400
2,000
1,300
1,200
900
900
600
0
0
0
308
235
275
281
279
441
437
524
587
525
357
310
227
271
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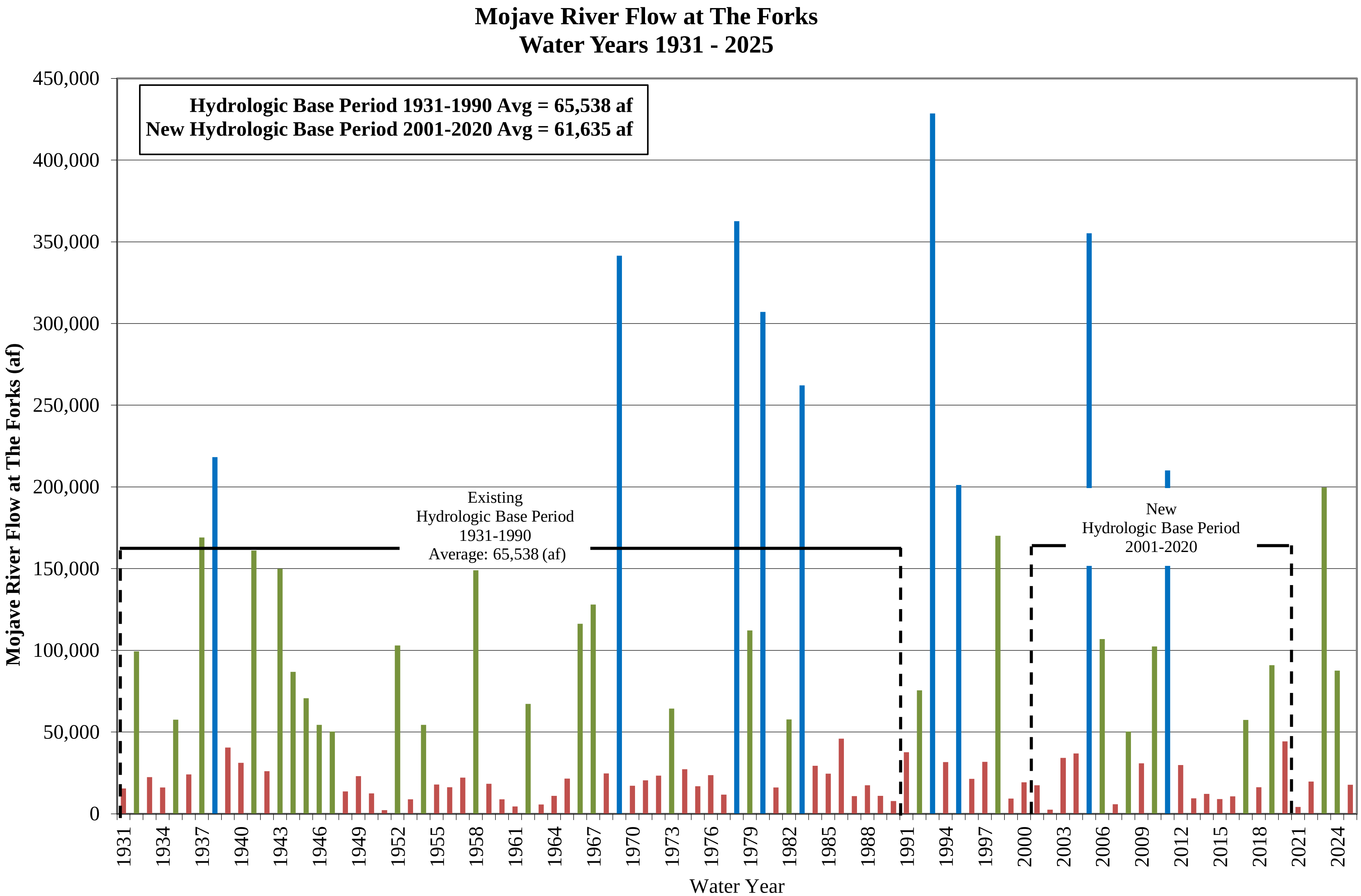
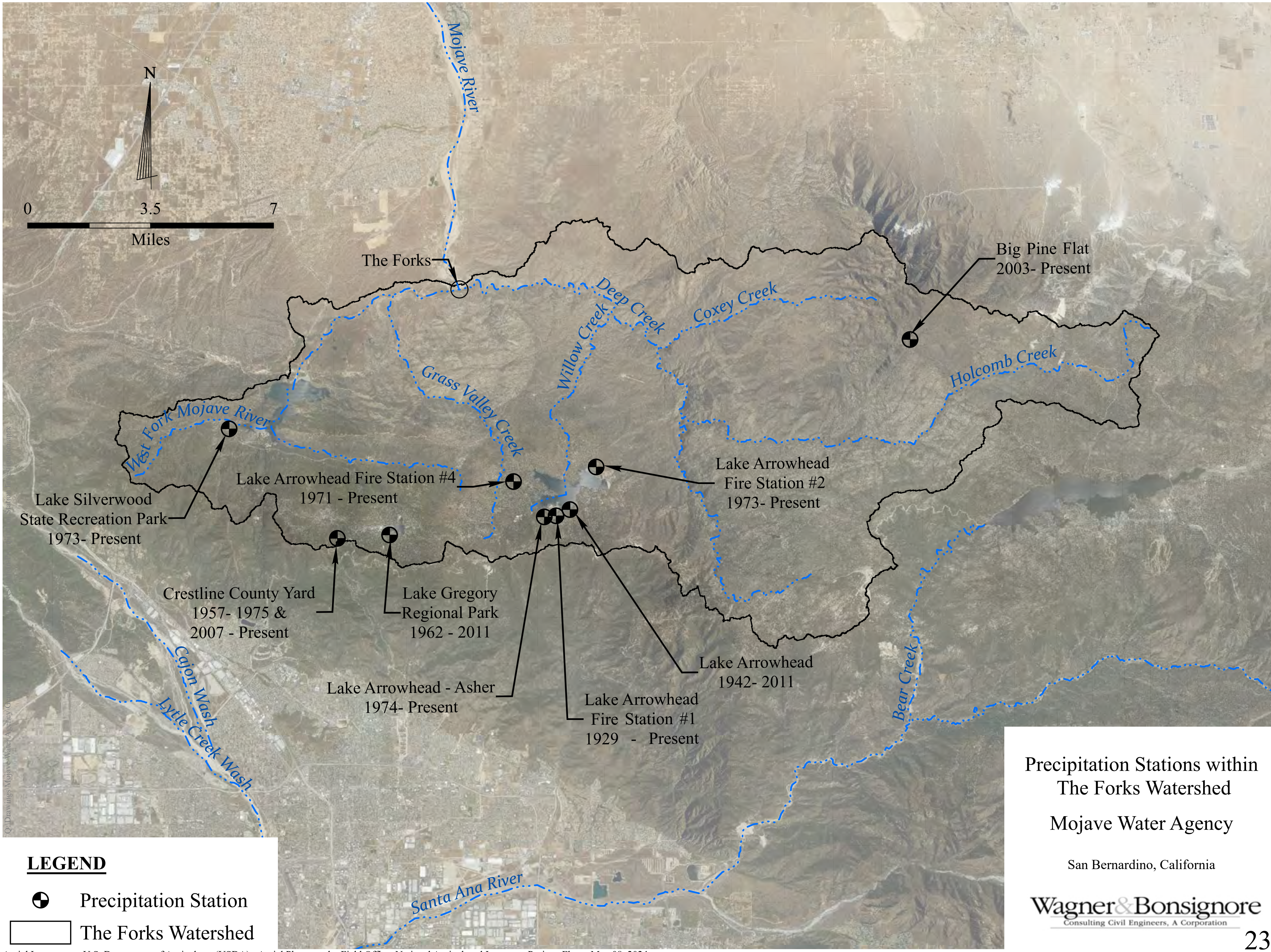
2024
Water Production
Acres Irrigated

EXHIBIT I



Note: Discharge of Mojave River at The Forks from the addition of values as reported from USGS stations at West Fork Mojave River Near Hesperia, CA (10261000), and Deep Creek Near Hesperia, CA (10260500) from 1931-1971, the greater of 10260500 and Mojave River Below Forks Reservoir Near Hesperia, CA (10261100) from 1972-1974, and the addition of West Fork Mojave River Above Mojave River Forks Reservoir Near Hesperia, CA (10260950) and 10260500 from 1975-Present.

EXHIBIT J



Precipitation Stations within The Forks Watershed

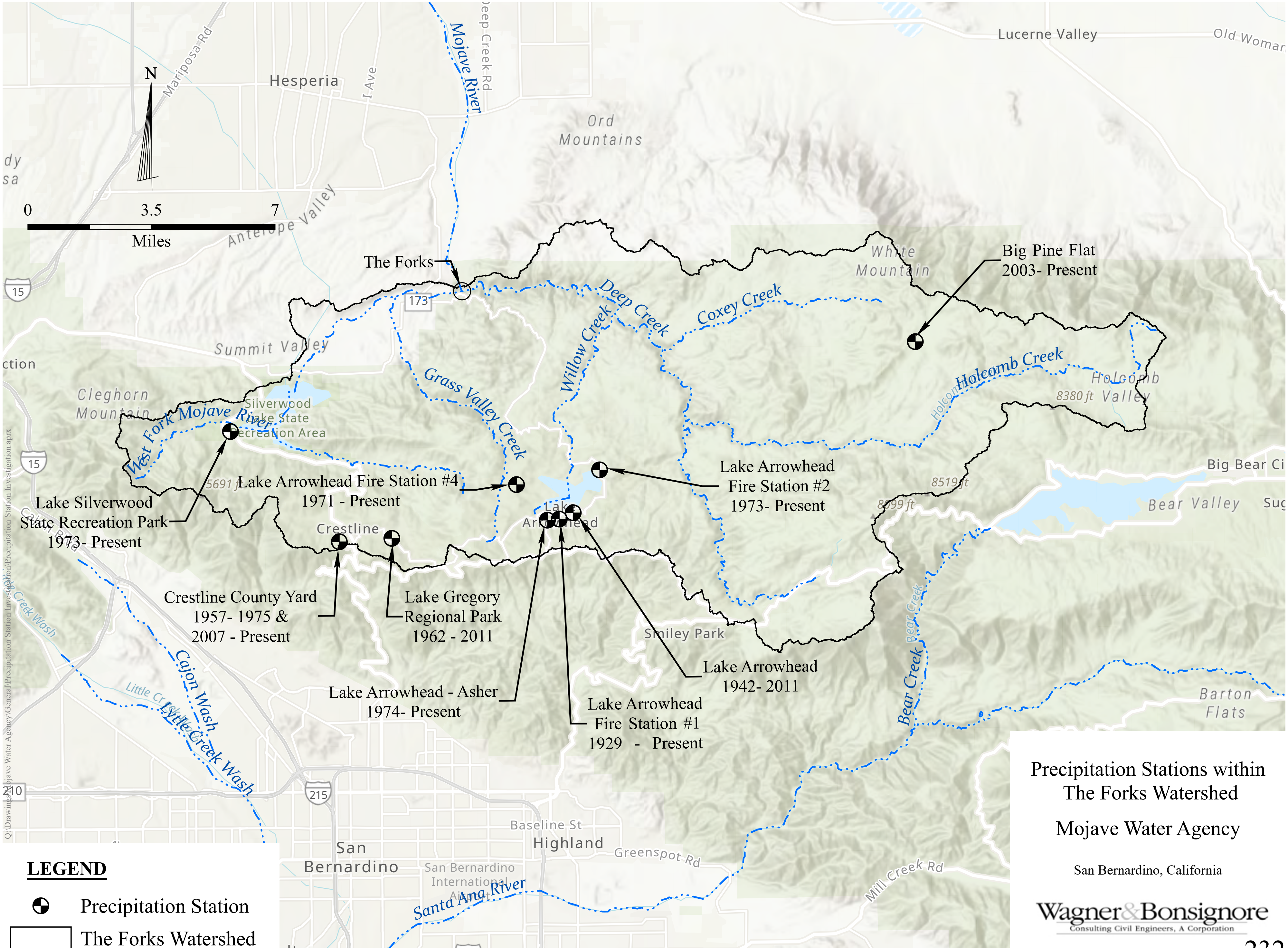
Mojave Water Agency

San Bernardino, California

Wagner&Bonsignore
Consulting Civil Engineers, A Corporation

Aerial Imagery per U.S. Department of Agriculture (USDA) - Aerial Photography Field Office, National Agricultural Inventory Project, Flown May 08, 2024.
Streams per California Dept. of Fish and Wildlife Clearinghouse, https://wildlife.ca.gov/Data/GIS/Clearinghouse accessed March 18, 2025.

October 2025



Precipitation Stations within The Forks Watershed

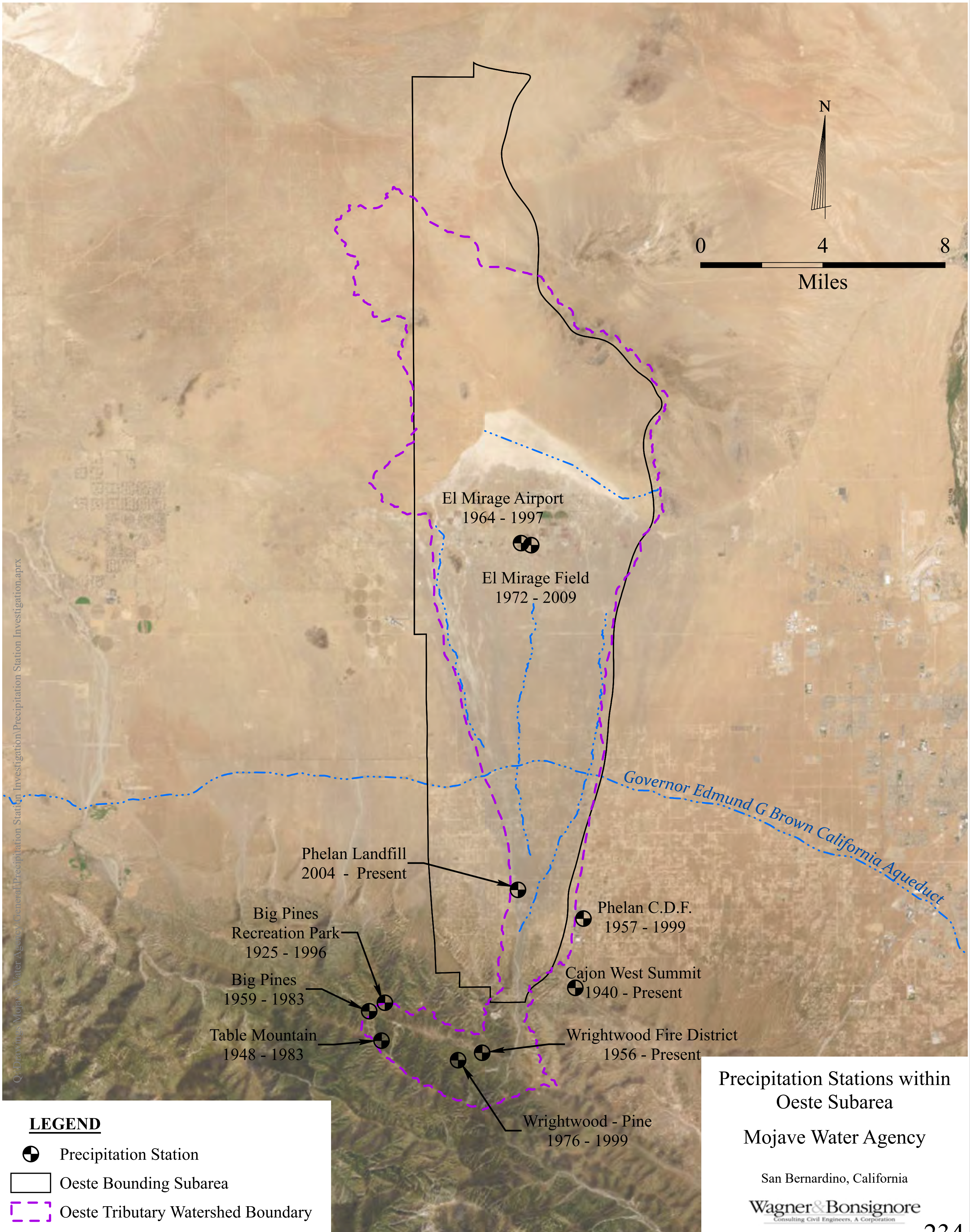
Mojave Water Agency

San Bernardino, California

Wagner & Bonsignore
Consulting Civil Engineers, A Corporation

Basemap Per: Esri, NASA, NGA, USGS, Sources: Esri, TomTom, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community
Streams per California Dept. of Fish and Wildlife Clearinghouse, https://wildlife.ca.gov/Data/GIS/Clearinghouse accessed March 18, 2025.

EXHIBIT K



Precipitation Stations within Oeste Subarea

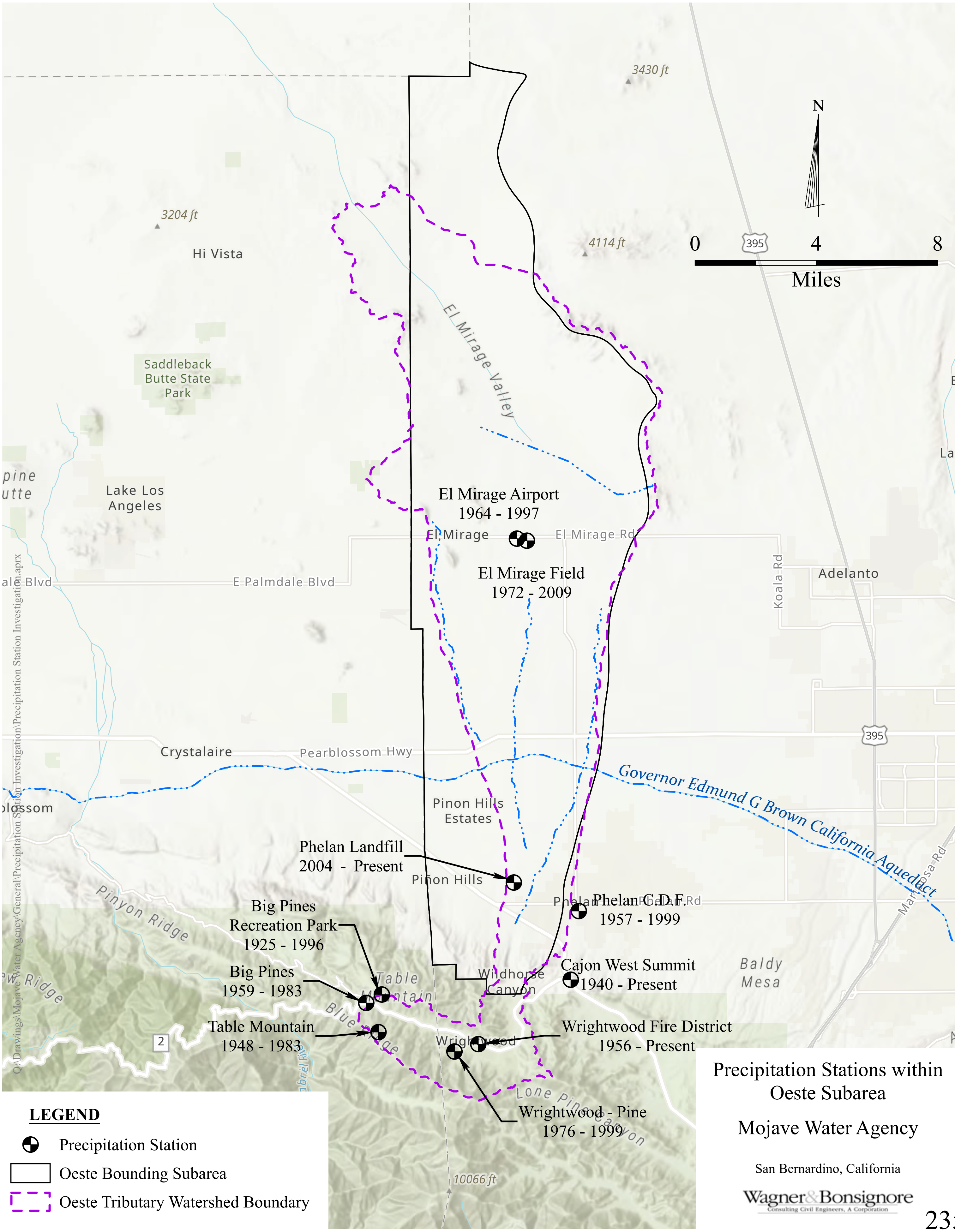
Mojave Water Agency

San Bernardino, California

Wagner & Bonsignore
Consulting Civil Engineers, A Corporation

October 2025

Basemap Per: Earthstar Geographics
Streams per California Dept. of Fish and Wildlife Clearinghouse, https://wildlife.ca.gov/Data/GIS/Clearinghouse accessed March 18, 2025.



Precipitation Stations within Oeste Subarea

Mojave Water Agency

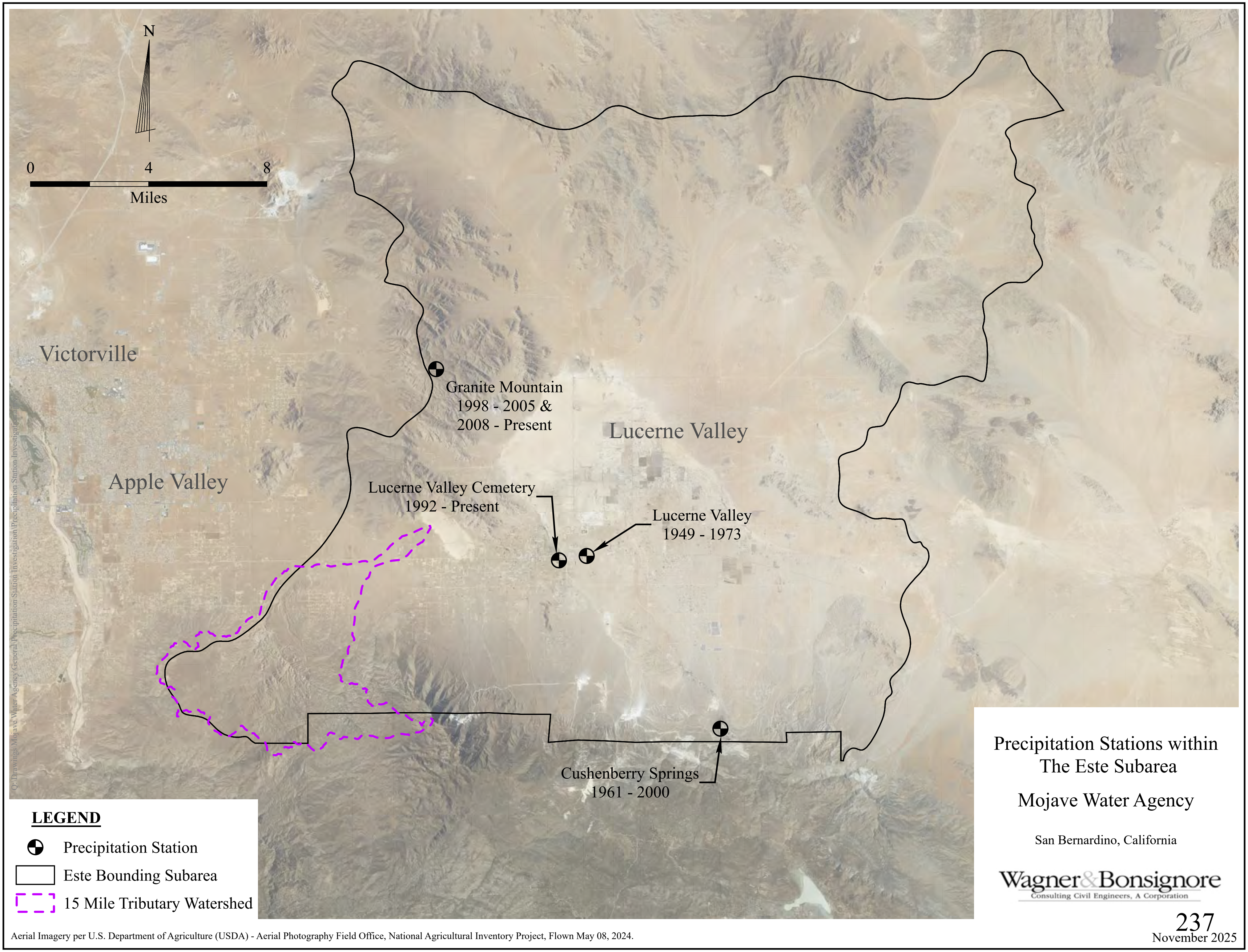
San Bernardino, California

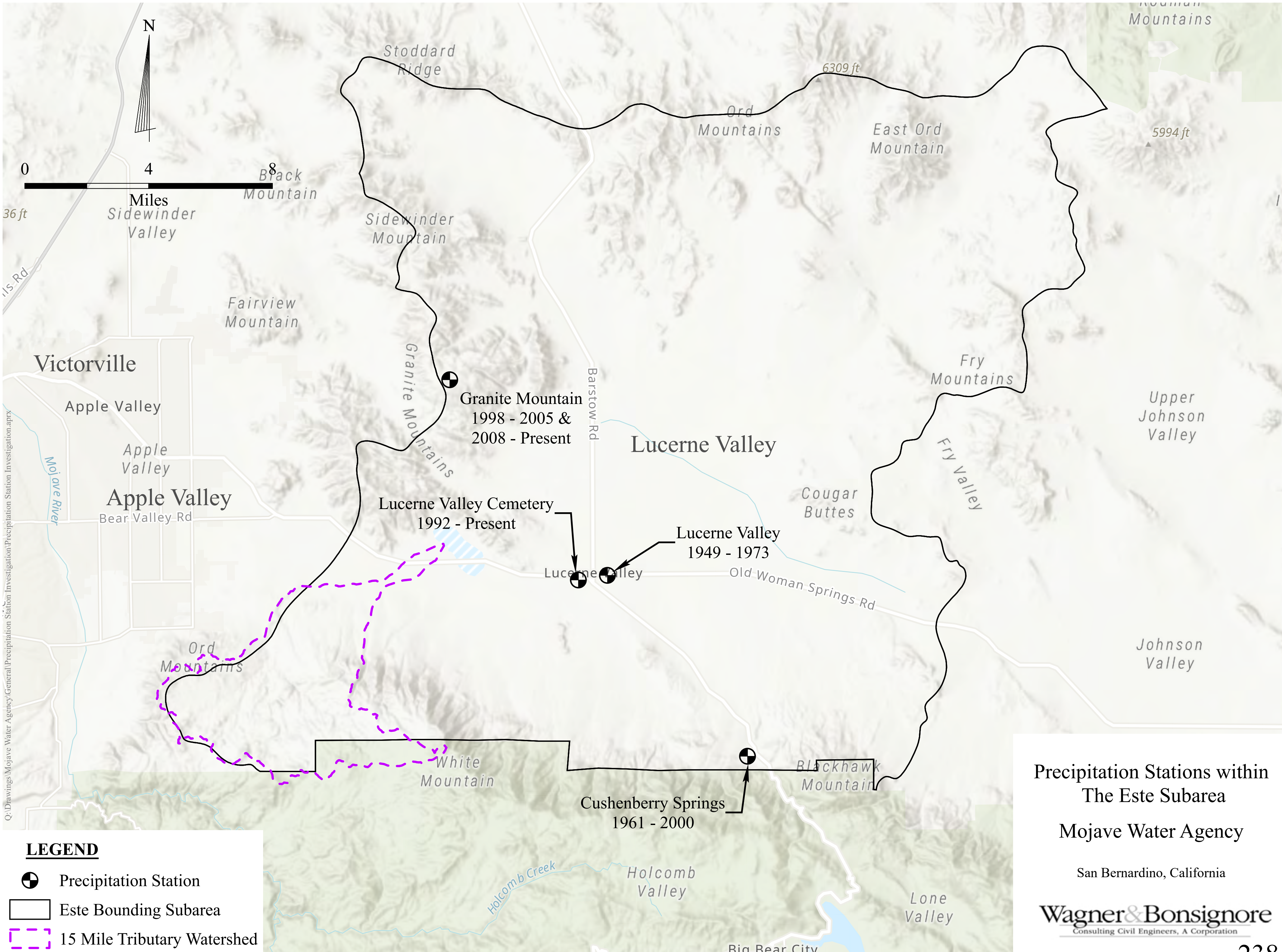
Wagner & Bonsignore
Consulting Civil Engineers, A Corporation

October 2025

Basemap Per: Esri, NASA, NGA, USGS, Sources: Esri, TomTom, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community
Streams per California Dept. of Fish and Wildlife Clearinghouse, https://wildlife.ca.gov/Data/GIS/Clearinghouse accessed March 18, 2025.

EXHIBIT L


N
0
4
8
Miles
Victorville
Apple Valley
Lucerne Valley
Granite Mountain
1998 - 2005 &
2008 - Present
Lucerne Valley Cemetery
1992 - Present
Lucerne Valley
1949 - 1973
Cushenberry Springs
1961 - 2000
LEGEND
Precipitation Station
Este Bounding Subarea
15 Mile Tributary Watershed
Precipitation Stations within
The Este Subarea
Mojave Water Agency
San Bernardino, California
Wagner&Bonsignore
Consulting Civil Engineers, A Corporation
Aerial Imagery per U.S. Department of Agriculture (USDA) - Aerial Photography Field Office, National Agricultural Inventory Project, Flown May 08, 2024.
November 2025



Q:\Drawings\Mojave Water Agency\General\Precipitation Station Investigation\Precipitation Station Investigation.aprx

Basemap Per: Esri, CGIAR, USGS, Sources: Esri, TomTom, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community

Precipitation Stations within The Este Subarea

Mojave Water Agency

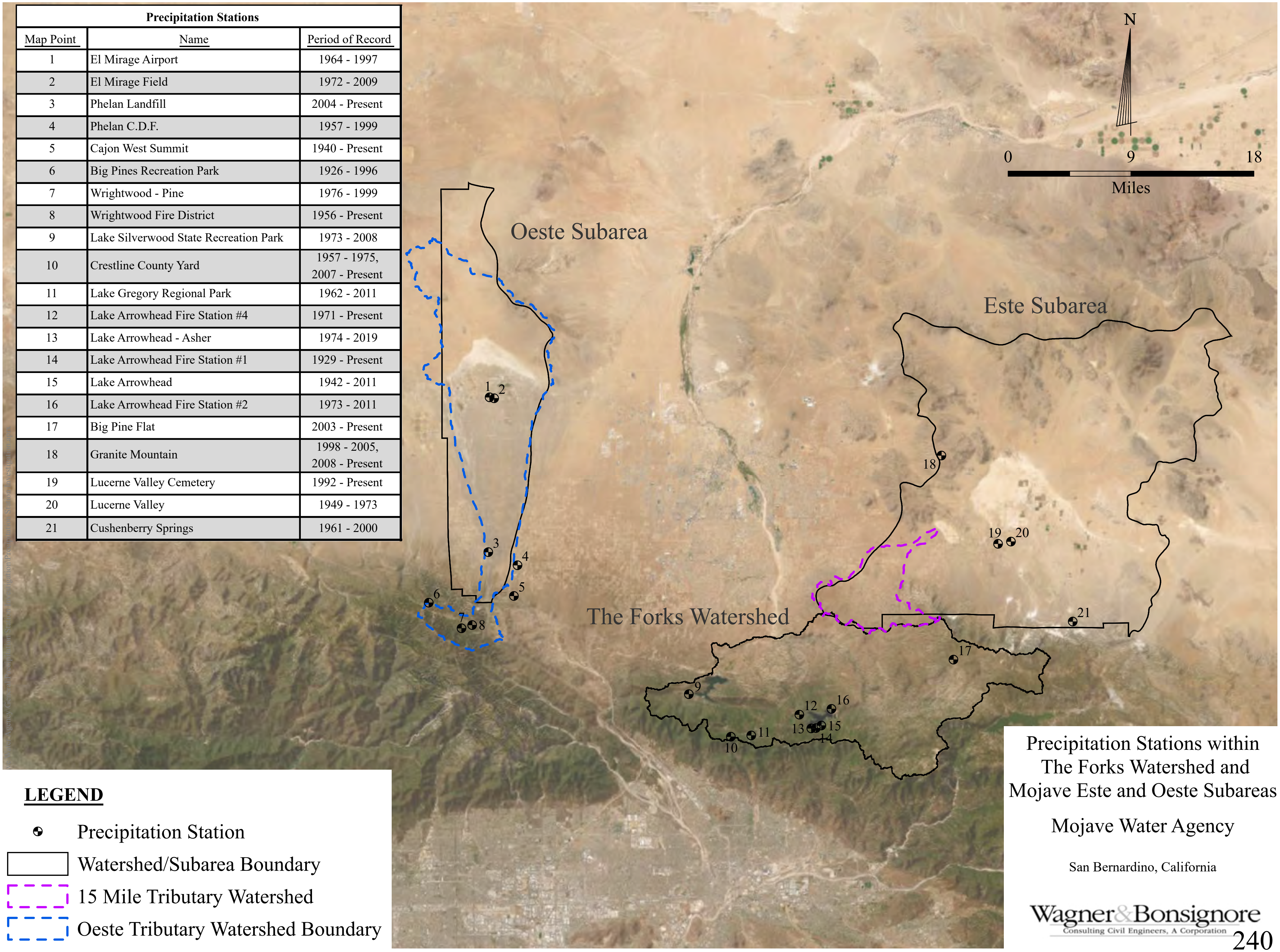
San Bernardino, California

Wagner & Bonsignore
Consulting Civil Engineers, A Corporation

November 2025

EXHIBIT M

Precipitation Stations		
Map Point	Name	Period of Record
1	El Mirage Airport	1964 - 1997
2	El Mirage Field	1972 - 2009
3	Phelan Landfill	2004 - Present
4	Phelan C.D.F.	1957 - 1999
5	Cajon West Summit	1940 - Present
6	Big Pines Recreation Park	1926 - 1996
7	Wrightwood - Pine	1976 - 1999
8	Wrightwood Fire District	1956 - Present
9	Lake Silverwood State Recreation Park	1973 - 2008
10	Crestline County Yard	1957 - 1975, 2007 - Present
11	Lake Gregory Regional Park	1962 - 2011
12	Lake Arrowhead Fire Station #4	1971 - Present
13	Lake Arrowhead - Asher	1974 - 2019
14	Lake Arrowhead Fire Station #1	1929 - Present
15	Lake Arrowhead	1942 - 2011
16	Lake Arrowhead Fire Station #2	1973 - 2011
17	Big Pine Flat	2003 - Present
18	Granite Mountain	1998 - 2005, 2008 - Present
19	Lucerne Valley Cemetery	1992 - Present
20	Lucerne Valley	1949 - 1973
21	Cushenberry Springs	1961 - 2000



LEGEND

Precipitation Station

Watershed/Subarea Boundary

15 Mile Tributary Watershed

Oeste Tributary Watershed Boundary

Precipitation Stations within The Forks Watershed and Mojave Este and Oeste Subareas

Mojave Water Agency

San Bernardino, California

Wagner & Bonsignore
Consulting Civil Engineers, A Corporation

Aerial Imagery per Earthstar Geographics

November 2025

Precipitation Stations

Map Point	Name	Period of Record
1	El Mirage Airport	1964 - 1997
2	El Mirage Field	1972 - 2009
3	Phelan Landfill	2004 - Present
4	Phelan C.D.F.	1957 - 1999
5	Cajon West Summit	1940 - Present
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7	Wrightwood - Pine	1976 - 1999
8	Wrightwood Fire District	1956 - Present
9	Lake Silverwood State Recreation Park	1973 - 2008
10	Crestline County Yard	1957 - 1975, 2007 - Present
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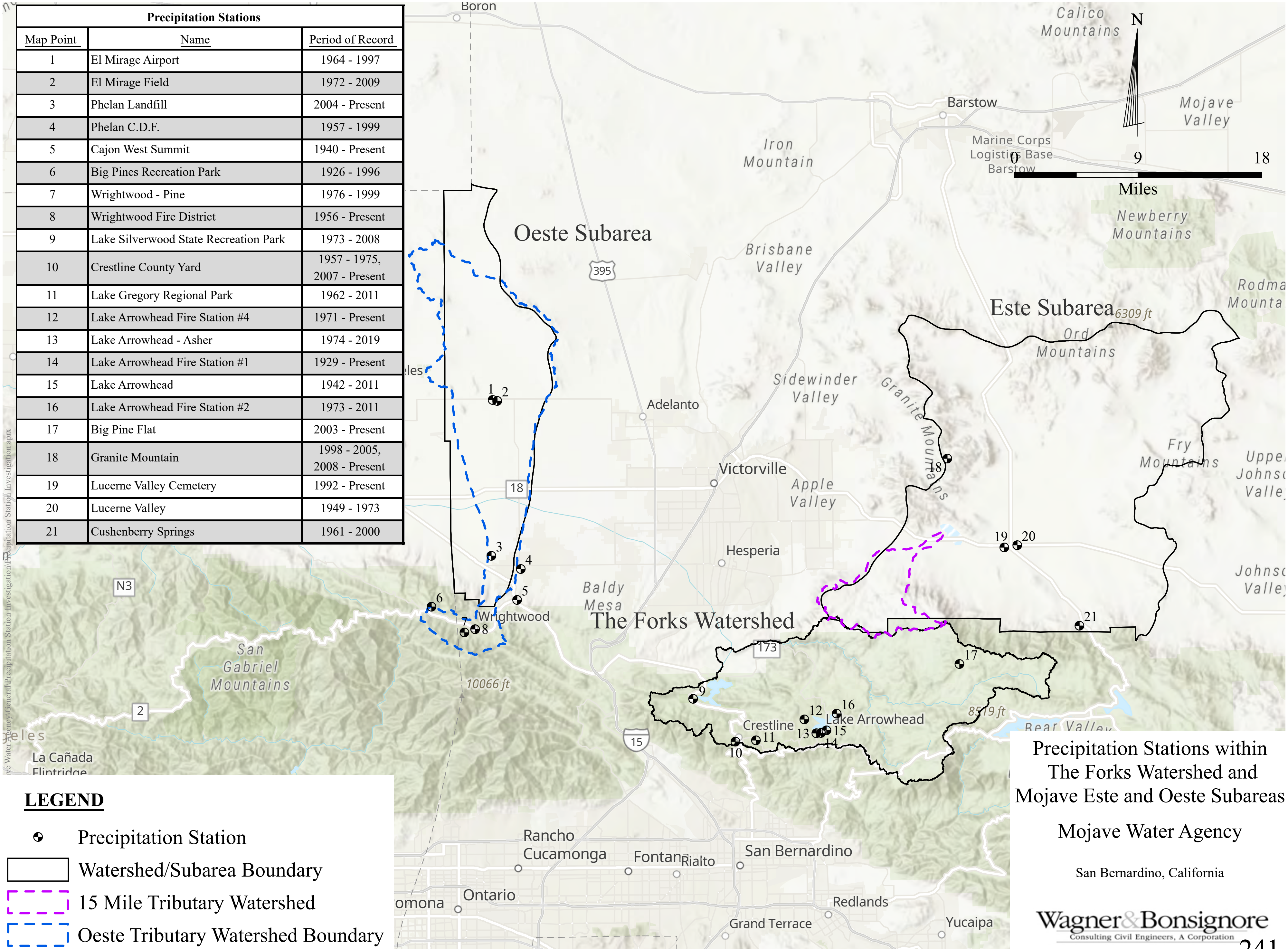
21	Cushenberry Springs	1961 - 2000



LEGEND

- Precipitation Station
- Watershed/Subarea Boundary
- 15 Mile Tributary Watershed
- Oeste Tributary Watershed Boundary

Aerial Imagery per Sources: Esri, TomTom, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community, Esri, USGS

Precipitation Stations within The Forks Watershed and Mojave Este and Oeste Subareas

Mojave Water Agency

San Bernardino, California

Wagner & Bonsignore
Consulting Civil Engineers, A Corporation

November 2025

EXHIBIT 2

EXHIBIT A

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MOJAVE WATER AGENCY

NO FEE PER GOV'T. CODE SEC. 6103

SUPERIOR COURT OF THE STATE OF CALIFORNIA

IN AND FOR THE COUNTY OF RIVERSIDE

Coordination Proceeding Special Title (Cal. Rules of Court, Rule 3.550) MOJAVE BASIN WATER CASES	CASE NO.: CIV 208568 / JCCP5265 Dept. 1. Riverside Superior Court Hon. Craig G. Riemer, Retired
CITY OF BARSTOW, et al., Plaintiff, v. CITY OF ADELANTO, et al., Defendant.	**WATERMASTER ENGINEER'S STATEMENT OF REASONS FOR RECOMMENDING 2001-2020 BASE PERIOD** Dept.: 1 Honorable Craig G. Riemer, Retired, Judge Presiding
AND RELATED CROSS ACTIONS	

DECLARATION OF ROBERT C. WAGNER

I, Robert C. Wagner, declare and state as follows:

I am a licensed Civil Engineer in the State of California and President of the firm of Wagner and Bonsignore, Consulting Civil Engineers in Sacramento, California. I serve in the capacity of Engineer for the Mojave Basin Area Watermaster in performance of its duties. I have personal knowledge of the matters set forth herein and, if called as a witness, I could and would testify competently thereto.

DWR Bulletin 84 guidance on the selection of a hydrologic base period.

The applicable hydrologic base period to be used to implement the terms of the Judgment is not defined in the Judgment. However, in January 1996, when judgment was entered in *City of Barstow v. City of Adelanto,* the Watermaster, the Court, and the Parties relied upon a study published in 1967 by the California Department of Water Resources (DWR), titled DWR Bulletin 84 (trial exhibit number 4006), a copy of which is attached as **Exhibit A** hereto. The Forward to that study states:

This investigation and report are the result of the recognition by the Mojave Water Agency of its need for reliable information on existing water resources, future water requirements, and sources of additional water supply to meet the needs for growth of the region it serves. Accordingly, the agency, through its legislative representatives, obtained state funds for the Department of Water Resources to undertake this investigation . . .

To provide interested agencies and persons with information as soon as it was available, informal meetings were held and two progress reports were published by the Department of Water Resources.

The results of this study show that additional water will be required if the Mojave region is to realize its growth potential. The meager rainfall and increasing water demands of the area indicate the need for a plan of basin operation that will take full advantage of existing and potential water resources, including ground water, imported water, and the use of the ground water basins for both storage and distribution of water.

The information provided by this study points out the need and provides a foundation for a ground water basin model simulation and operational and economic studies, leading to the selection by local agencies of an optimum plan of water resources management.

Bulletin 84 provides the following guidance as to precipitation serving as an index of the water supply (**Exhibit A**, p. 47):

In any watershed, precipitation is the original source of local water supply; therefore, the amount of precipitation to a groundwater basin and its tributary areas serve as an index of the water supply available to that basin. . . .

Bulletin 84 also provides the following guidance regarding the criteria to be used for selecting a long-term base period (**Exhibit A**, pp. 47-48):

The base period conditions should be reasonably representative of long-time hydrologic conditions and should include both normal and extreme wet and dry years. Both the beginning and the end of the base period should be preceded by a series of wet years or a series of dry years, so that the difference between the amount of water in transit within the zone of aeration at the beginning and end of the base period would be a minimum. The base period should also be within the period of available records and should include recent cultural conditions as an aid for projections under future basin operational studies.

. . .

On the basis of the criteria stated in preceding paragraphs, the water years 1936-37 through 1960-61 were chosen as the base hydrologic period. This 25-year period includes the most recent pair of wet and dry cycles; has an average annual precipitation (at Squirrel Inn No. 2) of 40.7 inches, which closely approximates the estimated long-time period average of 41.7 inches;

begins and ends after a series of dry years; is within the period of available data; and includes recent land use conditions.

The Los Angeles vs. San Fernando case

Similar criteria for selecting a hydrologic base period was adopted in *City of Los Angeles vs. City of San Fernando, et al.*, 14 Cal.3d 199 (1975), which is consistent with the SGMA definition of sustainable yield (Water Code Section 10721(v)). In *City of Los Angeles v. City of San Fernando, the* State Water Rights Board approved and adopted the Report of Referee dated July 1962 pursuant to the requirements of the Court's Order of Reference. **Exhibit B** hereto are excerpts from volume 1 of the July, 1962 State Water Rights Board "Report of Referee," filed in *City of Los Angeles v. City of San Fernando.*

In the selection of a base study period, the Los Angeles vs. San Fernando case states the base period corresponds to the one with precipitation similar to the long-term period of record 1872-73 through 1956-57. The Report of Referee (1962) also stated the following:

The desirable base study period is one during which precipitation characteristics in the Upper Los Angeles River area approximate the 85-year period of record, 1872-73 through 1956-57. A further requirement of such a period is that additional hydrologic information is available sufficient to permit an evaluation of the amount, occurrence and disposal of the normal water supply ***under recent culture conditions****. The desirable base period includes both wet and dry periods similar in magnitude and occurrence to the normal supply, and during which there are sufficient measurements and observations* ***to relate the hydrology to recent culture****.*

(**Exhibit B**, p. 182; emphasis added.)

Based on the above, the 29-year base period of 1929 through 1957 was selected for the following reasons (Report of Referee, pp. 72-73, filed with the Trial Court):

1. It was a period of normal precipitation, and sufficient records were available to calculate safe yield.
2. It was a representative period of normal precipitation including a series of wet and dry years similar in magnitude and occurrence to the long-term average supply conditions of 1872-73 to 1956-57. The average annual precipitation during these 29 years closely matched the long-term average, with only minor deviations.
3. The years preceding the first and last years of this period were drier than normal, thereby reducing unaccounted water in transit toward the water table at the start or end of the period.
4. It included years with water supply and disposal patterns under cultural conditions similar to those in 1949–50, 1954–55, and 1957–58, the years used for determining safe yield.

There are several similarities between the criteria for selection of a base period described in the Report of Referee (1962) by the State Water Rights Board and the guidance from DWR Bulletin 84.

The similarities in the criteria for a base period selection between DWR Bulletin 84 and City of Los Angeles vs. City of San Fernando are summarized as follows:

- Be representative (similar) to average long-term conditions of supply.
- Include a series of wet and dry years.
- Be based upon sufficient records depicting hydrologic conditions.
- Beginning and end of base periods are below normal (dry).
- Include periods of recent cultural conditions.

(**Exhibit B**, pp. 183-184)

Initial Hydrologic Base Period 1931-1990

Based upon DWR's guidance in Bulletin 84, the Parties and the Court in *City of* Barstow determined the initial hydrologic base period should be from 1931 to 1990, because it includes both normal and extreme wet and dry years, and meets the other requirements set forth in Bulletin 84.

Therefore, after January 10, 1996 (when the Judgment was entered), the hydrologic base period from 1931 to 1990 was accepted by the Parties as the applicable long-term hydrologic base period for purposes of implementing the Judgment.

The hydrologic base period is important because the production safe yield (PSY) requires a finite time period for evaluation. With pertinent information from the selected hydrologic base period, Watermaster determines PSY based on an estimate of consumptive uses and production to determine the amount of water that the Parties are required to purchase. The Judgment is intended as a funding mechanism so that those that pump more than their FPA will be required to purchase Replacement Water from Watermaster for recharge in a given subarea.

As indicated in Bulletin 84, the selected hydrologic base period should include recent cultural conditions, because those conditions are directly related to consumptive use and return flow which, in turn, directly impact water supply. The Court's Amended Statement of Decision in this proceeding acknowledges the importance of the cultural conditions: "Production Safe Yield is always based on a particular cultural condition." (Statement of Decision, C. 2.).

However, the "cultural conditions" for water use and disposal during the 1931-1990 hydrologic base period are not representative of recent cultural conditions. Watermaster has compiled land use data, historical pumping and irrigated acreages for the last 30 years. The following sections explain the changes in cultural conditions since 1990.

A. Changes in land uses

Changes over time are significant and must be considered. *City of Los Angeles v. City of San Fernando* notes: "The trial court found . . . that since the entry of the former judgment 'the culture of the area within the San Fernando Basin . . . has been transformed from essentially rural and agricultural to a highly developed urban society . . . .' Much of the land formerly devoted to irrigated crops has been covered by residential and commercial development." (*Id*, 14 Cal.3d at 258). A similar transformation has occurred in the Mojave Basin Area.

Exhibit C shows the 30-year changes in land use for each subarea. The National Land Cover Database (NLCD) is a product of the U.S. Geological Survey and provides nation-wide data on land cover and land cover changes in a 30-meter resolution. The NLCD dataset provides spatial reference and descriptive data for characteristics of the land surface such as developed areas, percent of impervious surfaces, and percent of tree canopy cover. The NLCD Land Cover dataset is represented categorically by 16 different land cover class codes. For purposes of evaluating land use changes in the Basin Area, Watermaster focused on two land cover classifications: "Developed" (shown as various shades of red colors for the different levels of development) and "Cultivated Crops" (class code 82, shown with a brown color and representing agricultural land).

The NLCD dataset for Alto Subarea (**Exhibit C**, p. 188) indicates a significant decrease in the land cover classified as "Cultivated Crops" from 1990 to 2020. The agricultural land use in Alto upstream of the Lower Narrows has disappeared, and agricultural land use in the Transition Zone was greatly reduced during that 30-year period. On the other hand, the developed areas in the Alto Subarea have extended and increased over that 30-year period, corresponding to the substantial growth in residential areas which are now sewered. The change in developed areas in the Alto Subarea is also evidenced by the flow patterns of the treated wastewater discharges by VVWRA into the Mojave River within the Transition Zone. **Exhibit D** shows the measured annual discharges by VVWRA for the period 1990 to 2024. VVWRA discharges started in the 1980s. As agricultural land use changed and new developed areas were connected to the sewered system, the patterns of return flows changed. In 1990, discharges by VVWRA were nearly 7,000 acre-feet. By 2020, the annual discharges by VVWRA were 13,719 acre-feet. The long-term increase suggests population growth related to the new developed areas shown in land use changes (**Exhibit C**, p. 188).

The NLCD dataset for the Centro Subarea (**Exhibit C**, p. 189) indicates a reduction in cultivated land, particularly in the Lockhart area and areas near Hodge. Similarly, the NLCD dataset for Este and Oeste subareas (**Exhibit C**, pp. 190-191) shows a considerable reduction in agricultural land use, and an increase in the developed areas in the Oeste Subarea. It is noteworthy that Oeste agricultural land use is expected to be almost zero now (2025).

Lastly, the NLCD dataset for the Baja Subarea (**Exhibit C**, p. 192-193) also shows a reduction in agricultural land use in the 30-year period evaluated. For the Baja Subarea, Watermaster also included a comparison of the most recent five years (2020 to 2024). This additional comparison documents the most recent changes in agricultural land uses, indicating that cultural conditions in the Baja Subarea have continued to change.

Watermaster findings on changes in land uses are consistent with the changes in groundwater pumping and number of acres irrigated ("irrigated acreage"), as indicated below.

B. Changes in Pumping and Irrigated Acreages

Exhibit E shows the distribution of the total water uses in the Water Years 1990, 2020, 2022, and 2024. In 1990, Water Use was predominantly agricultural accounting for 60%, and other uses (Commercial, Municipal, Industrial, Golf Course and Recreational) accounting for 40%. Thirty years later, with the implementation of the Judgment, the water use distribution has changed. In 2020, agricultural uses in the Basin Area was about 21%, while the other users were about 79%. Continuation of the rampdown has led to a continued decline in agricultural pumping. By 2024, agricultural uses declined further to only 14% and the remaining 86% corresponds to other uses.

Exhibit F shows the estimated total production for the Mojave Basin Area by the Type of Use from Water Year 1995 to Water Year 2024. The graphic indicates water use trends over nearly a 30-year period by five categories: Agricultural, Municipal, Industrial, Golf Course, and Recreational. During the peak Water Year 1996, total water production was close to 195,000 acre-feet. There was a remarkable downward trend in water use over time. By Water Year 2023-2024, total water use was about 111,000 acre-feet, a reduction of about 43% from the Water Year 1996 when the Judgment was implemented. In 1995, agricultural use (red bars) accounted for the largest share (nearly 88,000 acre-feet). Agricultural use dropped significantly after 1998 and continued to decline steadily. It is presently below 20,000 acre-feet indicating a major shift away from irrigated farming. Municipal use (blue bars) remains the largest component after agriculture declined. It fluctuates but generally stays between 70,000 and 100,000 acre-feet showing relative stability compared to other uses. Other use categories (Industrial, Golf Courses, Recreational) represent a small portion of the total use. In general, golf courses and recreational uses remain relatively constant, while industrial use has a slight variability.

Exhibit G provides a graphic of the Agricultural Water Production (blue bars) and Irrigated Acreages (red line) for all subareas combined from 1995 to 2024.

Exhibit H provides graphics of the Agricultural Water Production (blue bars) and Irrigated Acreages (red line) for each individual subarea from 1995 to 2024.

- **Alto Subarea**. For the Alto Subarea, both water production and irrigated acreage have declined consistently over time. In 1995, agricultural water production in Alto was about 14,600 acre-feet. By 2024, agricultural water production dropped to roughly 1,200 acre-feet. Watermaster's data on irrigated acreage shows a similar trend. In 2000, irrigated crops were grown on 1,452 acres. By 2024, irrigated crops were reduced to 221 acres. Irrigated acreages show a steady downward trend, with notable drops after 2002 (966 acres) and 2008 (711 acres).
- **Centro Subarea**. Agricultural water production and irrigated areas in Centro Subarea have declined over the 30-year period. In 1995, agricultural water production in Centro was about 27,400 acre-feet. By 2024, agricultural water production dropped to roughly 6,200 acre-feet. Watermaster's data on irrigated acreage shows a similar trend. In 2000, irrigated crops were

grown on 2,029 acres. By 2024, irrigated crops were reduced to 1,093 acres. Irrigated acreages show some variability over time; however, a steady downward trend can be observed after 2008.

- **Baja Subarea**. In 1995, agricultural water production in Baja was about 35,200 acre-feet. By 2024, agricultural water production dropped to roughly 5,500 acre-feet. Watermaster's data on irrigated acreage shows some variability; however, irrigated areas show a steady downward trend during recent years. In 2000, irrigated crops were grown on 5,296 acres. By 2024, irrigated acreages were reduced to 1,779 acres. Watermaster concludes that agricultural pumping patterns and irrigated areas have changed during the last five years. This is consistent with the evidence of land use changes observed in Baja during the 2020 to 2024 period (**Exhibit C**).
- **Este Subarea.** Both agricultural water production and irrigated acreage have declined significantly over time. In 1995, agricultural water production was about 6,900 acre-feet. By 2024, agricultural water production dropped to roughly 2,200 acre-feet. Watermaster's data on irrigated acreage shows a similar trend. In 2000, irrigated acreage was 956 acres. By 2024, irrigated acreage had been reduced to 496 acres. After 1996, with the implementation of the Judgment, agricultural water production and simultaneously irrigated land in the Este Subarea have been in continuous decline.
- **Oeste Subarea**. The graphic for Oeste Subarea shows a clear long-term decline in both agricultural water production and irrigated acreage from 1995 to 2024, with some notable fluctuations. In 1995, agricultural water production was about 3,600 acre-feet. By 2024, agricultural water production reached zero acre-feet. Watermaster's data on irrigated acreage shows fluctuations, with a rise in farmed acreages between 2004 and 2012, peaking at 612 acres in 2012, even as agricultural water production remained relatively stable. After 2013, irrigated acreage declined rapidly, falling below 200 acres by 2020 and reaching zero by 2022. By 2022, agricultural water production had dropped to about 100 acre-feet and by 2024, water production

reached zero acre-feet indicating a complete cessation of agricultural pumping and irrigation. The complete drop to zero in both agricultural water production and irrigated acreages suggests a transition out of agricultural use in the Oeste Subarea, likely due to the implementation of the Judgment. This is consistent with the evidence of land use changes observed in Oeste during the 1990 to 2020 period (**Exhibit C,** p.191).

The foregoing demonstrates conclusively that the previously utilized hydrologic base period from 1931 to 1990 does not represent "recent cultural conditions" and, therefore, does not meet the Bulletin 84 criteria for selection of a hydrologic base period to be used for calculating PSY. Accordingly, it is necessary to select a hydrologic base period that fairly represents, among other required elements, recent cultural conditions.

Water Supply to the Basin Area

Water supply to the Basin Area includes gaged and ungagged inflow, subsurface flow, deep percolation of precipitation, and certain imports.

Surface water inflow to the Alto Subarea is measured flow of the Mojave River at the Forks and is the sum of reported values from USGS gage stations at West Fork Mojave River near Hesperia, CA and Deep Creek near Hesperia, CA. This measured USGS gage data provides the best available information regarding the surface water inflow to the Basin Area. There are very few records of surface water inflow to the Este and Oeste Subareas.

Watermaster reviewed records of precipitation. Although there are several precipitation stations located within the Forks' watershed, the reliability of this data is questionable. The precipitation records are short, inconsistent, and intermittent (see **Exhibit M**). For these reasons, Watermaster believes the measured flow of the Mojave River at the Forks continues to be the record indicative of the long-term water supply to the Basin Area. Additionally, the flow record at the Forks provides a clear indication of wet and dry periods in the Basin Area.

New Proposed Hydrologic Base Period 2001-2020

The 2001-2020 hydrologic base period, which was proposed by Watermaster in 2024 and 2025 meets the guidance set forth in Bulletin 84 as evaluated at the Forks. It is reasonably representative of long-term hydrologic conditions for inflow at the Forks, contains normal, extreme wet and dry years, and begins and ends with dry years. It also is within the period of record and includes recent cultural conditions. The 2001-2020 hydrologic base period, while similar, is drier by about 6%, compared to the 1931-1990 period as measured at the Forks. **Exhibit I** is a hydrograph of the Mojave River at the Forks, showing the initial 60-year hydrologic base period of 1931-1990, and the proposed new hydrologic base period of 2001-2020.

Once the hydrologic base period is set, there is no reason to reset it every year, or at any other time unless the conditions upon which it is based change significantly.

Hydrologic Base Period vs. Pumping and Consumptive Uses for purposes of PSY determination

The purpose of this section is to provide an explanation of the differentiation between the selection of the hydrologic base period, and the selection of a year representative of pumping and consumptive uses for determination of PSY. For water supply, the hydrologic base period is used to determine the average water supply to the Basin Area, and it is assumed that this pattern will repeat itself in the future for planning purposes.

Watermaster needs to clarify that when calculating PSY, **the year representative of pumping and consumptive uses does not necessarily need to be strictly contained within the time frame of the hydrologic base period.** In 1996, when the Judgment was entered, the initial hydrologic base period was 1931-1990, and the PSY determination used the pumping and consumptive uses from the year 1990 (Table C-1 from the Judgment).

However, in 2000, Albert A. Webb Associates on behalf of Watermaster re-evaluated PSY using the base period for streamflow data of 1931-1990, and the pumping and consumptive uses from the Water Year 1997 (Webb, 2000). More recently, in 2019, Watermaster re-determined PSY using the water supply from the initial hydrologic base period of 1931-1990, and the pumping and consumptive uses from the Water Year 2018. Mr. Ernest Webber, one of the Bulletin 84 authors, contributed to the Webb 2000 study.

For purposes of planning, Watermaster operates under the assumption that the patterns of water supply will repeat itself in the future, since we do not know the future water supply. For PSY determination, we expect that pumping in the near future approximates the current pumping patterns. This allows Watermaster to calculate the amount of imported water that needs to be purchased by the Parties so that the Basin remains balanced.

In 2024, Watermaster prepared a report with an update to PSY titled "Production Safe Yield and Consumptive Use Update". In the 2024 PSY Update, Watermaster stated that "The Court previously asked that we consider a drier and more recent hydrologic planning period." Consequently, Watermaster updated the hydrologic base period and recommended 2001-2020 for purposes of re-determination of PSY. The 2024 PSY Update by Watermaster determined that for PSY calculations, the pumping and consumptive use data from the Water Year 2022 were representative because "Water year 2022, the most recent year that data is available is assumed to represent pumping and consumptive uses on a forward-looking basis."

As noted previously by Watermaster, patterns of production, applied water and consumptive uses are subject to change as land uses change, however they are not expected to change significantly from one year to the next (this has been largely true except in the Baja Subarea). Per the July 2025

Watermaster Motion, the pumping patterns and land use in the Baja Subarea have greatly changed in the recent five years. This was evidenced by the changes in agricultural pumping (**Exhibit H**) and changes in land use (**Exhibit C**).

Even though the hydrologic base period of 2001-2020 was recommended by Watermaster for all Subareas, Watermaster recognizes that for the Baja Subarea, special circumstances may warrant PSY determination based on limited data. For the Baja Subarea, the only reliable data available is pumping and water level measurements (which show recent recovery). This is true for the Este Subarea and the Oeste Subarea as well.

In 2024, Watermaster recommended Baja PSY of 12,749 acre-feet, which was determined by interpretation of water levels compared to the total pumping. Total pumping in the Baja Subarea during the representative Water Year 2022 was 12,749 acre-feet. Again, for planning purposes, this is assumed to be representative of the recent cultural conditions in the Baja Subarea.

Watermaster justification for the new hydrologic base period 2001-2020

The 60-year hydrologic base period of 1931-1990 was based on the guidance from DWR Bulletin 84 (1967), as was the 2001-2020 proposed 20-year hydrologic base period.

In September of 2022, the Court asked Watermaster to consider a drier and more recent hydrologic base period. The average water supply measured at The Forks for the hydrologic base period (1931-1990) was 65,538 acre-feet per year, while the average water supply for the proposed hydrologic base period (2001-2020) was 61,635 acre-feet per year, which is 6-percent drier than the 1931-1990 hydrologic base period.

In addition to the water supply measured at The Forks, Watermaster also evaluated precipitation in the Basin Area to determine if the new hydrologic base period is consistent with the selection criteria from the Los Angeles vs. San Fernando case in that the base period "was a representative period of normal precipitation including wet and dry periods of magnitude and occurrence similar to long-time mean supply conditions..." (**Exhibit B**, p. 183) To evaluate precipitation patterns in the Mojave Basin Area, the Watermaster reviewed precipitation stations located within the watershed tributary to The Forks (see **Exhibit J**), as well as stations in or near the Oeste subarea (see **Exhibit K**) and within the Este subarea (see **Exhibit L**) that have long-term records. **Exhibit M** shows the location of the precipitation stations with available record data, the period of record for each station, and the watershed in which each station is located. Watermaster noted that only one precipitation station covers the period of record of 1931-1990, this station is "Lake Arrowhead Fire Station #1". The average precipitation during the initial hydrologic base period of 1931-1990 was 41.36 inches, as measured at the Lake Arrowhead Fire Station #1. **Table 1** shows the results of this comparison, including the percentage of change from the 1931-1990 base period average.

Table 1. Average precipitation during the alternative hydrologic base periods and their comparison with the average precipitation during the initial 1931-1990 base period.

Alternative Hydrologic Base	**Precipitation Average (inches)**	**Change Relative to 1931-1990 Average (41.36 inches)**	**Criteria**
1991-2022	39.3	-4.9%	Start and end years are dry and are preceded by a series of dry years.
1995-2024	42.0	1.5%	Start and end years are wet and are preceded by a wet year/series of wet years.*
1998-2024	41.3	-0.1%	Start and end years are wet and are preceded by a wet year/series of wet years.
2001-2020	37.2	-10.1%	Start and end years are dry and are preceded by a series of dry years.
2002-2022	39.0	-5.8%	Start and end years are severe dry and are preceded by a series of severe dry years.

<u>Note:</u> As mentioned by Watermaster, precipitation stations within the Fork's watershed provide precipitation records that are short, inconsistent, and intermittent.

*The water supply at the Forks during the Water Years 1992 through 1995 was about three times the long-term average supply.

Evaluation of Alternative Hydrologic Base Periods

Watermaster evaluated a series of potential/alternative hydrologic base periods in addition to the 2001 to 2020 base period. These potential base periods meet the definition of a base period set forth in Bulletin 84. Table 2 is a summary of the alternative hydrologic base periods that were evaluated by Watermaster. Table 2 shows the average Mojave River flow at the Forks and the percentage of change relative to the initial hydrologic base period 1931-1990. Watermaster noted that the average water supply to the basin during each alternative base period was similar in magnitude to the average conditions during the initial base period of 1931-1990.

Table 2. Average water supply during the alternative hydrologic base periods and their comparison with the initial 1931-1990 base period.

Alternative Hydrologic Base Periods	Mojave River at the Forks Average (a.f.)	Change relative to the 1931-1990 average (65,538 a.f.)	Criteria
1991-2022	71,344	8%	Start and end years are dry and are preceded by a series of dry years.
1995-2024	67,057	2%	Start and end years are wet and are preceded by a wet year/series of wet years.*
1998-2024	65,090	-1%	Start and end years are wet and are preceded by a wet year/series of wet years.
2001-2020	61,635	-6%	Start and end years are dry and are preceded by a series of dry years.
2002-2022	59,009	-11%	Start and end years are severe dry and are preceded by a series of severe dry years.

Notes: The PSY Update prepared by Watermaster in February of 2024 updated the hydrologic base period to be 2001-2020 for purposes of establishing PSY. This selection was based on the information that was available and reliable for Watermaster at the time of the analysis (i.e., flow data up to the year 2023).

Also, the PSY Update by Watermaster evaluated the 2001-2020 hydrologic base period also because the Upper Mojave Basin Model was calibrated through the Water Year 2020.

*The water supply at the Forks during the Water Years 1992 through 1995 was about three times the long-term average supply.

The selection of the new hydrologic base period was based on the following criteria: land use changes and recent cultural conditions, availability of the records and satisfying the request from the Court to evaluate a dryer and more recent time period.

The hydrologic base period of 1991-2022 shows an average water supply about 8-percent higher than the average of the initial base period 1931-1990. The hydrologic base period of 1995-2024 shows an average water supply about 2-percent higher than the average of the initial base period 1931-1990. From a water supply perspective, a larger magnitude of average water supply might yield a higher PSY value. On the contrary, a smaller magnitude of water supply might yield a lower PSY value. However, as noted above, the Court previously asked Watermaster to consider a drier and more recent hydrologic base period. For these reasons, Watermaster does not recommend the two alternative hydrologic base periods of 1991-2022 and 1995-2024.

The alternative base period 2002-2022 starts and ends on a dry year and is preceded by a series of dry years. However, because the UMBM is calibrated through the year 2020 only, Watermaster does not consider this to be an appropriate selection. Additionally, this alternative is about 11% drier than the 1931-1990 base period. Because the alternative 2002-2022 base period is outside the period of the UMBM calibration, and the magnitude of water supply in the alternative 2002-2022 base period does not "closely approximate" the magnitude of the long-term water supply during the 1931-1990 base period (as indicated by DWR Bulletin 84), Watermaster believes the alternative 2002-2022 base period is not as appropriate as the recommended 2001-2020 base period.

The other alternative base periods evaluated by Watermaster were Water Years 1995-2024 and 1998-2024. As noted in Table 2, the PSY Update prepared by Watermaster in February of 2024 evaluated a new hydrologic base period based on the information available at that time (up to the end of Water Year 2023). For that reason, Watermaster did not include a base period ending in 2024. Importantly, the

Judgment does not require the hydrologic base period to be revised or updated each year as new information becomes available.

The average water supply during the base period of 1995-2024 was 67,057 acre-feet, which is about 2-percent higher than the long-term 1931-1990. The average water supply during the base period of 1998-2024 was 65,090 acre-feet, which is only 1-percent drier than the initial base period. Although these two potential base periods are similar in magnitude to the long-term average, they include years that are not representative of recent land uses. According to the evidence shown in **Exhibit C**, the land uses have greatly changed since the 1990s to present time, particularly due to Mojave Basin Area experiencing a major shift away from agricultural pumping and agricultural land use. The agricultural water use data suggest that pumping during the mid-1990s was in the order of 87,000 to 89,000 acre-feet per year (see **Exhibit G**). By 2022, agricultural water use was reduced to less than 20,000 acre-feet. As explained above, Watermaster's data on irrigated acreages show a similar trend of a constant reduction in irrigated land, particularly during recent years. Because the new hydrologic base period should meet the criteria of the DWR Bulletin 84 and include recent cultural conditions, Watermaster determined that the alternative hydrologic base periods that begin in the 1990s do not meet the representation of recent cultural conditions, and therefore, they should not be considered appropriate hydrologic base periods for PSY redetermination.

Based upon the foregoing, Watermaster concludes the average water supply during the proposed 20-year hydrologic base period from 2001 to 2020 is similar in magnitude to the average supply during the 1931-1990 hydrologic base period. However, as explained herein, the cultural conditions in the Basin have changed from those present from 1931-1990 and from those observed during the 1990s. Accordingly, a long-term hydrologic base period more representative of current cultural conditions is more appropriate and warranted – which is one reason Watermaster recommends using the 2001 to 2020 hydrologic base period for the PSY re-calculations.

Watermaster justification for recommending a new hydrologic base period

As noted, the 60-year hydrologic base period of 1931-1990 was based on guidance from DWR Bulletin 84 (1967), which explains:

> *The base period conditions should be reasonably representative of long-time hydrologic conditions and should include both normal and extreme wet and dry years. Both the beginning and the end of the base period should be preceded by a series of wet years or a series of dry years, so that the difference between the amount of water in transit within the zone of aeration at the beginning and end of the base period would be a minimum. The base period should also be within the period of available records and should include recent cultural conditions as an aid for projections under future basin operational studies.*

For water supply, Watermaster has proposed a new and more recent hydrologic base period of 2001-2020, which is consistent with DWR Bulletin 84 because: it starts and ends in a series of dry years, contains both normal and extreme wet and dry years, has a minimum difference in the amount of water at the beginning and the end, and **includes recent cultural conditions** (i.e., pumping, patterns of water use, land uses). Today's cultural conditions are represented by the new recent hydrologic base period of 2001-2020; cultural conditions are expected to change only slightly year to year in the near future (except for the Baja Subarea). Watermaster's reason for proposing a new and more recent hydrologic base period is because the original 60-year hydrologic base period of 1931-1990 does not reflect the recent cultural conditions. The total pumping, the patterns of pumping, water uses, and land uses have greatly changed from 1931-1990 to the recent time. Moreover, the water supply observed in 2001- 2020 is expected to repeat itself in the future for planning purposes. As mentioned above, Watermaster's analysis demonstrates the water supply for the 1931-1990 and 2001-2020 differed by only 6-percent; however, the cultural conditions from 1931-1990 are no longer representative of present and future cultural conditions.

I declare under penalty of perjury, under the laws of the State of California, that the foregoing is true and correct.

Dated: November 12, 2025

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INDEX OF EXHIBITS

EXHIBIT A

STATE OF CALIFORNIA
The Resources Agency
Department of Water Resources

BULLETIN No. 84

MOJAVE RIVER GROUND WATER BASINS INVESTIGATION

AUGUST 1967

RONALD REAGAN
Governor
State of California

WILLIAM R. GIANELLI
Director
Department of Water Resources

FOREWORD

This investigation and report are the result of the recognition by the Mojave Water Agency of its need for reliable information on existing water resources, future water requirements, and sources of additional water supply to meet the needs for growth of the region it serves. Accordingly, the agency, through its legislative representatives, obtained state funds for the Department of Water Resources to undertake this investigation. Appropriation of funds was made under Budget Item 263.2, A. B. No. 1, 1962 Second Extraordinary Session.

To provide interested agencies and persons with information as soon as it was available, informal meetings were held and two progress reports were published by the Department of Water Resources.

The results of this study show that additional water will be required if the Mojave region is to realize its growth potential. The meager rainfall and increasing water demands of the area indicate the need for a plan of basin operation that will take full advantage of existing and potential water resources, including ground water, imported water, and the use of the ground water basins for both storage and distribution of water.

The information provided by this study points out the need and provides a foundation for a ground water basin model simulation and operational and economic studies, leading to the selection by local agencies of an optimum plan of water resources management.

William R. Gianelli

William R. Gianelli, Director
Department of Water Resources
The Resources Agency
State of California

June 12, 1967

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State of California
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RONALD REAGAN, Governor
WILLIAM R. GIANELLI, Director, Department of Water Resources
JOHN R. TEERINK, Deputy Director

SOUTHERN DISTRICT

James J. Doody . . . . District Engineer
Herbert W. Greydanus . . . . Principal Engineer
Jack J. Coe . . . . Chief, Planning Branch

This investigation was conducted under the direction
of

Robert Y. D. Chun . . . . Chief, Project Planning and Special
Investigations Section

The Program Manager responsible for overall
supervision of the investigation and
preparation of the report
was

Ernest M. Weber . . . . Chief, Geology Unit

The geologic and hydrologic studies were conducted
by

Harvey L. Chun . . . . Assistant Civil Engineer
Thomas M. Schwarberg . . . . Assistant Engineering Geologist

Others who were connected with this investigation
in its early stages
were

Vernon E. Valantine . . . . Chief, Operations Branch
William X. Madden . . . . Chief, Desalination Unit,
Operations Branch
John R. Cummings . . . . Associate Engineering Geologist
Clifford R. Farrell . . . . Associate Engineering Geologist
Joseph F. LoBue . . . . Associate Engineering Geologist

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES

ENGINEERING CERTIFICATION

This report has been prepared under my direction as the professional engineer in direct responsible charge of the work, in accordance with the provisions of the Civil and Professional Engineers' Act of the State of California.

Harvey L. Chun
Registered Civil Engineer

Registration No. 16783

Date May 16, 1967

ATTEST:

J J Doody
District Engineer
Southern District

Registration No. 6500

Date MAY 16 1967

ABSTRACT

This bulletin presents data on the water resources and water requirements of a part of the Mojave Desert area, consisting of about 3,700 square miles located primarily in San Bernardino County. The study was authorized by the Legislature in 1962 for the purpose of providing fundamental geologic and hydrologic information to the State of California and to local water agencies in the Mojave area as the basis for planning for optimum use of water supplies and facilities. In this desert region, annual water supply from precipitation is not sufficient to meet the needs of existing agricultural and urban developments. The water deficiency that has existed in the area since about 1945 has been met by extraction of ground water. However, with the anticipated continuation--or acceleration--of the urban growth pattern of recent years, additional water will be required. These future water needs could be met by a combination of ground water and imported water. Control of non-beneficial riparian vegetation offers a potential secondary source of increased water supply. The bulletin describes geology, water supply, water quality, and water requirements in the study area. Tables give detailed information on resources and requirements. Figures and plates show the area of investigation, geology and geologic sections, precipitation patterns, hydrographic units, land use, and changes in ground water levels.

CHAPTER I. INTRODUCTION

Recently, residences and industry have grown up over much of the land along the Mojave River in San Bernardino County that formerly supported only agriculture. This development, which has increased the water uses, has caused concern among water agencies over the adequacy of the local supply. Although large amounts of water are known to be stored underground, the scanty rainfall in the vast desert areas surrounding the river raises a question as to the long-term reliability of local supplies and suggests the need for imported water. In addition, the quality of the local supplies is a matter of concern, particularly the possible changes in quality resulting from increased urban development and water use. As one means of relieving the problem, the Mojave Water Agency on June 22, 1963, signed a contract to take delivery of 50,000 acre-feet from the State Water Facility.

In recognition of the need for an analysis of the water resources along the Mojave River, the California Legislature requested the Department of Water Resources to make such an investigation. Studies were started in July 1962.

To provide interested agencies and persons with information as soon as it was available, informal meetings were held and two progress reports were published. This final report summarizes the results of the investigation.

Objectives of Investigation

The major objective of this study is to provide geologic and hydrologic information that can be used by local agencies in managing the surface and ground water resources of the area in the most productive and economic manner.

The specific objectives of this investigation are to:

1. Develop information on boundary conditions of the ground water resources, structures affecting ground water movement, transmissive and storage characteristics of the water-bearing material, and subsurface flow and change in ground water storage.

2. Increase the detail and extent of the knowledge pertaining to the amounts of annual water supply, use, and disposal for each subdivision of the study area for a selected base period. From this information, evaluate the character and amount of deep percolation, determine the average annual water supply surplus or deficiency, estimate the average annual safe yield and overdraft and determine where future imported water supplies must be delivered, by identifying the areas of water supply surplus and deficiency.

Scope of Investigation

The investigation consisted of a comprehensive and detailed geologic and hydrologic study of the area along the Mojave River. The hydrologic study concentrated on the 25-year period of 1936-37 through 1960-61, which was selected as the study base period. The hydrologic study included investigation of the mineral quality of both the surface and ground water supplies.

The geologic investigation consisted of the review of all available geologic data, detailed field mapping, and field transmissibility tests. Basin boundaries and physical properties of the area were then determined.

In the hydrologic investigation, the available reports on the study area were reviewed and data were compiled from reports published by the United States Geological Survey, United States Weather Bureau, and Department of Water Resources. Numerous contacts were made with individual agencies to gather the necessary data regarding the various items of water supply, use and disposal. This information was developed on an annual basis.

The water quality investigation consisted of review and evaluation of existing data and of new data obtained from a limited water sampling program. Areas in which the water quality is relatively consistent were delineated to show the mineral character and total dissolved solids content of the water. A limited salt balance analysis was made.

Conduct of Investigation

Geologic, hydrologic, and water quality studies were conducted to meet the objectives of this investigation. Standard engineering concepts were used to develop hydrologic information and, where necessary, simplifying assumptions were made to facilitate the geologic, hydrologic, and water quality analyses. The major steps in the conduct of this investigation are summarized below:

1. The geologic properties of the study area were determined, the study area was subdivided into convenient workable units, transmissibility and storage factors of the water-bearing sediments were estimated, and historical water level elevations were determined.

2. The annual amounts of water supply, use, and disposal were estimated; water use and disposal were subtracted from the water supply to obtain annual water supply surplus or deficiency for the base period.

3. The change in the amount of ground water in storage during the base period was estimated by the specific yield method.

4. The mineral quality of the water in the area was determined.

5. The total annual amount of water supply or deficiency was compared with the total annual change in the amount of ground water in storage during the base period.

During the first year of the investigation, activities were directed toward establishing, on a preliminary basis, the extent of the local water resources of the area; this information was used by the Mojave Water Agency and the State of California as the basis for a contract to import a supplemental water supply through the California Aqueduct. These activities were summarized in the first progress report.

During the second year of the investigation, the geologic studies of the area were expanded to identify and delineate the extent of the water-bearing materials, to establish the location of structures affecting ground water movement, and to determine the hydraulic characteristics of the water-bearing materials. The refinement of the preliminary estimates of water supply, use, and disposal was commenced; the seasonal amounts of the major components of both surface and subsurface flows within the area were determined; also, a study of the mineral characteristics of both the ground water and surface water was initiated. These activities were summarized in the second progress report.

During the third year of the investigation, the studies to achieve the specific objectives of the program were completed. These studies included a determination of the annual amount of supply, use, and disposal of water during the base period; the annual amount of water supply surplus or deficiency; and estimates of the present and future uses of water in the study area. The local water supplies and future water requirements were compared to ascertain the time, magnitude, and location of delivery of imported supplies. Ground water storage capacities estimates from the preliminary studies were revised, using an electronic digital computer. Change in the amount of ground water in storage during the base period was calculated and compared with water supply surplus or deficiency for the same period. This bulletin summarizes the activities and results of the entire investigation.

Related Investigations and Reports

Previous hydrologic investigations of the Mojave River region have been made and reported on by the Department of Water Resources and its predecessor agencies and by other federal, state, county, and private agencies. Reports of previous major investigations are listed below. Other reports utilized in preparing this bulletin are summarized in Appendix A, Bibliography.

1. Blaney, Harry F., and Ewing, Paul A. "Utilization of the Waters of Mojave River, California." United States Department of Agriculture, Division of Irrigation. August 1935.

2. California State Department of Public Works, Division of Water Resources. "Mojave River Investigation." Bulletin No. 47. 1934.

3. Frye, Arthur H., Jr. "Report on Survey for Flood Control, Mojave River, San Bernardino County, California." United States Corps of Engineers. December 28, 1956.

4. Koebig and Koebig, Incorporated. "Mojave Water Agency-Supplemental Water Report." Volume 1. March 1962.

5. ----. "Mojave Water Agency-Supplemental Water Report." Volume 1, Appendixes A, B, C, and D. March 1962.

6. Thompson, David G. "The Mojave Desert Region, California." United States Geological Survey Water-Supply Paper No. 578. 1929

7. United States Department of the Interior, Bureau of Reclamation. "Report on Victor Project, California." April 1952.

Area of Investigation

The area of investigation, which is outlined in Figures 1 and 2, is located almost entirely in San Bernardino County, with only

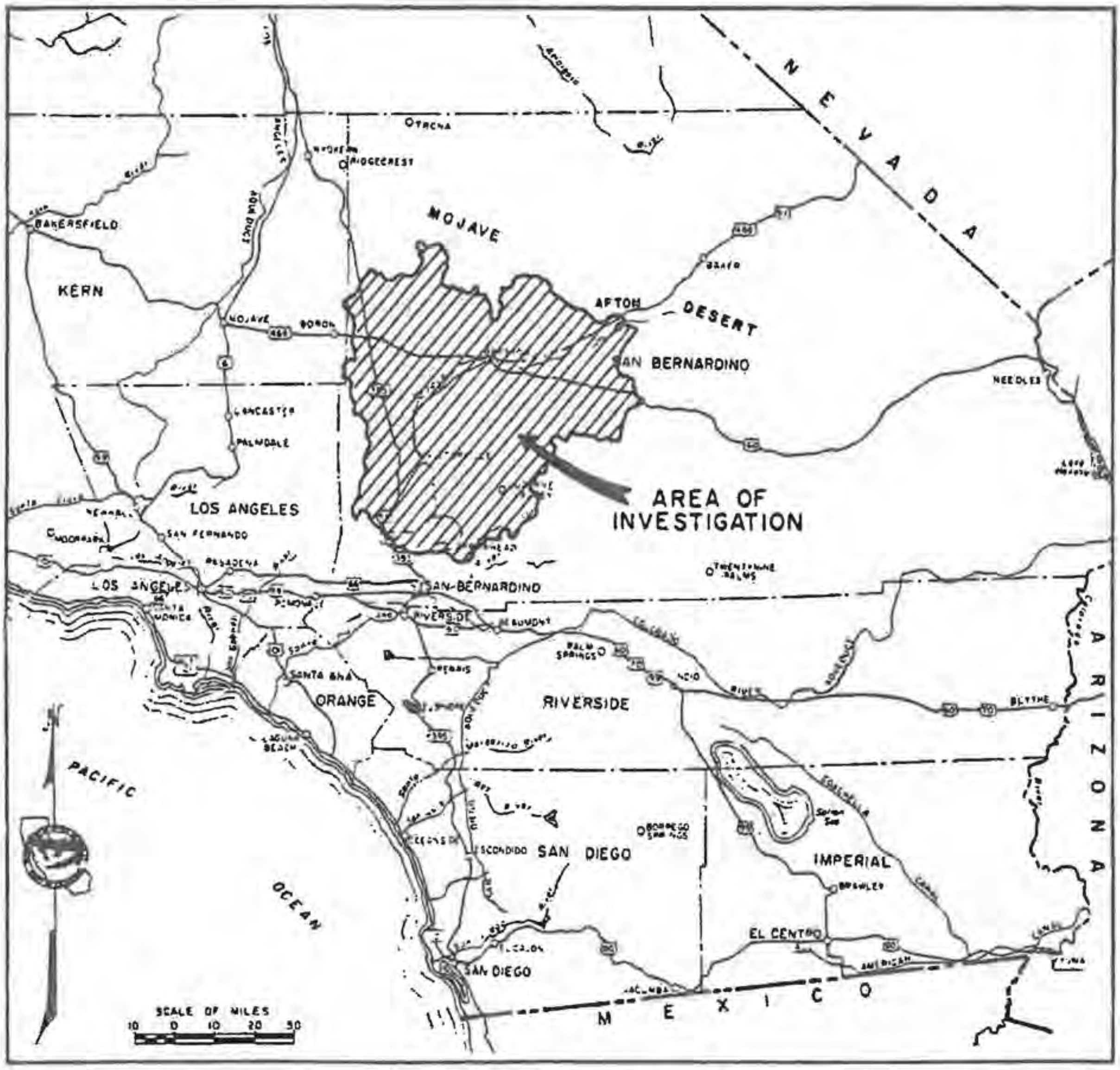


Figure I. LOCATION MAP

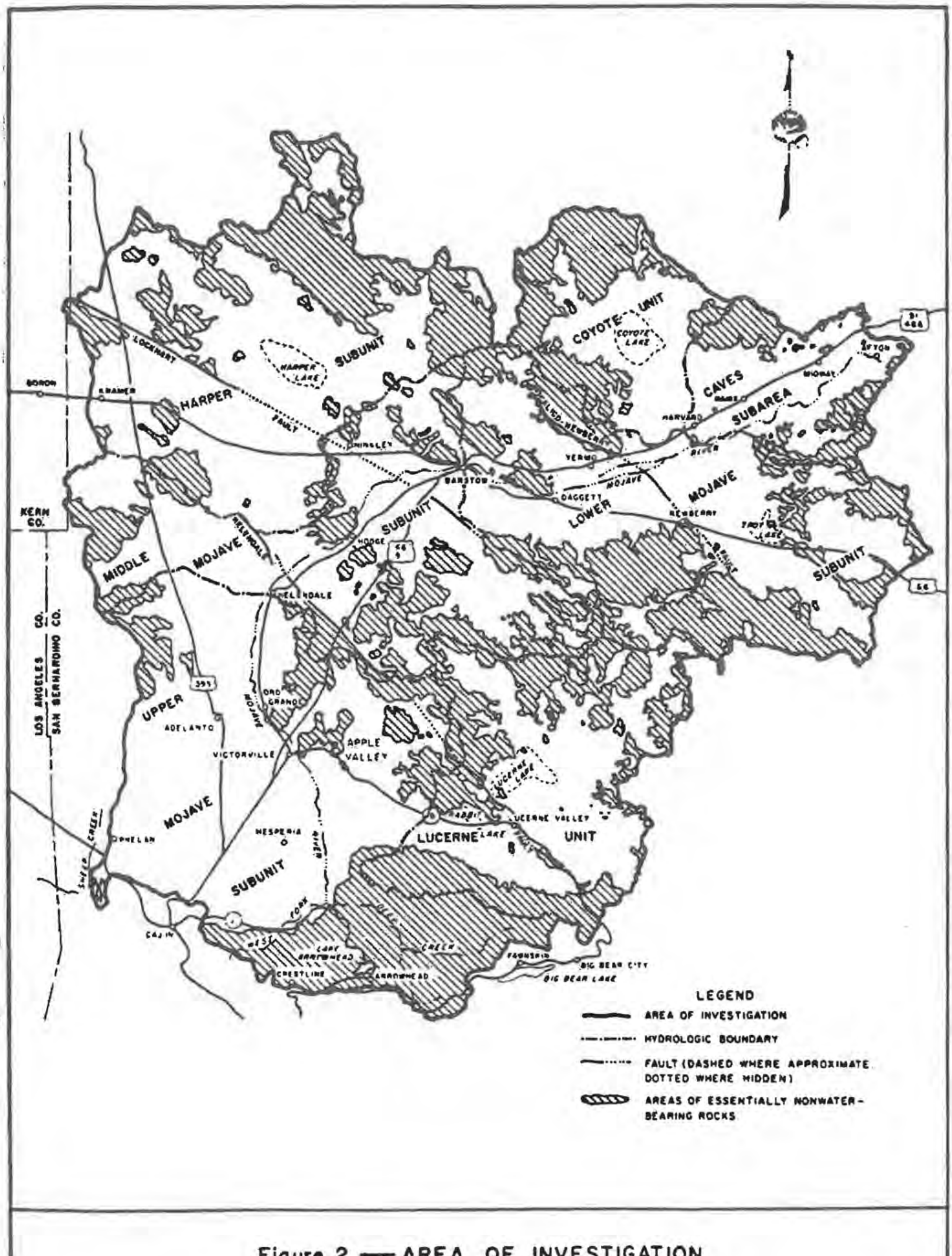


Figure 2 — AREA OF INVESTIGATION

DEPARTMENT OF WATER RESOURCES, SOUTHERN DISTRICT, 1967

a small portion in Kern County. The study area is part of the Mojave Desert, which covers vast areas of east-central Southern California.

The study area is irregularly shaped and covers about 3,700 square miles in the south-central part of the Mojave Desert. The area extends about 60 miles northerly and easterly along and adjacent to the Mojave River from its source in the San Bernardino Mountains, along the southern border of the study area, to the desert floor near Afton. Although the Mojave River extends beyond Afton, the area downstream from Afton was not included in the study because the use of water there is considered minor in quantity and economic importance to the total study area.

The study area is essentially a plain sloping gently northward and eastward. The plain is made up of small, broad valleys, or closed basins, separated by isolated hills, groups of hills, and low mountains. The bottoms of the closed basins are playas which contain water only following heavy rainfall. The largest playas in the study area are Lucerne Lake, Harper Lake, Coyote Lake, and Troy Lake.

Elevations in the study area range from more than 8,500 feet near Crestline in the San Bernardino Mountains to 2,715 feet at Victorville and 1,408 feet at Afton.

The Mojave River is the major stream traversing the study area. The river originates in the foothills of the San Bernardino Mountains at the junction of the West Fork and Deep Creek and flows north 12 miles to Victorville, then continues 18 miles adjacent to Highway 91 to Helendale. It then turns northeast and continues adjacent to Highway 91 past Barstow to Afton, the study area limit, approximately 90 miles from its beginning.

The river then flows to its terminus in Silver Lake. Flood waters in the Mojave River occasionally reach Silver Lake but soon evaporate. Perennial flow occurs only in the mountains and near Victorville, Harvard, and Afton.

Annual precipitation averages less than 4 inches in the desert area but exceeds 40 inches in the upper regions of the Mojave River watershed. Sixty percent of the precipitation occurs from December through March. The growing period between killing frosts averages about 245 days. The area is also noted for its high summer temperatures and low humidity; temperatures of more than 100° F and relative humidity below 20 percent are not uncommon.

The greater portion of the region is undeveloped. Historically, the development of irrigable lands and centers of population have been primarily along the Mojave River and the adjacent valleys where there has been an easily available supply of surface and/or ground water. Alfalfa and permanent pasture are the chief crops. The larger centers of urban development are the Cities of Barstow and Victorville, with 1960 populations of about 11,500 and 8,000. Other communities include Hesperia, Apple Valley, Lucerne Valley, Adelanto, and Yermo. Mining and the manufacture of cement are the chief industries. Several military installations are located in the study area, with George Air Force Base near Victorville being the largest.

Subdivisions of the Study Area

Because of the size and complexity of the study area and the need for localized information, the area was subdivided for this investigation. The subdivision was based mainly on information in the office report published by the Department, "Names and Areal Code Numbers of Hydrologic Areas in the Southern District", April 1964. The information in the publication is the basis for compiling, filing, and retrieving geologic and hydrologic data with high-speed electronic data processing machines in the Department.

It was found convenient for this study to adopt the names and areal code numbers used in that publication. However, some significant boundary changes were made, which are used in this study. The 1964 report will be updated to reflect these changes. The revised boundaries are a result of analysis of recent topographic and geologic maps of the United States Geological Survey and the Department of Water Resources. These changes are described later in this report. The names and areal code numbers of study area subdivisions are presented in Table 1. The subdivisions are shown on Figure 2, "Area of Investigation".

TABLE 1

NAMES AND AREAL CODE NUMBERS OF HYDROLOGIC AREAS

Areal Code	Designation
W-18.00	Coyote Hydrologic Unit
W-28.00	Mojave Hydrologic Unit
W-28.B0	Upper Mojave Hydrologic Subunit
W-28.C0	Middle Mojave Hydrologic Subunit
W-28.D0	Harper Hydrologic Subunit
W-28.E0	Lower Mojave Hydrologic Subunit*
W-28.G1	Caves Hydrologic Subarea
X-01.00	Lucerne Hydrologic Unit

*Troy Hydrologic Subunit has been combined with Lower Mojave Hydrologic Subunit for this study.

Each subdivision in Table 1 could be further segregated into a nonwater-bearing hill and mountain area and a ground water-bearing valley area. In this report the ground water-bearing valley area is referred to as the "ground water basin" or "basin" to distinguish it from the entire subdivision, which includes portions of the surrounding hills and mountains.

In most locations in this region, water-bearing areas are separated from each other by nonwater-bearing materials of hill and mountain areas and by bedrock highs, which created conditions of alluvial constriction. In some locations, the water-bearing areas are separated by surface drainage divides. The boundary conditions between the water-bearing areas, or basins, of the hydrologic subdivisions are presented in Table 2.

TABLE 2

BOUNDARY CONDITIONS BETWEEN BASINS

Basins	Physical conditions at boundary
Upper Mojave-Lucerne	Drainage divide and alluvial constriction
Lower Mojave-Middle Mojave	Drainage divide and alluvial constriction
Lower Mojave-Caves	Drainage divide
Caves-Coyote	Drainage divide
Caves Basin at study area boundary	Alluvial constriction
Harper-Middle Mojave	Drainage divide
Middle Mojave-Upper Mojave	Drainage divide

The most significant changes in boundaries which resulted from the recent topographic coverage were made to boundaries of the Lower Mojave Basin and Lucerne Basin. Previously, the boundary between the Lower Mojave Basin and Troy Basin was represented by a low relief surface drainage divide. Because there is no restriction to ground water movement across this divide, and because restrictions do occur elsewhere in these two divisions, Troy Basin has been included as part of the Lower Mojave Basin for this study. The boundaries of the Caves Basin, Coyote Basin, and Lower Mojave Basin were also revised considerably on the basis of the recent detailed topographic mapping, although the hydraulic characteristics which determine these divisions remain basically the same. The boundary between the Lucerne Basin and the Upper Mojave Basin was also revised on the basis of topographic criteria; the boundary now follows the surface drainage between Apple Valley and Rabbit Lake.

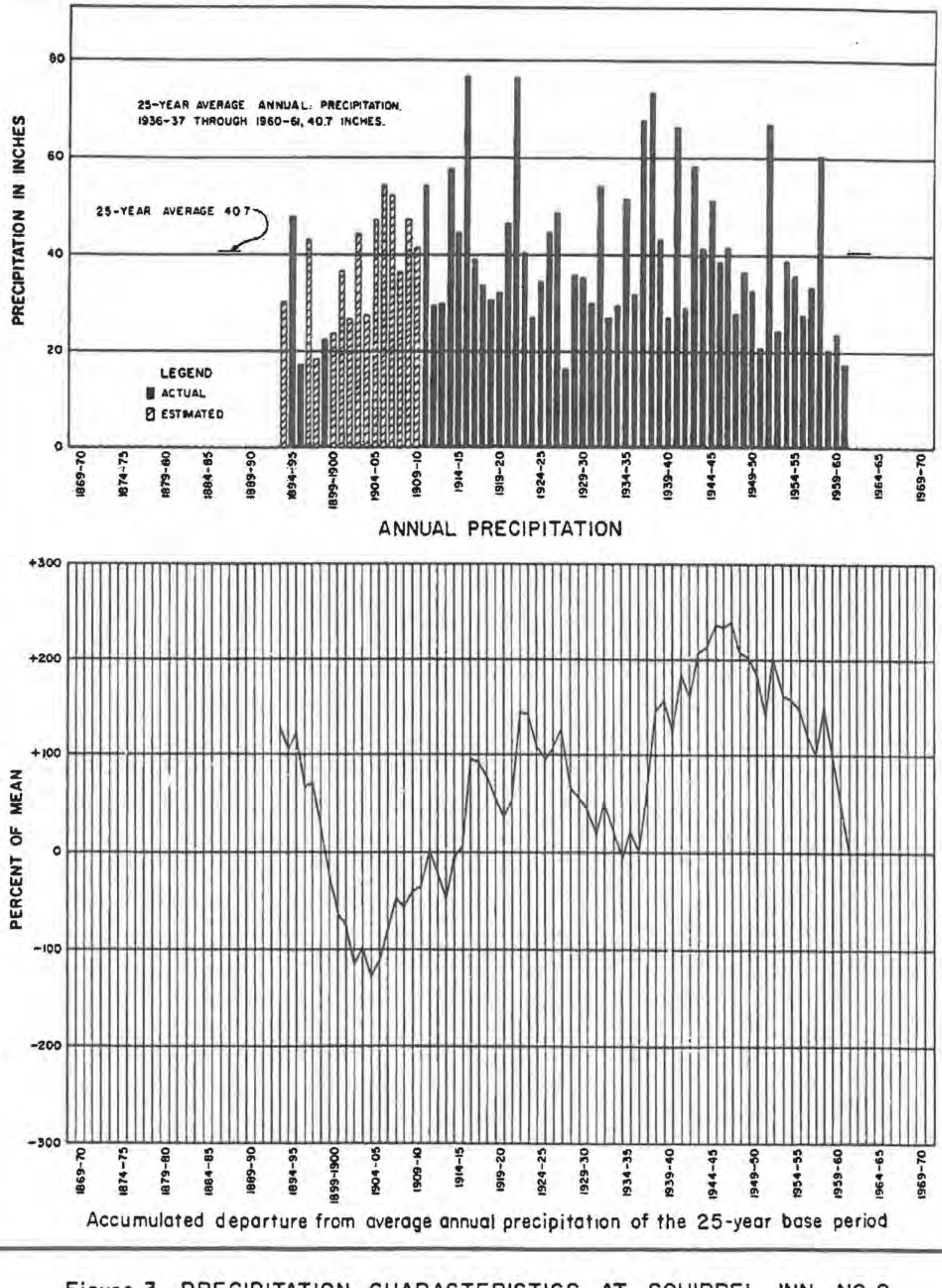
Base Hydrologic Period

In any watershed, precipitation is the original source of local water supply; therefore, the amount of precipitation to a ground water basin and its tributary areas serves as an index of the water supply available to that basin. By analysis of long-time precipitation records, it is possible to select as a "base period" a relatively short and recent period which represents the long-time average water supply. Such a period is needed for study purposes because long-time hydrologic data, other than rainfall records, are generally unavailable.

The base period conditions should be reasonably representative of long-time hydrologic conditions and should include both normal and extreme wet and dry years. Both the beginning and the end of the base period should be preceded by a series of wet years or a series of dry years, so that the difference between the amount of water in transit within the zone of aeration at the beginning and end of the base period would be a minimum. The base period should also be within the period of available records and should include recent cultural conditions as an aid for projections under future basin operational studies.

For this study, the base hydrologic period was determined from analysis of records of a precipitation station in the San Bernardino Mountains, the major area of water supply to the basin. The accumulated departure from the mean precipitation at this recording station appears to start during a dry period (1893-94), and it continues through 1960-61. It includes the 57-year period from 1904-05 through 1960-61, which covers two cycles of wet and dry periods. This 57-year period was selected as that which best represents the long-time hydrologic conditions in the Mojave River region.

On the basis of the criteria stated in preceding paragraphs, the water years 1936-37 through 1960-61 were chosen as the base hydrologic period. This 25-year period includes the most recent pair of wet and dry cycles; has an average annual precipitation (at Squirrel Inn No. 2) of 40.7 inches, which closely approximates the estimated long-time period average of 41.7 inches; begins and ends after a series of dry years; is within the period of available data; and includes recent land use conditions. The precipitation characteristics at the Squirrel Inn No. 2 Station are shown on Figure 3. Because of the similarity of hydrologic conditions (dry trends) preceding 1936-37 and 1960-61 and because valley precipitation averaged less than 6 inches annually, the assumption could be made that there was no significant change in the amount of water in transit at the beginning and end of the base period. In view of this, the difference in the amount of water percolating downward through the



Accumulated departure from average annual precipitation of the 25-year base period

Figure 3. PRECIPITATION CHARACTERISTICS AT SQUIRREL INN NO. 2

DEPARTMENT OF WATER RESOURCES, SOUTHERN DISTRICT, 1967

zone of aeration to the zone of saturation was considered to be negligible for both periods. This assumption facilitated computation of changes in the amount of ground water storage during the base period.

CHAPTER II. GEOLOGY

In this investigation, the geology studies included a detailed examination of the physiography, stratigraphy, and structure of the area. The primary objective of these studies was to develop a better understanding of the water-bearing formations of the area and to determine the occurrence, movement, and quality of ground water within the formations. To meet this objective, geologic formations and structures were inspected and were correlated with geologic units delineated by previous studies. An areal geology map of the study area was then prepared and lithologic units were grouped according to general water-yielding characteristics. Water well logs, water quality data, water level data, and aquifer test information were evaluated, along with data obtained from interviews with local water well drillers. The results of these studies are summarized and discussed in the following paragraphs.

Physiography

The Mojave study area is an alluviated plain that slopes gently northward and eastward. Bordering the plain are the San Bernardino Mountains on the south; the Fry, Rodman, and Cady Mountains on the east; the Alvord Mountains, the Paradise Range, the Calico Mountains, the Rainbow Hills, and the Gravel Hills on the north; and the Kramer Hills and the Shadow Mountains on the west.

The high San Bernardino Mountains are essentially nonwater-bearing crystalline and metamorphic rock. These mountains contribute the major amount of runoff to the ground water basin; they also are the source of the bulk of the alluvial debris deposited in the valley areas. Minor amounts of both runnoff and alluvial debris are contributed by the low mountains and hills interspersed throughout and bordering the basin.

The principal stream traversing the study area is the Mojave River, which originates in the San Bernardino Mountains, and flows north and east about 110 miles, terminating in Silver Lake, about 20 miles outside the study area.

Other important features of the study area are the Upper and Lower Narrows of the Mojave River, where rising ground water occurs as the result of constrictions in the cross-sectional area of the water-bearing materials. Physiographic features are shown on Plate 1, "Physiographic Features and Lines of Equal Average Annual Precipitation"; detailed areal geology is shown on Plate 2, "Areal Geology".

The Mojave River ground water basin is the subsurface reservoir which yields water to wells drilled in the area. The ground water basin area, or valley fill area, contains shallow, permeable alluvial deposits, and is underlain and surrounded by relatively impermeable rock. These features are shown on Plate 3, "Geologic Sections".

Stratigraphy

Geologic units of the region are grouped under two broad categories according to their water-yielding characteristics: water-bearing and nonwater-bearing. A crystalline complex of pre-Tertiary igneous and metamorphic rocks that characteristically yields little water to wells forms the major portion of the mountain and hill areas surrounding the water-bearing portions of the study area. These formations, which are considered nonwater bearing, underlie water-bearing sediments. The water-bearing sediments are unconsolidated to semiconsolidated alluvial deposits that are Quaternary in age, continental in origin, and made up primarily of materials ranging in size from coarse gravel to clay. These sediments are generally more consolidated with depth, and commonly exhibit cementation in the older formations. Interspersed within, and overlying these sediments, in local areas are nonwater-bearing volcanic deposits.

Water-Bearing Formations

The water-bearing deposits of the area result primarily from deposition of alluvial material eroded from the adjacent highlands. The streams carry debris onto the valley floor during flood flows, forming alluvial fans at the base of the mountains by dropping the coarse particles first. As the distance from the mountains becomes greater, the sediment-carrying capacity of the stream becomes less, resulting in deposition of finer grained sediments. Usually only the silts and clays reach the central or lowest portions of the basins. Generally, the coarser alluvial fan deposits and deposits within the streambed are more permeable and result in higher yield to wells, whereas the fine-grained deposits do not yield water readily. The older deposits have undergone chemical weathering and compaction and have been cemented to some degree, all of which tends to reduce the permeability of the materials.

The Mojave River has interrupted this general deposition pattern by traversing the study area, cutting a channel through both coarse-and fine-grained materials, and then backfilling with coarse-grained river channel deposits. These latter deposits are highly permeable and contain the major source of the water supply used at present in the study area.

Within the study area, the water-bearing materials include 11 lithologic units that range in age from Recent to Pleistocene; these units include: river deposits, playa deposits, dune sand, younger alluvium, younger fan deposits, old lake and lakeshore deposits, older alluvium, older fan deposits, landslide breccia, Shoemaker gravel, and the Harold Formation. Figure 4, "Generalized Stratigraphic Column of Water-Bearing Sequence, Mojave River Area" shows the stratigraphic sequence of the water-bearing formations or units, their lithology, and the maximum thickness of each formation or unit. The major characteristics of these water-bearing lithologic units are discussed in the following paragraphs.

River Deposits. Boulders, gravel, sand, and silt, with some interbeds of clay and sandy clay, occupy the channel of the Mojave River. The deposits are unconsolidated, unweathered, and range up to 90 feet in thickness. The river deposits form the most important aquifer in the study area. A majority of the irrigation and municipal water wells in the region draw water from this aquifer. These wells yield water at an average rate of 500 gallons per minute, although some wells yield as much as 1,600 gallons per minute. In addition, ground water in the river deposits is a major source of replenishment to the other ground water areas, through subsurface flow.

Playa Deposits. Playa deposits underlie the surfaces of the dry lakes in the study area. The deposits are fine sand, silts, and clays, which range in thickness from a few feet to about 25 feet. These fine-grained materials generally have a low permeability and, even when saturated, will yield only small quantities of water to wells. These materials generally

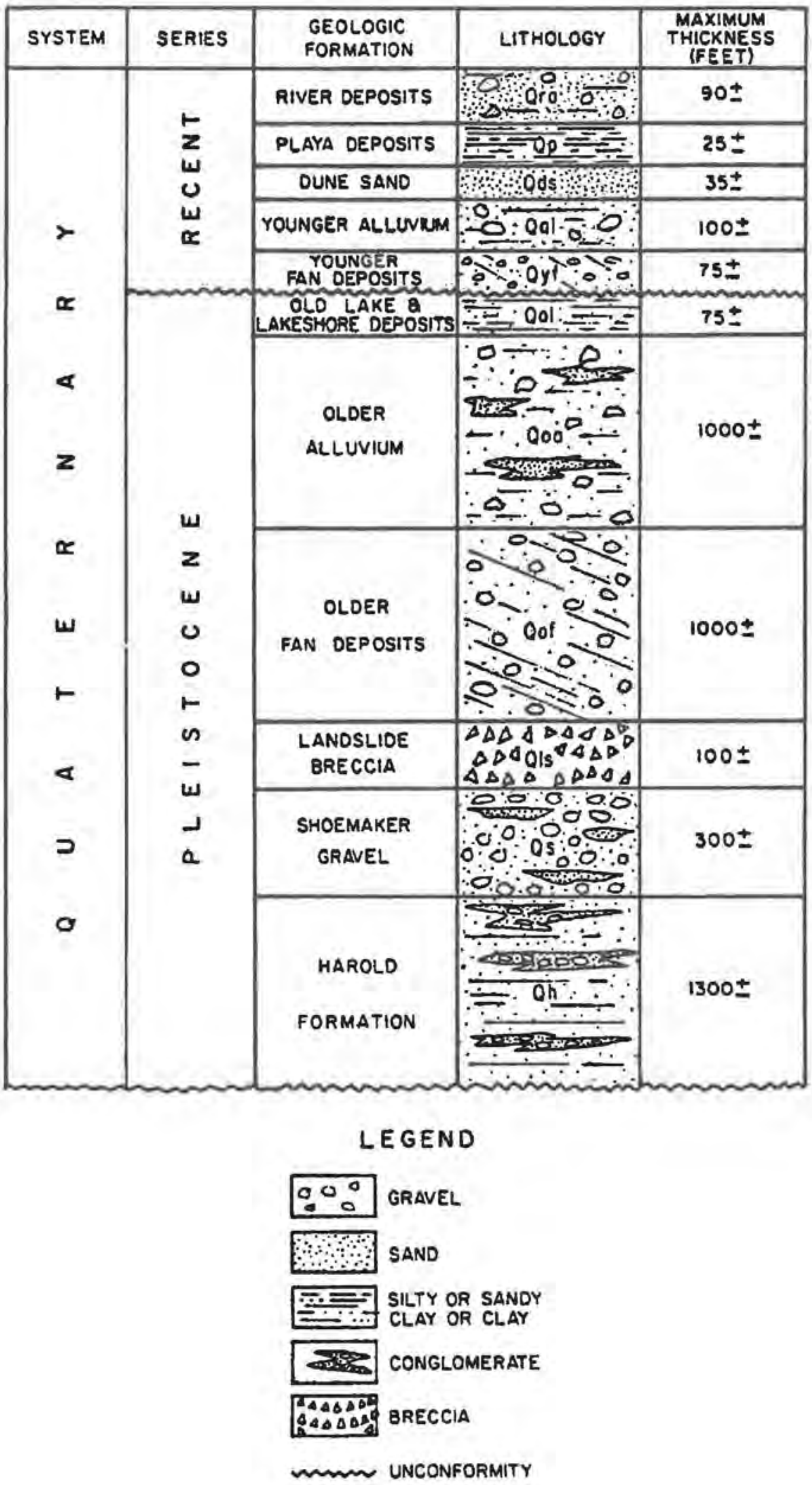


Fig. 4. GENERALIZED STRATIGRAPHIC COLUMN OF WATER-BEARING SEQUENCE, MOJAVE RIVER AREA

DEPARTMENT OF WATER RESOURCES, SOUTHERN DISTRICT, 1967

exhibit high concentrations of total dissolved solids, ranging from 380 to 5,300 parts per million.

Dune Sand. Sand dunes are present in all of the basins, commonly near the playas and adjacent to the Mojave River. Typical deposits are found downstream of Hodge and in Hinkley Valley. These deposits range in thickness from a few feet to as much as 35 feet. The dunes are porous and permeable and suitable for storage of ground water; however, they are above the existing water table.

Younger Alluvium. Younger alluvium occurs as a veneer overlying large portions of the older materials, and occupies small stream channels tributary to the Mojave River. The deposits are made up of material ranging in size from very small to large and are usually unweathered sands and silts, plus some gravel and clay. The younger alluvium ranges in thickness from a few inches to about 100 feet. Not only are the deposits less prolific water producers than the river deposits but yields are usually less than 300 gallons per minute. Large portions of the younger alluvium are above the water table, or only partially saturated.

Younger Fan Deposits. Unconsolidated younger fan deposits are located at the base of the highland areas, usually above the water table. These deposits are poorly-sorted gravel and sand with some silt and clay. The younger fan deposits range in thickness from a few inches to about 75 feet. They occur extensively as a thin veneer at the base of the desert mountain ranges, overlying bedrock. Reworked older material has been deposited as alluvial fans at the base of the bluffs adjacent to the Mojave River.

These are partially saturated, and wells penetrating them vary in yield from a few gallons per minute to about 1,200 gallons per minute.

Old Lake and Lakeshore Deposits. Old lake deposits of well-bedded silts, clays, and sands, interbedded with thin fresh-water limestones are exposed at four separate areas along the Mojave River: (1) in the bluffs at Victorville, (2) along the river northwest of Helendale, (3) in the low hills south of Barstow, and (4) in the bluffs of the Mojave River at the Caves Basin near Manix. Water well logs indicate the presence of blue and green clays which suggests that lake deposits underlie Hinkley and Harper Valleys. The Old Lake and Lakeshore deposits range in thickness from a few inches to about 75 feet. Lake deposits yield little water to wells, but may act as confining layers for deeper water-bearing materials.

Lakeshore deposits are remnants of sand and gravel bars of late Pleistocene lakes. These deposits, which are found south and east of Coyote Lake and near Manix, are above the water table.

Older Alluvium. Older alluvium underlies most of the study area. The unconsolidated to moderately consolidated deposits are interbedded gravel, sand, silt, and clay. The deposits are weathered, and some cementation has developed, usually in the form of caliche.

The older alluvium ranges in thickness from a few inches to about 1,000 feet and contains the major portion of ground water in storage in the area. Generally, the alluvium yields water freely to wells; however, in some areas the materials are poor in their water-yielding characteristics. A few wells in the vicinity of Hesperia and near Daggett produce more than 2,000 gallons per minute from older alluvium; in contrast, water wells in older alluvium north of Adelanto characteristically yield 30 gallons per minute or less.

Older Fan Deposits. Deposits of older fans are exposed irregularly throughout the region, but generally occur near the flanks of the highland areas. The deposits include gravels, sands, and silts, which in some areas, are cemented with caliche deposits. The materials are moderately consolidated, and in some places, deeply weathered. Maximum thickness is estimated to be 1,000 feet. Records of the few wells known to penetrate older fan material indicate that the yield varies considerably, but is generally low.

Landslide Breccia. In the southeasterly portion of the Lucerne Basin, on the flank of the San Bernardino Mountains, is a large slide deposit which apparently occurred during Pleistocene time. This area, known as the Blackhawk slide, contains primarily poorly-sorted and partially cemented blocks of limestone. Maximum thickness is estimated to be 100 feet. There are no known water wells in the landslide. If saturated, the breccia would probably have low water-yielding capacity.

Shoemaker Gravel. The Shoemaker gravel is a deposit of poorly-sorted, subangular gravel with lenses of sand and silt that underlies older alluvium and overlies the Harold Formation in depths of as much as 300 feet. Although some unused water wells penetrate the Shoemaker gravel, it generally lies above the water table and there are no known wells extracting from it. However, if it were saturated it probably would yield water freely.

Harold Formation. The Harold Formation is exposed in the bluffs facing south near the crest of Cajon Pass as a series of discontinuous beds of grayish silty sandstone with lenses of conglomerate, and occasional thin beds of clayey silt; it is approximately 1,300 feet thick.

The Harold Formation apparently yields little water to wells, as indicated by two known wells that produce less than 20 gallons per minute.

Nonwater-Bearing Formations

Pre-Tertiary crystalline rocks enclose the entire study area and comprise the major portions of the mountain and hill areas; the area also includes consolidated Tertiary sedimentary and volcanic rocks and Quaternary basalt. The crystalline complex and the Tertiary deposits also underlie the valley areas, but are buried by the unconsolidated Quaternary alluvial deposits that comprise the water-bearing formations.

In the mountain and hill areas, the rocks may be the only source of water; however, because the yield from wells is typically less than 50 gallons per minute, these formations are considered to be essentially nonwater-bearing. In addition to being poor storage reservoirs, these formations also act as impediments to ground water movement. The nonwater-bearing units, listed generally from younger to older, include: Quaternary basalt, Tertiary sedimentary rocks, Tertiary volcanic rocks, and the basement complex. The major characteristics of these nonwater-bearing lithologic units are discussed in the following paragraphs:

Quaternary Basalt. Abundant outcrops of Quaternary volcanic rocks with thicknesses ranging from a few inches to about 265 feet are located in the Black Mountain area north of Harper Lake, in a long belt extending south of Troy Lake, and in the Rodman Mountains. The dominant rock type is basalt, which occurs as vesicular to dense basalt dikes and flows, associated with some cinders, and local deposits of scoriaceous tuff. In the study area, all of these deposits occur above the regional water table. They are not tapped by any known wells, and therefore are not a significant source of ground water. However, water is yielded freely from basalt deposits in other localities through springs.

Tertiary Sedimentary Rocks. The Tertiary continental sedimentary deposits identified in the study area range in age from Miocene to Pliocene and range in thickness from a few inches to about 4,800 feet. Major outcrops occur in the mountain and hill areas northeast of the Lockhart fault and some isolated exposures occur in the Kramer Hills.

These consolidated rocks consist of water-deposited conglomerates, sandstone, siltstone, mudstone, limestone, agglomerates, and volcanic tuffs. In the study area, these formations do include pervious layers, but the water they contain is generally of poor quality and yields from wells are low. Because of their fine grain size and low porosity, the limited recharge they receive in outcrop areas, and the great depths at which they occur in the valleys, these deposits are considered to be nonwater-bearing.

Tertiary Volcanic Rocks. Tertiary volcanic rocks consist of extrusive and intrusive rock of various compositions, interbedded with Tertiary continental sedimentary rocks. These formations occur in large and small outcrop areas in the mountain and hill region predominantly northeast of the Lockhart fault, and in small, isolated areas within the Kramer Hills. These rocks yield little water to wells and are considered to be nonwater-bearing.

Basement Complex. Basement rocks of the study area are a highly complex assemblage of pre-Tertiary crystalline and metamorphic rocks that are exposed in the mountain and hill areas, and underlie the younger deposits of the valley areas. These rocks are generally nonwater-bearing, but locally yield small-to-moderate quantities of water from springs, cracks, and from a few shallow wells in the residuum.

Structures Affecting Ground Water Movement

Geologic structural features, which affect ground water movement, include anticlines, synclines, faults, and valleys or topographic highs formed by folding or faulting. Within the area of investigation, structural features which affect ground water movement are generally obscured by alluvial cover and are not well defined on the surface. The exceptions are the San Bernardino Mountains, a high, rugged east-west trending uplifted block of the San Andreas fault system, and the other more subdued highland areas which generally form the internal and external borders of the Mojave River Ground Water Basin. The general nonlinear alignment of these highlands indicates that, in the main, the alluvial valleys owe their formation to normal erosional processes rather than to faulting, and the irregular, barren hills and mountains are stubborn, erosion resistant remnants. However, the greater depths of fill that occur in certain parts of the basin can be satisfactorily explained only by the assumption of faulting and folding.

At several places along the Mojave River channel, shallow alluvial sections underlain by near-surface, topographically-high masses of bedrock obstruct ground water underflow and serve to perpetuate conditions of rising ground water. This rising ground water condition occurs at four locations: the Upper Narrows, Lower Narrows, near Camp Cady, and at Afton.

The major faults within the study area which impede and affect the flow of ground water significantly are the Helendale fault, the Lockhart fault, and the Calico-Newberry fault. These three northwest-southeast trending faults are associated with, and subordinate to, the dominating San Andreas and Garlock fault systems. The locations of these faults are shown on Plate 2, "Areal Geology". The major characteristics and the principal structural influences of these faults are discussed in the following paragraphs:

Helendale Fault

The active Helendale fault extends northwest from the vicinity north of Baldwin Lake to the southeast flank of the Kramer Hills, a distance of over 45 miles. Directly east of the Kramer Hills and north of the northwest end of the Helendale fault trace is an unnamed fault, which extends in a general northwest direction for over 30 miles. This unnamed fault may be part of the Helendale fault system; however, due to the lack of supporting evidence, definite conclusions cannot be drawn.

Ground water levels in the vicinity of the Helendale fault indicate that it impedes the movement of ground water. This is particularly true in the Lucerne Basin where differences of 48 feet in water levels have been measured in wells 250 feet apart on either side of the fault. Table 3 includes water level data for wells on both sides of the fault.

In Lucerne Basin, the highest water levels are on the western side of the fault. These levels occur near the northwest end of the fault trace where ground water flowing northeasterly spills over the fault. Some flowing wells are in the vicinity, as indicated in Table 3.

In the Middle Mojave Basin, where the Helendale fault crosses the Mojave River, ground water levels indicate that the fault impedes ground water

TABLE 3

WATER LEVEL DATA FOR WELLS ADJACENT TO
HELENDALE FAULT IN LUCERNE BASIN

State well number	Date of observation	Depth of well, in feet	Depth to water, in feet	Elevation of water in well, in feet
Southwesterly of the Fault				
4N/1W-10A1	4-15-54	568	4	2,903
4N/1W-10H2	2- 9-54	168	8	2,902
4N/1W-10R2	2-10-54	250	0.2	2,930
4N/1W-11Q3	2-10-54	250	Flowing	Flowing
4N/1W-14B2	2- 2-54	100	10	2,930
4N/1W-14K2	2-16-54	219	Flowing	Flowing
4N/1W-14Q4	2-17-54	129	18	3,012
Northeasterly of the Fault				
4N/1W- 2P1	11-18-54	410	60	2,808
4N/1W-11B1	4-14-54	376	45	2,840
4N/1W-11J1	4-14-54	300	53	2,872
4N/1W-11Q1	3-15-55	85	51	2,882
4N/1W-13M1	11-23-54	--	112	2,803
4N/1W-14A2	2- 3-54	140	74	2,891
4N/1W-14H1	2-16-54	44	44	2,936

movement in the older alluvium, but not within the Recent channel deposits of the Mojave River. Upstream from the fault, rising water contributes to the Mojave River; downstream of the fault this condition is reversed.

Lockhart Fault

In the area of investigation, the Lockhart fault extends northwest from the southwest flank of the Fry Mountains to the extreme northwest portion of the study area, a distance of over 70 miles. The fault trace continues for another 15 miles beyond the study area. The Lockhart fault impedes the movement of ground water in the Harper Basin and in older alluvium within Hinkley Valley in the Middle Mojave Basin. Although the paucity of water wells in the Harper Basin precludes quantitative estimates of this impediment, the generally higher level of the water table southwest of the fault suggests the fault impedes ground water flow. Ground water level data for wells adjacent to the Lockhart fault in the Harper Basin are shown in Table 4.

TABLE 4

WATER LEVEL DATA FOR WELLS ADJACENT TO LOCKHART FAULT

State well number	Date of observation	Depth of well, in feet	Depth to water, in feet	Elevation of water in well, in feet
Southwesterly of the Fault				
10N/4W-8P1	1- 7-59	789	18	2,007
Northeasterly of the Fault				
10N/4W- 4C1	5-27-59	419	160	1,940
10N/4W- 6A1	5-19-59	250	250	1,870
10N/4W-10A1	5-20-59	325	187	1,933

Although there is no surface trace of the Lockhart fault in Hinkley Valley, the extension of the trace from Harper Basin coincides with the southwest flank of a deep pumping hole in Hinkley Valley. The steep gradient of that flank indicates an effective impediment to ground water flow.

Calico-Newberry Fault

The active Calico-Newberry fault trends northwest from the northeast flank of the Rodman Mountains to, and along, the southwest flank of the Calico Mountains, a distance of over 35 miles.

Water level measurements in wells indicate the Calico-Newberry fault impedes the movement of ground water in Lower Mojave Basin except along the northwestern portion of the fault, from the Mojave River to just east of the community of Yermo. In that portion of the fault area, little difference was observed in the water levels on either side of the fault. On the other hand, ground water level elevations measured in wells adjacent to either side of the fault southeast of the Mojave River indicate a marked difference in levels. In this area, the water levels south of the fault are higher than those north of the fault. Representative ground water level data are listed in Table 5.

TABLE 5

WATER LEVEL DATA FOR WELLS ADJACENT TO CALICO-NEWBERRY FAULT

State well number	Date of observation	Depth of well, in feet	Depth to water, in feet	Elevation of water in well, in feet
Southwesterly of the Fault				
9N/2E- 3C1	1-13-60	63	17.5	1,853
9N/2E-11H1	1-12-60	--	17.5	1,848
9N/2E-13Q1	12- 7-60	230	14.6	1,855
9N/3E-19P1	3-24-60	151	8.6	1,847
9N/3E-29G1	3-24-60	--	11.2	1,839
9N/3E-33E1	8- 8-61	304	Flowing	1,830
Northeasterly of the Fault				
9N/2E- 3A2	3-23-60	65	40.1	1,845
9N/3E-18M1	12-16-59	253	54	1,860
9N/3E-20Q1	6- 2-60	390	58	1,845
9N/3E-29A1	3-24-60	90	68.2	1,846
9N/3E-34N1	12-17-59	99	23.1	1,818

CHAPTER III. WATER SUPPLY, USE, AND DISPOSAL

Hydrologic studies of water supply, use, and disposal are essential in evaluating the surplus or deficiency of the water supply and in determining the overdraft and safe yield. These studies, which are discussed and summarized in this chapter, include analyses of precipitation, surface flow, subsurface flow, import-export of water, and consumptive use. For these studies, the 25-year base period from 1936-37 through 1960-61 was used. (The selection of this base period is discussed in Chapter II.)

In the study area, data sufficient for these hydrologic studies are available in areas along the Mojave River and the adjacent valleys that constitute the Upper Mojave, Middle Mojave, Lower Mojave, and Lucerne Ground Water Basins. The limited amount of data that are available on the other three basins--Harper, Coyote, and Caves--does not permit comparable analyses. Where information is available, it is included in the following text and tables as a matter of interest.

For most items of water supply, use, and disposal, the historical data on the annual amounts for each year of the base period were available for the four major basins. For some items, such as subsurface inflow and outflow across basin boundaries, the surface inflow from the desert mountain area, it was necessary to estimate the average annual amounts.

Water Supply

The ground water basins discussed in this report are equivalent to the water-bearing portions of the study area. Plate 4, "Ground Water

Basins and Effective Base of Fresh Water", shows the boundaries of each of the basins in the study area.

For this study, sources of water supply are considered to be precipitation falling on the ground water basins and surface, subsurface, and import waters flowing into the basins.

Because the basins are interrelated, a part of the surface and subsurface inflow and the imported water supply to one basin may originate as outflow or as exported water from other basins. For this reason, water supply to and within the total study area from these sources is discussed as surface flow, subsurface flow, and import-export water.

Because the amount of pumped ground water which is not consumptively used is assumed to return to the ground water basin, this amount could be considered as water supply. However, because pumped ground water cancels out as a factor in the overall hydrologic equation when surface and ground water supplies are considered together, it is not discussed here as an item of supply, but is included later in this chapter as an item of water use and disposal.

Precipitation

The average annual precipitation in the study area ranges from less than 4 inches on the desert valley floor to over 40 inches in the San Bernardino Mountains. This range in average annual precipitation is shown on Plate 1. The data utilized on this map were prepared by the U. S. Weather Bureau as part of its meteorological studies of the southwestern United States.

Records of two long-term precipitation stations in the study area indicate a similar wide range in average annual precipitation. At Barstow, on the desert valley floor, the average annual rainfall is

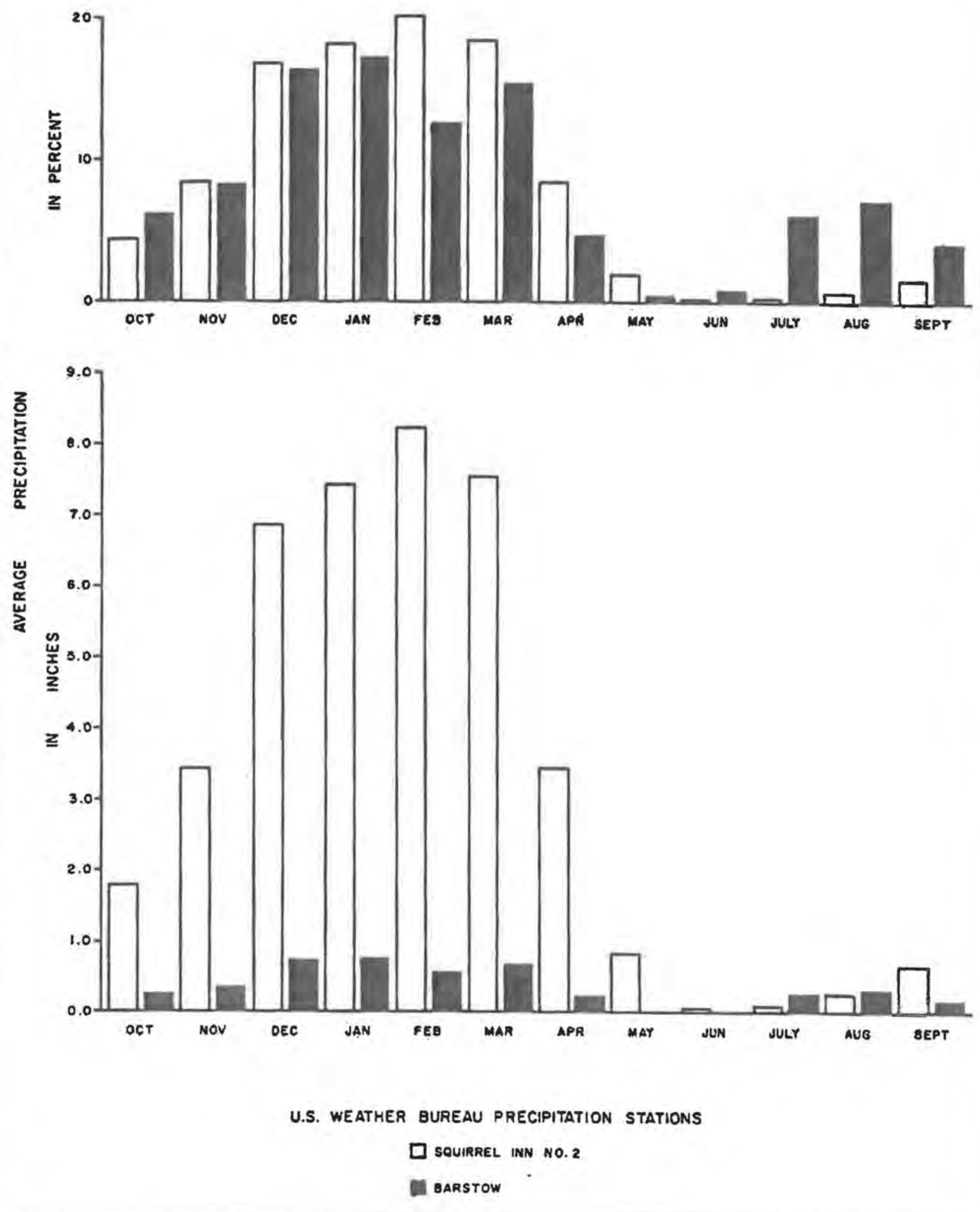


Fig. 5. AVERAGE MONTHLY DISTRIBUTION OF PRECIPITATION AT REPRESENTATIVE STATIONS–1936-37 THROUGH 1960-61

DEPARTMENT OF WATER RESOURCES, SOUTHERN DISTRICT, 1967

TABLE 7

ESTIMATED AVERAGE ANNUAL PRECIPITATION
BY AREA*

Location	Area, in acres	Precipitation, in inches
Mountain Areas		
San Bernardino Mountains	169,600	24.6
Desert Mountains		
Upper Mojave Basin	46,800	6.4
Middle Mojave Basin	107,500	6.1
Lower Mojave Basin	136,900	6.9
Lucerne Basin	71,600	7.6
Harper Basin	100,800	6.7
Coyote Basin	66,100	7.8
Caves Basin	34,000	5.7
Valley Areas		
Upper Mojave Basin	371,100	6.3
Middle Mojave Basin	260,500	5.0
Lower Mojave Basin	259,200	4.2
Lucerne Basin	190,100	6.4
Harper Basin	297,200	4.5
Coyote Basin	99,900	5.0
Caves Basin	94,000	4.5

*For the base period

Rainfall in the area south of the town of Hesperia is -- in some years -- in excess of 8 inches and, therefore, contributes to the ground water supply. In this area, the average annual amount of precipitation exceeding 8 inches during the base period of the study was sufficient to provide to the land surface an estimated 4,500 acre-feet of water supply annually. The average annual amount of deep percolation from precipitation to the valley floor was estimated by applying a technique used by the Department in previous investigations. This technique relates deep percolation to the amount of precipitation, the evapotranspiration requirements and soil moisture deficiency that must be satisfied above the selected 8 inch value, and the residual amount of runoff. The technique was developed from data used in studies reported in Department of Water Resources' Bulletin No. 33, "Rainfall Penetration and Consumptive Use of Water -- in Santa Ana River Valley and Coastal Plain", 1930, and in U. S. Department of Agriculture publication, "Determining Water Requirements in Irrigated Areas from Climatological and Irrigation Data", by Harry F. Blaney and Wayne D. Criddle of the Soil Conservation Service, dated August 1950.

Based on this technique, the amount of precipitation that may percolate was determined to be 3,850 acre-feet. However, to make allowances for any loss of this water as it passes from the root zone to ground water due to vapor transport, the amount of precipitation that percolates and becomes ground water was assumed to be 3,500 acre-feet.

Table 8 summarizes the estimated annual deep percolation of precipitation on the valley floor south of Hesperia during the base period. The occurrence of perched ground water in the same region confirms the occurrence of deep percolation as a source of water supply. However, the available data were not sufficient to define the magnitude and areal extent of the perched ground water body or to check the seasonal amounts of deep percolation from this source during the base period.

Surface Flow

Surface flow has two sources: base flow from the discharge of ground water to the stream channels and storm runoff from precipitation on the tributary hill and mountain areas. Base flow is found in four

TABLE 8

ESTIMATED SEASONAL DEEP PERCOLATION OF
PRECIPITATION ON THE VALLEY FLOOR
SOUTH OF HESPERIA DURING THE BASE PERIOD

In acre-feet

Water year	Deep percolation	Water year	Deep percolation
1936-37	3,500	1950-51	0
38	2,000	52	7,450
39	350	53	0
40	0	54	1,450
		55	0
1940-41	30,150	1955-56	0
42	0	57	0
43	5,600	58	5,400
44	30,550	59	0
45	1,000	60	0
1945-46 through 1948-50	0	1960-61	0
		25-year average	3,500

reaches of the Mojave River. At the point of origin of the Mojave River, the confluence of the West Fork of the Mojave River and Deep Creek, base flow results from the perennial supply available from the drainage area of Deep Creek. At Victorville, Camp Cady, and Afton, base flow, or rising water results from constrictions in the alluvial section of water-bearing materials, which force the ground water to the surface of the stream channel.

Runoff enters the study area through stream channels or as overland flow. The sources of runoff from precipitation are the San Bernardino Mountains and the desert mountains on the valley floor, shown on Table 7. In addition, as discussed earlier in the chapter, runoff from precipitation on the valley floor is a source of water supply in the area south of Hesperia.

Those stream gaging stations in the study area from which data were obtained for use in this report are presented in Table 9, by station name, length of record, and drainage area. In addition, the gaging station from the diversion site on Deep Creek to Hesperia is also listed. Although the records of the station at Beacon Creek near Helendale were not utilized in this study, it is part of the United States Geological Survey program to determine runoff characteristics for small drainage areas, which may provide valuable information in the future. Location of these stations is shown on Plate 1.

The principal surface flow in the study area is the Mojave River. The two major streams in the San Bernardino Mountains are Deep Creek and the West Fork of the Mojave River. These streams combine at the base of the mountains to form the Mojave River. This confluence is referred to as the forks. The flows in these streams are gaged by the U. S. Geological Survey about 1 mile upstream of their confluence. The records of the combined flow of the two streams and the diversion on Deep Creek are indicative of the flow of the Mojave River at the forks into the Upper Mojave Basin. The average annual flow at the forks during the base period was about 62,000 acre-feet, including diversion above the forks.

The major sources of surface inflow, or water supply to the basin, are the two forks of the Mojave River: Deep Creek and West Fork.

TABLE 9

STREAM GAGING STATIONS

Index No.*	Name[a]	Period of record: From	Period of record: To	Incomplete or missing years	Drainage area, in square miles
Active Stations					
1[b]	Deep Creek near Hesperia	1904-05	1960-61	9	137.0
2[c]	West Fork Mojave River near Hesperia	1904-05	1960-61	9	74.8
3[d]	Mojave River at Lower Narrows, near Victorville	1898-99	1960-61	17	530.0
4	Mojave River at Barstow	1930-31	1960-61	0	f
5	Mojave River at Afton	1929-30	1960-61	21	f
6	Beacon Creek at Helendale	1959-60	1960-61	0	0.7
7	Cushenbury Creek near Lucerne Valley	1956-57	1960-61	1	6.4
Inactive Stations					
8	Deep Creek Diversion	1950-51	1958-59	0	---
9[e]	Mojave River at Point of Rocks	1908-09	1910-11	2	f
10	Mojave River at Hodge	1930-31	1931-32	0	f

a. USGS gaging station unless otherwise noted.
b. Lake Arrowhead Company records as East Fork of Mojave River from 1904-05 through 1921-22; USGS records from 1929-30 through 1960-61.
c. Lake Arrowhead Company records from 1904-05 through 1960-61; USGS records from 1929-30 through 1960-61.
d. Lake Arrowhead Company records from 1904-05 through 1914-15; USGS records from 1898-99 through 1905-06 and from 1930-31 through 1960-61.
e. Lake Arrowhead Company records.
f. Not available.
* These index numbers are as shown on Plate 1.

The flows in these forks are gaged about 1 mile upstream of their confluence at the forks, and the records of the combined flow of the two streams and the diversion on Deep Creek are considered indicative of the flow of the Mojave River at the forks. The flow at the forks essentially occurs at the boundary of the water-bearing material, although a portion of the area above the gage on the West Fork is underlain with water-bearing material. Consequently, some of the runoff from the San Bernardino Mountains has an opportunity to infiltrate and percolate to the ground water reservoir before it reaches the gage.

The average annual runoff at the forks during the base period was computed to be 62,000 acre-feet. The amount is about 16 percent less than the average annual amount for the entire period of record, which begins in 1904, and about 26 percent less than for the period 1904-05 through 1936-37 that includes one wet and one dry period. This shows that the runoff during the earlier time was more than during the base period. However, in previous studies of the selection of the base period, the average annual precipitation for these same periods was determined to be about equal. Because of this condition, it is reasonable to expect that the average annual runoff for the base period and the longer time would be about equal.

To determine whether or not the streamflow records should be adjusted to account for the difference in runoff, the records of the gaged stations at the forks were checked against records of other streams by applying a double mass curve technique commonly used by hydrologists.

The results showed that the data plot is a straight line and that the amounts of runoff at the forks are proportional to the amounts occurring in other streams. Therefore, two conclusions were arrived at: first, the runoff records of the Mojave River at the forks are accurate over the entire period of record; second, the difference in the amounts of runoff from comparable amounts of precipitation is apparently due to the changing physical conditions and precipitation characteristics affecting the precipitation runoff relationship of the drainage area above the forks. Accordingly, the average annual runoff at the forks during the base period is considered representative of the amount of water supply to the basin under present physical conditions and precipitation characteristics.

Because a small portion of the water-bearing material is above the gage on the West Fork of the Mojave River, some of the runoff from the San Bernardino Mountains percolates and becomes ground water before it reaches the gage. The amount that becomes ground water is considered as part of the surface flow of the Mojave River in this study. During the year, the average annual amount of ungaged runoff above the gage contributing to the water supply of the basin was estimated to be 1,150 acre-feet. This amount was determined by comparing the estimate of runoff for the West Fork drainage area with the gaged record at the forks. The estimate of runoff was based on the precipitation-runoff relationship discussed hereinafter and the amount of precipitation over the drainage area which was obtained from the isohyetal map.

For the balance of the ungaged portion of the San Bernardino Mountains, the average annual surface inflow from runoff was estimated to be 50 acre-feet to the Upper Mojave Basin and 600 acre-feet to the

Lucerne Basin. These estimates were determined by applying precipitation-runoff relationships discussed later in this chapter.

Although there is a gage on a 6.4 square mile drainage area of Cushenbury Creek, which is tributary to Lucerne Basin, the average annual amount of runoff in this area during the base period could not be determined from the short period of record. Therefore, the estimate of runoff from the San Bernardino Mountains to Lucerne Basin includes the amount from the Cushenbury Creek drainage area.

From the San Bernardino Mountains to Afton, the Mojave River crosses the boundaries between ground water basins, which are identified and discussed in Chapter II. At the basin boundaries, the flow of the Mojave River is surface outflow from the upstream basin or surface inflow to the downstream basin. There are four of these boundaries along the river: Helendale, Barstow, Camp Cady site, and Afton. Except at Barstow, the flow is a combination of storm flow and base flow. At Barstow, the flow is entirely storm flow from runoff originating in the San Bernardino Mountains.

There is no record of a stream-gaging station at the boundary between the Upper and Middle Mojave Basins which is near Helendale. However, flow data are available for stations at two nearby locations: less than three years of record at Point of the Rocks, about 1½ miles downstream from the boundary, and two years of record at Hodge. These data were used to check the estimates of flow at the boundary.

The estimates of flow at the basin boundary near Helendale were based on: (1) a correlation developed from the flow data of the

Lower Narrows station and the Barstow station to be discussed next; (2) the criteria that, for the same amounts of annual flow entering the initial reach, the total amount of annual riverbed percolation in any number of reaches must equal the amount of riverbed percolation in the entire reach; and (3) the assumption that there is no change in the amount of storm flow in the reach between Victorville and Helendale because the majority of the storm flow occurs when there is base flow at Helendale. This correlation shows the relationship between the annual amounts of riverbed percolation and the annual amounts of flow at the Lower Narrows station, with riverbed percolation being computed as the difference in the annual amounts of gaged flow at the two stations. Therefore, knowing the annual flows at the Lower Narrows station, the annual amounts of riverbed percolation in the reach between the station and the boundary were determined. The annual amounts of flow at the boundary were determined by deducting percolation from flows at the Lower Narrows station. The average annual flow at the basin boundary during the base period was estimated to be 35,500 acre-feet.

The flow of the Mojave River is gaged at Barstow, about one-half mile downstream of the boundary between the Middle and Lower Mojave Basins. For study purposes, the flow at the gage is considered representative of flow at the boundary. The flow of the Mojave River at Barstow consists entirely of storm flow, 96 percent of which occurs from January through April. This storm flow originates as storm runoff in the San Bernardino Mountains above the forks and occurs when the storm runoff is of sufficient magnitude to reach Barstow. During the base period, the record of the gage at Barstow indicates no flow occurred at the station during 13 of the 25 years of the base period.

Based on these records, the average annual flow of the Mojave River at Barstow was computed to be 21,450 acre-feet during the base period. The seasonal flow ranged from zero to 130,000 acre-feet in 1937-38. In addition, the records at the station were used for estimating the flow of the Mojave River at the basin boundary near Helendale, previously discussed, and at the basin boundary at the Camp Cady site, to be discussed next.

The Mojave River crosses the boundary between the Lower Mojave and Caves Basins near the abandoned Camp Cady which is approximately 5 miles southeast of Harvard. The flow in the river at this point comprises base flow (rising water at the constriction in the alluvial section) and storm flow. During the base period, the average annual flow at the boundary was estimated to be 12,200 acre-feet and comprised 11,300 acre-feet storm flow and 900 acre-feet base flow.

In determining the average annual flow, it was first necessary to estimate the average annual storm flow by applying the same technique used in analyzing the flow of the Mojave River near Helendale. Where, (1) knowing the annual flows at the Barstow station, (2) based on a correlation developed from the flow data of the Barstow station and Afton station to be discussed next, and (3) based on the same criteria presented in analyzing the flow of the Mojave River near Helendale, the annual amounts of storm flow were estimated and the average annual storm flow determined to be 11,300 acre-feet.

The paucity of data precludes an analysis to determine the base flow at the boundary and, therefore, the average seasonal amount of base flow was assumed to be the same amount as at the Afton gage.

The flow of the Mojave River is gaged at the basin boundary at Afton. The flow at the station is the amount leaving the study area and comprises base flow (rising ground water at the constriction in the cross-sectional area of water-bearing materials at Afton Canyon) and storm flow. The storm flow at the station is a combination of runoff originating in the San Bernardino Mountains and runoff from local summer storms. The major portion of the storm flow originates in the San Bernardino Mountains. During the base period, flow at Afton was recorded only for the years 1952-53 through 1960-61; therefore, it was necessary to estimate the flow for the other 16 years of the base period. Flow data prior to the base period, from January 1930 through September 1932, and ground water level data during the missing 16 years of record between the Barstow and Afton stations aided in estimating the annual flow during the base period. Based on these data, the annual amounts for the 16 years of missing record were determined, and the average annual storm flow at Afton from the runoff originating in the San Bernardino Mountains was estimated to be 8,650 acre-feet. In addition, the average annual storm flow at Afton due to local summer storms was determined by a study of the magnitude and frequency of the amounts found in the 9 years of record at the station. From this study, the average annual storm flow from local summer storms was determined to be 50 acre-feet.

The annual base flow during the missing years of record was estimated by establishing a relationship between the base flow for the years of record and ground water level data at nearby wells. Based on this relationship, the base flow for the 16 years of missing record was determined, and the average annual base flow was estimated to be 900 acre-feet. Combined with the storm flow at the station, the average annual flow at the boundary where the Mojave River leaves the study area was estimated to be 9,600 acre-feet.

The average annual flows of the Mojave River at the various basin boundaries are shown in Table 10.

TABLE 10

AVERAGE ANNUAL FLOWS AT THE BASIN BOUNDARIES

Basin boundary	In acre-feet
At the Forks	62,000
Near Helendale	35,500
At Barstow*	21,450
Camp Cady Site	12,200
At Afton*	9,600

*Stream-gaging station.

The ungaged desert mountains on the valley floor contribute runoff to the water supply of the basins. This runoff constitutes about five percent of the total water supply of the study area. However, it is an important source of water supply to the basins that do not border the Mojave River. Estimated average annual runoff to these three basins -- Lucerne, Harper, and Coyote -- amounted to 450 acre-feet, 550 acre-feet, and 450 acre-feet during the base period. This is the only source of surface inflow to Harper and Coyote Basins; Lucerne receives additional runoff from the San Bernardino Mountains.

The amount of runoff from the ungaged desert mountains to the basins was estimated from an average seasonal precipitation-runoff relationship which was developed by adjusting a curve of the relationship for various streams in Southern California to reflect local conditions in the Mojave Desert region. The adjustment was made by creating a curve parallel to the original curve. The amount of offset from the original curve was based on the relationship of the average annual precipitation and runoff of the Deep Creek drainage area to the average of various streams in Southern California. Values of percent runoff for different depths of average annual precipitation used in estimating the runoff from ungaged drainage areas in the current studies and in the preliminary studies are presented in Table 11. By applying these values to the average annual precipitation on the various ungaged areas, the average annual surface inflow to the basins could be determined.

TABLE 11

AVERAGE PRECIPITATION-PERCENT RUNOFF VALUES

Average annual precipitation, in inches	Average annual runoff, in percent of precipitation
10	3.1
9	2.6
8	2.1
7	1.7
6 or less	1.0

As discussed earlier in the chapter, runoff from precipitation on the valley floor south of Hesperia percolates and becomes ground water. This is a source of water supply and, for this study, is considered surface inflow to the Upper Mojave Basin. The estimate of the average annual amount was based on the precipitation-runoff relationship discussed previously, modified for slope and soil conditions. The area of the valley floor south of Hesperia is flatter and composed of more permeable older alluvium than the steep and crystalline rock drainage areas used in originally developing the curve; therefore, it is reasonable to expect less runoff to occur in this area for equal amounts of precipitation. Analysis of limited data suggests that the amount of runoff is about half the amount determined from the precipitation-runoff relationship. On this basis, the average annual runoff from precipitation on the valley floor south of Hesperia during the base period was estimated to be 1,350 acre-feet. Most of this amount percolates in the many natural channels and becomes ground water in the area. However, because small amounts may be consumptively used by native vegetation, the amount of this runoff that becomes water supply to the Upper Mojave Ground Water Basin was assumed to be 1,000 acre-feet.

The flow of the Mojave River at the basin boundaries, the runoff from desert mountains on the valley floor, and runoff from precipitation on the basin as surface inflow to the Upper Mojave, Middle Mojave, Lower Mojave, and Lucerne Basins are summarized in Table 12.

TABLE 12

ESTIMATED SURFACE INFLOW DURING THE BASE PERIOD

In acre-feet

Water year	To Upper Mojave Basin: From: San Bernardino Mountains: At the forks	To Upper Mojave Basin: From: San Bernardino Mountains: Above West Fork	To Upper Mojave Basin: From: San Bernardino Mountains: Other areas	To Upper Mojave Basin: From: Desert Mountains	To Upper Mojave Basin: Valley Area	To Upper Mojave Basin: Total	To Middle Mojave Basin: From: Mojave River	To Middle Mojave Basin: Desert Mountains	To Middle Mojave Basin: Total	To Lower Mojave Basin: From: Mojave River	To Lower Mojave Basin: Desert Mountains	To Lower Mojave Basin: Total	To Lucerne Basin: From: San Bernardino Mountains	To Lucerne Basin: Desert Mountains	To Lucerne Basin: Total
1936-37	169,250	1,150	50	250	2,800	173,500	125,200	550	125,750	103,900	800	104,700	600	450	1,050
38	218,900	1,150	50	250	3,700	224,050	159,150	550	159,700	138,100	800	138,900	600	450	1,050
39	40,600	1,150	50	250	500	42,550	17,250	550	17,800	550	800	1,350	600	450	1,050
40	31,250	1,150	50	250	350	33,050	15,350	550	15,900	0	800	800	600	450	1,050
1940-41	161,200	1,150	50	250	2,800	165,450	118,950	550	119,500	96,000	800	96,800	600	450	1,050
42	26,100	1,150	50	250	400	27,950	13,700	550	14,250	100	800	900	600	450	1,050
43	150,000	1,150	50	250	2,800	154,250	104,700	550	105,250	91,000	800	91,800	600	450	1,050
44	86,850	1,150	50	250	1,900	90,200	60,300	550	60,850	36,250	800	37,050	600	450	1,050
45	70,850	1,150	50	250	1,150	73,450	39,500	550	40,050	22,100	800	22,900	600	450	1,050
1945-46	54,550	1,150	50	250	700	56,700	29,350	550	29,900	12,550	800	13,350	600	450	1,050
47	50,350	1,150	50	250	1,150	52,950	17,150	550	17,700	2,900	800	3,700	600	450	1,050
48	16,750	1,150	50	250	150	18,350	10,550	550	11,100	0	800	800	600	450	1,050
49	26,150	1,150	50	250	400	28,000	8,350	550	8,900	0	800	800	600	450	1,050
50	15,550	1,150	50	250	250	17,250	7,650	550	8,200	0	800	800	600	250	1,050
1950-51	4,350	1,150	50	250	0	5,800	7,200	550	7,750	0	800	800	600	450	1,050
52	106,450	1,150	50	250	2,150	110,050	35,200	550	35,750	12,550	800	13,350	600	450	1,050
53	13,000	1,150	50	250	100	14,550	7,850	550	8,400	0	800	800	600	450	1,050
54	57,400	1,150	50	250	850	59,700	13,500	550	14,050	0	800	800	600	450	1,050
55	21,050	1,150	50	250	200	22,700	8,150	550	8,700	0	800	800	600	450	1,050
1955-56	19,100	1,150	50	250	100	20,650	7,750	550	8,300	0	800	800	600	450	1,050
57	23,750	1,150	50	250	150	25,350	7,100	550	7,650	0	800	800	600	450	1,050
58	151,950	1,150	50	250	2,200	155,600	54,150	550	54,700	20,050	800	20,850	600	450	1,050
59	20,850	1,150	50	250	200	22,500	6,800	550	7,350	0	800	800	600	450	1,050
60	8,750	1,150	50	250	0	10,200	6,350	550	6,900	0	800	800	600	450	1,050
1960-61	4,500	1,150	50	250	0	5,950	6,300	550	6,850	0	800	800	600	450	1,050
25-year average	61,980	1,150	50	250	1,000	64,430	35,500	550	(36,050	21,442	800	22,242)	600	450	1,050

Estimated average annual inflow to: Harper Basin -- 550 acre-feet. (desert mountains)
Coyote Basin -- 450 acre-feet. (desert mountains)
Caves Basin -- 12,350 acre-feet. (12,200 acre-feet from Mojave River; 150 acre-feet from desert mountains)

Subsurface Flow

Primarily, ground water movement within the study area occurs parallel and adjacent to the Mojave River in a south to north direction. Minor subsurface movement occurs in alluvium adjacent to the hills and mountains. The prevailing ground water gradients generally conform to the regional slope of the land surface; however, in portions of the study area, the gradients are reversed. This reversed gradient is caused by pumping from ground water in storage.

Ground water can move across the boundaries of the basins within the study area and its subdivisions when the permeability of the subsurface materials, the hydraulic gradient, and the cross-sectional area are sufficient for movement to occur and provided there is no subsurface barrier. At some of the boundaries, data on the permeability, hydraulic gradient, and cross-sectional area were not available for computing the amount of subsurface flow. However, it is believed the limited extent of alluvial materials at these boundaries prohibits the movement of significant quantities of water.

There is no subsurface outflow from the study area. However, subsurface inflow into the study area apparently occurs at the southwest boundary of the study area, which is also the west boundary of the Upper Mojave Basin. Because information on the depth and nature of the alluvial materials and the hydraulic gradient at this location is lacking, no direct determination of the amount of this flow was possible. However, on the basis of analysis of the natural recharge to the ground water basin west of the Upper Mojave Basin (primarily from Sheep Creek which is outside the study area), it appears reasonable that some ground water moves into the study area across this boundary. For this study, it was assumed that one-third of the estimated average seasonal runoff of Sheep Creek, less the average seasonal diversion to Phelan, percolated and moved easterly into the study area and the Upper Mojave Basin.

The amounts of underflow across the basin boundaries were determined from estimates of the factors in the equation, Q=TIW, which is based on Darcy's Law. In this equation, the subsurface flow (Q) is equal to the transmissibility (permeability times saturated aquifer depth) (T) of the subsurface materials, multiplied by the width of the cross-sectional area (W) through which the flow passes, and the slope, or the hydraulic gradient, (I) of the ground water at the cross-sectional area.

The estimates of underflow for each of the selected boundaries are listed in Table 13.

TABLE 13

ESTIMATED AVERAGE ANNUAL SUBSURFACE INFLOW

In acre-feet

Basin	Average annual amount during the base period	
Upper Mojave from:		
West Boundary	850	
Lucerne	100	
TOTAL		950
Middle Mojave from Upper Mojave		2,000
Lower Mojave from Middle Mojave		2,000
Harper from Middle Mojave		1,000
Coyote from Lower Mojave		1,000
Caves from Lower Mojave		1,000

Import-Export of Water

A small amount of water is imported from outside the study area to the town of Phelan, in the Upper Mojave Basin. Some water supply, as well as sewage, crosses the boundary from the Middle to Lower Mojave Basins within the City of Barstow.

The water supply for Phelan is imported by pipeline from the Sheep Creek drainage area which is in the San Gabriel Mountains just outside the study area. Although the major purpose of the imported water is for urban and suburban use, a portion may overflow into another pipeline for agricultural use when there is no available storage in the tank.

Records of the amount of water imported are fragmentary until late 1963, when a meter was installed. From this recent information, the average annual amount of imported water to Phelan during the base period was estimated to be 250 acre-feet.

The boundary between the Middle and Lower Mojave Basins passes through the City of Barstow, which is supplied with water pumped from wells in the two basins. The water is distributed by the Southern California Water Company. Based on information on the amounts pumped and the demand by population in each basin, it was established that some of the water extracted in the Middle Mojave Basin is transported across the basin boundary to service areas in the Lower Mojave Basin. The estimate of the average annual amount of water supply transported across the basin boundary during the base period was 700 acre-feet.

A second source of water exported from the Middle Mojave Basin is sewage that originated from the City of Barstow and was transported across the boundary to a treatment plant in the Lower Mojave Basin. The smaller portion of the City is in the Middle Mojave Basin. The average annual amount of sewage exported from the basin is estimated to be 100 acre-feet. This estimate is based on the amount of applied water and its consumptive use, the population in the two basins, and the amount of flow through the treatment plant in 1961.

Table 14 summarizes the amounts of water imported to the Upper Mojave Basin from outside the study area and to the Lower Mojave Basin from Middle Mojave Basin.

TABLE 14

ESTIMATED AVERAGE ANNUAL AMOUNTS OF WATER IMPORTED TO THE UPPER AND LOWER MOJAVE BASINS

In acre-feet

Basin		Average annual amount during the base period
Upper Mojave		250
Lower Mojave from Middle Mojave:		
Water	(700)	
Sewage	(100)	
TOTAL		800

In Table 15 is shown the annual supply and the 25-year average annual supply from each source of supply to each of the four main basins: Upper Mojave, Middle Mojave, Lower Mojave, and Lucerne. The estimated annual supply to each of the other three basins -- Harper, Coyote, and Caves -- is also indicated by footnote. Although there is insufficient hydrologic data available in these last three basins to make definite determinations of the amounts of water supply, estimates were made to provide an indication of existing conditions.

TABLE 15

ESTIMATED WATER SUPPLY DURING THE BASE PERIOD

In acre-feet

Water year	Upper Mojave Basin					Middle Mojave Basin				Lower Mojave Basin					Lucerne Basin		
	Precipitation*	Surface inflow	Subsurface inflow	Imported water	Total	Precipitation*	Surface inflow	Subsurface inflow	Total	Precipitation*	Surface inflow	Subsurface inflow	Imported water	Total	Precipitation*	Surface inflow	Total
1936-37	8,600	173,500	950	250	183,300	1,250	125,750	2,000	129,000	900	104,700	2,000	800	108,400	150	1,050	1,200
38	6,850	224,050	950	250	232,100	1,350	159,700	2,000	163,050	950	138,900	2,000	800	142,650	150	1,050	1,200
39	4,800	42,550	950	250	48,550	1,500	17,800	2,000	21,300	1,250	1,350	2,000	800	5,400	150	1,050	1,200
40	4,000	33,050	950	250	38,250	1,350	15,900	2,000	19,250	950	800	2,000	800	4,550	150	1,050	1,200
1940-41	36,950	165,450	950	250	203,600	2,000	119,500	2,000	123,500	1,850	96,800	2,000	800	101,450	150	1,050	1,200
42	4,100	27,950	950	250	33,250	1,650	14,250	2,000	17,900	1,400	900	2,000	800	5,100	150	1,050	1,200
43	11,650	154,250	950	250	167,100	1,500	105,250	2,000	108,750	1,100	91,800	2,000	800	95,700	150	1,050	1,200
44	36,850	90,200	950	250	128,250	1,350	60,850	2,000	64,200	850	37,050	2,000	800	40,700	150	1,050	1,200
45	6,350	73,450	950	250	81,000	1,700	40,050	2,000	43,750	1,300	22,900	2,000	800	27,000	150	1,050	1,200
1945-46	4,250	56,700	950	250	62,150	1,150	29,900	2,000	33,050	450	13,350	2,000	800	16,600	150	1,050	1,200
47	4,850	52,950	950	250	59,000	1,250	17,700	2,000	20,950	500	3,700	2,000	800	7,000	350	1,050	1,400
48	4,800	18,350	950	250	24,350	1,500	11,100	2,000	14,600	700	800	2,000	800	4,300	550	1,050	1,600
49	6,150	28,000	950	250	35,350	2,050	8,900	2,000	12,950	1,450	800	2,000	800	5,050	700	1,050	1,750
50	4,550	17,250	950	250	23,000	2,050	8,200	2,000	12,250	1,300	800	2,000	800	4,900	850	1,050	1,900
1950-51	5,300	5,800	950	250	12,300	2,100	7,750	2,000	11,850	1,250	800	2,000	800	4,850	1,000	1,050	2,050
52	15,150	110,050	950	250	126,400	2,300	35,750	2,000	40,050	2,450	13,350	2,000	800	18,600	1,200	1,050	2,250
53	5,850	14,550	950	250	21,600	2,300	8,400	2,000	12,700	1,650	800	2,000	800	5,250	1,250	1,050	2,300
54	7,300	59,700	950	250	68,200	2,400	14,050	2,000	18,450	1,800	800	2,000	800	5,400	1,250	1,050	2,300
55	7,500	22,700	950	250	31,400	2,450	8,700	2,000	13,150	1,750	800	2,000	800	5,350	1,250	1,050	2,300
1955-56	5,300	20,650	950	250	27,150	2,350	8,300	2,000	12,650	1,500	800	2,000	800	5,100	1,300	1,050	2,350
57	5,250	25,350	950	250	31,800	2,000	7,650	2,000	11,650	900	800	2,000	800	4,500	1,300	1,050	2,350
58	11,900	155,600	950	250	168,700	2,850	54,700	2,000	59,550	2,050	20,850	2,000	800	25,700	1,250	1,050	2,300
59	4,500	22,500	950	250	28,200	2,250	7,350	2,000	11,600	1,050	800	2,000	800	4,650	1,250	1,050	2,300
60	4,900	10,200	950	250	16,300	2,500	6,900	2,000	11,400	1,400	800	2,000	800	5,000	1,200	1,050	2,250
1960-61	4,700	5,950	950	250	11,850	2,250	6,850	2,000	11,100	1,050	800	2,000	800	4,650	1,150	1,050	2,200
25-year average	8,896	64,430	950	250	74,526	1,896	36,050	2,000	39,946	1,272	22,242	2,000	800	26,314	694	1,050	1,744

Estimated average annual supply to: Harper Basin -- 1,550 acre-feet.
Coyote Basin -- 1,450 acre-feet.
Caves Basin -- 13,350 acre-feet.

*The amount of precipitation on the basin consumptively used by native vegetation is not included.

Water Use and Disposal

The use and disposal of water during the base period, 1936-37 through 1960-61, are discussed here under the headings of surface outflow, subsurface outflow, exported water, and consumptive use.

The figures shown below for surface outflow, subsurface outflow, and exported water were arrived at by the methods described in the previous section for determining the flows at basin boundaries within the study area.

Surface Outflow

Surface outflow from the study area takes place only at the northeast boundary near Afton. The average annual amount of surface outflow during the base period was estimated to be 9,600 acre-feet.

Amounts of average annual surface outflow from each of the basins within the study area during the 25-year base period are given below.

Basins	Average annual surface outflow in acre-feet
Upper Mojave to Middle Mojave	35,500
Middle Mojave to Lower Mojave	21,450
Lower Mojave to Caves	12,200

There is no surface outflow from the Lucerne Basin.

Subsurface Outflow

There is no subsurface outflow from the study area. The amount of average annual subsurface outflow from basins during the 25-year base period was:

Basins	Average annual subsurface outflow in acre-feet
Upper Mojave to Middle Mojave	2,000
Middle Mojave to Lower Mojave	2,000
Middle Mojave to Harper	1,000
Lower Mojave to Caves	1,000
Lower Mojave to Coyote	1,000

Exported Water

The only export of water is from the Middle Mojave Basin to the Lower Mojave Basin, an estimated average annual amount of 700 acre-feet.

Consumptive Use

Water is consumptively used by vegetation and by man and his associated activities. Water is consumed by vegetation through the transpiration processes and building of plant tissues and by evaporation from the soil, from free water surfaces, and from foliage. Water consumptively used by man and his activities includes water used for agriculture, domestic uses, industrial purposes, and water evaporated by urban and nonvegetative types of land use. Water for consumptive use is obtained from natural sources and from man-made facilities.

Applied water from man-made sources meets the consumptive use requirements not supplied through natural sources and is usually in excess of the consumptive use requirements. The portion of the applied water that is not consumed replenishes the basin by becoming ground water through deep percolation.

In the following discussion of beneficial and nonbeneficial uses of water in the study area, the land use data was obtained from a comprehensive survey of the Mojave River region, conducted by the Department of Water Resources in 1961. The results of this survey are shown on Plate 5, "Land Use, 1961".

The three kinds of plant growth in the study area are: native vegetation, which covers much of the desert; riparian native vegetation, which grows in and near streams; and agricultural crops. Consumptive use of both precipitation and ground water by agriculture is a beneficial use. In addition, consumptive use of water by man in urban or suburban developments and industry is a beneficial use. Consumption of precipitation by native vegetation and consumption of both precipitation and ground water by riparian native vegetation are nonbeneficial uses.

The studies of beneficial consumptive use include determining the total amount of water used by the various crops and the amounts of water used by the population of the study area and its associated commerce and industry.

Agriculture. Estimates of consumptive use of precipitation and applied water by agriculture during the base period were based on the mean annual unit consumptive use values and acreages of the various types of crops. The unit use values for the Mojave River region are presented in State Water Resources Board Bulletin No. 2, "Water Utilization and Requirements of California", 1955. These unit use values are derived by the "Blaney-Criddle Method". Briefly, this method uses an empirical consumptive use coefficient, the average monthly temperature, the monthly percent of daylight hours, and the length of growing season to arrive at the unit use values.

In applying these unit use values to the base period, the values were modified to reflect the average monthly temperature in the Upper Mojave Basin as recorded at the climatological station at Victorville, and the temperature in the Middle and Lower Mojave Basins based on temperature data at the station at Barstow. The modified, or average, annual unit consumptive use values of precipitation and applied water for various types of crops are shown in Table 16.

As shown in Table 16, the amount of precipitation consumptively used by crops is equal to the small amount of precipitation that occurs during the nongrowing season. This is based on precipitation observed at stations in Victorville and Barstow. These records confirm that the average annual precipitation during the nongrowing season is too small to permit runoff from the tilled area. This amount of rainfall is also well within the moisture-holding capacity of the soil, where it is retained until the growing season. During the growing season, this water is consumptively used; thus, the moisture-holding capacity of the soil was assumed to be depleted at the beginning of the water year.

A description of the various classifications of crops used in this study is presented in Appendix C. These groupings are similar to those used in State Water Resources Board Bulletin No. 2.

TABLE 16

ESTIMATED AVERAGE SEASONAL UNIT CONSUMPTIVE USE VALUES FOR AGRICULTURAL CROPS DURING THE BASE PERIOD

In acre-feet per acre

Agricultural crop	Unit consumptive use values					
	Upper Mojave and Lucerne Basins			Middle and Lower Mojave Basin		
	Precipi-tation	Ground water*	Total	Precipi-tation	Ground water*	Total
Alfalfa	0.5	3.0	3.5	0.4	3.3	3.7
Pasture	0.5	2.8	3.3	0.4	3.1	3.5
Truck crops	0.5	1.6	2.1	0.4	1.7	2.1
Field crops	0.5	1.6	2.1	0.4	1.7	2.1
Deciduous fruits and nuts	0.5	2.3	2.8	0.4	2.5	2.9
Small grains	0.5	1.0	1.5	0.4	1.2	1.6
Vineyards	0.5	2.5	3.0	0.4	2.7	3.1

*Pumped ground water that is applied to crops.

The total acreage and the acreages of the various types of crops in the study area were obtained from federal, state, and county land and water use surveys. These included Department of Water Resources surveys in 1929, 1950, 1957, and 1961, a United States Bureau of Reclamation survey in 1946, and United States Bureau of Census surveys in 1934, 1939, and 1949. County crop reports for the Mojave Desert portion of the San Bernardino County were also available for 15 years of the base period, beginning with 1946.

The data for only two of the surveys -- those conducted by the Department in 1957 and 1961 -- included acreages of all the various crops in each basin. Data from the balance of the surveys are of lesser detail, and crop acreage by basin was partially estimated. Based on the data from these surveys, the total acreage and the acreage of the various types of crops in each basin during each year of the base period were determined. Total acreage for each was interpolated from a curve of the plotted data that shows the variation of the acreage of agriculture from 1929 through 1961. Acreages of the various types of crops were assumed to follow the percentage distribution of the three distinct periods of agricultural development in the study area, for which data on the types of crops are available. The three distinct periods of agricultural development are from 1936-37 to 1946-47, 1946-47 to 1959-60, and 1959-60 to end of the base period 1960-61. The estimated land use in 1961 in each basin is shown in Table 17.

TABLE 17

ESTIMATED LAND USE IN THE BASINS IN 1961

In acres

Nature and class of land use[a]	Mojave Basins			Lucerne Basin	Harper Basin	Coyote Basin	Caves Basin
	Upper	Middle	Lower				
WATER SERVICE AREA							
Urban and Suburban							
Residential	5,850	800	1,200	b	0	0	0
Recreational residential	3,250	0	0	b	0	0	0
Commercial	550	100	250	b	0	0	0
Industrial	100	0	50	b	0	0	0
Unsegregated urban and suburban area	1,850	700	650	b	150	0	50
Subtotal	11,600	1,600	2,100	b	150	0	50
Included Nonwater Service Area	29,050	2,550	3,200	b	250	0	0
Gross Urban and Suburban Area	40,650	4,150	5,300	b	400	0	50
Irrigated Agriculture							
Alfalfa	4,050	3,100	1,750	850[c]	300	400	650
Pasture	1,300	900	300	800[c]	200	0	0
Truck crops	200	0	0	0[c]	0	0	0
Field crops	400	200	150	0[c]	0	50	0
Deciduous fruits and nuts	50	0	150	0	0	0	0
Small grains	900	1,350	50	300[c]	0	0	0
Subtotal	6,900	5,550	2,400	1,950[c]	500	450	650
Fallow	150	50	0	0[c]	50	0	0
Included Nonwater Service Area	350	300	100	100[c]	50	50	50
Gross Irrigated Agriculture	7,400	5,900	2,500	2,050[c]	600	500	700

a. Described in Appendix C.
b. Data not available.
c. Estimated.

Estimates of the annual and average annual amounts of consumptive use of precipitation and applied water during the base period for the Upper Mojave, Middle Mojave, Lower Mojave, and Lucerne Basins are presented in Table 18.

TABLE 18

CONSUMPTIVE USE OF WATER BY AGRICULTURE DURING THE BASE PERIOD

In acre-feet

Water year	Upper Mojave Basin			Middle Mojave Basin			Lower Mojave Basin			Lucerne Basin		
	Precipitation	Ground water*	Total	Precipitation	Ground water*	Total	Precipitation	Ground water*	Total	Precipitation	Ground water*	Total
1936-37	1,950	9,300	11,250	750	5,200	5,950	150	1,050	1,200	150	900	1,050
38	1,950	9,250	11,200	750	5,200	5,950	150	1,050	1,200	150	900	1,050
39	1,950	9,250	11,200	750	5,150	5,900	150	1,050	1,200	150	900	1,050
40	2,000	9,450	11,450	750	5,300	6,050	150	1,100	1,250	150	900	1,050
1940-41	2,050	9,750	11,800	800	5,450	6,250	150	1,100	1,250	150	900	1,050
42	2,150	10,100	12,250	800	5,600	6,400	150	1,150	1,300	150	900	1,050
43	2,200	10,400	12,600	850	5,800	6,650	150	1,200	1,350	150	900	1,050
44	2,300	10,750	13,050	850	6,000	6,850	150	1,250	1,400	150	900	1,050
45	2,400	11,300	13,700	900	6,300	7,200	200	1,300	1,500	150	900	1,050
1945-46	2,500	11,850	14,350	950	6,600	7,550	200	1,350	1,550	150	900	1,050
47	2,800	14,200	17,000	1,150	8,400	9,550	350	2,700	3,050	350	1,800	2,150
48	3,050	15,550	18,600	1,350	9,950	11,300	550	4,100	4,650	550	2,700	3,250
49	3,300	16,750	20,050	1,550	11,500	13,050	750	5,450	6,200	700	3,600	4,300
50	3,550	18,150	21,700	1,750	12,900	14,650	900	6,900	7,800	850	4,500	5,350
1950-51	3,800	19,450	23,250	1,950	14,450	16,400	1,100	8,200	9,300	1,000	5,400	6,400
52	4,050	20,750	24,800	1,950	14,300	16,250	1,250	9,600	10,850	1,200	6,300	7,500
53	3,950	20,150	24,100	1,950	14,300	16,250	1,200	9,200	10,400	1,250	6,550	7,800
54	3,800	19,500	23,300	1,900	14,150	16,050	1,100	8,300	9,400	1,250	6,600	7,850
55	3,700	19,850	23,550	1,900	14,150	16,050	950	7,350	8,300	1,250	6,750	8,000
1955-56	3,600	19,350	22,950	1,900	14,000	15,900	850	6,450	7,300	1,300	6,800	8,100
57	3,550	18,850	22,400	1,850	13,750	15,600	700	5,450	6,150	1,300	6,900	8,200
58	3,500	18,750	22,250	1,950	14,450	16,400	750	5,600	6,350	1,250	6,750	8,000
59	3,500	18,750	22,250	2,050	15,100	17,150	800	6,100	6,900	1,250	6,550	7,800
60	3,500	18,200	21,700	2,150	14,300	16,450	900	6,650	7,550	1,200	6,300	7,500
1960-61	3,500	18,200	21,700	2,200	14,950	17,150	950	7,200	8,150	1,150	6,150	7,300
25-year average	2,984	15,114	18,098	1,428	10,290	11,718	588	4,434	5,022	694	3,706	4,400

Estimated (1961 land use conditions):

	Precipitation	Ground water	Total
Harper Basin	200	1,600	1,800 acre-feet
Coyote Basin	200	1,400	1,600 acre-feet
Caves Basin	250	2,150	2,400 acre-feet

*Pumped ground water that is applied to crops.

Urban-Suburban and Industry. In the study area, because of the lack of historic urban and suburban land use surveys and the minor amounts of heavy industry in the basins, it was appropriate to estimate urban-suburban water use on the basis of a per capita use of water and population data.

The population of the study area is concentrated in the four major basins. Estimates of population in these basins from 1930 through 1960 are presented in Table 19 and are based on federal census surveys of 1950 and 1960, supplemented by information from earlier state reports. Detailed estimates of the population of the other three basins, Harper, Caves, and Coyote, are not available; however, they are sparsely settled areas and constitute approximately 2 percent of the total study area population.

TABLE 19

ESTIMATED POPULATION
1930 TO 1960

Year	Population				Total
	Mojave Basin			Lucerne Basin	
	Upper	Middle	Lower		
1930	2,650	2,300	1,100	150	6,200
40	3,250	1,550	3,800	200	8,800
50	8,400	4,100	9,750	450	22,700
60	25,000	8,100	18,300	1,600	53,000

The amount of applied, or delivered, water that is consumptively used by the population in the study area was determined from data in Department of Water Resources Bulletin No. 78, "Investigation of Alternative Aqueduct Systems to Serve Southern California", Appendix D, "Economic Demand for Imported Water", 1960. Based on information in the report, the average per capita applied water in the study area was estimated to have increased from about 130 gallons per capita per day at the start of the base period (1936-37) to 200 gallons per capita per day at the end (1960-61). The information in the report was also the basis for the assumption that 50 percent of the applied water is consumptively used.

The annual and average annual amounts of consumptive use of water during the base period by urban and suburban areas in the Upper Mojave, Middle Mojave, Lower Mojave, and Lucerne Basins are presented in Table 20.

Industrial use of water in the study area is by a railway maintenance yard, a steam power generating plant, and three cement plants.

TABLE 20

CONSUMPTIVE USE OF WATER BY URBAN AND SUBURBAN AREAS DURING THE BASE PERIOD

In acre-feet

Water year	Mojave River			Lucerne Basin
	Upper	Middle	Lower	
1936-37	200	100	250	--
38	200	100	250	--
39	250	100	250	--
40	250	100	300	50[a]
1940-41	300	150	350	--
42	350	150	400	--
43	400	200	450	--
44	450	200	500	--
45	500	250	550	100[b]
1945-46	550	250	650	--
47	600	300	700	--
48	650	300	750	--
49	700	350	850	--
50	800	400	900	200[b]
1950-51	850	400	950	50
52	950	450	1,050	50
53	1,050	450	1,100	50
54	1,150	500	1,150	50
55	1,250	500	1,200	100
1955-56	1,400	550	1,200	100
57	1,500	550	1,250	100
58	1,850	600	1,500	100
59	2,300	750	1,750	150
60	2,750	900	2,000	200
1960-61	2,950	900	2,050	200
25-year average	968	384	894	60

a. Four-year total.
b. Five-year total.

Water consumption by these industries was computed from records of metered pumping of wells and records of the amounts used in the industrial process. Where these records were not complete, additional data on water purchases and plant production (computed in terms of use of water per product) were also used for estimating the water consumption. Table 21 shows the amounts of consumptive use of water by industry.

Nonbeneficial Consumptive Use

Throughout most of the undeveloped portions of the study area, the consumptive use of water by native vegetation is assumed equal to the precipitation. However, vegetation along the banks of the Mojave River derives only a small part of its water supply from precipitation, but consumes large quantities of ground water that might be beneficially used by man if the vegetation were eliminated and controlled. Estimates of nonbeneficial consumptive use of water by this riparian native vegetation were based on the "Blaney-Criddle Method" applied to the acreages of the four classifications of riparian native vegetation considered in this study. These classifications are based on the Department's 1961 land use survey modified by field correlation. The classifications provide a direct means of determining an individual consumptive use value for each type of riparian native vegetation, as shown in Table 22.

As shown in Table 23, the acreages of riparian native vegetation were classified according to areal (surface) density and kind of plants, taking into account the areas of high ground water and minor areas of free water surfaces. The amounts in each basin were determined from aerial photos of the Mojave River area taken in 1929, 1939, and 1959.

TABLE 21

CONSUMPTIVE USE OF WATER BY INDUSTRY
DURING THE BASE PERIOD

In acre-feet

Water Year	Upper Mojave Basin	Lower Mojave Basin	Lucerne Basin
1936-37	250	200	0
38	200	200	0
39	200	200	0
40	200	200	0
1940-41	300	200	0
42	350	200	0
43	250	200	0
44	250	200	0
45	250	200	0
1945-46	350	200	0
47	350	200	0
48	350	200	0
49	350	200	0
50	450	200	0
1950-51	500	200	0
52	550	200	0
53	550	200	0
54	650	200	0
55	1,250	200	0
1955-56	1,450	200	0
57	1,500	200	250
58	1,450	200	400
59	1,450	200	400
60	1,300	200	450
1960-61	1,400	700	500
25-year average	646	220	80

The 1929 photos were used for coverage along the river from the forks to the Lower Narrows near Victorville where 1939 photos were not available. The 1959 survey was considered to approximate conditions in 1961, the end of the base period for this study.

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TABLE 22

AVERAGE ANNUAL UNIT CONSUMPTIVE USE VALUE OF RIPARIAN NATIVE VEGATATION

In acre-feet per acre

Classification of riparian native vegetation	Unit consumptive use value					
	Upper Mojave Basin			Middle and Lower Mojave Basin		
	Precipi-tation	Ground water	Total	Precipi-tation	Ground water	Total
Trees, 80 percent areal density or greater	0.4	4.7	5.1	0.3	5.1	5.4
Trees, 79 percent areal density or less	0.4	4.2	4.6	0.3	4.6	4.9
Brush and meadowland	0.4	2.9	3.3	0.3	3.2	3.5
Swamp	0.4	6.8	7.2	0.3	7.3	7.6

Table 23 shows the classifications of riparian native vegetation and the acreages of each in the Upper, Middle, and Lower Mojave Basins in 1960-61.

TABLE 23

AREAS DEVOTED TO
RIPARIAN NATIVE VEGETATION IN 1960-61

In acres

Classification of riparian native vegetation	Mojave Basin		
	Upper	Middle	Lower
Trees, 80 percent areal density or greater	1,790	170	1,010
Trees, 79 percent areal density or less	1,350	1,110	680
Brush and meadowland	1,320	70	180
Swamp	600	0	0

Utilizing the Blaney-Criddle method and the estimated acreage and assigned consumptive use coefficient for each classification of riparian native vegetation, the unit water use values and the amounts of consumptive use were determined for each year of the base period.

The annual and average annual amounts of consumptive use of precipitation and ground water by riparian native vegetation in the Upper, Middle, and Lower Mojave Basins during the base period, is shown on Table 24.

Estimated amounts of water use and disposal during the base period are presented in Table 25 for each of the main basins: Upper Mojave, Middle Mojave, Lower Mojave, and Lucerne. Estimates for the other three basins -- Harper, Coyote, and Caves -- are also indicated by footnote.

TABLE 24

CONSUMPTIVE USE OF WATER BY RIPARIAN NATIVE VEGETATION DURING THE BASE PERIOD

In acre-feet

Water year	Upper Mojave Basin			Middle Mojave Basin			Lower Mojave Basin		
	Precipitation	Ground water	Total	Precipitation	Ground water	Total	Precipitation	Ground water	Total
1936-37	3,100	20,450	23,550	500	7,300	7,800	750	11,250	12,000
38	2,900	20,850	23,750	600	7,300	7,900	800	11,200	12,000
39	2,500	21,500	24,000	750	7,200	7,950	1,100	10,900	12,000
40	2,000	22,200	24,200	600	7,400	8,000	800	11,200	12,000
1940-41	4,750	19,650	24,400	1,200	6,850	8,050	1,700	10,300	12,000
42	1,950	22,650	24,600	850	7,250	8,100	1,250	10,750	12,000
43	3,850	20,950	24,800	650	7,500	8,150	950	11,050	12,000
44	4,000	19,700	23,700	500	7,550	8,050	700	11,050	11,750
45	2,950	21,800	24,750	800	7,650	8,450	1,100	11,100	12,200
1945-46	1,750	23,350	25,100	200	8,550	8,750	250	12,300	12,550
47	2,050	23,100	25,150	100	8,500	8,600	150	12,100	12,250
48	1,750	22,600	24,350	150	8,050	8,200	150	11,500	11,650
49	2,850	21,500	24,350	500	7,400	7,900	700	10,450	11,150
50	1,000	24,100	25,100	300	7,850	8,150	400	11,250	11,650
1950-51	1,500	23,950	25,450	150	8,000	8,150	150	11,450	11,600
52	3,650	20,750	24,400	350	7,400	7,750	1,200	9,850	11,050
53	1,900	22,600	24,500	350	7,300	7,650	450	10,500	10,950
54	2,050	22,750	24,800	500	7,150	7,650	700	10,300	11,000
55	3,800	20,250	24,050	550	6,750	7,300	800	9,700	10,500
1955-56	1,700	22,750	24,450	450	6,800	7,250	650	9,800	10,450
57	1,700	23,200	24,900	150	7,000	7,150	200	10,100	10,300
58	3,000	21,250	24,250	900	6,100	7,000	1,300	8,800	10,100
59	1,000	23,950	24,950	200	6,850	7,050	250	9,950	10,200
60	1,400	23,500	24,900	350	6,550	6,900	500	9,450	9,950
1960-61	1,200	23,150	24,350	50	6,700	6,750	100	9,600	9,700
25-year average	2,412	22,100	24,512	468	7,318	7,786	684	10,636	11,320

Estimated (1961 land use conditions):	Precipitation	Ground water	Total
Caves Basin	negligible	1,150	1,150 acre-feet

TABLE 25

ESTIMATED WATER USE AND DISPOSAL DURING THE BASE PERIOD

In acre-feet

Water year	Upper Mojave Basin				Middle Mojave Basin					Lower Mojave Basin				Lucerne Basin		
	Surface outflow	Subsurface outflow[a]	Consumptive use	Total	Surface outflow	Subsurface outflow[a]	Exported water	Consumptive use	Total	Surface outflow	Subsurface outflow[a]	Consumptive use	Total	Subsurface outflow[a]	Consumptive use	Total
1936-37	125,200	2,000	35,250	162,450	103,900	3,000	800	13,850	121,550	54,950	2,000	13,650	70,600	100	1,050	1,150
38	159,150	2,000	35,350	196,500	138,100	3,000	800	13,950	155,850	109,050	2,000	13,650	124,700	100	1,050	1,150
39	17,250	2,000	35,650	54,900	550	3,000	800	13,950	18,300	1,050	2,000	13,650	16,700	100	1,050	1,150
40	15,350	2,000	36,100	53,450	0	3,000	800	14,150	17,950	1,050	2,000	13,750	16,800	100	1,100	1,200
1940-41	118,950	2,000	36,800	157,750	96,000	3,000	800	14,450	114,250	50,550	2,000	13,800	66,350	100	1,050	1,150
42	13,700	2,000	37,550	53,250	100	3,000	800	14,650	18,550	1,050	2,000	13,900	16,950	100	1,050	1,150
43	104,700	2,000	38,050	144,750	91,000	3,000	800	15,000	109,800	48,050	2,000	14,000	64,050	100	1,050	1,150
44	60,300	2,000	37,450	99,750	36,250	3,000	800	15,100	55,150	8,800	2,000	13,850	24,650	100	1,050	1,150
45	39,500	2,000	39,200	80,700	22,100	3,000	800	15,900	41,800	5,650	2,000	14,450	22,100	100	1,150	[illegible]
1945-46	29,350	2,000	40,350	71,700	12,550	3,000	800	16,550	32,900	3,600	2,000	14,950	20,550	100	1,050	1,150
47	17,150	2,000	43,100	[illegible]	2,900	3,000	800	18,450	25,150	1,950	2,000	16,200	20,150	100	2,150	2,250
48	10,550	2,000	43,950	56,500	0	3,000	800	19,800	23,600	1,050	2,000	17,250	20,300	100	3,250	3,350
49	8,350	2,000	45,450	55,800	0	3,000	800	21,300	25,100	1,050	2,000	18,400	21,450	100	4,300	4,400
50	7,650	2,000	48,050	57,700	0	3,000	800	23,200	27,000	1,050	2,000	20,550	23,600	100	5,550	5,650
1950-51	7,200	2,000	50,050	59,250	0	3,000	800	24,950	28,750	1,050	2,000	22,050	25,100	100	6,450	6,550
52	35,200	2,000	50,700	87,900	12,550	3,000	800	24,450	40,800	3,600	2,000	23,150	28,750	100	8,550	8,650
53	7,850	2,000	50,200	60,050	0	3,000	800	24,350	28,150	1,000	2,000	22,650	25,650	100	7,850	7,950
54	13,500	2,000	49,900	65,400	0	3,000	800	24,200	28,000	950	2,000	21,750	24,700	100	7,900	8,000
55	8,150	2,000	50,100	60,250	0	3,000	800	23,850	27,650	900	2,000	20,200	23,100	100	8,100	8,200
1955-56	7,750	2,000	50,250	60,000	0	3,000	800	23,700	27,500	900	2,000	19,150	22,050	100	8,200	8,300
57	7,100	2,000	50,300	59,400	0	3,000	800	23,300	27,100	750	2,000	17,900	20,650	100	8,550	8,650
58	54,150	2,000	49,800	105,950	20,050	3,000	800	24,000	47,850	4,900	2,000	18,150	25,050	100	8,500	8,600
59	6,800	2,000	50,950	59,750	0	3,000	800	24,950	28,750	600	2,000	19,050	21,650	100	8,350	8,450
60	6,350	2,000	50,650	59,000	0	3,000	800	24,250	28,050	700	2,000	19,700	22,400	100	8,150	8,250
1960-61	6,300	2,000	50,400	58,700	0	3,000	800	24,800	28,600	650	2,000	20,600	23,250	100	8,000	8,100
25-year average	35,500	2,000	44,224	81,724	21,442	3,000	800	19,884	45,126	12,196	2,000	17,456	31,652	100	4,540	4,640

a. Estimated average annual outflow.

Estimated total use and disposal:
Harper Basin 1,800 acre-feet -- 1961 land use conditions.
Coyote Basin 1,600 acre-feet -- 1961 land use conditions.
Caves Basin 13,150 acre-feet (3,550 acre-feet -- 1961 land use conditions and 9,600 acre-feet, estimated average annual surface outflow at Afton)

Water Supply Surplus or Deficiency

A balance must exist between the sum of water entering and leaving the water-bearing portion of the study area and change in storage within that portion. A quantitative statement of this balance for any increment of time is provided by the equation of hydrologic equilibrium which, expressed in its general form, is:

Inflow-Outflow = ± Change in Storage.

In this report, the water-bearing area, from the base of the alluvium to and including the ground surface, is considered as the free body, as shown in Figure 6, and the equation of hydrologic equilibrium is expressed as:

Water Supply - Water Use and Disposal =
Water Supply Surplus or Deficiency.

Based on the water year as the increment of time, the annual water supply surplus or deficiency for each year of the 25-year base period was determined, using this equation.

In each of the four main basins, Upper Mojave, Middle Mojave, Lower Mojave, and Lucerne Basins, the total water supply during the base period was less than the total water use and disposal. In each basin, this resulted in a water supply deficiency which was met by using ground water in storage.

The amount of annual water supply, annual water use and disposal, and the resulting annual and accumulated deficiency during the base period for each basin is presented in Table 26. The accumulated deficiencies -- 179,950 acre-feet, 129,500 acre-feet, 133,450 acre-feet, and 72,400 acre-feet for the Upper Mojave, Middle Mojave, Lower Mojave, and Lucerne Basins -- represent the reduction in ground water in storage during the base period in each of these basins. The total water supply, use and disposal, and deficiency is shown in the following tabulation:

Basin	In acre-feet		
	Water Supply	Water Use and Disposal	Deficiency
Upper Mojave Basin	1,863,150	2,043,100	179,950
Middle Mojave Basin	998,650	1,128,150	129,500
Lower Mojave Basin	657,850	791,300	133,450
Lucerne Basin	43,600	116,000	72,400
Totals	3,563,250	4,078,550	515,300

Due to lack of complete data, it is not possible to compute comparable water supply, use and disposal amounts for the other three basins -- Harper, Coyote, and Caves. However, it is apparent from the limited information available that a water deficiency also existed in these basins during the base period, and that future development of these areas will require supplemental water.

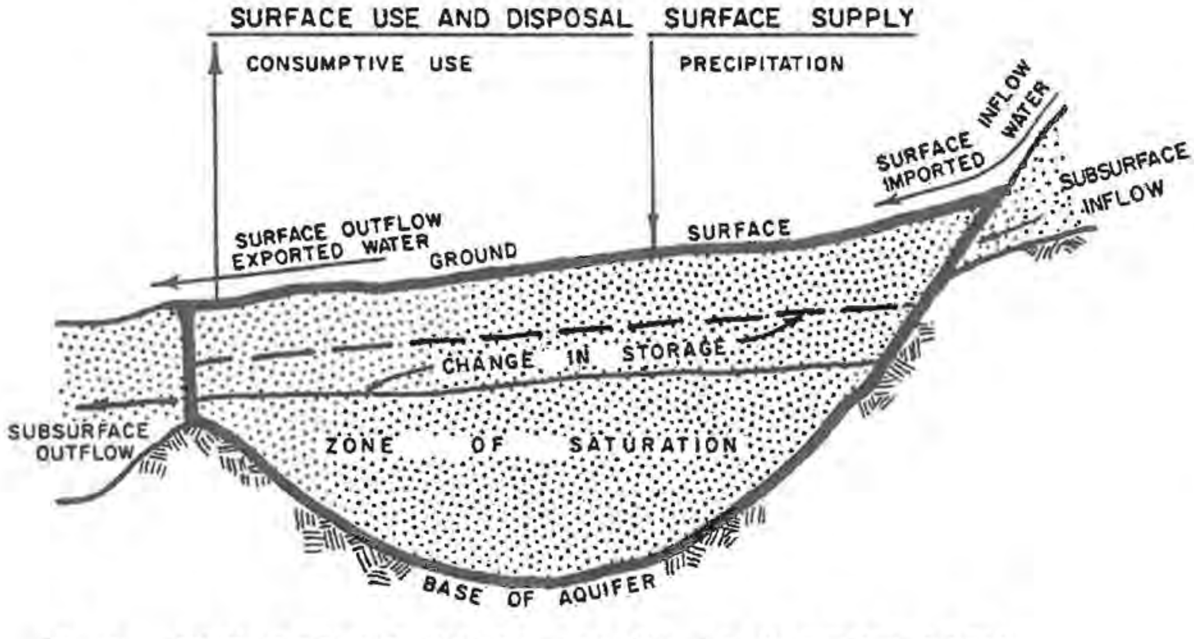

Fig. 6. THE GROUND WATER BASIN AS A FREE BODY

TABLE 26

ESTIMATED WATER SUPPLY, USE AND DISPOSAL, AND WATER SUPPLY SURPLUS OR DEFICIENCY DURING THE BASE PERIOD

In acre-feet

Water year	Upper Mojave Basin				Middle Mojave Basin				Lower Mojave Basin				Lucerne Basin			
	Water supply	Water use and disposal	Surplus or deficiency: Annual	Surplus or deficiency: Accumulated	Water supply	Water use and disposal	Surplus or deficiency: Annual	Surplus or deficiency: Accumulated	Water supply	Water use and disposal	Surplus or deficiency: Annual	Surplus or deficiency: Accumulated	Water supply	Water use and disposal	Surplus or deficiency: Annual	Surplus or deficiency: Accumulated
1936-37	183,300	162,450	20,850	20,850	129,000	121,550	7,450	7,450	108,400	70,600	37,800	37,800	1,200	1,150	50	50
38	232,100	196,500	35,600	56,450	163,050	155,850	7,200	14,650	142,650	124,700	17,950	55,750	1,200	1,150	50	100
39	48,550	54,900	- 6,350	50,100	21,300	18,300	3,000	17,650	5,400	16,700	-11,300	44,450	1,200	1,150	50	150
40	38,250	53,450	-15,200	34,900	19,250	17,950	1,300	18,950	4,550	16,800	-12,250	32,200	1,200	1,200		150
1940-41	203,600	157,750	45,850	80,750	123,500	114,250	9,250	28,200	101,450	66,350	35,100	67,300	1,200	1,150	50	200
42	33,250	53,250	-20,000	60,750	17,900	18,550	- 650	27,550	5,100	16,950	-11,850	55,450	1,200	1,150	50	250
43	167,100	144,750	22,350	83,100	108,750	109,800	- 1,050	26,500	95,700	64,050	31,650	87,100	1,200	1,150	50	300
44	128,250	99,750	28,500	111,600	64,200	55,150	9,050	35,550	40,700	24,650	16,050	103,150	1,200	1,150	50	350
45	81,000	80,700	300	111,900	43,750	41,800	1,950	37,500	27,000	22,100	4,900	108,050	1,200	1,250	- 50	300
1945-46	62,150	71,700	- 9,550	102,350	33,050	32,900	150	37,650	16,600	20,550	- 3,950	104,100	1,200	1,150	50	350
47	59,000	62,250	- 3,250	99,100	20,950	25,150	- 4,200	33,450	7,000	20,150	-13,150	90,950	1,400	2,250	- 850	- 500
48	24,350	56,500	-32,150	66,950	14,600	23,600	- 9,000	24,450	4,300	20,300	-16,000	74,950	1,600	3,350	-1,750	- 2,250
49	35,350	55,800	-20,450	46,500	12,950	25,100	-12,150	12,300	5,050	21,450	-16,400	58,550	1,750	4,400	-2,650	- 4,900
50	23,000	57,700	-34,700	11,800	12,250	27,000	-14,750	- 2,450	4,900	23,600	-18,700	39,850	1,900	5,650	-3,750	- 8,650
1950-51	12,300	59,250	-46,950	- 35,150	11,850	28,750	-16,900	- 19,350	4,850	25,100	-20,250	19,600	2,050	6,550	-4,500	-13,150
52	126,400	87,900	38,500	3,350	40,050	40,800	- 750	- 20,100	18,600	28,750	-10,150	9,450	2,250	7,650	-5,400	-18,550
53	21,600	60,050	-38,450	- 35,100	12,700	28,150	-15,450	- 35,550	5,250	25,650	-20,400	- 10,950	2,300	7,950	-5,650	-24,200
54	68,200	65,400	2,800	- 32,300	18,450	28,000	- 9,550	- 45,100	5,400	24,700	-19,300	- 30,250	2,300	8,000	-5,700	-29,900
55	31,400	60,250	-28,850	- 61,150	13,150	27,650	-14,500	- 59,600	5,350	23,100	-17,750	- 48,000	2,300	8,200	-5,900	-35,800
1955-56	27,150	60,000	-32,850	- 94,000	12,650	27,500	-14,850	- 74,450	5,100	22,050	-16,950	- 64,950	2,350	8,300	-5,950	-41,750
57	31,800	59,400	-27,600	-121,600	11,650	27,100	-15,450	- 89,900	4,500	20,650	-16,150	- 81,100	2,350	8,650	-6,300	-48,050
58	168,700	105,950	62,750	- 58,850	59,550	47,850	11,700	- 78,200	25,700	25,050	650	- 80,450	2,300	8,600	-6,300	-54,350
59	28,200	59,750	-31,550	- 90,400	11,600	28,750	-17,150	- 95,350	4,650	21,650	-17,000	- 97,450	2,300	8,450	-6,150	-60,500
60	16,300	59,000	-42,700	-133,100	11,400	28,050	-16,650	-112,000	5,000	22,400	-17,400	-114,850	2,250	8,250	-6,000	-66,500
1960-61	11,850	58,700	-46,850	-179,950	11,100	28,600	-17,500	-129,500	4,650	23,250	-18,600	-133,450	2,200	8,100	-5,900	-72,400
25-year average	74,526	81,724			39,946	45,126			26,314	31,652			1,744	4,640		

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CHAPTER IV. WATER QUALITY

Surface and ground waters contain dissolved minerals that vary in amount and composition. Surface water character is primarily dependent upon mineral composition of rocks within the upper source areas of a stream. As the stream proceeds to lower levels, the basic water character continues to be influenced by mineral characteristics of materials through which it flows and by secondary contributions of other water types from tributaries and rising ground water.

Concentrations of mineral constituents in ground water are influenced primarily by the quality and quantity of water which percolates to the ground water basin. The sources of this replenishment by percolation include surface flow, precipitation, sewage and industrial waste waters, and irrigation waters. Ground water quality is also influenced by the lithologic type and relative age of water-bearing materials; the hydrologic and geologic conditions that govern rates of ground water movement; well construction and destruction techniques; the season of the year; changes in water level elevations; and duration and rate of pumping prior to sampling of the ground water.

Regional and local correlation of the quality of extracted ground water is, therefore, dependent on the knowledge of geology, hydrology, well drilling practices, duration, and rates of ground water extractions and drawdowns, and water use. Such information is vital to the identification and comprehension of factors that produce water of dissimilar qualities from closely spaced wells, or water of similar quality from wells in widely separated regions within the study area.

In the vast and remote Mojave region, however, collection of adequate data is a major problem. Wells are scarce--in some areas, nonexistent. There are few records of well construction or water production rates; for this reason, interpretation of conditions which produce waters of varying qualitites in the area can only be based on approximations.

From such records as are available, it is apparent that there is a wide variation in the mineral character and quality of ground water within the individual basins of the Mojave study area. The existence of marked differences of water quality in certain basins necessitated the grouping of individual water types into broader more general categories to facilitate description and discussion. This procedure resulted in the identification of some relatively consistent and distinct ground water quality characteristics within each basin. Moreover, these characteristics made it possible to identify those basin areas that were influenced by flows from the Mojave River and to locate restrictions to ground water movement.

As a general guide on the acceptability and use of various water supplies in the Mojave River region, water quality criteria are presented in Appendix D.

Sampling and Analyses

A regular water quality monitoring program in the area of investigation has been conducted by the Department since 1952 in cooperation with the San Bernardino County Flood Control District. Additional samples were taken during this investigation to confirm previous data. Samples

TABLE 27

MINERAL ANALYSES OF REPRESENTATIVE SURFACE WATERS

Constituent	Heath Canyon-tributary to Sheep Creek Sec.9 T3N/R7W		Mojave River: West Fork (floodflow) Sec.32 T3N/R4W		The Forks Sec.18 T3N/R3W		Victorville Sec.29 T6N/R4W		Helendale Sec.31 T8N/R4W		Barstow (floodflow) Sec.31 T10N/R1W		Barstow Sec.31 T10N/R1W		Harvard Crossing (floodflow) Sec.34 T10N/R3E		Afton Canyon Sec.18 T11N/R6E	
	epm[a]	ppm[b]	epm	ppm	epm	ppm	epm	ppm	epm	ppm	epm	ppm	epm	ppm	epm	ppm	epm	ppm
Ca	2.37	47	1.00	20	1.05	21	2.15	43	2.30	46	1.24	25	1.63	33	2.19	44	1.20	24
Mg	0.47	6.0	0.41	5	0.33	4	0.75	9	0.74	9	0.44	5	0.34	4	0.77	9	0.30	4
Na	0.15	3.0	0.39	9	1.22	28	1.83	42	2.39	55	0.64	15	2.93	68	4.26	98	12.65	291
K	0.16	6.4	0.08	3	0.05	2	0.08	3	0.118	4.6	0.046	1.9	0.25	9.6	0.02	0.8	0.26	10.2
CO_3	0	0	0	0	0	0	0	0	0.32	10	0	0	0	0	0	0	0.80	24
HCO_3	1.45	88	1.19	73	1.69	103	3.18	194	3.24	198	1.30	79	3.48	212	4.59	280	6.60	403
Cl	0	0	0.17	6	0.37	13	0.79	28	0.87	31	0.28	10	0.73	26	1.30	46	4.65	165
SO_4	1.68	81	0.32	15	0.55	26	0.83	40	1.02	49	0.70	33.6	0.94	45	1.42	68	2.55	122
NO_3	0	0	0.13	8	0.02	1	0.05	3	0.029	1.8	0.03	1.63	0.04	1.54	0.032	2.0	0.09	5.6
F	0.02	0.4	0.02	0.4	0.09	1.8	0.03	0.6	0.041	0.78			0.021	0.40		0.16	0.04	0.8
Boron		0		0.07						0.145		0.20		0.40				1.12
Silica		4.0										26		5				64
TDS[c] by Evaporation	262		132		171		283		310		139		293		455		916	
Percent Na	48		21		46		38		43		27		57		59		88	
Total hardness	142		71		68		145		153		84		99		148		75	
Sampled by[d]	DWR		DWR		DWR		DWR		SBCFCD		DWR		DWR		SBCFCD		DWR	
Date sampled	3/28/63		4/2/65		2/5/65		2/5/65		2/4/64		4/4/58		8/28/58		3/27/58		10/25/61	
Discharge (cfs)	3		135		18		31				1500		40				1.5	
Temperature	45° F.		46° F.		50° F.		51° F.				50° F.						57° F.	
pH	7.5		7.2		7.6		8.0		8.1		7.6		7.1		7.6		8.5	
$EC \times 10^6$	320		194		272		476		493		216		484		700		1520	

a. Chemical equivalents per million.
b. Parts per million by weight.
c. Total dissolved solids.
d. SBCFCD-San Bernardino County Flood Control District; DWR-Department of Water Resources

were also drawn from wells in areas not previously covered by the monitoring program. Another major source of water quality data was information compiled by the United States Geological Survey, and published by the Department of Water Resources in the Bulletin 91 series. In addition, useful information was obtained from the Department's Bulletin No. 106-1, "Ground Water, Occurrence and Quality, Lahontan Region", June 1964.

Representative analyses of surface water within the individual basins are presented in Table 27. Ground water analyses are presented in Table 28.

Mineral Character and Quality of Surface and Ground Water

The mineral character and quality of water in the study area depends upon the geologic composition of the study area, the movement and occurrence of surface and ground waters, and the use of these waters. Surface and ground waters exhibit several distinct types of mineral character and ranges of total dissolved solids.

Surface Water

Available mineral analyses depicting surface water character and quality within the study area are primarily confined to the flows of the Mojave River, the main source of water supply to the region. Average of all data shows that storm flow of the Mojave River is primarily calcium bicarbonate in character and has less than

TABLE 28

MINERAL ANALYSES OF REPRESENTATIVE GROUND WATERS FROM WELLS

Constituent	Lucerne Basin						Upper Mojave Basin						Middle Mojave Basin					
	South of Lucerne Lake 4N,1W-1P		Lucerne Valley 5N/1W-29R2		Near Fifteenmile Valley 4N/2W-20K1		Near Apple Valley 4N/3W-23D1		Apple Valley 5N/3W-33R1		Near Adelanto 6N/5W-9B1		Stoddard Valley 7N/1W-9E1		Near Helendale 8N/4W-30E1		Hinkley Valley 10N/3W-23H4	
	epm[a]	ppm[b]	epm	ppm	epm	ppm	epm	ppm	epm	ppm	epm	ppm	epm	ppm	epm	ppm	epm	ppm
Ca	3.52	70	2.77	55	2.40	48	6.14	123	2.54	51	0.41	8.2	1.59	32	4.20	84	0.66	13
Mg	4.82	59	1.22	15	1.34	16	1.00	12	1.24	15	0.18	2.2	0.59	7.2	0.52	6.3	0.06	0.7
Na	2.05	47	27.43	631	1.87	43	8.44	194	2.83	65	5.00	115	1.95	45	10.43	240	5.20	120
K	0.06	2.3	0.10	4.0	0.06	2.5	0.14	5.4	0.06	2.4	0.02	0.8	0.05	1.9	0.09	3.5	0.03	1.3
CO_3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HCO_3	2.50	152	3.20	195	2.36	144	0.66	40	2.35	143	2.83	173	2.28	139	2.81	172	4.50	274
SO_4	4.73	227	11.60	557	1.87	90	13.93	668	2.82	135	2.36	113	0.86	41	4.85	233	0.71	34
Cl	3.01	106	16.00	567	1.16	41	1.18	42	1.32	47	0.19	6.8	0.77	27	7.57	269	0.70	25
NO_3	0.39	24	0.16	10	0.06	3.8	0.02	1.2	0.06	3.6	0.02	1.3	0.12	7.3	0.01	0.5	0.02	1.4
F	0.01	0.2	0.20	4.0	0.13	2.4	0.17	3.3	0.04	0.8	0.06	1.2	0.06	1.2	0.02	0.4	0.08	1.6
Boron		0.08		1.2		0.09		1.90		0.46		0.27		0.20		0.52		1.62
Silica		18		32		31		30		23		15		24		24		25
TDS[c] by Evaporation	732		1,934		305		1,105		412		342		252		924		346	
Percent Na	20		87		33		54		42		89		47		69		88	
Total hardness	417		200		187		357		189		30		109		236		36	
Sampled by[d]	DWR		DWR		DWR		DWR		DWR		DWR		DWR		DWR		DWR	
Date sampled	8/23/63		7/17/63		6/13/63		6/14/63		3/28/63		1/10/64		4/27/64		1/22/64		1/8/64	
Temperature	68° F.										68° F.				74° F.		68° F.	
pH	7.6		7.6		7.8		8.1		7.9		7.9		8.0		7.6		8.2	
EC x 10^6	990		3,000		557		1,529		650		550		400		1,460		570	

a. Chemical equivalents per million.
b. Parts per million by weight.
c. Total dissolved solids.
d. DWR-Department of Water Resources.

MINERAL ANALYSES OF REPRESENTATIVE GROUND WATERS FROM WELLS
(continued)

Constituent	Harper Basin						Lower Mojave Basin						Coyote Basin near Coyote Lake 12N/2E-32G1		Caves Basin near Harvard 10N/3E-14J1	
	South of Harper Lake 11N/4W-33G1		Northwest of Harper Lake 32S/43E-28K1		Near Lockhart 11N/4W-30N2		West of Yermo 10N/1E-33P1		Near Toomey 10N/2E-25P1		South of Troy Lake 8N/4E-7E1					
	epm[a]	ppm[b]	epm	ppm	epm	ppm	epm	ppm	epm	ppm	epm	ppm	epm	ppm	epm	ppm
Ca	1.30	26	1.70	34	3.49	70	1.75	35	1.13	23	0.49	9.9	1.88	38	2.62	52
Mg	0.20	2	0.60	7	0.83	10	0.43	5	0.80	10	0.53	6.4	0.46	5.6	0.68	9
Na	10.70	246	8.75	201	15.60	359	2.97	68	3.17	73	5.35	123	10.65	245	3.60	83
K	0.12	5	0.13	5	0.20	8	0.06	2	0.03	1	0.11	4.4	0.06	2.5	0.03	1
CO_3	0	0	0	0	0	0	0	0	0.32	10	0.40	12	0	0	0	0
HCO_3	2.45	211	1.15	70	3.36	205	2.48	151	2.92	178	3.15	192	1.86	114	2.44	148
SO_4	3.74	180	6.89	331	5.60	269	1.19	57	0.97	46	1.19	57	5.47	262	1.57	75
Cl	6.00	213	3.00	106	10.69	379	1.41	50	0.90	32	1.35	48	5.73	203	2.71	96
NO_3	0.18	11	0.09	5.6	0.06	4	0.02	1	0	0	0.01	0.7	0	0	0.03	2
F	0.043	0.8	0.060	1.1		1.8	0.03	0.5	0.01	0.2	0.10	1.90	0.10	2.0	0.03	0.6
Boron		0.32		1.73				1.4		0.29		1.0		0.82		0.46
Silica		60		24										28		
TDS[c] by Evaporation	804		763		1,221		301		296		426		848		402	
Percent Na	87		79		78		57		62		82.6		82		52	
Total hardness	75		115		216		109		96		51		117		165	
Sampled by[d]	DWR		DWR		DWR		DWR		DWR		SBCFCD		DWR		DWR	
Date sampled	7/25/61		7/25/61		4/7/65		4/6/65		6/24/64		4/22/64		4/29/64		6/24/64	
Temperature	78° F.		78° F.										67° F.		78° F.	
pH	7.7		8.0		7.7		8.0		8.5		8.3		8.0		7.9	
EC x 10^6	1,315		1,205		2,076		533		475		61.35		1,220		670	

a. Chemical equivalents per million.
b. Parts per million by weight.
c. Total dissolved solids
d. DWR-Department of Water Resources; SBCFCD-San Bernardino County Flood Control District.

400 parts per million (ppm) total dissolved solids (TDS) before it percolates into the ground water basins of the region. Mineral analyses of samples of ground water rising to the stream channel at Victorville indicate that the rising water is higher in TDS, about 300 ppm, and has a larger percent of sodium than its source of replenishment, the storm flow of the Mojave River. At Afton, where rising water maintains a perennial stream, the water character is primarily sodium bicarbonate-chloride and is significantly poorer in quality than the rising water at Victorville. At Afton, the total dissolved solids were about 900 ppm in 1962.

Ground Water

The classification of ground water quality is based upon water samples obtained from pumped wells. For study purposes, the quality of ground water in the study area was grouped into four broad, general water types. The first type is generally relatively low in total dissolved solids, with calcium, sodium, or a combination of the two being the major dissolved cation, and bicarbonate the major dissolved anion constituent. A second general type contains a relatively high total dissolved solids content that is either sodium, calcium sulfate, or sodium or calcium sulfate-chloride in character. A third distinct type is high in total dissolved solids and is either sodium chloride or sodium-calcium chloride in character. A fourth general type has a relatively high total dissolved solid content and consists of a mixture of bicarbonate-sulfate water or bicarbonate-chloride water with either sodium, calcium, or a combination of both as the predominant cation.

For illustrative purposes, and for more detail, 13 distinct ground water types have been identified and are shown on Plate 6, "Water Quality Conditions". These are the results of selective data reduction and condensation of the wide range of water type variations which are present in the study area. Each of these 13 types, however, falls into at least one of the four broad categories previously outlined, which are discussed in detail in the following paragraphs:

Bicarbonate Ground Water. Ground water within the area influenced by surface waters of the Mojave River is predominantly bicarbonate in character, with the dominant cations being either sodium, calcium, or a mixture of sodium and calcium. The bicarbonate characteristic of the ground water is believed to be derived from runoff from the bordering granitic rocks that occur in the San Bernardino Mountains to the south. Ion exchange within the area influenced by percolating stream waters is indicated by the change from a predominantly calcium bicarbonate character in the Upper Mojave Basin to a predominantly sodium bicarbonate character downstream in the Middle and Lower Mojave Basins. This ion exchange phenomena is believed to occur between water and clay within the water-bearing materials.

A magnesium bicarbonate type water occurs in the southern portion of Lucerne Basin adjacent to the Helendale fault. The magnesium cation is derived principally from dolomitic limestone outcrops that occur in the mountains to the south and from dolomitic limestone detritus that is contained in the sediments.

Mineral analyses indicate that for the study area as a whole, the average total dissolved solids (TDS) content of the bicarbonate type ground water is approximately 300 parts per million (ppm), although the range of TDS is from 90 to 2,000 ppm. Fluoride concentrations found in bicarbonate type ground water throughout the study area are commonly less than 1 ppm; however, a few isolated wells at scattered locations in the Middle Mojave Basin have revealed fluoride concentrations up to 4.0 ppm. Mineral analyses also indicate that the boron content in the area as a whole is commonly less than 1 ppm; however, excessive boron concentrations have been recorded in a few isolated wells, predominately in areas where wells have penetrated older sediments. This penetration allows a mixing between poorer quality water from the older sediments and better quality water from the younger sediments.

Sulfate and Sulfate-Chloride Ground Water. In areas where there is a predominance of older alluvium (particularly older alluvium whose source rocks include the Tertiary sedimentary deposits) or where portions of the ground water basin receive very little recharge and have only a slight amount of ground water movement, ground water typically has a sulfate or sulfate-chloride anion content. The dominant cation is usually sodium, although calcium occurs occasionally as the dominant cation constituent. In addition, where the ground water basins are intersected by or closely related to faults, ground water is dominantly sodium-calcium sulfate in character and usually has a relatively high total dissolved solids concentration. Total dissolved solids content in the area's sulfate or sulfate-chloride type water ranges from 200 to more than 3,000 parts per million (ppm), although it is typically 700 to 1,000 ppm.

Mineral analysis of ground water extracted from one well in the extreme southwest portion of Harper Basin, in a structural wedge southwest of the Lockhart fault and northeast of the Helendale fault, revealed a TDS concentration of nearly 15,000 ppm and a water character of sodium sulfate-chloride. This concentration and water type, together with the proximity to the Helendale fault and the evidence of very little recharge and ground water movement in the immediate area, lend credence to the assumption that ground water in this particular locale is connate water and has probably been virtually static since entrapment. However, this condition could also result from meteoric water that has been concentrated by evaporation. Phenomenon of this sort presumably exists in other areas within the basins; however, the lack of adequate well data renders it impossible to determine the extent and frequency of the condition.

Analyses also indicate that the concentration of fluoride in the sulfate or sulfate-chloride type ground water ranges from less than 1 part per million to almost 4.0 ppm; the average fluoride content ranges between 1 and 2 ppm. Boron concentrations are typically between 1 and 2 ppm in Upper Mojave and Lucerne Basins; however, the downstream basins contain water that has a boron content that is commonly greater than 2 ppm. In one particular area in Harper Basin, it ranges from 0 up to 35 ppm.

Sodium Chloride Ground Water. The third general ground water type present in the area of investigation contains sodium as the dominant cation and chloride as the dominant anion. Calcium occasionally occurs with sodium in nearly equal concentrations; however, predominance of this condition is limited to the Lower Mojave Basin in an area directly northwest of Troy Dry Lake. Examples of modifications in water type resulting from significant amounts of the sulfate ion are also found in the study area. Such modifications are rare and are prevalent in only one small area of Lucerne Basin.

Sodium chloride type ground water occurs consistently in the study area, being typically present in the fine-grained playa deposits found at lower elevations of the basins and in the older lake deposits. The total dissolved solids content ranges from 380 ppm to more than 5,300 ppm; the average is approximately 1,200 ppm.

Fluoride and boron concentrations are commonly between 1 and 2 ppm. However, in the Middle Mojave Basin, fluoride content frequently ranges from 4 to 8 ppm; boron, from 4.9 to 10 ppm. In the Harper Basin these ranges are: fluoride, 0.5 to 1.6 ppm; and boron, 0.32 to 8.7 ppm.

Ground Water of More Than One Type. Ground water, in which two or more of the four major water types are present, is pumped in some isolated places in the study area. This condition, which has also been observed during investigations of other regions, indicates that ground water quality types may be related to the formations in which they occur, rather than to areal distribution. In the Mojave region, for example, where older alluvium is overlain by channel deposits of the Mojave River, a well penetrating both of these formations would yield a combination of bicarbonate water from the channel deposits and sulfate water from the underlying alluvium. This appears to be one explanation for the combinations of water types that are pumped in some areas.

Total dissolved solids concentrations of these combined water types tend to be moderately high, in the 600 to 900 ppm range, while the fluoride and boron content varies from 0 to 1 ppm from basin to basin. There are very few instances where fluoride and boron reach a high level of concentration in these waters. In the Barstow-Daggett area, however, well log data indicate that some water wells penetrate volcanic material, which is known to contribute significant amounts of boron and increased mineral content to the water.

Changes in Ground Water Character and Quality. It is difficult to trace any distinct trend in ground water character and quality because of the lack of historical data in the major portion of the study area. In general, available data indicate that the character and quality of water in and adjacent to the downstream reaches of the Mojave River have declined. At Afton, the total dissolved solids content has increased from about 650 ppm in 1950 to about 900 ppm in 1962. The mineral character of ground water has also changed in various areas of the basins. In some of these areas, domestic and agricultural uses have increased the total dissolved solids content by 300 to 1,000 ppm. Along the Mojave River, ground water impairment may be attributed to waste waters derived from man's agricultural, urban and suburban, and industrial activities. The natural recycling of these "used" waters to and from the ground water basin reservoir, slowly but continually increases the total dissolved solids concentration, thereby decreasing the water quality. The change in ground water characteristics may also reflect types of water encountered in the various water-bearing formations as the ground water levels throughout the basins declined.

In addition, the sources of water supply are continually adding salts to the basins that far exceed the amounts removed by water disposal. A limited study of the amount of salts added to the water-bearing portion of the study area shows that water supply contributed an average of 21,000 tons of salts during the base period, 1936-37 through 1960-61, and that water disposal by surface outflow removed an average of 3,000 tons of salts. With man's activities in the basins contributing an additional average of 4,000 tons of salt during the base period, an adverse salt balance, or accumulation of salts, at the rate of 22,000 tons per year exists in the basin.

At present, there are only scattered areas in the basin where water quality is a problem because of the undesirable character and high TDS of the water. A more comprehensive study may be needed in the future to provide specific information on the water quality conditions in the Mojave River area.

CHAPTER V. GROUND WATER STORAGE, OVERDRAFT, AND SAFE YIELD

The ground water basins, or water-bearing portions, of the study area contain millions of acre-feet of storage space. These provide for natural regulation of the water supply, use, and disposal. During periods of heavy precipitation, when there is a surplus of water supply, water levels rise and ground water in storage increases. However, in dry periods, the deficiency in water supply is met by extraction and use of ground water, which in time lowers water levels and decreases the amount of ground water in storage.

Ground Water Storage

The ground water in storage in each basin of the study area is many times greater than the average annual water supply to the basin. These natural reservoirs are the primary water resource in the study area. Most of the wells that pump ground water are located along the river and in adjacent valleys where, historically, there has been a readily available supply of ground water. Generally, as the distance from the river increases, the depth at which ground water occurs also increases. Thus, although there are vast amounts of ground water in storage, only limited use has been made of this water resource.

For studies on ground water storage, some of the ground water basins were subdivided into smaller units, on the basis that geologic faults and alluvial constrictions limit the movement of ground water from one portion of the basin to another. These limited areas of the basins are referred to as storage units. These storage units were used in computing the ground water storage capacity and the change in storage for each basin discussed here. The storage units are shown on Figure 7.

Storage Capacity

For the basins in the study area, the storage capacity is defined as the amount of storage space between the ground surface and the 1961 water levels. The ground water in storage is considered to be the amount contained in the zone between the 1961 water levels and the base of the water-bearing materials. Plate 7, "Ground Water Level Contours, 1961", shows the ground water levels at the end of the base period. The most recent water levels for this study are shown on Plate 8, "Ground Water Level Contours, Spring 1964".

Although the base of the water-bearing materials in the study area was not well known, estimates were made, based primarily on well logs that extend to the nonwater-bearing materials, and on gravity surveys conducted by the United States Geological Survey. Materials were considered to be water-bearing if they produced a minimum yield of 50 gallons per minute. This limit was assumed to provide a reasonable estimate of the base of the water-bearing materials, which lie at great depths and are generally considered to be too consolidated to yield water readily. Estimates of the elevation of the base of the water-bearing materials are shown on Plate 4.

The total thickness of the water-bearing materials from the ground surface to the base of these materials ranges from a foot at its contact with nonwater-bearing crystalline rock to over 1,000 feet near Phelan, with an average total thickness of about 300 feet for the

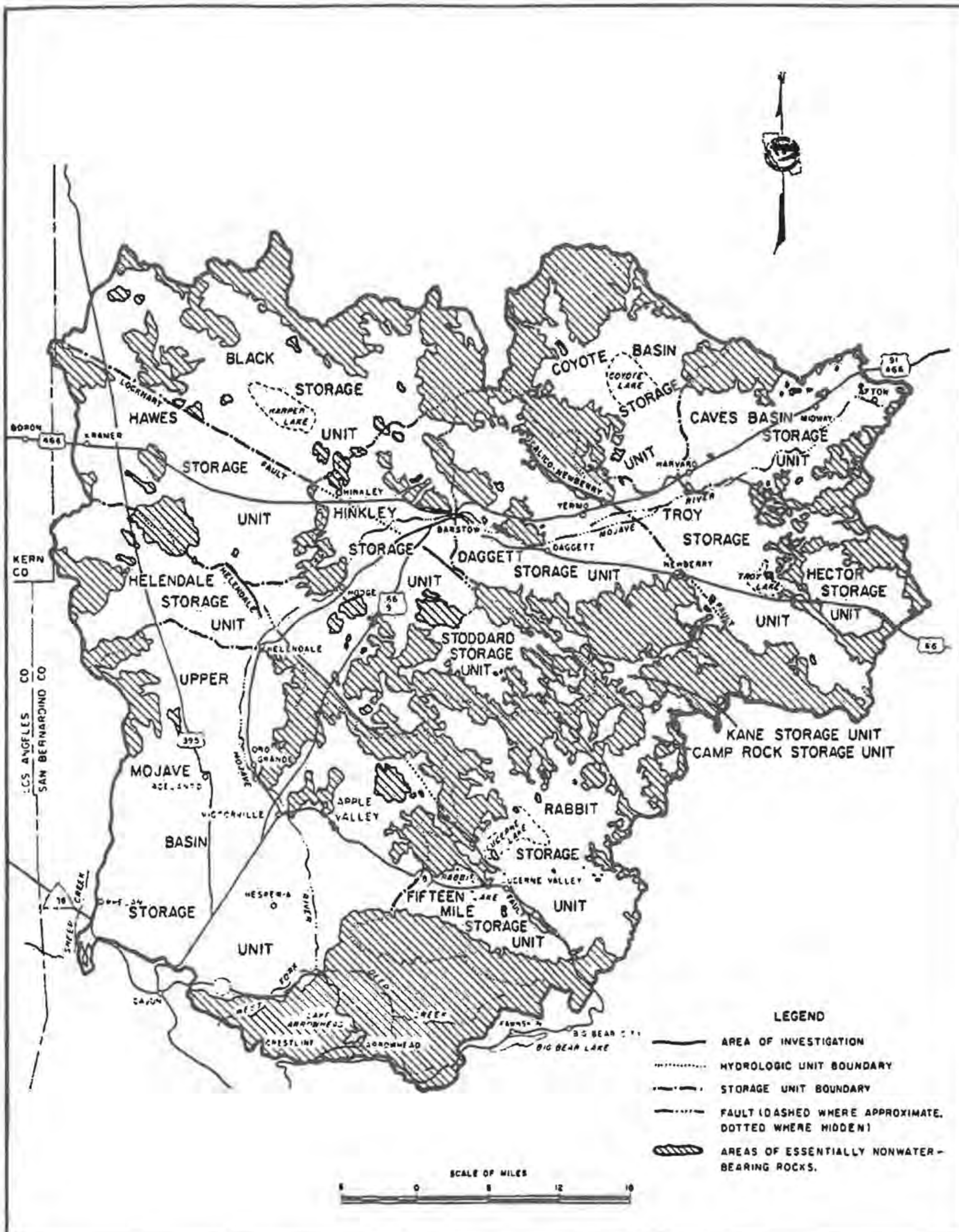

FIGURE 7 - GROUND WATER STORAGE UNITS

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alluviated portion of the study area. Overall, the average saturated thickness, based on the 1961 water levels, is approximately 230 feet. For the portion of the basins that receive surface and/or subsurface inflow from the Mojave River, the average saturated thickness, based on the 1961 water levels, is approximately 275 feet, in an average total thickness of 360 feet. In general, as the distance from the river increases the average saturated thickness becomes smaller in proportion to the total thickness of the water-bearing materials.

To estimate the volume of water stored in the interstices within the water-bearing sediments, the volume of sediments is multiplied by its specific yield value. The specific yield of water-bearing materials is defined as the ratio of the volume of water that saturated materials will yield by gravity drainage over a period of time to the total volume of the saturated materials, prior to draining; it is usually expressed as a percent. Specific yield values of these materials, as described in water well driller's logs, were determined in a cooperative study by the Department and the United States Geologic Survey. Specific yield values and representative driller's terms are presented in Appendix E. These values range from 3 to 35 percent.

The average specific yield from the ground surface to the base of the water-bearing materials varies according to the lithologic composition of the materials, resulting in a wide range (4 to 25 percent) and wide distribution of the average specific yield values in the study area. In those portions of the basins in which surface and/or subsurface inflow from the Mojave River constitutes the most important source of ground water supply, the average specific yield was found to be 14 percent.

The average specific yield for the other areas was estimated to be about 10 percent.

The storage capacity of each basin and storage unit is shown in Table 29. As presented in the table, total storage capacity consists of available storage space and the ground water in storage, in relation to the 1961 water levels.

TABLE 29

ESTIMATED GROUND WATER STORAGE CAPACITY, AVAILABLE STORAGE, AND GROUND WATER IN STORAGE

In acre-feet

Basin	Total storage capacity		Available storage space, above 1961 water levels		Ground water in storage, below 1961 water levels	
Upper Mojave		26,532,000		8,212,000		18,320,000
Middle Mojave						
Helendale storage unit	5,649,000		1,907,000		3,742,000	
Hinkley storage unit	1,792,000		936,000		856,000	
Stoddard storage unit	607,000		174,000		433,000	
		8,048,000		3,017,000		5,031,000
Lower Mojave						
Daggett storage unit	3,919,000		1,465,000		2,454,000	
Troy storage unit	4,035,000		973,000		3,062,000	
Hector storage unit	643,000		575,000		68,000	
Kane storage unit	105,000		53,000		52,000	
		8,702,000		3,066,000		5,636,000
Lucerne						
Fifteen Mile storage unit	1,307,000		792,000		515,000	
Rabbit storage unit	2,861,000		1,463,000		1,398,000	
Camp Rock storage unit	568,000		328,000		240,000	
		4,736,000		2,583,000		2,153,000
TOTAL		48,018,000		16,878,000		31,140,000
Harper						
Black storage unit	3,791,000					
Haves storage unit	3,184,000					
		6,975,000		*		*
Coyote		7,530,000		*		*
Caves		4,152,000		*		*

* Data not available.

Change in Storage

Change in the amount of ground water in storage over a specified period is reflected by the change in ground water levels. One method to compute changes in storage is by use of the equation of hydrologic equilibrium (Inflow-Outflow = $\pm$ change in storage). Storage changes during the base period using this method are shown in Table 26 as water supply surplus or deficiency.

The change in storage during the base period was also determined by use of the Specific Yield Method:

(Specific yield value) x (thickness of saturated water-bearing materials) x (area) = ground water in storage.

The results of this computation substantiate the results obtained by the use of the hydrologic equation. The amounts of surplus and deficiency computed by the Specific Yield Method are shown in Table 30.

TABLE 30

ESTIMATED CHANGE IN AMOUNTS OF GROUND WATER IN STORAGE DURING THE BASE PERIOD

In acre-feet

Basin	Ground water in storage					
	Below 1936 water levels		Below 1961 water levels		Change in 25-years	
Upper Mojave		18,506,000		18,320,000		-186,000
Middle Mojave						
Helendale storage unit	3,772,000		3,742,000		30,000	
Hinkley storage unit	952,000		856,000		96,000	
Stoddard storage unit	433,000	5,157,000	433,000	5,031,000	0	-126,000
Lower Mojave						
Daggett storage unit	2,522,000		2,454,000		68,000	
Troy storage unit	3,124,000		3,062,000		62,000	
Hector storage unit	68,000		68,000		0	
Kane storage unit	52,000	5,766,000	52,000	5,636,000	0	-130,000
Lucerne						
Fifteen Mile storage unit	516,000		515,000		1,000	
Rabbit storage unit	1,477,000		1,398,000		79,000	
Camp Rock storage unit	240,000	2,233,000	240,000	2,153,000	0	- 80,000

When the annual amounts of water supply surplus or deficiency from Table 26 are accumulated and plotted, as shown on Figure 8, "Cumulative Water Supply Surplus or Deficiency", the general trend corresponds to the hydrographs of the wells numbers 4N/3W-18E1, 10N/2W-19P1, and 9N/1E-13E2 shown on Figure 9, "Hydrographs of Ground Water at Representative Wells". These wells are in areas where substantial changes in storage have occurred. Figure 9 also shows hydrographs of wells in outlying areas, where a smaller reduction in storage occurred during the base period.

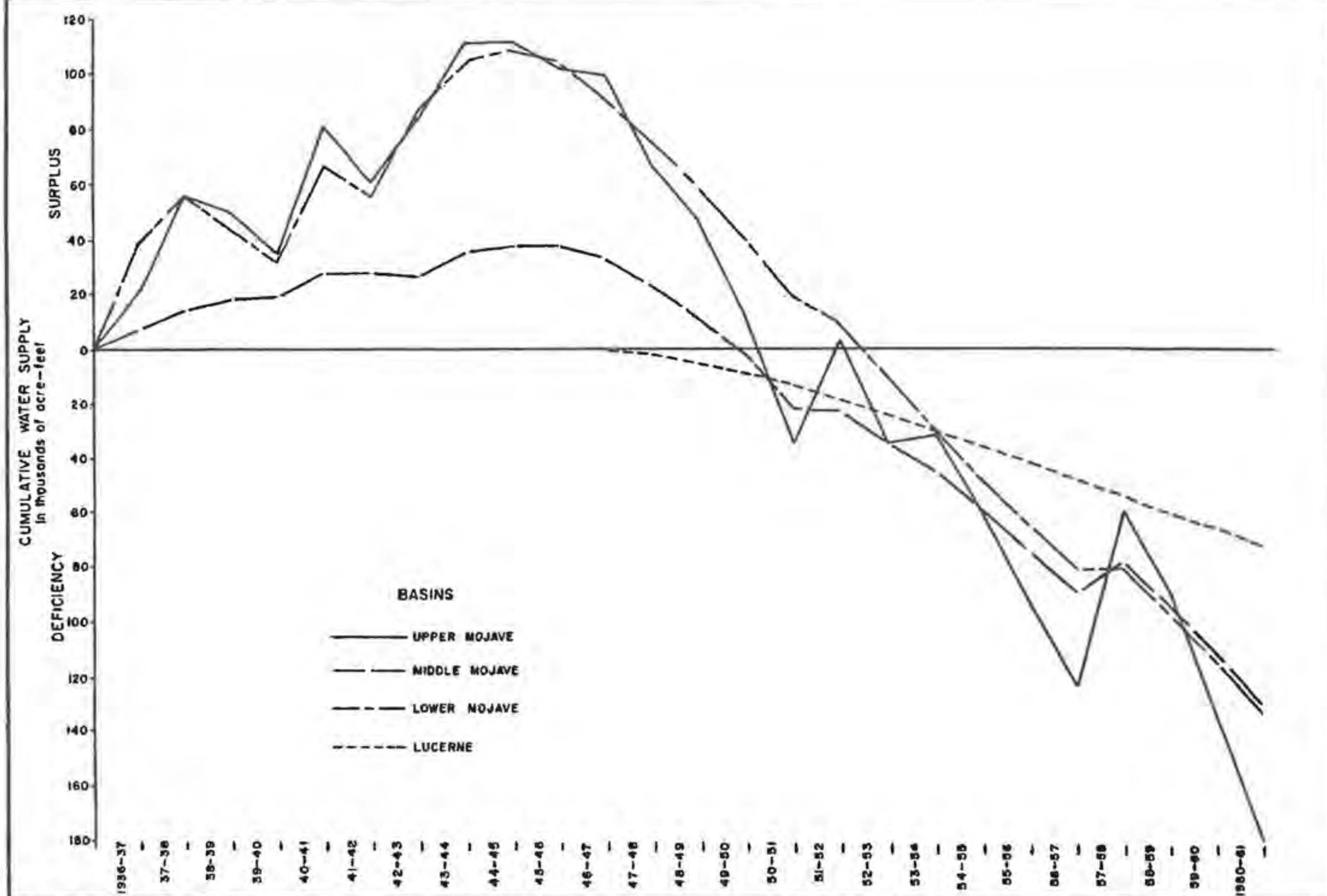

Fig. 8. CUMULATIVE WATER SUPPLY SURPLUS OR DEFICIENCY

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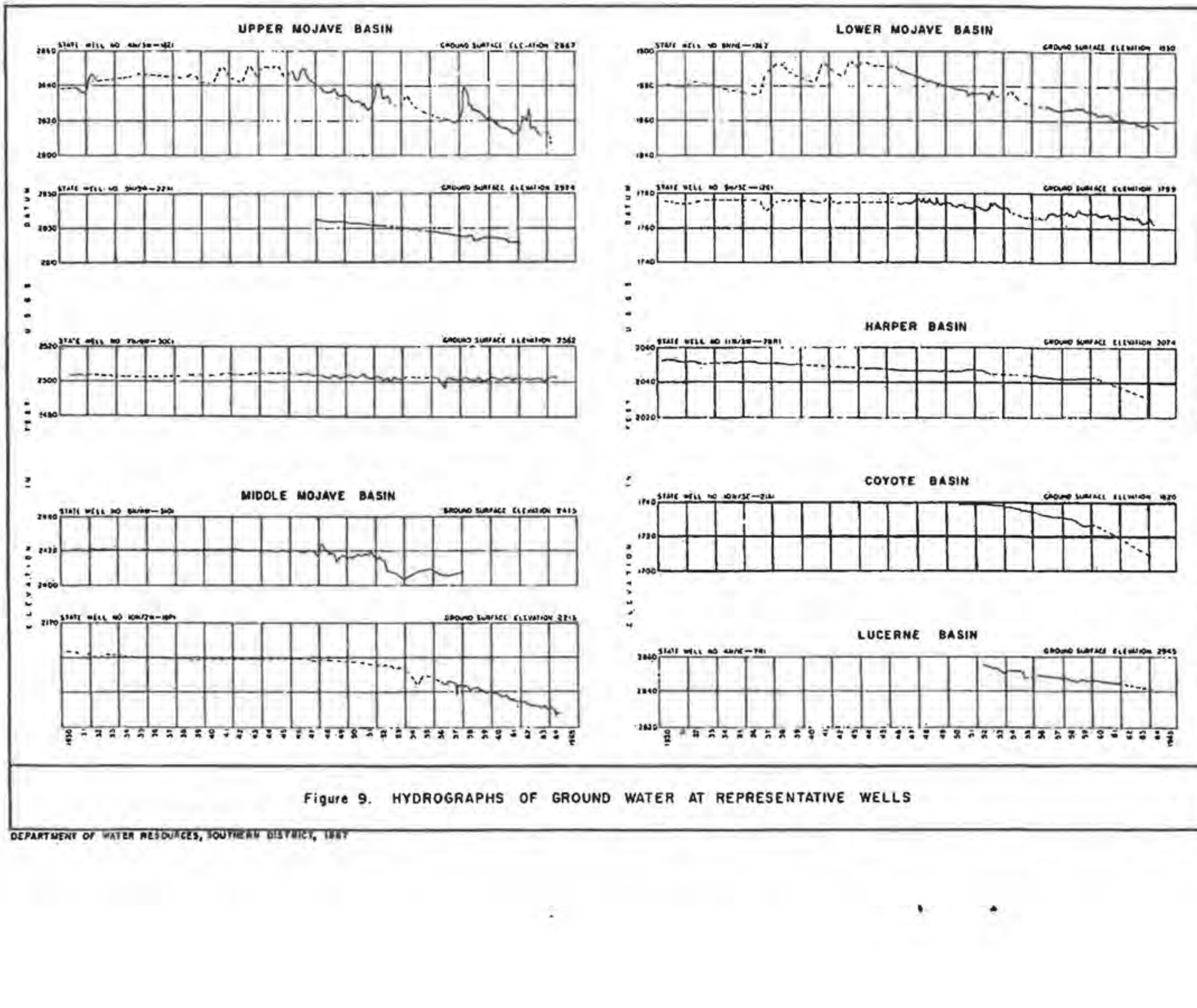

Figure 9. HYDROGRAPHS OF GROUND WATER AT REPRESENTATIVE WELLS

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Comparison of the two figures shows that, in general, water levels in the study area increased from 1936-37 to about 1945, but decreased from 1945 to 1961, the end of the study base period. This trend has continued to 1966. The distribution and amounts of pumping in the basins in 1961 is shown in Table 31.

TABLE 31

PUMPAGE OF GROUND WATER IN 1961*

In acre-feet

Basin	Pumpage	
Upper Mojave		
San Bernardino Mountains to Upper Narrows	33,737	
Upper to Lower Narrows	4,291	
Lower Narrows to Helendale	14,173	
		52,201
Middle Mojave		
Helendale to Hodge	9,111	
Hodge to Barstow	17,264	
		26,375
Lower Mojave		
Barstow to Daggett	4,698	
Daggett to Calico-Newberry fault	9,208	
East of Calico-Newberry fault	5,963	
		19,869
Lucerne		
Southwest of Helendale fault	667	
Northeast of Helendale fault	9,876	
		10,543
TOTAL		108,988

Estimated:	Harper	1
	Coyote	5,601
	Caves	2,861

*The amounts of pumpage were estimated from State Water Rights Board's records. However, currently a detailed verification of pumpage is being made by the Mojave Water Agency. Preliminary figures from this determination indicate the pumpage within the area served by the Agency in 1961 to be on the order to 180,000 acre-feet.

Because, after use, a substantial portion of water extracted from wells returns by deep percolation to the zone of saturation, amounts pumped from wells should not be construed as reduction in ground water sotrage.

Plate 9 depicts the amounts of change in water levels in wells in the study area during the base period, 1936-37 to 1960-61.

Ground Water Overdraft and Safe Yield

In this report, the value assigned to ground water overdraft is equal to the mean annual decrease in the amount of ground water in storage over a longtime period, under a particular set of physical conditions affecting the supply, use, and disposal of water.[1] The value assigned to ground water safe yield is equal to the mean annual amount of ground water that can be pumped from the ground water basin, under the same specific physical conditions, without causing a longtime net change in the amount of ground water in storage.

As was pointed out earlier, the water supply and climatic conditions during the 25-year base period were considered to be equivalent to those conditions during the longtime period.

The set of physical conditions used in the determination of overdraft and safe yield were those that existed in the study area in 1960-61, the last year of the base period. These physical conditions were assumed fixed throughout the base period. In other words, this assumption established the annual amount of water supply, use, and disposal to sustain the 1960-61 physical conditions under mean water supply and climate the entire base period; it also established the places and ways in which the fixed amounts of water supply were applied, used, and disposed.

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[1] See Chapter III for specific items on water supply, use, and disposal.

Ground water overdraft was computed to be the average annual water supply deficiency under actual conditions plus the difference between the average annual consumptive use during the base period and the mean annual consumptive use under 1960-61 physical conditions. This is true because the mean annual amounts of water supply, use, and disposal were found to be the same as the average amounts of the corresponding hydrologic items, except the amount of consumptive use which increased significantly.

The values of ground water basin overdraft for each of the four major basins are derived in Table 32.

TABLE 32

ESTIMATED ANNUAL OVERDRAFT UNDER
1960-61 LAND USE CONDITIONS AND PUMPAGE

In acre-feet per year

Basin	Average annual water supply deficiency under actual conditions	Consumptive Use: Average annual under actual conditions	Consumptive Use: Mean annual under 1960-61 conditions	Consumptive Use: Increase	Ground water overdraft
Upper Mojave	7,200	44,200	50,400	6,200	13,400
Middle Mojave	5,200	19,900	24,800	4,900	10,100
Lower Mojave	5,350	17,450	20,600	3,150	8,500
Lucerne	2,900	4,550	8,000	3,450	6,350
Totals	20,650	86,100	103,800	17,700	38,350

Estimates of annual safe yield were obtained by subtracting the estimates of annual overdraft from estimates of the annual amounts of ground water pumpage that would have been necessary to sustain the

1960-61 physical conditions under mean water supply and climate over a longtime period. Values of safe yield for the four major basins are presented in Table 33.

TABLE 33

ESTIMATED MEAN ANNUAL SAFE YIELD
UNDER 1960-61 LAND USE CONDITIONS AND PUMPAGE*

In acre-feet per year

Basin	Estimated annual pumpage under 1960-61 conditions	Ground water	
		Overdraft	Safe yield
Upper Mojave	57,000	13,400	43,600
Middle Mojave	32,000	10,100	21,900
Lower Mojave	22,000	8,500	13,500
Lucerne	12,000	6,350	5,650
Totals	123,000	38,350	84,650

*The amounts of pumpage were estimated from State Water Rights Board's records. However, currently a detailed verification of pumpage is being made by the Mojave Water Agency. Preliminary figures from this determination indicate the pumpage within the area served by the Agency in 1961 to be on the order of 180,000 acre-feet. Using this figure, the estimated mean annual safe yield would be on the order of 140,000 acre-feet.

It should be pointed out again that two basic assumptions were made in the determination of overdraft and safe yield in this study: (1) a particular set of physical conditions affecting the supply, use, and disposal (including pumpage) of water in the ground water basin was assumed, and (2) it was further assumed that these conditions remained constant at the 1960-61 level throughout the 25-year base period. These assumptions then fixed the amounts of the items of supply, use, and disposal of water at one level for the entire base period; they also held constant the place and manner in which the fixed amount of water supply was applied, used, and disposed. These assumptions were hypothetical, of course, since this situation did not occur in the past and will probably not occur in the future.

In the management of ground water basins in the Mojave area, an understanding of these assumptions and the manner in which they are used is necessary, if the estimates of safe yield and overdraft obtained by this method are to be used as guides in controlling the amounts of pumpage from the ground water basins and in estimating the needs for imports to the area. For example, should it be deemed necessary to reduce the amounts of pumpage by the amount of the overdraft in order to achieve safe yield, the amount of such reduction would have to be made up by an equal amount of supplemental water, such as water obtained by removal of riparian native vegetation or by importing water. This supplemental water would have to be applied in the same place and manner as the extracted water for which it is being substituted, if the estimates of safe yield of the basin determined under constant conditions are to remain unchanged.

The amounts of annual overdraft and safe yield would be different for different sets of physical conditions. Sufficient changes could be made to eliminate overdraft and maintain safe yield. Man has control over, and could change, such physical conditions as (a) urban, suburban, industrial, agricultural land use; (b) intensity of native vegetation, especially riparian native vegetation; and (c) water conservation featues such as reclamation of waste water and artificial recharge of water. In turn, these will change the amounts of water supply, use, and disposal.

An example by which the amount of annual overdraft could be reduced and the annual amount of safe yield could be increased significantly would be by economically removing and controlling the amount of riparian native vegetation. Assuming that the set of physical conditions previously used would have been the same, except that 50 percent of the riparian native vegetational use would have been removed, the annual amount of overdraft would have decreased from about 38,000 acre-feet to 19,000 acre-feet and the annual amount of safe yield would have correspondingly increased from 79,000 acre-feet to 98,000 acre-feet.

There are major flood control and water supply features under way that could affect the physical conditions of the basin. The U. S. Army Corps of Engineers is currently designing the federally authorized flood control dam at the fork site, at the confluence of Deep Creek and the West Fork of the Mojave River. Also, the U. S. Bureau of Reclamation has investigated a multiple-purpose dam and reservoir project at the same site. Principally, it would reduce peak floodflows, decreasing the amount of surface outflow from the study area. In turn, the annual overdraft would decrease and the annual safe yield would increase.

The amounts of ground water overdraft and safe yield are dependent upon the set physical conditions used in their determination, one of which is pumpage. Accordingly, the amounts of ground water overdraft and safe yield are subject to redetermination whenever major changes occur in these conditions. Such a reevaluation may be necessary periodically in the future to provide a continuing guide to the use of ground water in storage.

CHAPTER VI. FUTURE SUPPLEMENTAL WATER REQUIREMENTS AND SOURCES

The San Bernardino Mountains separate the Mojave River desert region from the coastal metropolitan area of Southern California but the region is affected by the social and economic trends of the coastal area. The future expansion in the developed coastal area will tend to spill over into the inland Mojave desert and should have a profound effect on the economy of the study area.

Although the major portion is undeveloped, the study area is strategically located in relation to the great Southern California market with its center in Los Angeles. It is traversed by major transcontinental rail and highway routes, and a dependable supply of electricity and natural gas. Land is available at much lower prices than in coastal Southern California and in its present relatively undeveloped state, the study area could easily accommodate additional agricultural, urban and suburban, and industrial development.

The development of the study area will be limited by the local, social and economic factors affecting agriculture, urban and suburban areas, and industry. Agriculture is influenced by the economic feasibility of producing particular crops under certain market conditions, the availability of land, the pressure for land for other developments, and the availability of low-cost water. In general, farming is marginal and is affected by the late spring and early fall frosts which, in contrast to other more productive and desirable areas, limit production of most crops to the summer months when market prices are lowest. The number of crops that can be produced annually is also limited. In addition, any significant increase in the cost of water would make it uneconomical for the farmer to continue. Therefore, assuming that future agricultural water costs will remain close to the current levels and that the cost of imported water to the Mojave Water Agency would be recovered by increased urban and sub-urban water rates and by ad valorem taxation, the total gross agricultural acreage is expected to decrease only slightly -- to 16,800 acres in 1970, 15,600 acres in 1980, and 14,500 acres in 1990.

The present urban-suburban areas will continue to be the center for most of the future social and economic activity. Under the influence of the current trend toward development of recreational and retirement areas in the desert regions and the closely associated growth in commercial activity to support these areas, the population of the Mojave region is expected to increase. However, the magnitude of growth will probably not be as great as the growth anticipated in other regions of Southern California.

Population projections to the year 1990 are given in the Department's Bulletin 119-12, "Feasibility of Serving the Mojave Water Agency from the State Water Project", printed in December 1965. This bulletin updates the population figures given in Bulletin 78, "Investigation of Alternative Aqueduct Systems to Serve Southern California", Appendix D, "Economic Demand for Imported Water", published in March 1960.

The current estimates of future population of the Mojave Water Agency (which is essentially the population of the study area) are: 90,000 in 1970, 211,000 in 1980, and 393,000 in 1990. The per capita population demand is estimated to increase from the 200 gallons per capita per day in 1960-61 to 213 gpcd in 1970, 222 gpcd in 1980, and 228 gpcd in 1990.

Industrial activity is not expected to increase in the same proportions as the population. Although the area has the potential for industrial development, the initial investment required to install utilities and other services may deter industries from locating in the area. Furthermore, the study area will be competing with other areas of Southern California for industry. However, the growth of cement production can be expected to continue. The basic raw materials are in abundant supply and the demand will continue to grow and be stimulated by the projected growth of California, generally, and Southern California, specifically. Cement production, however, is not a labor-intensive industry and it has become increasingly mechanized in recent years. For this reason, the expected further expansion of the capacity of the present plants and the probable construction of new plants will not necessarily lead to a proportionate increase in employment within the industry and in demand for water. On this basis, industrial use of water was assumed to increase from 2,600 acre-feet in 1960-61 to 5,000 acre-feet in 1970.

Amounts of water use and disposal, water supply, and water deficiency under 1960-61 land use conditions, and projected amounts for the years 1970, 1980, and 1990 are presented in Table 34.

The water deficiency of 1960-61 and earlier years was met by use of ground water in storage. However, the anticipated growth of the area will result in increased need for supplemental water in future years. To meet these needs, the Mojave Water Agency has contracted with the State of California Department of Water Resources for importation of Northern California water through the State Water Project. These deliveries are to begin in 1972.

TABLE 34

WATER REQUIREMENTS AND SOURCES OF SUPPLY
(Total Study Area)

In acre-feet

Study area	1960-61	1970	1980	1990
Water Use and Disposal:				
Surface Outflow[a]	9,600	9,600	9,600	9,600
Consumptive use				
Agriculture	60,100	51,000	48,000	44,000
Riparian Native Vegetation[b]	41,950	41,950	41,950	41,950
Urban and Suburban	6,200	11,000	26,000	50,000
Industry	2,600	3,000	4,000	5,000
TOTAL	120,450	116,550	129,550	150,550
Existing Sources of Water Supply:				
Precipitation	12,750	12,750	12,750	12,750
Surface inflow	68,000	68,000	68,000	68,000
Subsurface inflow	850	850	850	850
Imported water	250	250	250	250
TOTAL	81,850	81,850	81,850	81,850
Water Supply Deficiency	38,600	34,700	47,700	68,700
Supplemental Sources of Water Supply:				
State Water Project Annual Entitlement[c]			27,200	50,800
Water Deficiency[d]	38,600	34,700	20,500	17,900

a. May be reduced if a proposed dam is constructed at the Forks site.
b. Water salvage could result from a program of elimination and control of riparian native vegetation.
c. Delivery scheduled to begin in 1972 with importation of 8,400 acre-feet.
d. To be met by use of ground water. Amount could be reduced under conditions a and b above.

Consideration was also given to the possibility of additional inflow occurring in future years as the result of importation of water into the mountain area by the Crestline-Lake Arrowhead Water Agency, which has contracted for 5,800 acre-feet of water annually from the State Water Project. Deliveries are scheduled to begin in 1972.

The Crestline-Lake Arrowhead region is primarily a recreation and resort area. Small streams, springs, and shallow wells are the current sources of water. Currently, about 30 percent of the total area within the water agency service area is sewered and this treated sewage is disposed of through evaporation ponds. The remaining portion of the sewage is disposed of through individual septic tank cesspool systems.

About 85 percent of the consumptive use of water by man occurs during the summer months, when consumptive use of water by vegetation and evaporation is also highest. Assuming that the current rate of development continues and that present weather cycles also continue, the amount of imported water supply from the State Water Project will be sufficient only to meet the future additional water demands; there will be no increase in inflow to the study area due to the application of imported water in the mountain area.

As shown in Table 34, a significant possible source of supplemental water is water salvaged as a result of a program of elimination and control of riparian native vegetation. Based on the limited amount of available information, the approximate cost of such a program would be about $50 per acre for clearing, plus about $10 per acre for control by spraying or burning. These amounts include the direct cost of equipment, operating expenses, and salaries and wages.

Because these areas are along the river, where free water surface and high ground water conditions may exist, it may be necessary to collect and distribute the recovered water to other areas to prevent loss by evaporation. If collection and distribution facilities are included in the program, there would be additional cost. Management costs should also be included in determining the total cost of a program to eliminate and control areas of riparian native vegetation to provide a source of supplemental water.

In meeting the future water demands by identifying the above mentioned sources of supplemental water supplies, consideration could be given to a planned reduction of ground water in storage since approximately 30,000,000 acre-feet of ground water exists within the basins and the average annual deficiency is in the order of 38,000 acre-feet.

CHAPTER VII. SUMMARY OF FINDINGS AND CONCLUDING STATEMENTS

In this chapter, the results of the geologic, hydrologic, and water quality studies are summarized as findings. The concluding statements evaluate the objectives achieved and indicate the further application of the findings.

Summary of Findings

Geology

The area of investigation is irregularly shaped, covers about 3,700 square miles, and contains about 2,500 square miles of water-bearing area. It is essentially an alluviated plain made up of small, broad valleys, separated by hills, groups of hills, and low mountains.

Structurally, the study area is dissected by three major northwest-southeast trending faults, which have an important influence on ground water flow: the Helendale, Lockhart, and Calico-Newberry faults. These faults exhibit very little surface expression, primarily because of burial by alluvium. Ground water levels are higher on the southwest side of each of these faults than on the northeast side. Water level differences range from a few feet to about 60 feet.

The water-bearing portion of the study area comprises seven ground water basins: Upper, Middle, and Lower Mojave Basins, and Harper, Coyote, Caves, and Lucerne

Basins. All except Lucerne Basin receive the major portion of their water supply from the Mojave River. The major source of water supply to the Lucerne Basin is from surface inflow from the mountain area.

The heterogeneous, water-bearing alluvial deposits that constitute the ground water basins are primarily the result of stream erosion of the adjacent highlands. These alluvial deposits average about 300 feet in thickness, within a range of a few feet to over 1,000 feet. The saturated portion of these deposits, over the entire study area, averages about 230 feet in depth. However, in those portions of the area that receive inflow from the Mojave River, the average saturated thickness is 275 feet, in an average total thickness of 360 feet.

The specific yield of the water-bearing alluvial deposits varies throughout the basins. The average specific yield for areas influenced by inflow from the Mojave River is approximately 14 percent. For the entire water-bearing portion of the study area, the specific yield ranges from 3 to 25 percent; for the other areas, the average is 10 percent.

Hydrology

Historical Conditions.

The amounts of annual water supply, water use and disposal, and water supply deficiency during the 25-year base period

(1936-37 through 1960-61) were determined for the Upper, Middle, and Lower Mojave Basins, and Lucerne Basin, where adequate geologic and hydrologic data were available. Data for the other three basins -- Harper, Coyote, and Caves -- were limited; however, the findings in the four major areas of record are indicative of conditions throughout the study area.

Water supply sources consist of precipitation, surface inflow, subsurface inflow, and imported water. Precipitation on the valley floor is not sufficient to contribute to the water supply of the basins, except in a portion of the Upper Mojave Basin, south of the town of Hesperia, where the average annual precipitation is greater than eight inches. The average annual amount of water from this source that percolates to the ground water body is about 4,500 acre-feet. The existence of perched ground water in the same general area confirms the addition of water to the ground water body in this area.

Surface inflow to the study area from the surrounding hills and mountains averaged about 68,000 acre-feet annually during the base period. Subsurface inflow to the study area from bordering regions occurs only at the southwest boundary, where inflow to the Upper Mojave Basin contributes about 900 acre-feet annually to the water supply.

During the study base period, imported water was a minor source of supply. About 300 acre-feet of domestic water was imported annually from outside the study area to the town of Phelan.

Surface or subsurface flow between basins within the study area and water piped across these basin boundaries are items of inflow or imported water supply to the receiving basin. However, because this water originates as outflow or exported water from adjacent basins within the study area, these amounts balance out and do not increase the overall water supply.

Water use and disposal is by surface outflow, subsurface outflow, exported water, and consumptive use. Surface outflow from the study area occurs at the northeast boundary, an average annual amount of 9,600 acre-feet from Caves Basin at Afton.

There is no subsurface outflow or water export from the study area to the outlying regions.

The average annual amounts of consumptive use in the study area could only be determined for the four major basins. These amounts were about 44,000 acre-feet for the Upper Mojave Basin, 20,000 acre-feet for the Middle Mojave Basin, 17,000 acre-feet for the Lower Mojave Basin, and 4,500 acre-feet for Lucerne Basin.

The average annual water supply, disposal, and deficiency are as follows:

AVERAGE ANNUAL AMOUNTS

In acre-feet

Basin	Supply	Disposal	Deficiency
Upper Mojave	74,500	81,700	7,200
Middle Mojave	39,900	45,100	5,200
Lower Mojave	26,300	31,600	5,300
Lucerne	1,700	4,600	2,900

The average annual deficiency in water supply, about 21,000 acre-feet, was met by use of pumped ground water.

The deficiency in water supply was the result of increased urbanization and development of the area and the prolonged drought conditions that have prevailed in southwestern United States since about 1945.

If 1961 physical conditions had prevailed throughout the 25-year base period, the average annual overdraft would have been about 38,000 acre-feet and the corresponding average annual safe yield would have been about 85,000 acre-feet for these four basins.

The principal regions where quantitative estimates of ground water storage could be made are the Upper Mojave, Middle Mojave, Lower Mojave, and Lucerne Basins. These basins have a total storage capacity, between the ground surface and the base of the water-bearing materials, of about 48,000,000 acre-feet. There was a net decrease of 522,000 acre-feet in the amount of ground water in storage between the beginning and the end of the 25-year base period. At the close of the base period, in 1961, about 31,100,000 acre-feet of ground water remained in storage in these four basins.

Future Conditions

The study area is primarily desert, and development of farms and communities has been limited to areas along the Mojave River and the adjacent valleys where water has been readily available. However, the study area is strategically located in relation to the expanding Southern California market and will be influenced by the social and economic trends of the region, in general, and of Los Angeles, in particular.

The population of the study area is expected to increase from 55,300 in 1960-61 to 393,000 in 1990. Urban and suburban water use will rise from 6,200 acre-feet in 1960-61 to 50,000 acre-feet in 1990. Agricultural land use is expected to decline during this period, from 18,650 acres to 14,500 acres, resulting in a decrease in agricultural water use, from 60,100 acre-feet to 44,000 acre-feet annually. Conversely, water use and disposal by industry will require 5,000 acre-feet annually by 1990 -- almost double the 2,600 acre-feet needed by industry in 1960-61. These changes in population and occupation will result in a net increase in water use from about 120,000 acre-feet in 1960-61 to about 151,000 acre-feet in 1990.

Historical climatic and hydrologic conditions are assumed to continue in the future; thus, water supply from natural sources will remain at about the same level as it was during the 25-year base study period. In view of the anticipated increase in water needs under future conditions of growth and development in the study area, water supply deficiency will amount to about 68,700 acre-feet annually by 1990, as compared to the 1960-61 deficiency of 38,600 acre-feet.

In order to provide supplemental water to meet the future needs, the Mojave Water Agency has entered into a contract with the State of California for water from the State Water Project. Deliveries of imported water are scheduled to begin in 1972. Use of this water will reduce the 1990 water deficiency from 68,700 acre-feet to 17,900 acre-feet. The remaining water supply deficiency can be met by use of pumped ground water.

Consideration was also given to possible future sources of supplemental water supply. In the event that a dam is constructed at the forks site, as proposed by the U. S. Army Corps of Engineers and studied by the U. S. Bureau of Reclamation, outflow at Afton could be reduced. The water thus conserved would be available for use in the study area. An additional potential supply of supplemental water could be developed by elimination and control of riparian native vegetation or by introduction of a planned program of reduction of ground water storage.

Water Quality

There is a wide variation in the quality and mineral character of the water in the study area. This variation is related to the source of replenishment, the geological formation in which the ground water is found, and use of water by man. Ground water influenced by the Mojave River is typically bicarbonate, with an average total dissolved solids content of about 300 parts per million. Ion exchange is indicated by a change in the character of the water from predominately calcium bicarbonate in the Upper Mojave Basin to predominately sodium bicarbonate in the downstream Middle and Lower Mojave Basins. The other most common type of ground water found in the study area is related to older alluvium. This water is typically sulfate or sulfate-chloride in character with a total dissolved solids range from 700 to 1,000 ppm.

Sodium chloride type ground water is consistently present in the fine-grained playa deposits found at lower elevations of the basins and in the older lake deposits. The total dissolved solids content ranges from 380 ppm to more than 5,300 ppm. The average is approximately 1,200 ppm.

Inflow of salts to the study area exceeds the outflow of salts at the rate of 22,000 tons per year. However, there are only a few areas in which problems due to the accumulation of salts occur. These are in the vicinity of dry lakes and near Afton.

Concluding Statements

Studies leading to this report were conducted to determine the location, amount and quality of local water supply in the basins along the Mojave River, to evaluate the adequacy of the local water supply to meet present and future water requirements, and to indicate potential sources of supplemental water.

The geologic and hydrologic information provided by this study can be used by local agencies in planning for effective use of existing surface and ground water resources of the study area and in developing supplemental sources of water. The information provided by this study points out the need and provides a foundation for a ground water basin model simulation and operational economics studies, leading to the selection by local agencies of an optimum plan of water resources management.

APPENDIX A

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also includes water similarly consumed and evaporated by urban and nonvegetative types of land use.

Darcy's Equation - An equation applied to ground water studies, based on Darcy's Law (the flow rate through porous media is proportional to the head loss and inversely proportional to the length of the flow path). Expressed as Q = PIA, where the subsurface flow (Q) is equal to the permeability (P) of the subsurface materials, times the cross-sectional area (A) and the slope or the hydraulic gradient (I) of the ground water at the cross-sectional area.

P = gallons per day square foot

I = feet per foot

A = square feet

Q = gallons per day

Deep Percolation - See Percolation, Deep.

Ground Water - Subsurface water occurring in the zone of saturation and moving under control of the water table slope or piezometric gradient.

Ground Water Basin - As used in this report, an area underlain by water-bearing sediments capable of storing and yielding a ground water supply.

Ground Water Overdraft - For this study, the value is equal to average annual decrease in the amount of ground water in storage that occurs during a longtime period, under a particular set of physical conditions affecting the supply, use, and disposal (including pumpage) of water in the ground water basin.[1]

[1] See Chapter III for specific items of water supply, use, and disposal.

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APPENDIX B

DEFINITION OF TERMS

DEFINITION OF TERMS

Acre-foot - The volume of water required to cover one acre one foot in depth (43,560 cubic feet or 325,829 gallons).

Applied Water - The water delivered to a farmer's headgate or to an urban individual's meter, or its equivalent. Excludes precipitation.

Blaney-Criddle Method - Based on an empirical formula developed by Harry F. Blaney and Wayne D. Criddle for the U.S. Department of Agriculture. Used to obtain estimates of evapotranspiration. (For a detailed description, see California State Water Resources Board Bulletin No. 2 and U.S. Department of Agriculture Technical Bulletin No. 1275.)

Character of Water - A classification of water based on predominant anion and/or cation in equivalents per million (epm). Identified by the name of the ion which constitutes one-half or more of the total ions for that water group.

Connate Water - Water entrapped in the interstices of a sedimentary rock at the time it was deposited. These waters may be fresh, brackish or saline in character. Because of the dynamic geologic and hydrologic conditions in California, this definition has been altered in practice to apply to water in older formations, even though in these the water may have been altered in quality since the rock was originally deposited.

Consumptive Use of Water - Water consumed by vegetative growth in transpiration and building plant tissue, and water evaporated from adjacent soil, from water surfaces, and from foliage. It

also includes water similarly consumed and evaporated by urban and nonvegetative types of land use.

Darcy's Equation - An equation applied to ground water studies, based on Darcy's Law (the flow rate through porous media is proportional to the head loss and inversely proportional to the length of the flow path). Expressed as Q = PIA, where the subsurface flow (Q) is equal to the permeability (P) of the subsurface materials, times the cross-sectional area (A) and the slope or the hydraulic gradient (I) of the ground water at the cross-sectional area.

P = gallons per day square foot

I = feet per foot

A = square feet

Q = gallons per day

Deep Percolation - See Percolation, Deep.

Ground Water - Subsurface water occurring in the zone of saturation and moving under control of the water table slope or piezometric gradient.

Ground Water Basin - As used in this report, an area underlain by water-bearing sediments capable of storing and yielding a ground water supply.

Ground Water Overdraft - For this study, the value is equal to average annual decrease in the amount of ground water in storage that occurs during a longtime period, under a particular set of physical conditions affecting the supply, use, and disposal (including pumpage) of water in the ground water basin.1/

1/ See Chapter III for specific items of water supply, use, and disposal.

Ground Water Safe Yield - For this study, the value is equal to average annual amount of ground water that could be pumped from a ground water basin over a long-time period without causing a long-time net change in storage of ground water. The extractions must occur under a particular set of physical conditions affecting the supply, use, and disposal of water in the ground water basin.[1]

Ground Water Storage - That stage of the hydrologic cycle during which water occurs as ground water in the zone of saturation.

Ground Water Table - See Water Table.

Hydraulic Gradient - Under unconfined ground water conditions, the slope of the profile of the water table. Under confined ground water conditions, the line joining the elevations to which the water would rise in wells if they were perforated in the aquifer.

Hydrology - The applied science concerned with the waters of the earth, their occurrences, distribution, use, and circulation through the unending hydrologic cycle of precipitation; consequent runoff, infiltration, storage, use, and disposal; eventual evaporation; and reprecipitation. It is concerned with the physical and chemical reaction of water with the rest of the earth, and its relation to the life of the earth.

Hydrology, Ground Water - The branch of hydrology that treats of subsurface water -- its occurrence, movement, and storage and its replenishment and depletion -- also, of the properties of unconsolidated materials and rocks that control the occurrence, movement,

[1] See Chapter III for specific items of water supply, use, and disposal.

and storage of subsurface water and of the method of investigation and utilization of subsurface water.

Impermeable - Impervious; having a texture that does not permit water to move through it perceptibly under the head differences ordinarily found in subsurface water.

Infiltration - The flow, or movement, of water through the soil surface into the ground.

Overdraft - See Ground Water Overdraft.

Perched Ground Water - Ground water occurring in a saturated zone separated from the main body of ground water by unsaturated rock or by an impervious formation.

Percolation - The movement or flow of water through the interstices, or the pores, of a soil or other porous media.

Percolation, Deep - The movement of water entering the zone of saturation, below the root zone.

Period - A specified division or portion of time.

a. Average. An arithmetical average relating to a period other than a mean period.

b. Base. A period chosen for detailed hydrologic analysis, because prevailing conditions of water supply and climate are approximately equivalent to mean conditions and because adequate data for such hydrologic analysis are available.

c. Mean. A period chosen to represent conditions of water supply and climate over a long series of years.

d. Annual. Any 12-month period other than the calendar year. In this study, annual period is synonymous with the runoff period, October 1 through September 30.

Permeability - The permeability (or perviousness) of rock is its capacity for transmitting a fluid. Degree of permeability depends upon the size and shape of the pores, the size, shape, and extent of their interconnections.

Permeable - Pervious, having a texture that permits water to move through it perceptibly under the head differences ordinarily found in subsurface water.

Physical Conditions - For this study, the state of man's activities, particularly land use -- agriculture, urban, suburban, and industrial -- and the resulting physical structures affecting the supply, use, and disposal of water.

Rising Water - Ground water from the zone of saturation which appears at the ground surface, usually to a streambed, when the ground surface is at a lower elevation than the ground water table or the piezometric surface of a confined aquifer.

Safe Yield - See Ground Water Safe Yield.

Specific Yield - The ratio of the volume of water a saturated sediment will yield by gravity drainage to the total volume of the sediment and water prior to draining, customarily expressed in percent.

Total Dissolved Solids (TDS) - The dry residue from the dissolved matter in an aliquot of a water sample remaining after evaporation of the sample at a definite temperature.

Transmissibility, Coefficient of - The rate of flow of water, expressed in gallons per day, at the prevailing water temperature through each vertical strip, 1 foot wide, having a height equal to the thickness of the aquifer, and under a unit hydraulic gradient.

Transpiration - The exhalation of water vapor from the stomata of plant leaves and other surfaces.

Unconfined Ground Water - Ground water that is not immediately overlain by impervious materials and that moves under control of the water table slope.

Unconformity - A surface or erosion or nondeposition, usually the first, that separates younger strata from older rocks.

Vapor Transport - The loss of percolating water in the zone of aeration in areas of low annual precipitation, infrequent high annual precipitation, and great depth to the zone of saturation.

Water Quality - Those physical, chemical, biological, and radiological characteristics of water which affect its suitability for beneficial uses.

Water Table - The surface of ground water at atmospheric pressure in an unconfined aquifer. This is revealed by the levels at which water stands in wells penetrating the unconfined aquifer.

Water Supply Surplus or Deficiency - For this study, the difference between the inflow to and the outflow from a ground water basin during any given period. The outflow of water includes the consumptive use of water. A water supply surplus results when the inflow is greater than the outflow; a water supply deficiency results when the inflow is less than the outflow.

APPENDIX C

CLASSIFICATION OF LAND USE

WATER SERVICE AREA

Urban and Suburban Category

Class of Land Use	Type of Land Use
Residential.	Single and multiple family houses and apartments, institutions, motels, 1- and 2-story hotels, trailer parks, and residential subdivisions under construction at time of survey.
Recreational residential . .	Weekend and summer home tracts within a primarily recreational area.
Commercial	All classes of commercial enterprises, including strip commercial, downtown commercial, and schools, but excluding 1- and 2-story hotels, motels, and institutions.
Industrial	All classes of industrial land uses involving manufacturing, processing, and packaging, but excluding extractive industries (oil, sand, and gravel), air fields, and storage, distribution, and transportation facilities.
Unsegregated urban and suburban area	Farmsteads, dairies, livestock ranches, parks, cemeteries, and golf courses.
Included nonwater service area	Oil fields, tank farms, vacant lots, quarries, gravel pits, warehouses and storage yards, railroads, public streets, landing strips of airfields, and subdivisions with streets and utilities in place but with no buildings constructed.

Irrigated Agriculture Category

Class of Land Use	Type of Land Use
Alfalfa	Alfalfa raised for hay, seed, or pasture

Class of Land Use (continued)	Type of Land Use
Pasture.	Irrigated grasses and legumes other than alfalfa used for livestock forage.
Truck crops	Vegetables of all varieties, melons, flower seed, and nursery crops.
Field crops	Cotton, sorghum, sugar beets, and field corn.
Deciduous fruits and nuts .	All varieties.
Small grains	Barley, wheat, and oats.
Fallow	Tilled, between crops.
Included nonwater service area	Public highways and roads, farm access roads, canals, and other inclusions not devoted to crop production, including idle and abandoned lands.

APPENDIX D

WATER QUALITY CRITERIA

WATER QUALITY CRITERIA

Criteria presented in the following sections can be utilized in evaluating mineral quality of water relative to existing or anticipated beneficial uses. It should be noted that these criteria are merely guides to the appraisal of water quality. Except for those constituents which are considered toxic to human beings, these criteria should be considered as suggested limiting values. Water which exceeds one or more of these limiting values need not be eliminated from consideration as a source of supply, but other sources of better quality water should be investigated.

Criteria for Drinking Water

Criteria for appraising the suitability of water for domestic and municipal use in connection with interstate quarantine have been promulgated by the United States Public Health Service. The limiting concentrations of chemical substances in drinking water have been abstracted from these criteria and are shown in Table 35. Other organic or mineral substances may be limited if their presence renders the water hazardous for use.

Interim standards for certain mineral constituents have been adopted by the California State Board of Public Health. Based on these standards, temporary permits may be issued for drinking water supplies failing to meet the United States Public Health Service Drinking Water Standards, provided the mineral constituents in Table 36 are not exceeded.

TABLE 35

UNITED STATES PUBLIC HEALTH SERVICE
DRINKING WATER STANDARDS
1962

Chemical Substance	Mandatory limit in ppm
Arsenic (As)	0.05
Barium (Ba)	1.0
Cadmium (Cd)	0.01
Hexavalent chromium (Cr^{+6})	0.05
Cyanide (CN)	0.2
Lead (Pb)	0.05
Salenium (Se)	0.01
Silver (Ag)	0.05
	Nonmandatory, but recommended limit in ppm
Alkyl benzene sulfonate (detergent)	0.5
Arsenic (As)	0.01
Carbon chloroform extract (exotic organic chemicals)	0.2
Chloride (Cl)	250
Copper (Cu)	1.0
Cyanide (CN)	0.01
Fluoride (F) (See Table 37)	
Iron (Fe)	0.3
Manganese (Mn)	0.05
Nitrate (NO_3)	45
Phenols	0.001
Sulfate (SO_4)	250
Total dissolved solids (TDS)	500
Zinc (Zn)	5

TABLE 36

UPPER LIMITS OF TOTAL SOLIDS AND SELECTED MINERALS IN DRINKING WATER AS DELIVERED TO THE CONSUMER

	Permit	Temporary Permit
Total solids	500 (1000)*	1500 ppm
Sulfates (SO_4)	250 (500)*	600 ppm
Chlorides (Cl)	250 (500)*	600 ppm
Magnesium (Mg)	125 (125)	150 ppm

* Numbers in parentheses are maximum permissible, to be used only where no other more suitable water is available in sufficient quantity for use in the system.

The relationship of infant methemoglobinemia (a reduction of oxygen content in the blood, constituting a form of asphyxia) to nitrates in the water supply has led to limitation of nitrates in drinking water. The California State Department of Public Health has recommended a tentative limit of 10 ppm nitrogen (44 ppm nitrates) for domestic water. Water containing higher concentrations of nitrates may be considered to be of questionable quality for domestic and municipal use.

The California State Board of Public Health has defined the maximum safe amounts of fluoride ion in drinking water in relation to mean annual temperature. These relationships are shown in Table 37.

TABLE 37

RELATIONSHIP OF TEMPERATURE TO FLUORIDE CONCENTRATION IN DRINKING WATER

Mean Annual Temperature	Mean monthly fluoride ion concentration
50°F	1.5 ppm
60°F	1.0 ppm
70°F - above	0.7 ppm

Criteria for Hardness

Even though hardness in water is not included in the foregoing standards, it is of importance in domestic and industrial uses. Excessive hardness in water used for domestic purposes causes increased consumption of soap and formation of scale in pipe and fixtures. Table 38 showing degrees of hardness in water has been suggested by the United States Geological Survey.

TABLE 38

HARDNESS CLASSIFICATION

Range of hardness, expressed as $CaCO_3$ in ppm	Relative classification
0 - 60	Soft
61 - 120	Moderately hard
121 - 200	Hard
Greater than 200	Usually requires softening

Criteria for Irrigation Water

Criteria for mineral quality of irrigation water have been developed by the Regional Salinity Laboratories of the United States Department of Agriculture in cooperation with the University of California. Because of diverse climatological conditions and the variation in crops and soils in California, only general limits of quality for irrigation waters can be suggested. The department uses three broad classifications of irrigation waters as listed below and in Table 39.

Class 1 - Regarded as safe and suitable for most plants under most conditions of soil and climate.

Class 2 - Regarded as possibly harmful for certain crops under certain conditions of soil or climate, particularly in the higher ranges of this class.

Class 3 - Regarded as probably harmful to most crops and unsatisfactory for all but the most tolerant.

TABLE 39

QUALITATIVE CLASSIFICATION OF IRRIGATION WATERS

Chemical properties	Class 1 Excellent to good	Class 2 Good to injurious	Class 3 Injurious to unsatisfactory
Total dissolved solids, in ppm	Less than 700	700 - 2000	More than 2000
Conductance, in micromhos at 25°C	Less than 1000	1000 - 3000	More than 3000
Chlorides, in ppm	Less than 175	175 - 350	More than 350
Sodium, in percent of base constituents	Less than 60	60 - 75	More than 75
Boron, in ppm	Less than 0.5	0.5 - 2.0	More than 2.0

These criteria have limitations in actual practice. In many instances, water may be wholly unsuitable for irrigation under certain conditions of use and yet be completely satisfactory under other circumstances. Consideration also should be given to soil permeability, drainage, temperature, humidity, rainfall, and other conditions that can alter the response of a crop to a particular quality of water.

Criteria for Industrial Uses

It is beyond the scope of this report to present water quality requirements for the various types of industry found in the Mojave River region or for the diverse processes within these industries, since such criteria are as varied as industry itself. In general, where a water supply meets drinking water standards, it is satisfactory for industrial use, either directly or following a limited amount of treatment or softening by the industry.

APPENDIX E

SPECIFIC YIELD VALUES

AND REPRESENTATIVE DRILLERS' TERMS

3 Percent (Clay)

Black rock
Black schist
Blue shale
Boulders, chunk rock
Boulders, hard
Caliche
Cemented boulders
Clay
Clay cobblestones
Hard pan
Hard shelf
Hillside clay conglomerate
Lime "shelves"
Rotten granite
Soft granite

Sticky clay

Tight clay
White quartz & Black shale

5 Percent (Sandy Clay)

Basalt
Basaltic sandstone
Cemented conglomerate
Clay - scattered gravel
Clay - scattered lime
Clay - with embedded rock

Crumbly clay
Crushed rock
Decomposed granite
Fractured granite
Gravelly clay
Hard lime shale
Kaolin
Limerock & Biotite clay
Muck
Nodules
Rotten Ledge rock
Sandy clay
Sandy Muck
Sandstone reefs
Silty clay
Volcanic rock
White limestone

10 Percent (Silt)

Black swamp mud & silt
Cemented gravels
Clay - embedded gravel
Coarse granulated water-bearing kaolin
Limy silt
River silt
Silt
Soft silt
Soil (Topsoil)
Talc

12 Percent (Cemented Sand)

Cemented sand
Cemented sand & gravel
Conglomerate sand
Hard cemented sand
Hard sand
Sandy clay & cobbles
Water gravel with cement reef

15 Percent (Sandy Silt)

Granulated kaolin
Kaolin with grit
Mucky sand, gravel & bits
Sandy silt

18 Percent (Coarse, Medium, or Undiff. Gravel)

Alluvial fill boulders
Brittle conglomerate - water
Brittle FM - water
Coarse, medium, or undifferentiated gravel
Cobblestone - coarse sand - some gravel
Loose "Granite" formation
Sand w/clay ribs

20 Percent (Silty Sand)

Dirty sand
Hilldrift
Silty sand
Soft sand

22 Percent (Fine Gravel)

Fine gravel
Pea gravel

26 Percent (Fine Sand)

Blow sand
Dune sand
Fine sand
Quicksand

EXHIBIT B

IN THE SUPERIOR COURT OF THE STATE OF CALIFORNIA
IN AND FOR THE COUNTY OF LOS ANGELES

THE CITY OF LOS ANGELES,
a Municipal Corporation,
Plaintiff,
vs.
CITY OF SAN FERNANDO,
a Municipal Corporation, et al.,
Defendants.

No. 650079

REPORT OF REFEREE

Volume I
TEXT AND PLATES

By
STATE WATER RIGHTS BOARD
REFEREE

July, 1962

APPROVAL AND ADOPTION BY STATE WATER RIGHTS BOARD

The State Water Rights Board, Referee in the action entitled "The City of Los Angeles, a Municipal Corporation, Plaintiff, vs. City of San Fernando, a Municipal Corporation, et al., Defendants," before the Superior Court of the State of California in and for the County of Los Angeles, No. 650079, approves and adopts this "Report of Referee" dated July 1962, pursuant to the requirements of the "Order of Reference to State Water Rights Board to Investigate and Report Upon the Physical Facts (Section 2001, Water Code)," dated June 11, 1958, and the "Interim Order," dated November 19, 1958, entered by the Court in said action. In accordance with paragraph III of said Order of Reference dated June 11, 1958, the Board will file with the Court and retain in its office the basic data upon which it bases its findings.

Approved and adopted by the State Water Rights Board at a meeting duly called and held at Sacramento, California, on the 27th day of July, 1962.

Kent Silverthorne, Chairman

Ralph J. McGill, Member

W. A. Alexander, Member

Selection of Base Study Period

The desirable base study period is one during which precipitation characteristics in the Upper Los Angeles River area approximate the 85-year period of record, 1872-73 through 1956-57. A further requirement of such a period is that additional hydrologic information is available sufficient to permit an evaluation of the amount, occurrence and disposal of the normal water supply under recent culture conditions. The desirable base period includes both wet and dry periods similar in magnitude and occurrence to the normal supply, and during which there are sufficient measurements and observations to relate the hydrology to recent culture.

Subsequent to 1927-28, records of stream outflow, culture distribution and water utilization on the valley floor, and ground water levels at wells are fairly comprehensive and adequate. In contrast, earlier records concerning these items are available only on a limited basis. There is a paucity of earlier measurements required to determine basin-wide ground water levels and continuous stream outflow. Because of the aforementioned requirements and limitations, the selection of a base period was restricted to years subsequent to 1927-28.

To determine the regimen of occurrence of rain in the Upper Los Angeles River area, selected precipitation stations on the valley floor having long periods of record were studied for an indication of periods with an occurrence of rain equivalent to the normal period. The 85-year mean seasonal precipitation was used to compute the indices of wetness for these selected stations, and annual averages of these indices of wetness were utilized to construct the cumulative percentage deviation mass diagram for the Upper Los Angeles River area, shown on Plate 10.

Comparison of the precipitation trends in the Upper Los Angeles River area with those reflected by the longer record of precipitation at Los Angeles, Pasadena, Acton and Sawtelle Soldiers Home, also shown on Plate 10, indicates that even though the magnitude of the annual deviation varies, the cyclic trends of these four stations are generally in agreement with the trends indicated by precipitation records within the area.

The 29-year period, 1928-29 through 1956-57, was selected as the base study period for the following reasons:

1. It was a period of normal precipitation during which sufficient records were available for purposes of determining safe yield.
2. It was a representative period of normal precipitation including both wet and dry periods of magnitude and occurrence similar to long-time mean supply conditions of 1872-73 through 1956-57. A wet period occurred from 1936-37 through 1944-45, and a predominantly dry period from 1945-46 through 1956-57. The 29-year period 1928-29 through 1956-57 contains nine years when precipitation was predominantly above average, that is, 115 percent of normal or greater. These nine years comprise 31 percent of the 29-year period as compared to 29 years of similar wetness occurring during the 85-year or normal period which comprise about 34 percent of that period. The average annual amount of precipitation during the 29-year period approximates the long-time mean

having the following average annual deviation from the 85-year mean expressed as a percentage thereof:

Valley lands	+3.5 percent
Hill and mountain areas	-2.2 percent
Combined	-0.4 percent

3. The years immediately preceding the first and last years of this period were of below normal wetness, which thereby minimized the difference of unaccounted-for water in transit to the water table at the start and end of the period.
4. It includes a period of record of supply and disposal under conditions of culture which approximate those existing in 1949-50, 1954-55 and 1957-58, the years during which safe yield is to be determined.

Special Study Periods

The period 1933-34 through 1948-49 is of significance in that it can be used to check change in storage computations. During this 16-year period a substantial rise and fall of ground water levels occurred with average levels at the beginning and end of the period being approximately the same elevation.

The 29-year base study period contains periods of differing practices as to the use of water which are related to change in land use, economic conditions, living standards and téchnological improvements. Thus, to properly evaluate the use of water under current conditions, a study period during recent years having a rain supply equivalent to the long-time mean was desirable. The 9-year period 1949-50 through 1957-58

14

EXHIBIT C

Mojave Watermaster
Land Use Changes

Wagner&Bonsignore
Consulting Civil Engineers, A Corporation

USGS Annual NLCD Land Cover Classification

- The annual NLCD (National Land Cover Database) uses a modified Anderson Level II classification system with 16 land cover classes. For example:

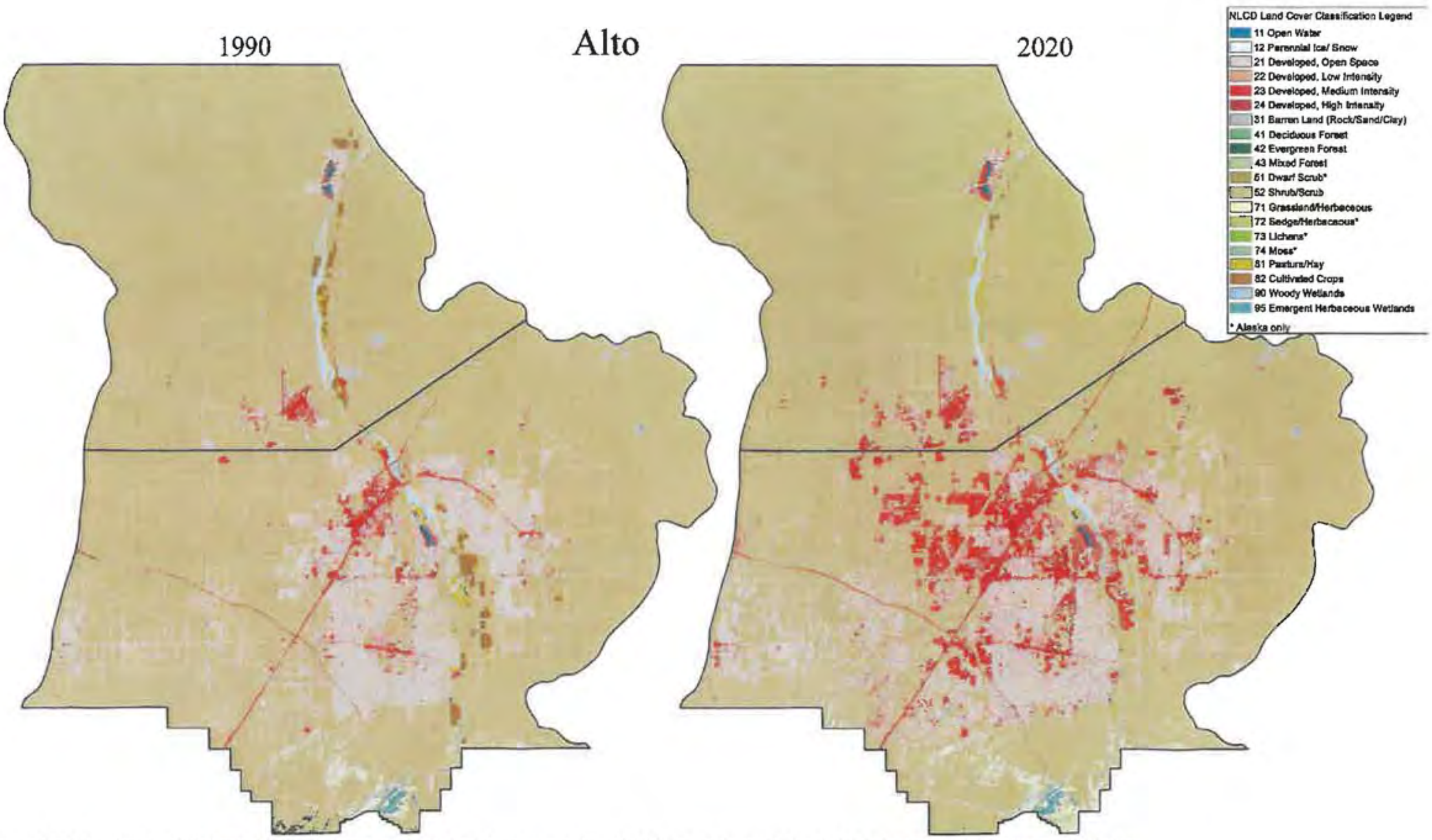
Developed	
21	**Developed, Open Space**- areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for less than 20% of total cover. These areas most commonly include large-lot single-family housing units, parks, golf courses, and vegetation planted in developed settings for recreation, erosion control, or aesthetic purposes.
22	**Developed, Low Intensity**- areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 20% to 49% percent of total cover. These areas most commonly include single-family housing units.
[illegible]	[illegible]
[illegible]	[illegible]

Planted/Cultivated	
81	**Pasture/Hay**-areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops, typically on a perennial cycle. Pasture/hay vegetation accounts for greater than 20% of total vegetation.
82	[illegible]

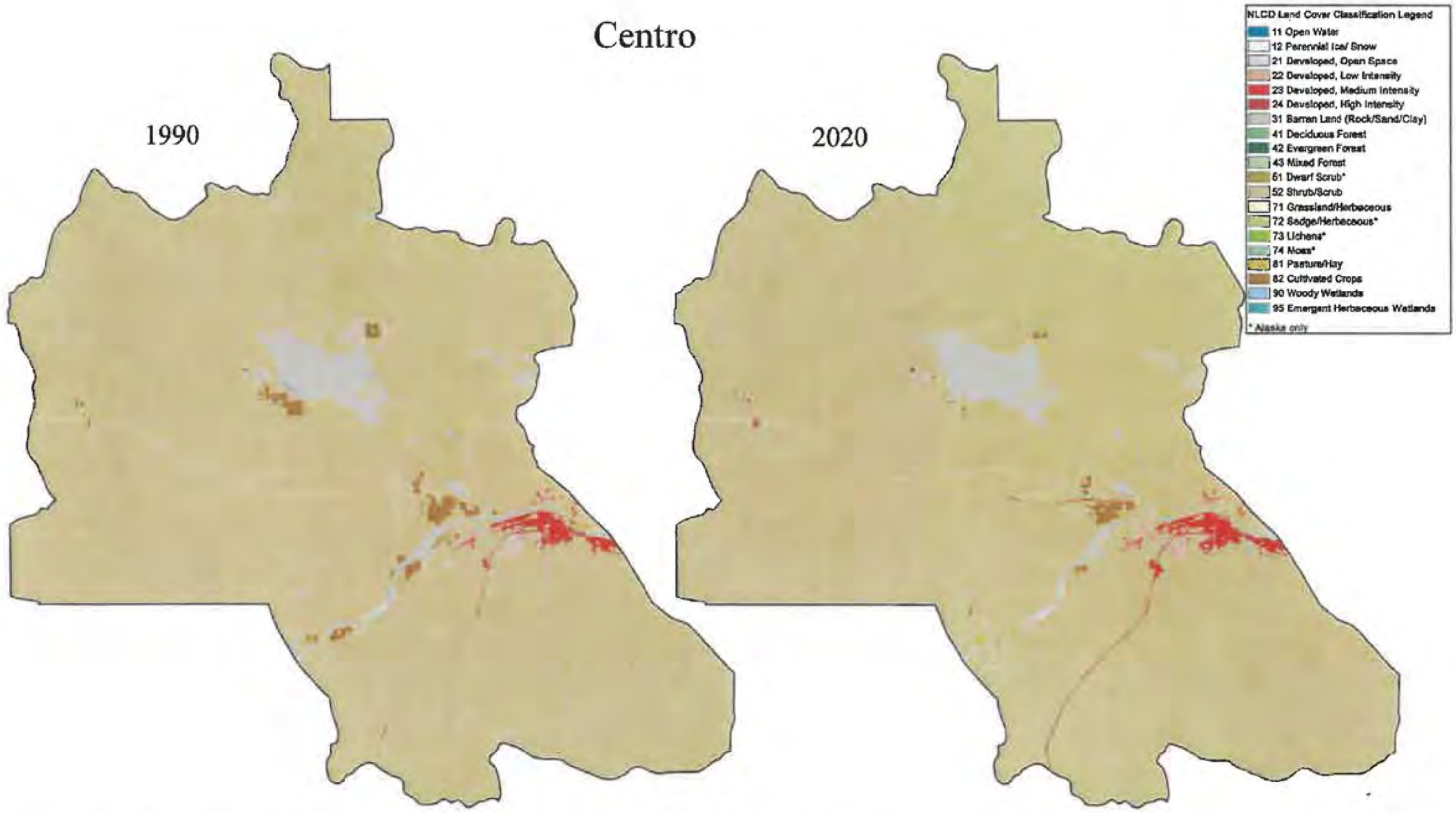
Shrubland	
[illegible]	[illegible]
52	**Shrub/Scrub**- areas dominated by shrubs; less than 5 meters tall with shrub canopy typically greater than 20% of total vegetation. This class includes true shrubs, young trees in an early successional stage or trees stunted from environmental conditions.

Source: Annual NLCD Land Cover Classification by the U.S. Geological Survey (USGS). Available at https://www.usgs.gov/centers/eros/science/annual-nlcd-land-cover-classification

Alto

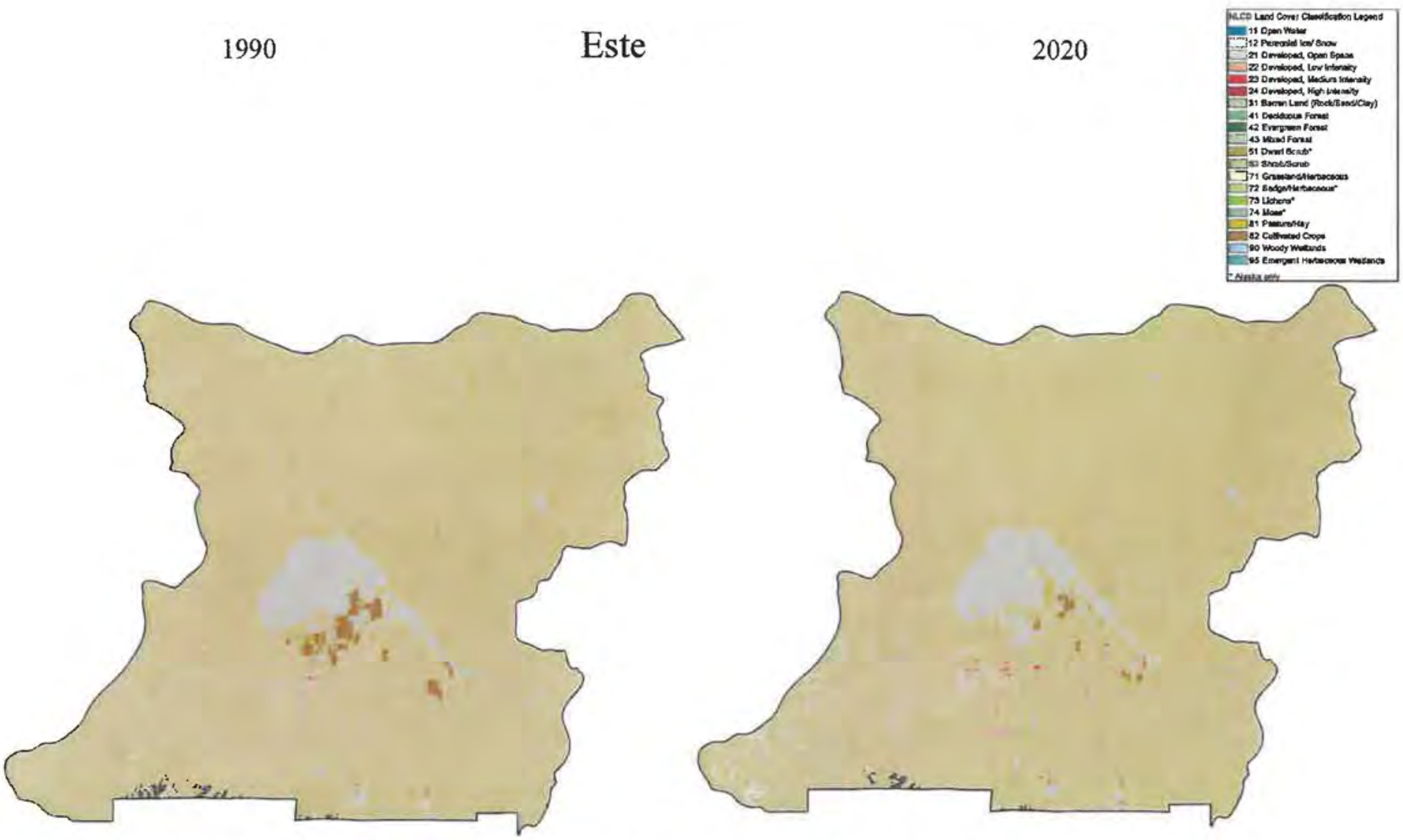


Annual National Land Cover Database (NLCD) by the U.S. Geological Survey (USGS)'s Land Cover program. Annual NLCD data was downloaded from the *Multi-Resolution Land Characteristics* (MRLC) site.



Annual National Land Cover Database (NLCD) by the U.S. Geological Survey (USGS)'s Land Cover program. Annual NLCD data was downloaded from the *Multi-Resolution Land Characteristics* (MRLC) site.

Este



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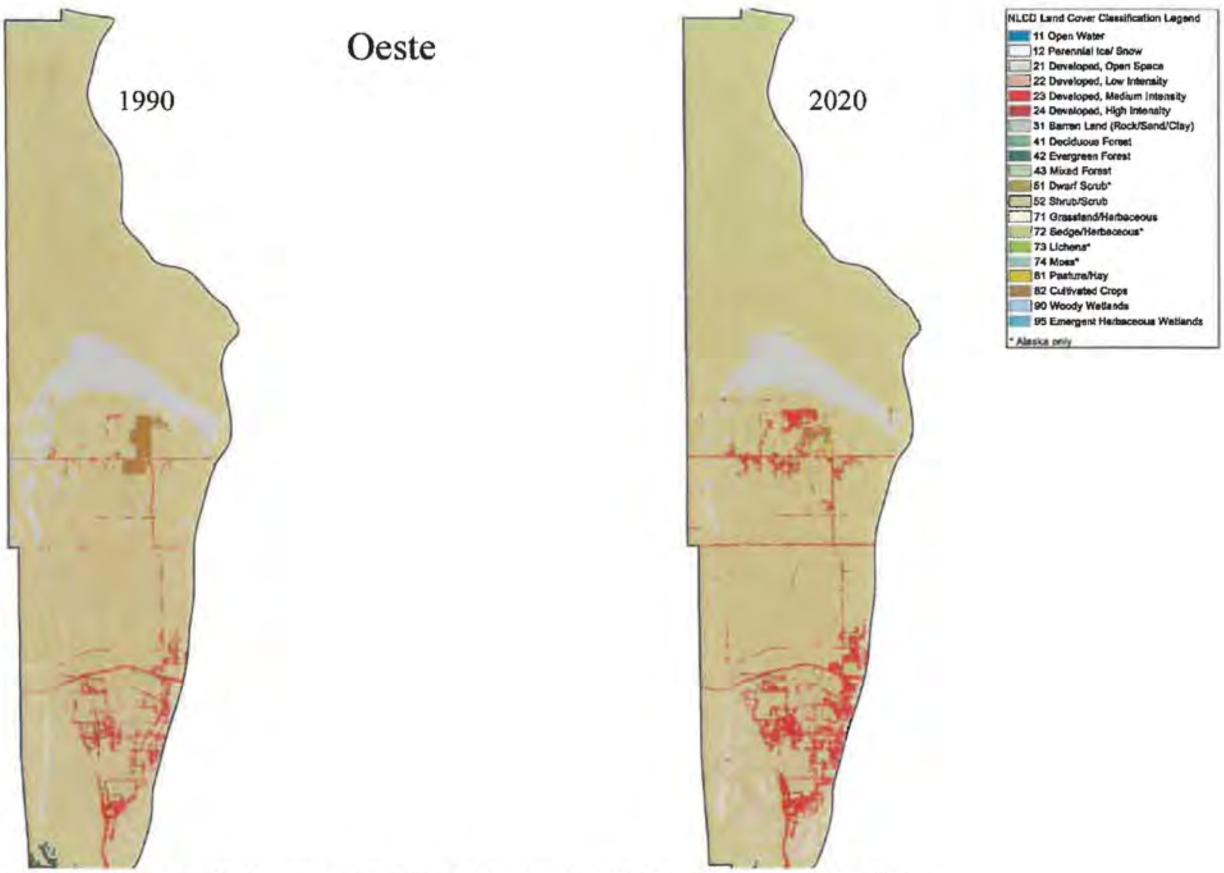

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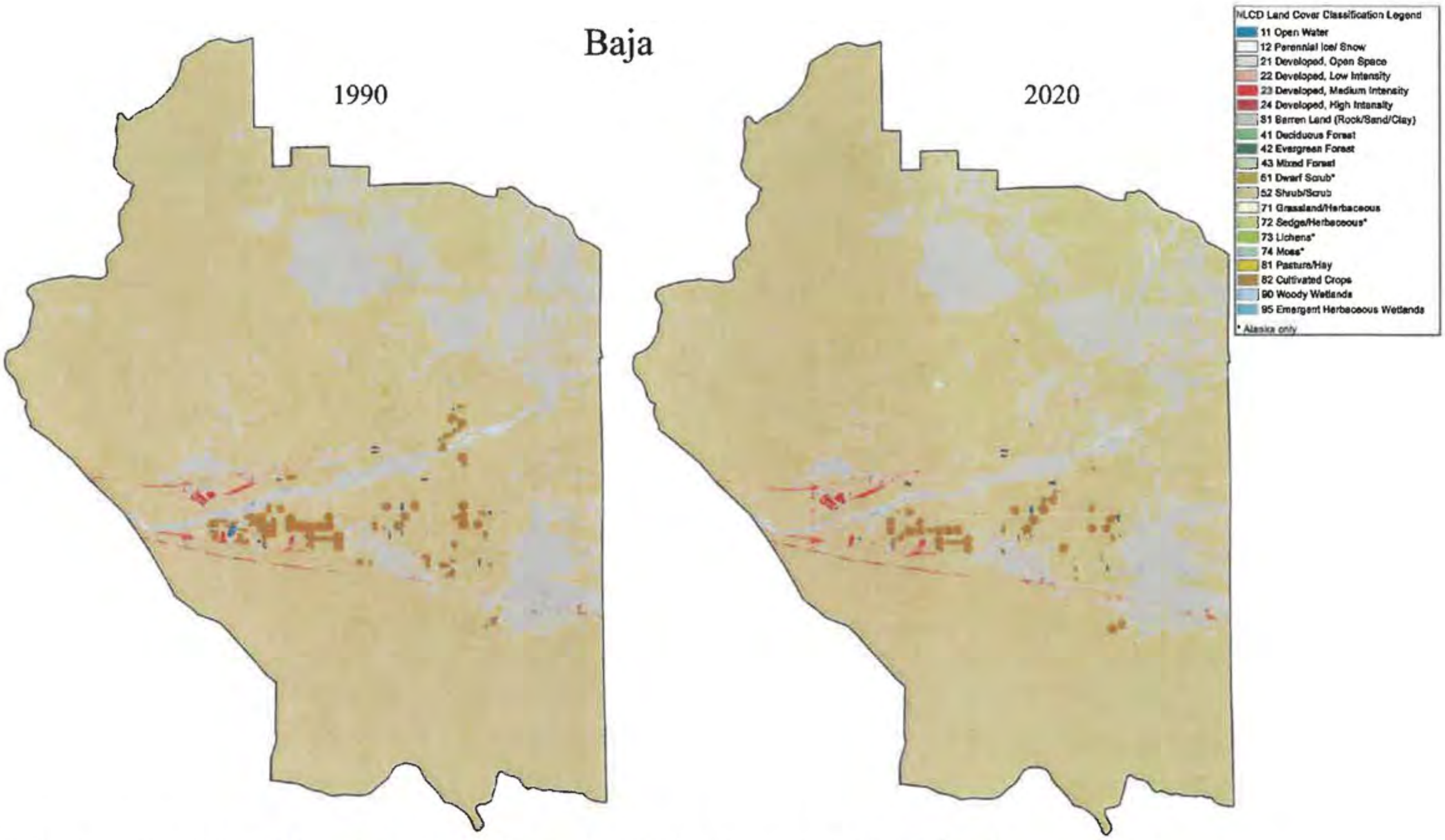
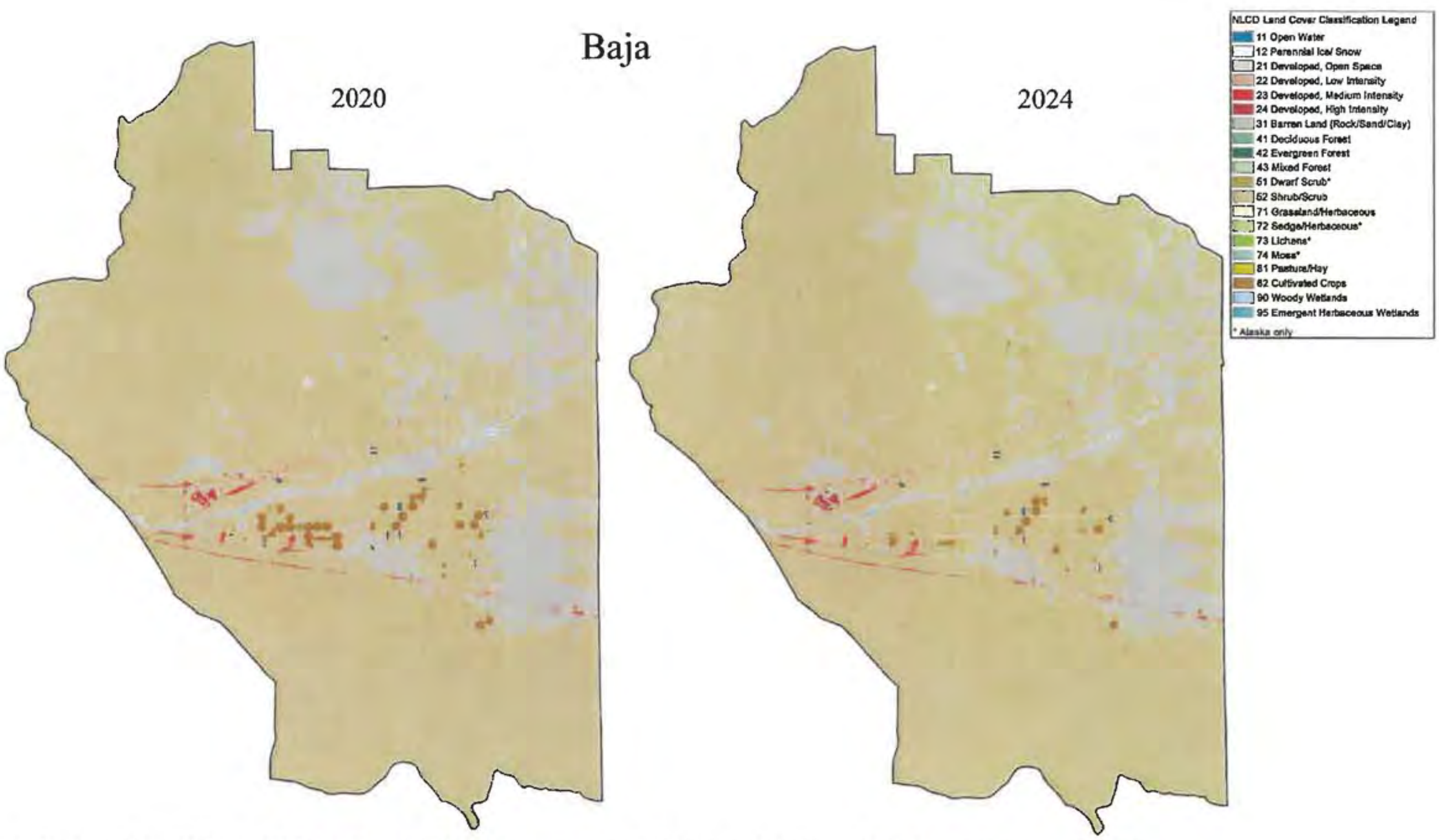


Annual National Land Cover Database (NLCD) by the U.S. Geological Survey (USGS)'s Land Cover program. Annual NLCD data was downloaded from the *Multi-Resolution Land Characteristics (*MRLC) site.

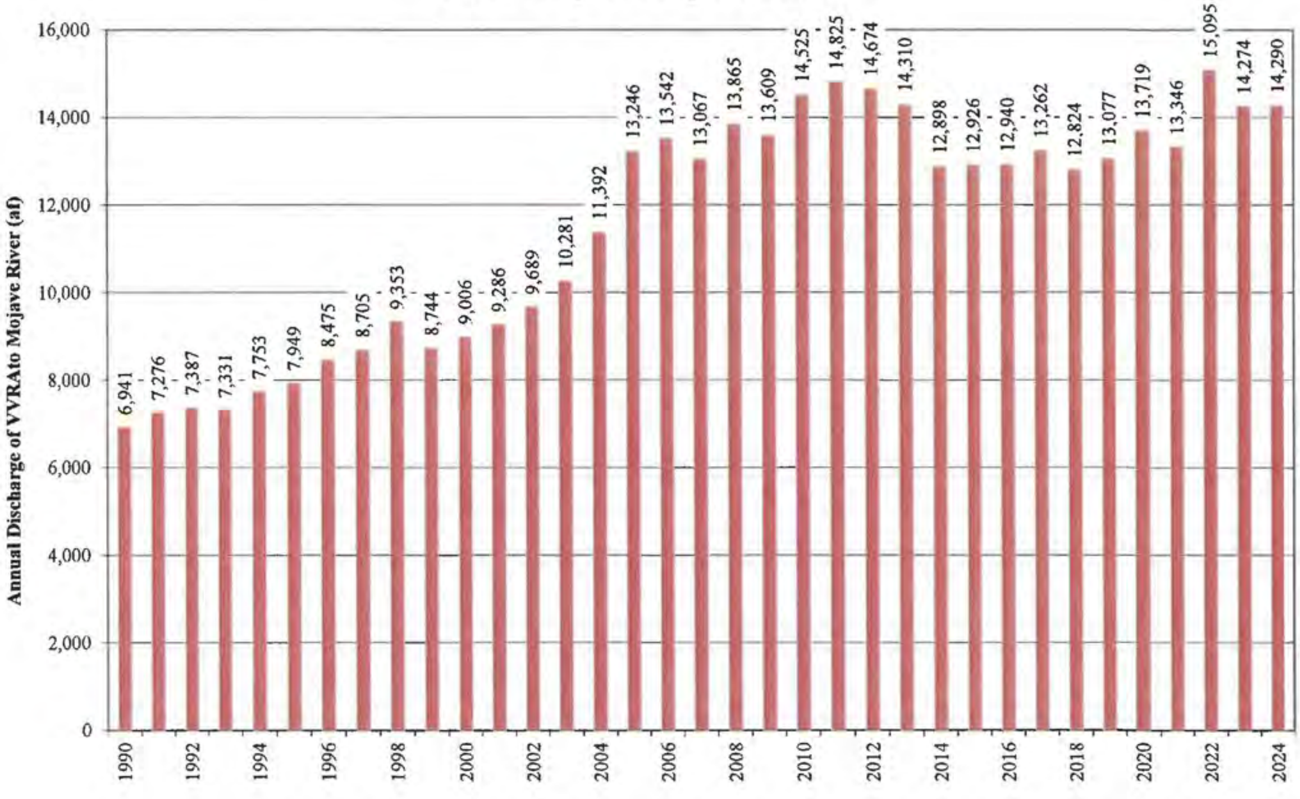


Annual National Land Cover Database (NLCD) by the U.S. Geological Survey (USGS)'s Land Cover program. Annual NLCD data was downloaded from the *Multi-Resolution Land Characteristics* (MRLC) site.

EXHIBIT D

11/7/2025

Annual Discharge of Victor Valley Wastewater Reclamation Authority to Mojave River



G:\MOJAVE WATERMASTER - 3040\Analysis\3040-225H-Mojave River Discharge (modified from 018x). VVWRA

EXHIBIT E

Mojave Basin Area

Estimated Water Production by Agricultural and Other Uses

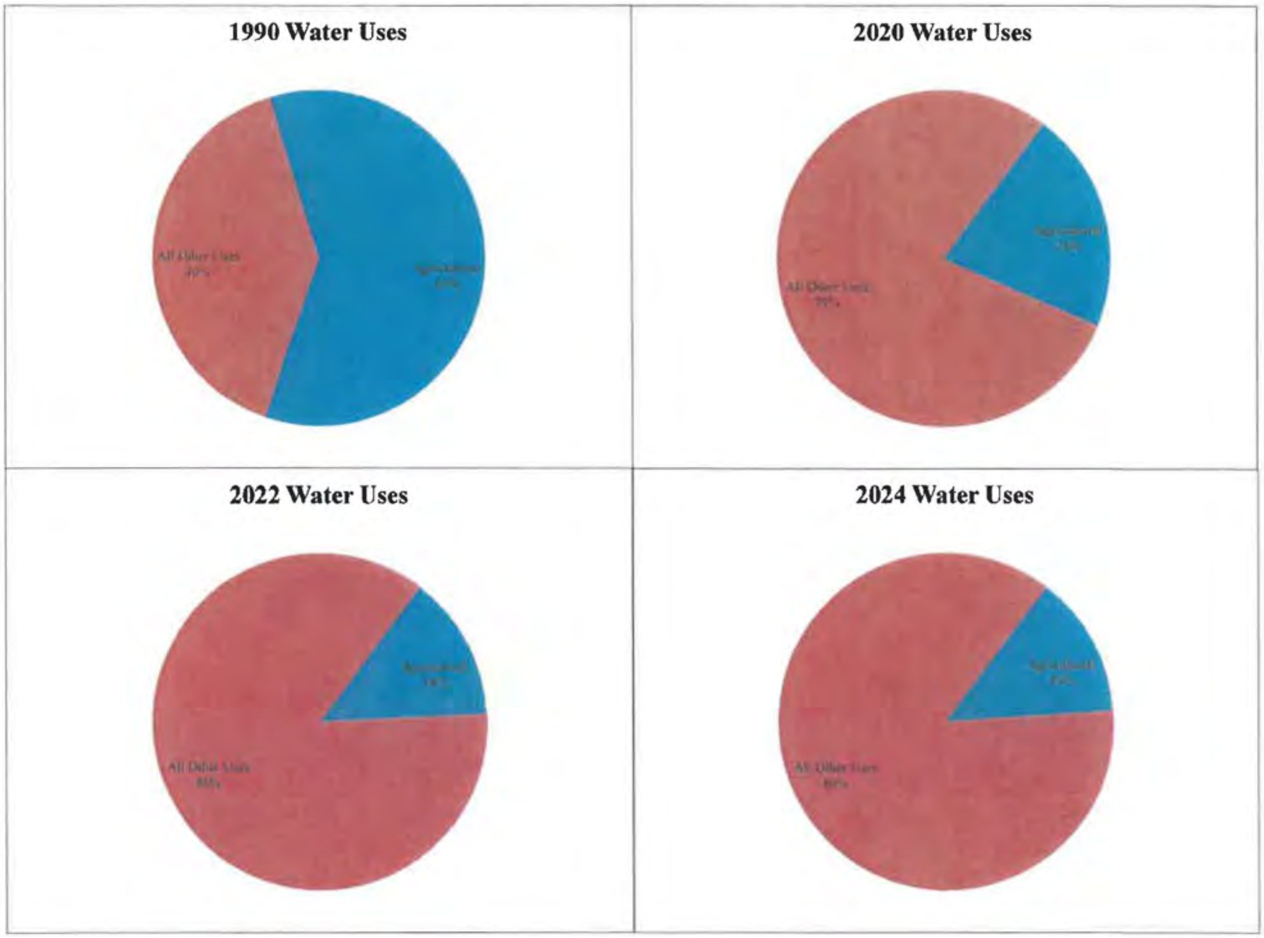


EXHIBIT F

Mojave Basin Area
Estimated Water Production by Type of Use
1994-95 Through 2023-24

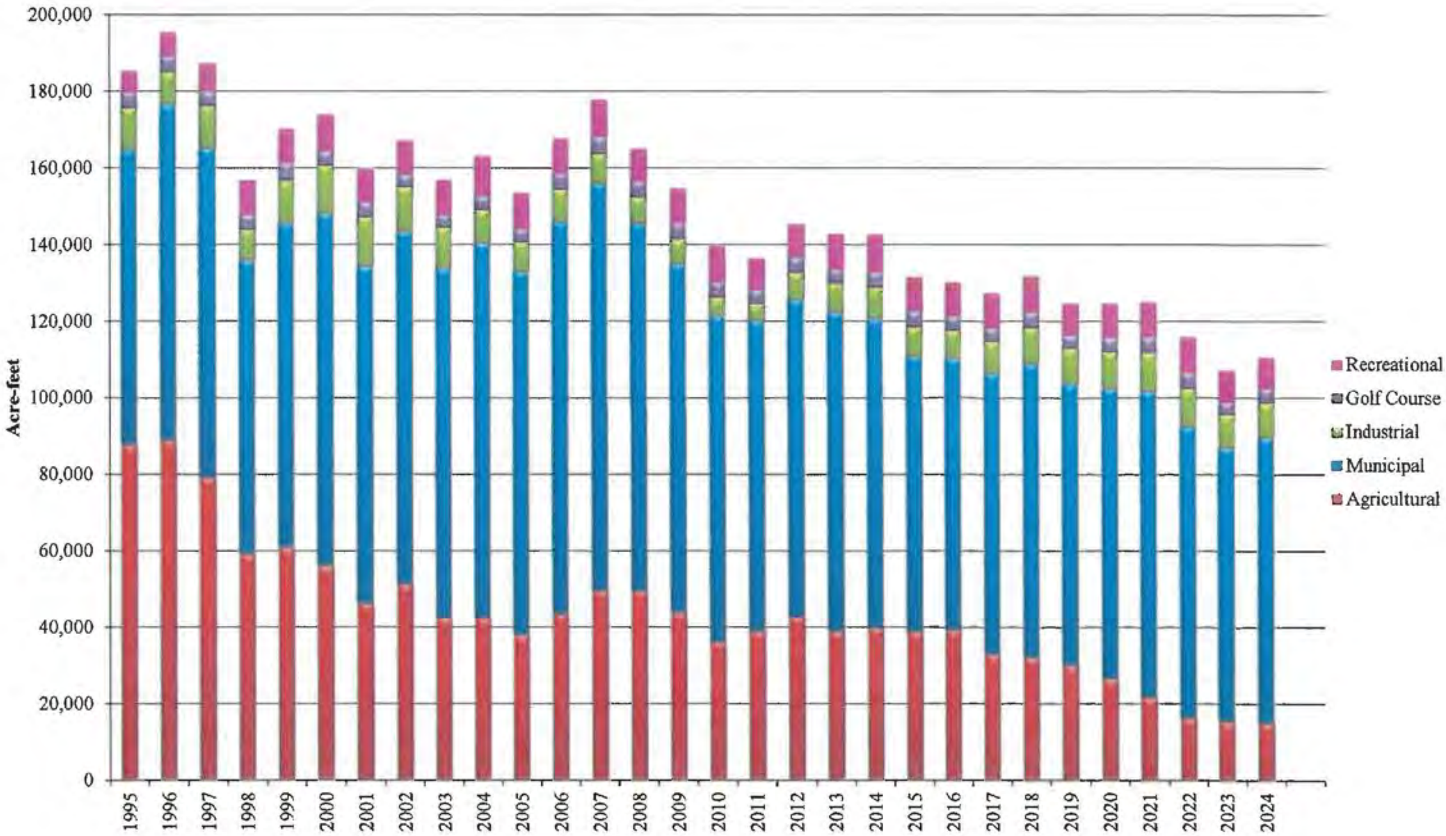


EXHIBIT G

Agricultural Water Production and Irrigated Acreage All Subareas

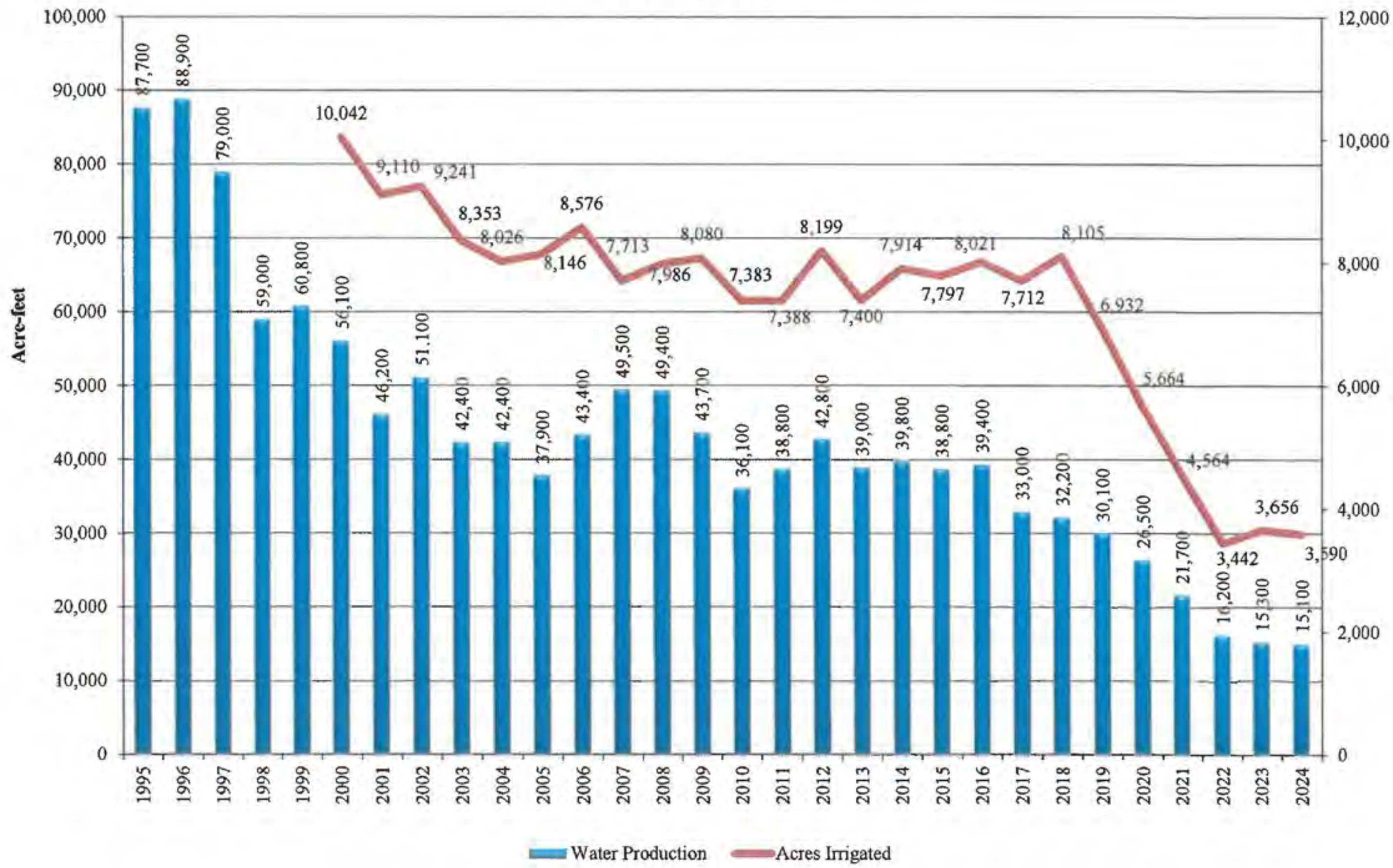
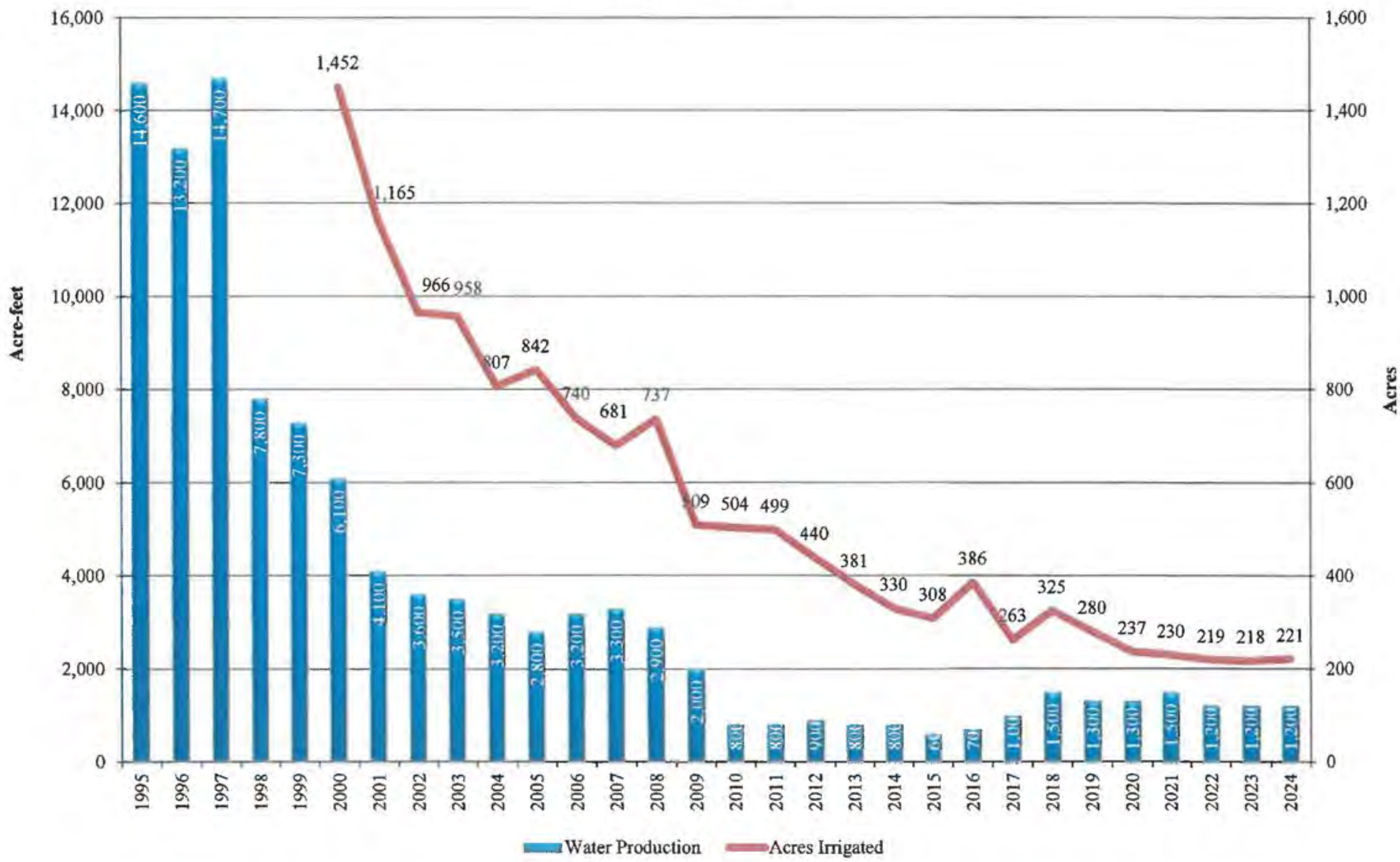
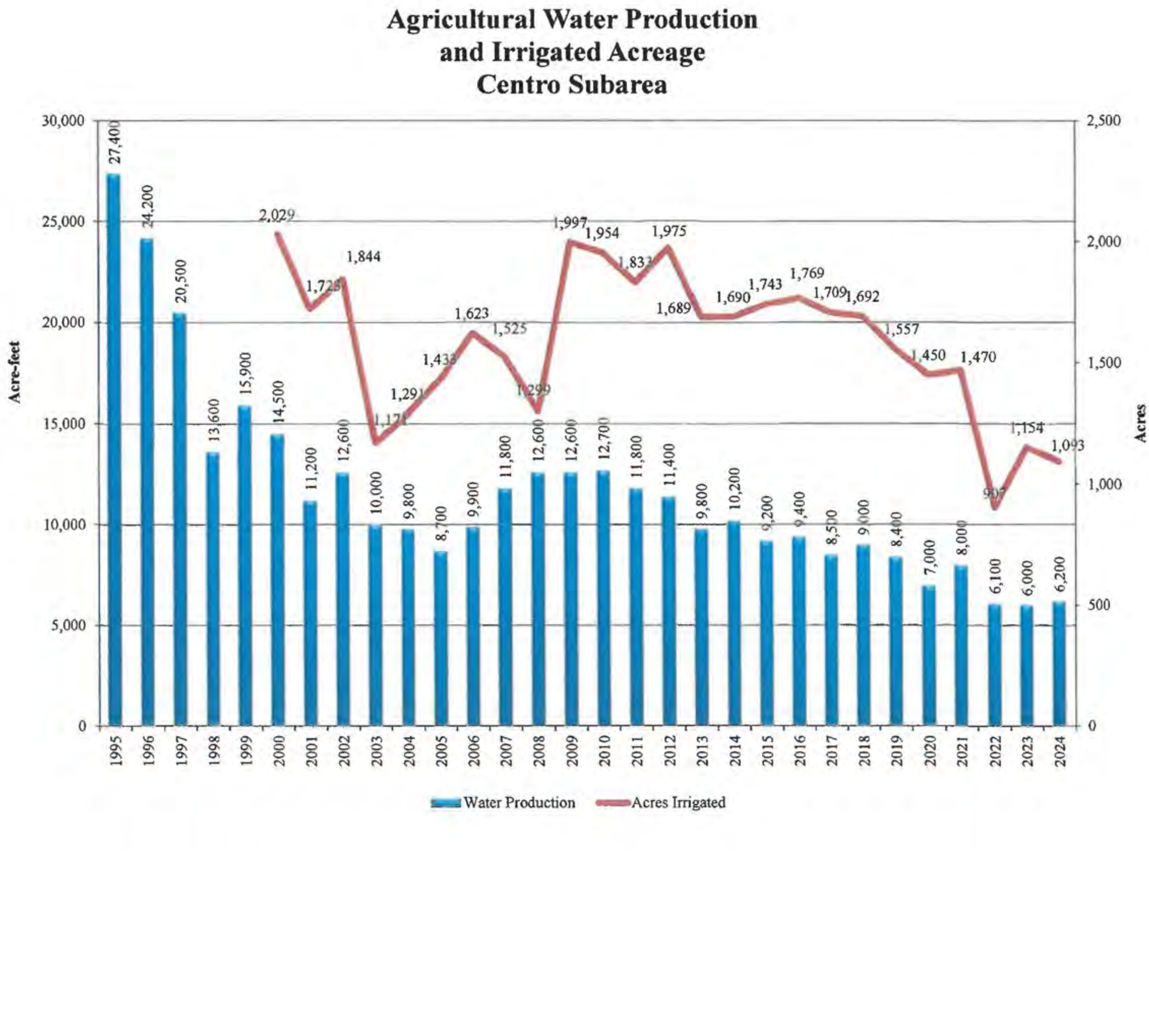


EXHIBIT H

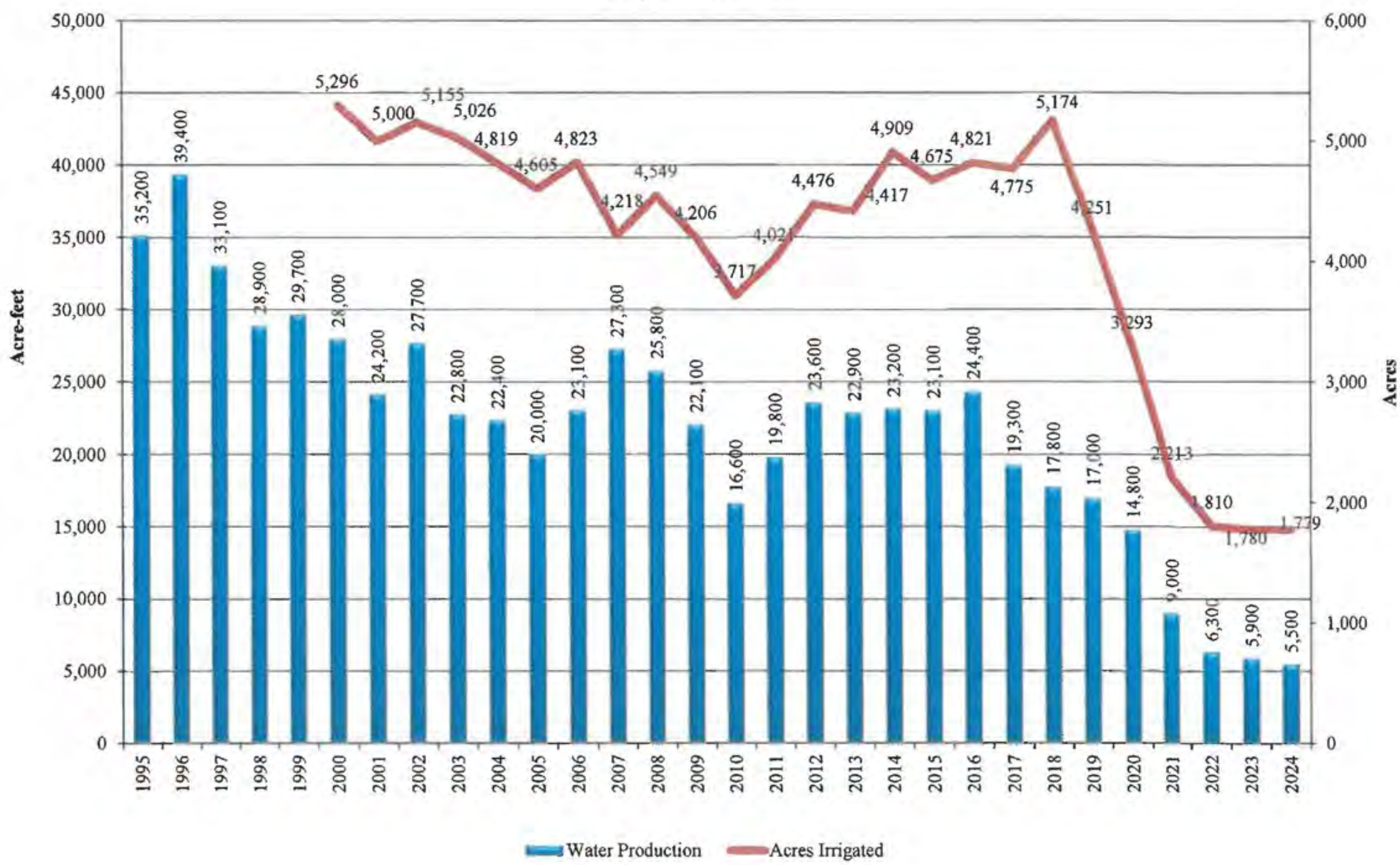
Agricultural Water Production and Irrigated Acreage Alto Subarea

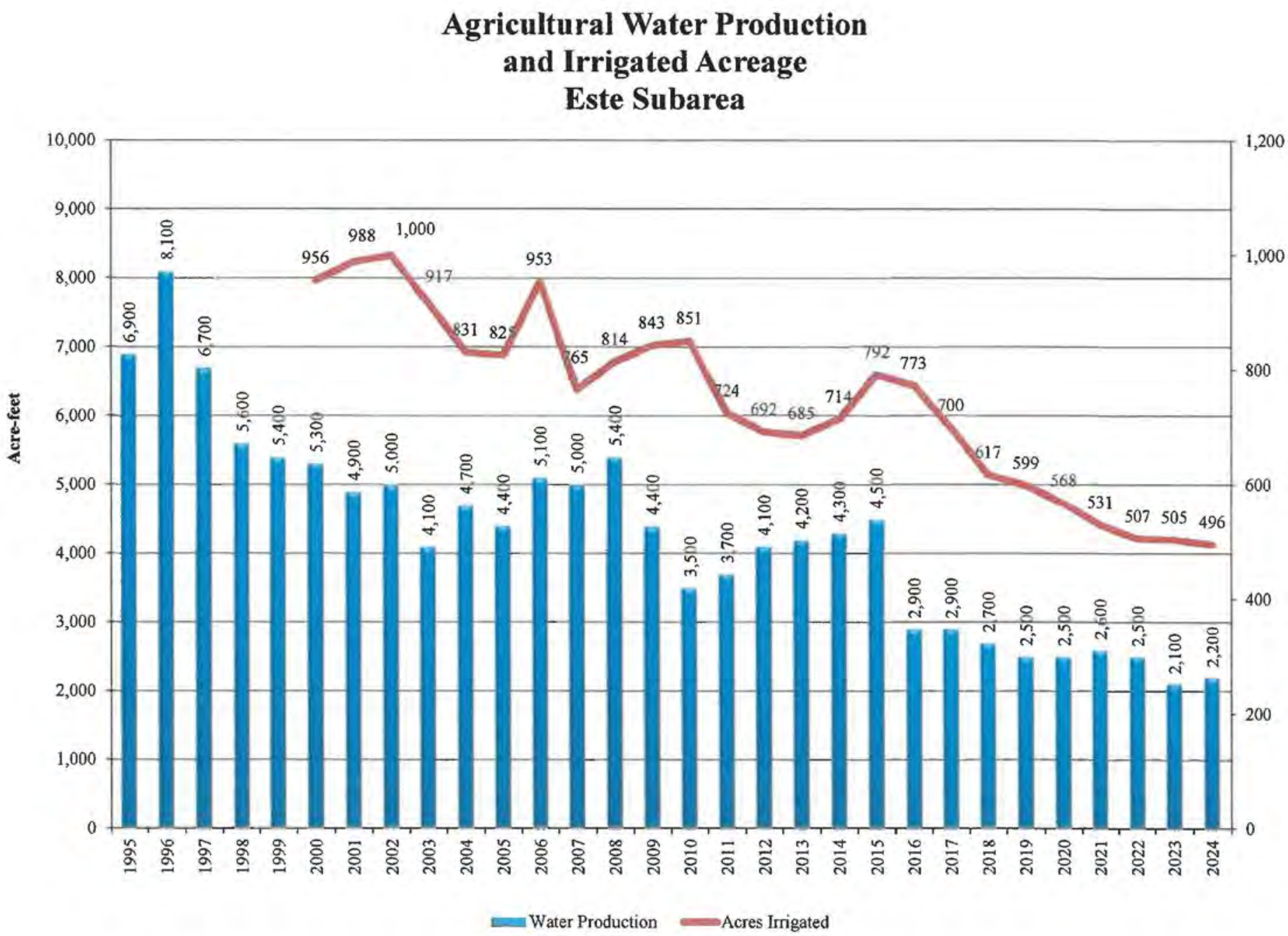


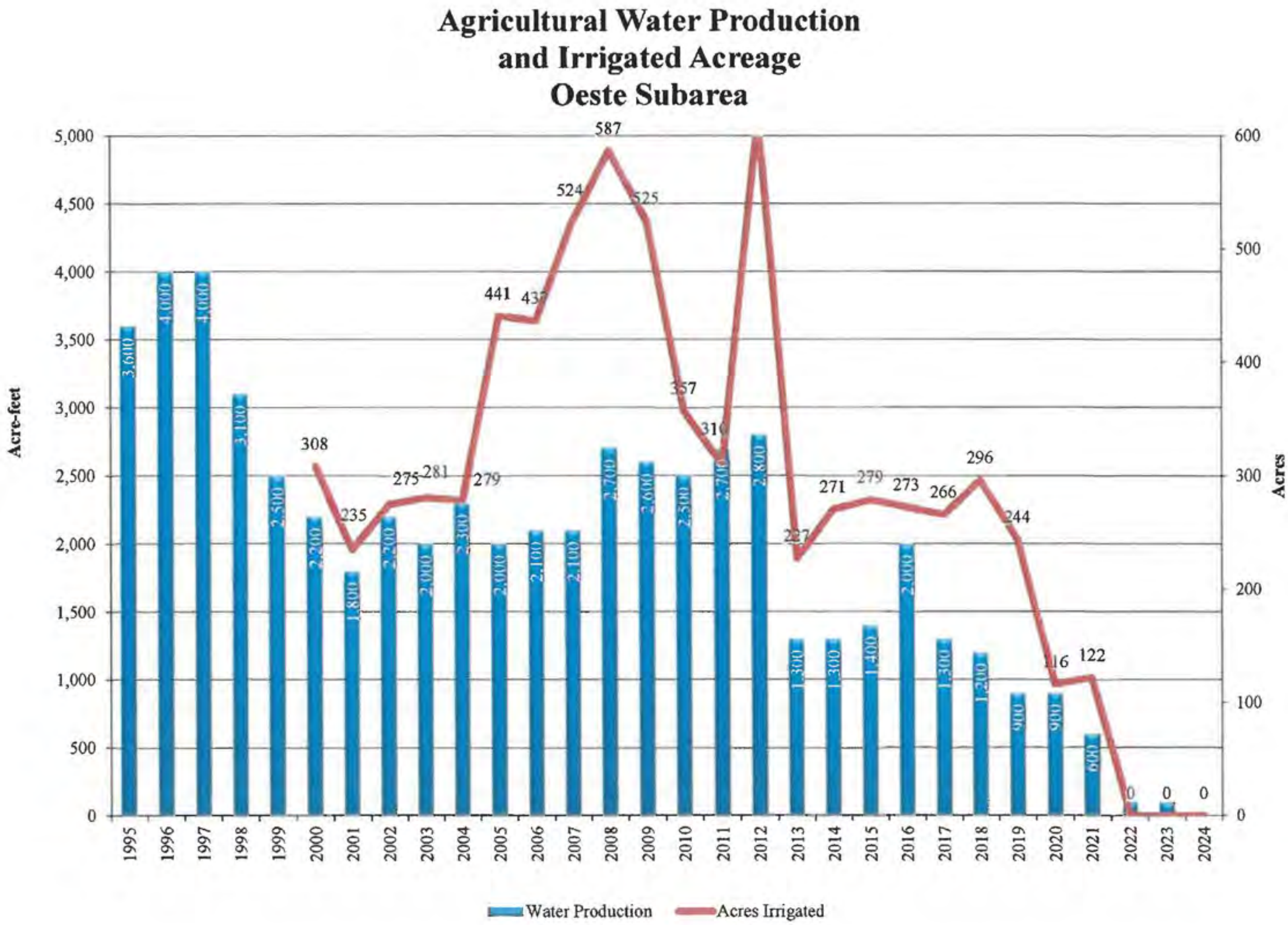


Agricultural Water Production
and Irrigated Acreage
Centro Subarea
Acre-feet
Acres
Water Production
Acres Irrigated

Agricultural Water Production and Irrigated Acreage Baja Subarea




Agricultural Water Production
and Irrigated Acreage
Este Subarea
Acre-feet
Acres
Water Production
Acres Irrigated

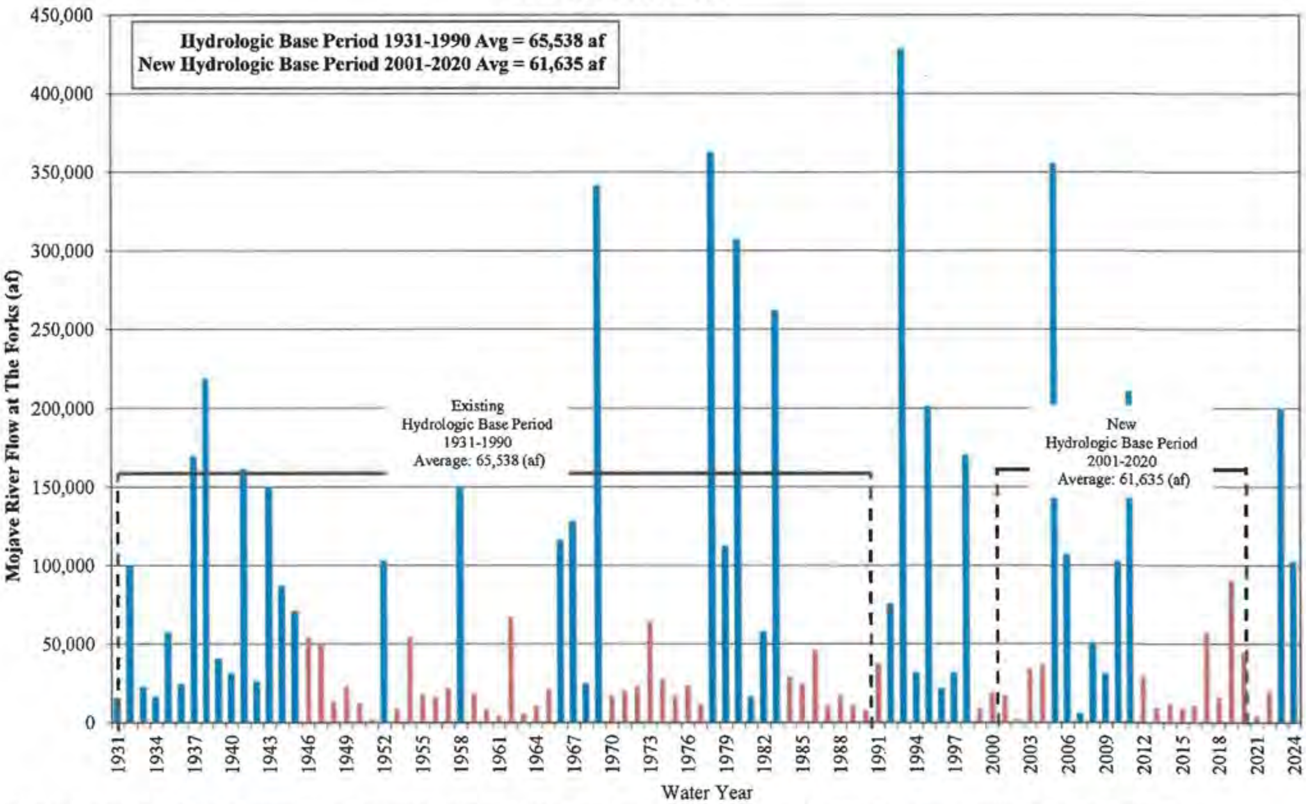


Agricultural Water Production
and Irrigated Acreage
Oeste Subarea
Acre-feet
Acres
Water Production
Acres Irrigated

EXHIBIT I

11/4/2025

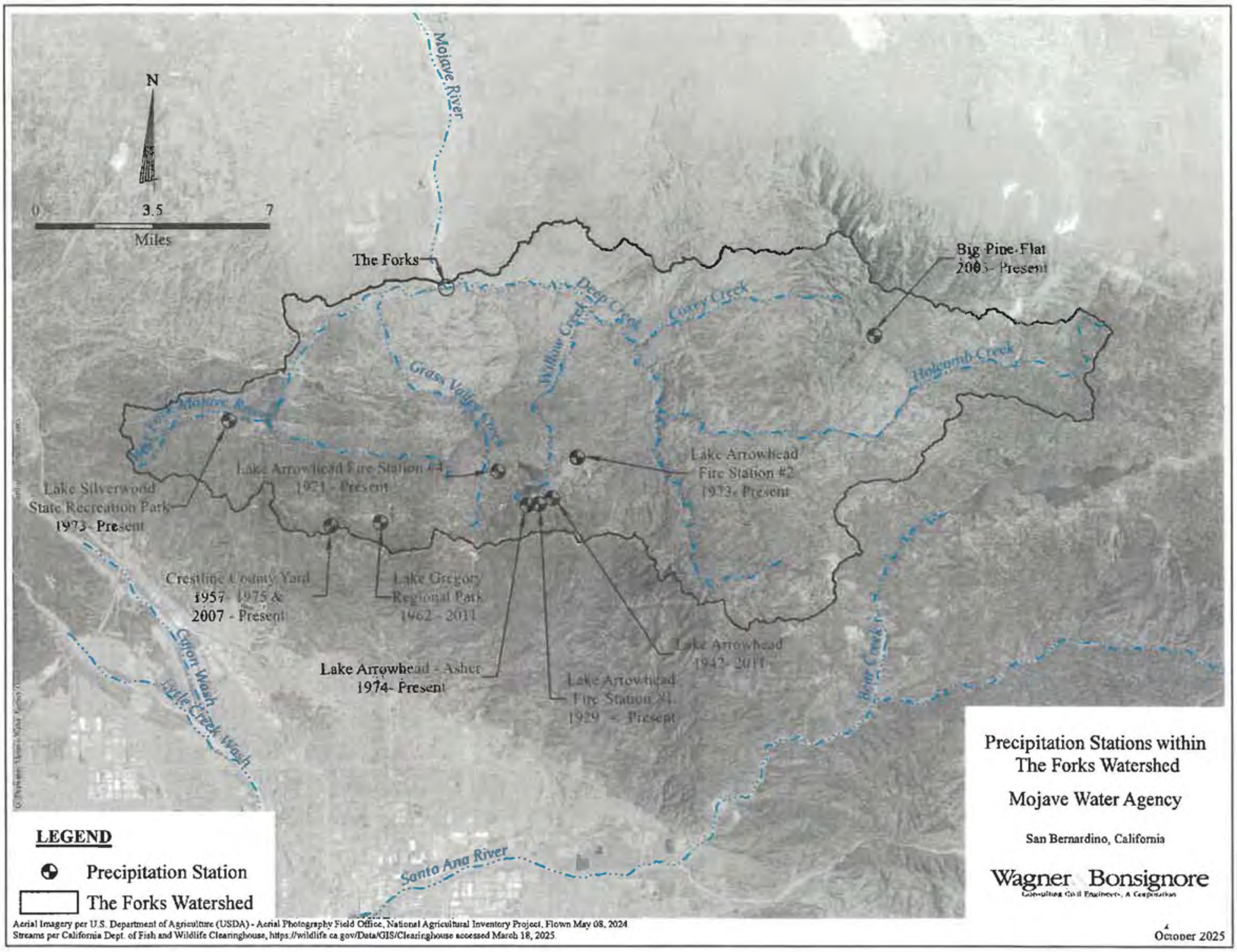
Mojave River Flow at The Forks
Water Years 1931 - 2024



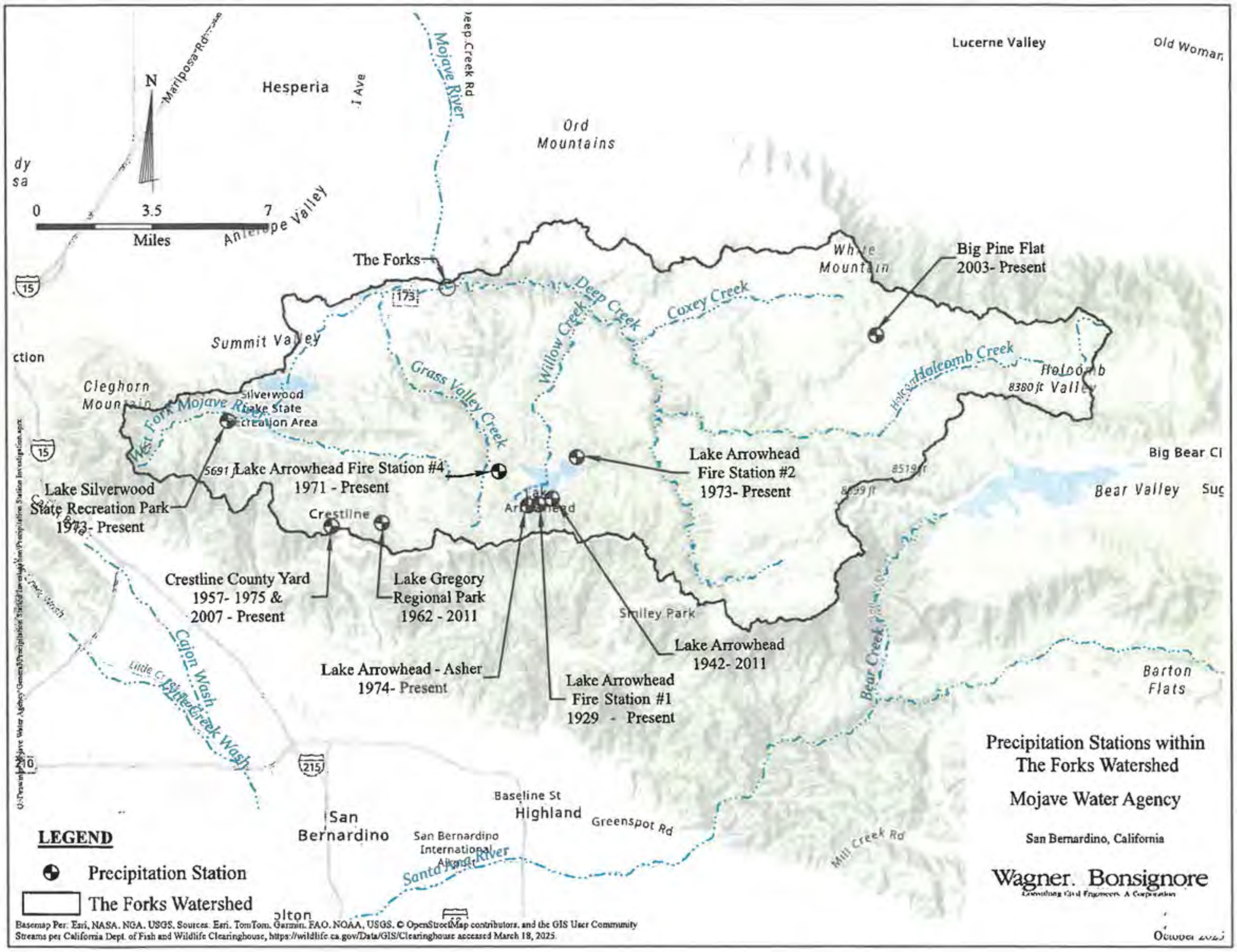
Note: Discharge of Mojave River at The Forks from the addition of values as reported from USGS stations at West Fork Mojave River Near Hesperia, CA (10261000), and Deep Creek Near Hesperia, CA (10260500) from 1931-1971, the greater of 10260500 and Mojave River Below Forks Reservoir Near Hesperia, CA (10261100) from 1972-1974, and the addition of West Fork Mojave River Above Mojave River Forks Reservoir Near Hesperia, CA (10260950) and 10260500 from 1975-Present

G. MOJAVE WATERMASTER - 3040 Analysis 3040-225H-Mojave River Discharge (modified from 018x). Forks Hydrograph FPA Motion

EXHIBIT J

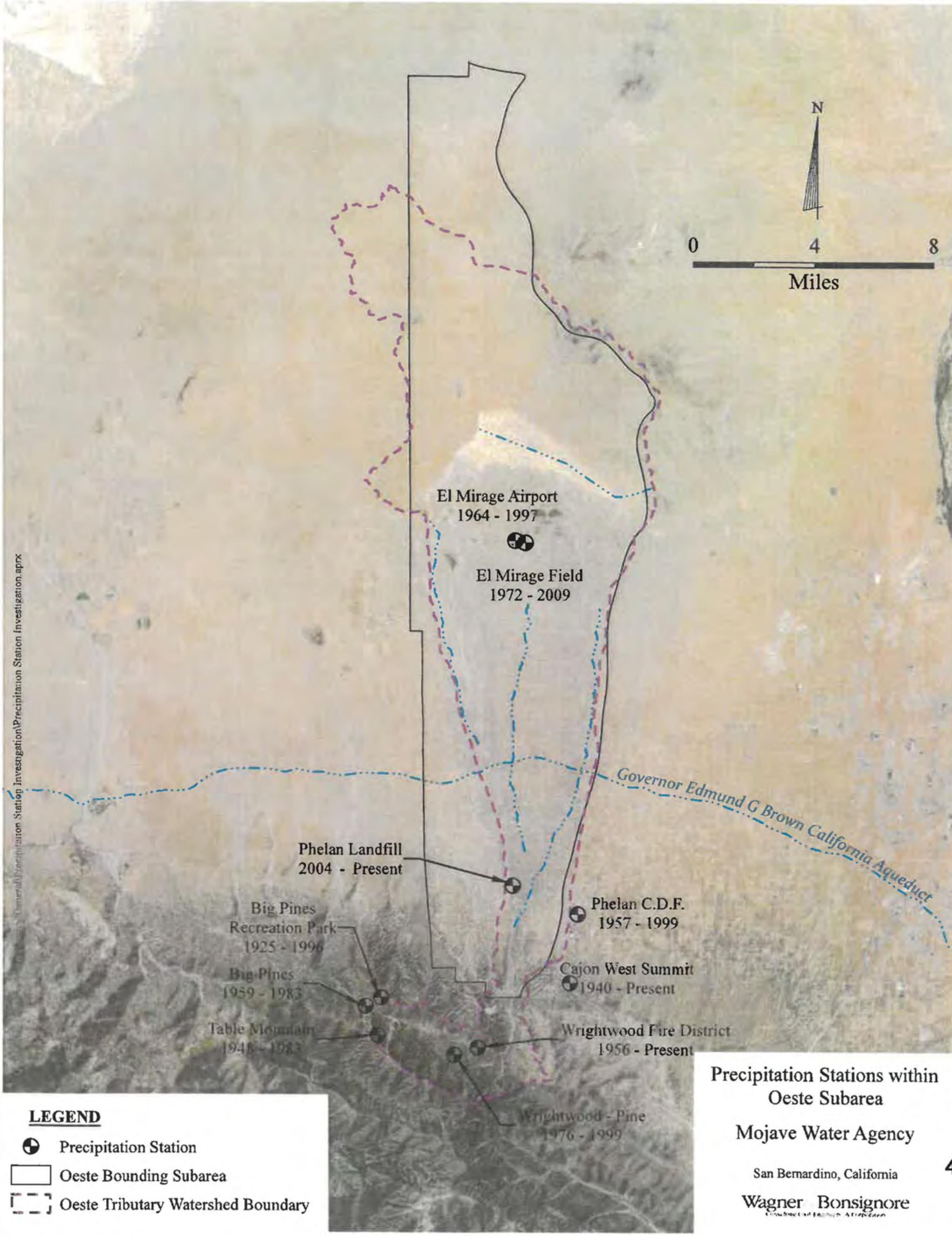


N
0
3.5
7
Miles
Mojave River
The Forks
Deep Creek
Coxey Creek
Willow Creek
Grass Valley Creek
Holcomb Creek
Big Pine Flat
Lake Silverwood
State Recreation Park
1973 - Present
Lake Arrowhead Fire Station #4
1921 - Present
Lake Arrowhead
Fire Station #2
1973 - Present
Crestline County Yard
1957 - 1975 &
2007 - Present
Lake Gregory
Regional Park
1962 - 2011
Lake Arrowhead - Asher
1974 - Present
Lake Arrowhead
Fire Station 91
1929 - Present
Lake Arrowhead
1942 - 2011
Cajon Wash
Lytle Creek Wash
Bear Creek
Santa Ana River
Precipitation Stations within
The Forks Watershed
Mojave Water Agency
San Bernardino, California
Wagner Bonsignore
LEGEND
Precipitation Station
The Forks Watershed
Aerial Imagery per U.S. Department of Agriculture (USDA) - Aerial Photography Field Office, National Agricultural Inventory Project, Flown May 08, 2024
Streams per California Dept. of Fish and Wildlife Clearinghouse, https://wildlife.ca.gov/Data/GIS/Clearinghouse accessed March 18, 2025
October 2025



Hesperia
Lucerne Valley
Old Woman
Ord Mountains
N
0
3.5
7
Miles
The Forks
Big Pine Flat
2003- Present
White Mountain
Summit Valley
Cleghorn Mountain
Silverwood Lake State Recreation Area
West Fork Mojave River
Grass Valley Creek
Willow Creek
Deep Creek
Coxey Creek
Holcomb Creek
Holcomb Valley
8380 ft
Lake Arrowhead Fire Station #4
1971 - Present
Lake Arrowhead
Fire Station #2
1973- Present
Big Bear City
Bear Valley
Lake Silverwood
State Recreation Park
1973- Present
Crestline
Crestline County Yard
1957- 1975 &
2007 - Present
Lake Gregory
Regional Park
1962 - 2011
Smiley Park
Lake Arrowhead
1942- 2011
Lake Arrowhead - Asher
1974- Present
Lake Arrowhead
Fire Station #1
1929 - Present
Cajon Wash
Bear Creek
Barton Flats
Precipitation Stations within
The Forks Watershed
Mojave Water Agency
San Bernardino, California
Wagner. Bonsignore
Baseline St
Highland
Greenspot Rd
San Bernardino
San Bernardino International Airport
Santa Ana River
Mill Creek Rd
LEGEND
Precipitation Station
The Forks Watershed
Basemap Per: Esri, NASA, NGA, USGS. Sources: Esri, TomTom, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community
Streams per California Dept. of Fish and Wildlife Clearinghouse, https://wildlife.ca.gov/Data/GIS/Clearinghouse accessed March 18, 2025.

EXHIBIT K



Precipitation Stations within Oeste Subarea

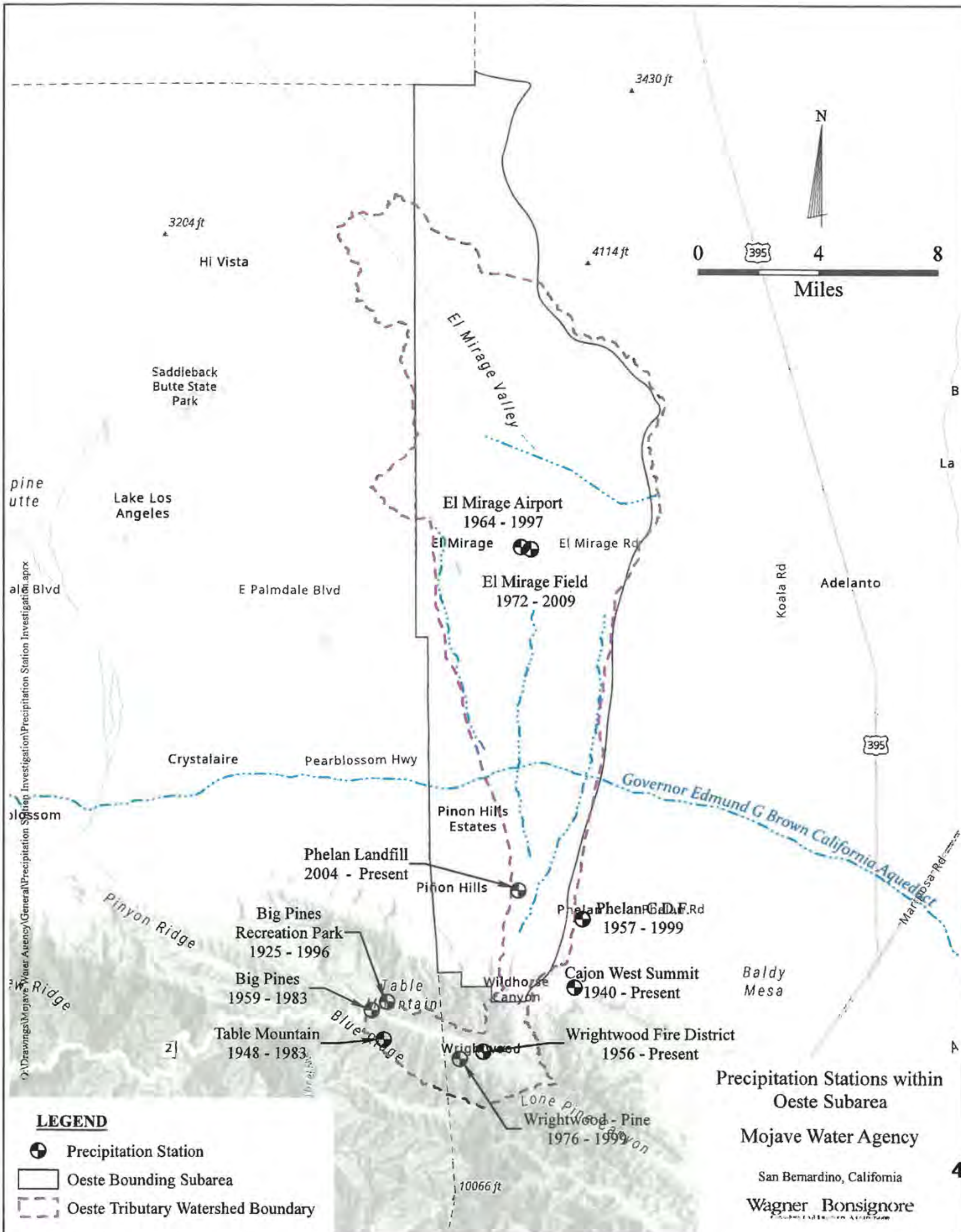
Mojave Water Agency

San Bernardino, California

Wagner Bonsignore

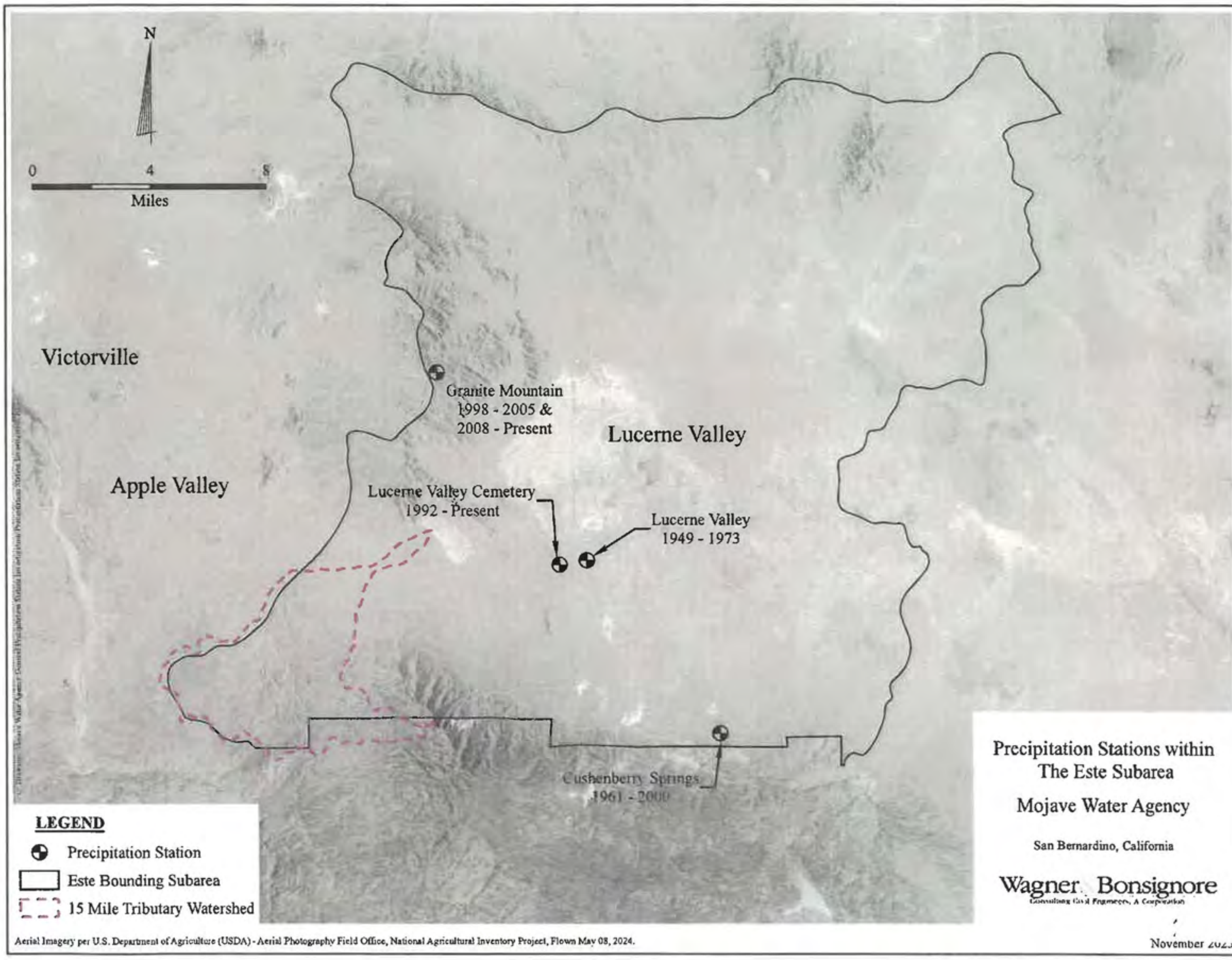
Basemap Per: Earthstar Geographics
Streams per California Dept. of Fish and Wildlife Clearinghouse, https://wildlife.ca.gov/Data/GIS/Clearinghouse accessed March 18, 2025.

October 2025



Basemap Per: Esri, NASA, NGA, USGS, Sources: Esri, TomTom, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community
Streams per California Dept. of Fish and Wildlife Clearinghouse, https://wildlife.ca.gov/Data/GIS/Clearinghouse accessed March 18, 2025.

EXHIBIT L



N
0
4
8
Miles
Victorville
Apple Valley
Lucerne Valley
Granite Mountain
1998 - 2005 &
2008 - Present
Lucerne Valley Cemetery
1992 - Present
Lucerne Valley
1949 - 1973
Cushenberry Springs
1961 - 2000
LEGEND
Precipitation Station
Este Bounding Subarea
15 Mile Tributary Watershed
Precipitation Stations within
The Este Subarea
Mojave Water Agency
San Bernardino, California
Wagner Bonsignore
Aerial Imagery per U.S. Department of Agriculture (USDA) - Aerial Photography Field Office, National Agricultural Inventory Project, Flown May 08, 2024.
November

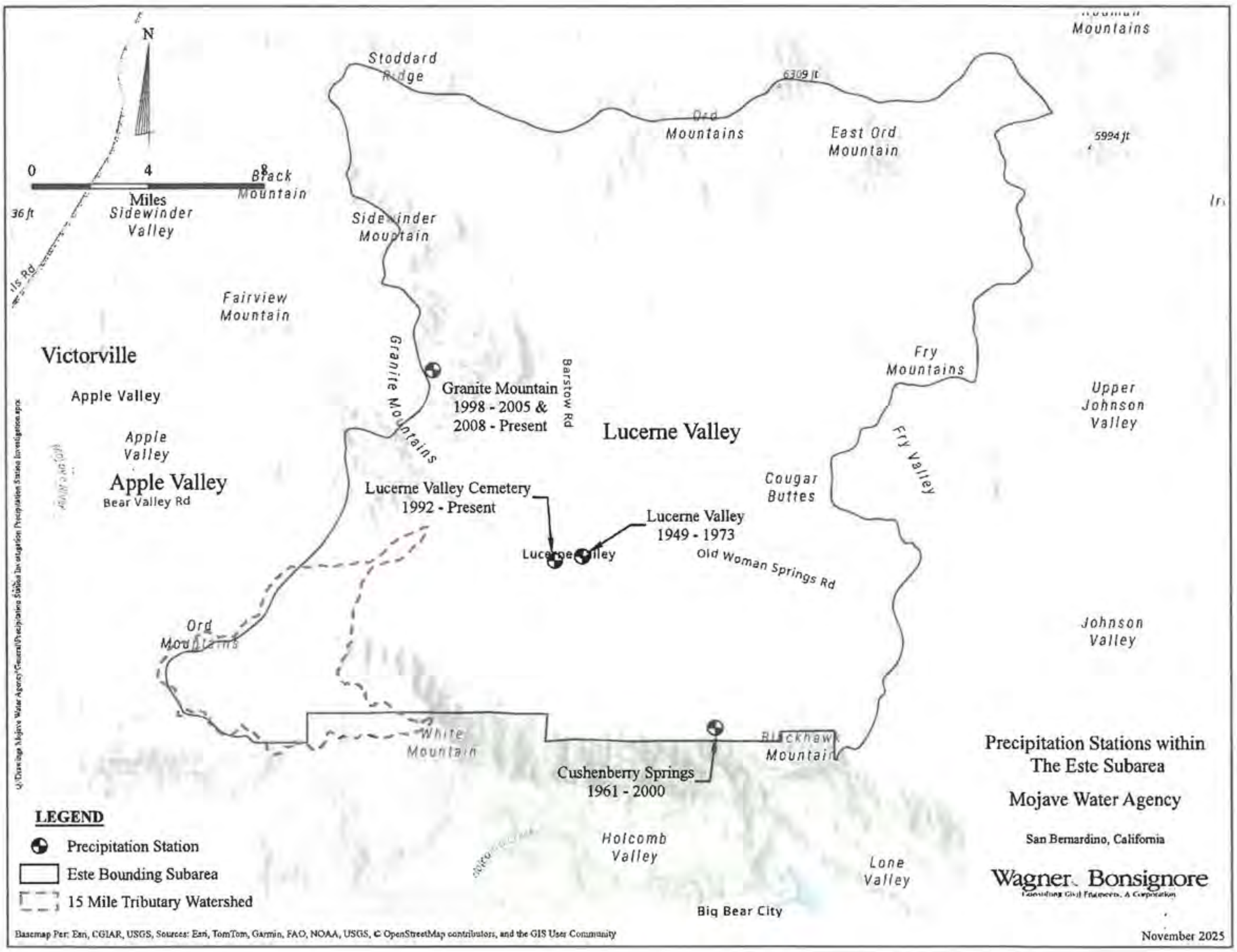
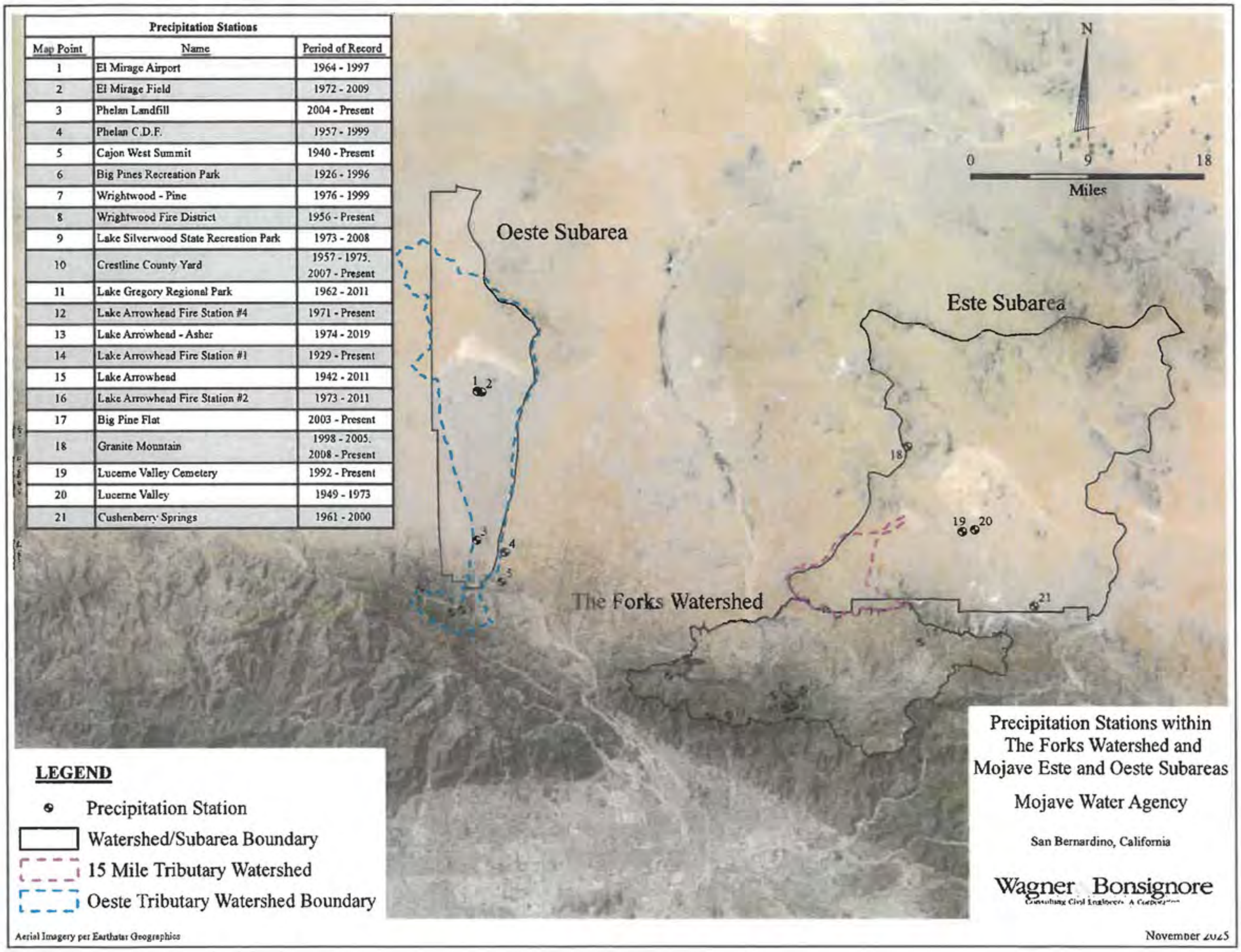

N
0
4
8
Miles
Stoddard Ridge
6309 ft
Ord Mountains
East Ord Mountain
Mountains
5994 ft
Black Mountain
Sidewinder Valley
Sidewinder Mountain
Fairview Mountain
Victorville
Apple Valley
Apple Valley
Apple Valley
Bear Valley Rd
Granite Mountains
Barstow Rd
Granite Mountain 1998 - 2005 & 2008 - Present
Lucerne Valley
Fry Mountains
Upper Johnson Valley
Fry Valley
Cougar Buttes
Lucerne Valley Cemetery 1992 - Present
Lucerne Valley 1949 - 1973
Old Woman Springs Rd
Johnson Valley
Ord Mountains
White Mountain
Blackhawk Mountain
Cushenberry Springs 1961 - 2000
Holcomb Valley
Lone Valley
Big Bear City
LEGEND
Precipitation Station
Este Bounding Subarea
15 Mile Tributary Watershed
Precipitation Stations within The Este Subarea
Mojave Water Agency
San Bernardino, California
Wagner & Bonsignore
Consulting Civil Engineers, A Corporation
Basemap Per: Esri, CGIAR, USGS, Sources: Esri, TomTom, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community
November 2025

EXHIBIT M



Precipitation Stations		
Map Point	Name	Period of Record
1	El Mirage Airport	1964 - 1997
2	El Mirage Field	1972 - 2009
3	Phelan Landfill	2004 - Present
4	Phelan C.D.F.	1957 - 1999
5	Cajon West Summit	1940 - Present
6	Big Pines Recreation Park	1926 - 1996
7	Wrightwood - Pine	1976 - 1999
8	Wrightwood Fire District	1956 - Present
9	Lake Silverwood State Recreation Park	1973 - 2008
10	Crestline County Yard	1957 - 1975, 2007 - Present
11	Lake Gregory Regional Park	1962 - 2011
12	Lake Arrowhead Fire Station #4	1971 - Present
13	Lake Arrowhead - Asher	1974 - 2019
14	Lake Arrowhead Fire Station #1	1929 - Present
15	Lake Arrowhead	1942 - 2011
16	Lake Arrowhead Fire Station #2	1973 - 2011
17	Big Pine Flat	2003 - Present
18	Granite Mountain	1998 - 2005, 2008 - Present
19	Lucerne Valley Cemetery	1992 - Present
20	Lucerne Valley	1949 - 1973
21	Cushenberry Springs	1961 - 2000


Precipitation Stations

Map Point	Name	Period of Record
1	El Mirage Airport	1964 - 1997
2	El Mirage Field	1972 - 2009
3	Phelan Landfill	2004 - Present
4	Phelan C.D.F.	1957 - 1999
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10	Crestline County Yard	1957 - 1975, 2007 - Present
11	Lake Gregory Regional Park	1962 - 2011
12	Lake Arrowhead Fire Station #4	1971 - Present
13	Lake Arrowhead - Asher	1974 - 2019
14	Lake Arrowhead Fire Station #1	1929 - Present
15	Lake Arrowhead	1942 - 2011
16	Lake Arrowhead Fire Station #2	1973 - 2011
17	Big Pine Flat	2003 - Present
18	Granite Mountain	1998 - 2005, 2008 - Present
19	Lucerne Valley Cemetery	1992 - Present
20	Lucerne Valley	1949 - 1973
21	Cushenberry Springs	1961 - 2000

Boron
Calico Mountains
N
Barstow
Mojave Valley
Marine Corps Logistics Base Barstow
9
18
Miles
Iron Mountain
Newberry Mountains
Oeste Subarea
395
Brisbane Valley
Rodman Mountains
Este Subarea
6309 ft
Ord Mountains
Sidewinder Valley
Granite Mountains
Adelanto
Victorville
Apple Valley
Fry Mountains
Hesperia
Baldy Mesa
Wrightwood
The Forks Watershed
173
18
N3
San Gabriel Mountains
10066 ft
15
Crestline
Lake Arrowhead
La Cañada Flintridge
Rancho Cucamonga
Fontana
Rialto
San Bernardino
Ontario
Pomona
Redlands
Grand Terrace
Yucaipa
LEGEND
Precipitation Station
Watershed/Subarea Boundary
15 Mile Tributary Watershed
Oeste Tributary Watershed Boundary
Precipitation Stations within The Forks Watershed and Mojave Este and Oeste Subareas
Mojave Water Agency
San Bernardino, California
Wagner Bonsignore
Aerial Imagery per Sources: Esri, TomTom, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community, Esri, USGS
November 2025

PROOF OF SERVICE

STATE OF CALIFORNIA }
COUNTY OF SAN BERNARDINO}

I am employed in the County of the San Bernardino, State of California. I am over the age of 18 and not a party to the within action; my business address is 13846 Conference Center Drive, Apple Valley, California 92307.

On November 12, 2025, the document(s) described below were served pursuant to the Mojave Basin Area Watermaster's Rules and Regulations paragraph 8.B.2 which provides for service by electronic mail upon election by the Party or paragraph 10.D, which provides that Watermaster shall mail a postcard describing each document being served, to each Party or its designee according to the official service list, a copy of which is attached hereto, and which shall be maintained by the Mojave Basin Area Watermaster pursuant to Paragraph 37 of the Judgment. Served documents will be posted to and maintained on the Mojave Water Agency's internet website for printing and/or download by Parties wishing to do so.

Document(s) filed with the court and served herein are described as follows:

WATERMASTER ENGINEER'S STATEMENT OF REASONS FOR RECOMMEDING 2001-2020 BASE PERIOD

_X_ (STATE) I declare under penalty of perjury under the laws of the State of California that the above is true and correct.

Executed on November 12, 2025 at Apple Valley, California.

Jeffrey D. Ruesch

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Attn: Jessie Florez
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Apple Valley Unified School District
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Brommer House Trust
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Attn: Paul Johnson
Brown Family Trust Dated August 11, 1999
26776 Vista Road
Helendale, CA 92342-9789

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CDFW - Mojave Narrows Regional Park
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Gabrych Family Trust dated October 9, 2007
2006 Old Highway 395
Fallbrook, CA 92028

Gabrych Family Trust dated October 9, 2007
2006 Old Highway 395
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Gaeta, Miguel and Maria
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Attn: Jay Storer
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(Matthew.wood@martinmarietta.com)
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Hass, Pauline L.
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EXHIBIT B

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Subject: Questions and Comments for Watermaster's December 12, 2025, Proposed Hydrologic Base Period Change Workshop

Dear Watermaster Board, Engineer, and staff,

As you are aware, the California Department of Fish and Wildlife (CDFW) is the trustee agency for the state's fish and wildlife resources and is a party to the January 10, 1996, Judgment After Trial (Judgment). CDFW is also a landowner in two of the Judgment's five Subareas, Baja and Alto. In the Baja Subarea, CDFW owns the Camp Cady Wildlife Area (Camp Cady) and in the Alto Subarea, it owns the Mojave Narrows Regional Park and Mojave River Fish Hatchery. CDFW worked closely with the parties on developing the Judgment and its Exhibit H, which among other things establishes shallow groundwater level criteria necessary to maintain and protect sensitive riparian resources and species (i.e., public trust resources) associated with the Mojave River system.

CDFW has followed the topic of the hydrologic base period with interest since the Court's September 2022 Order directing Watermaster to re-evaluate Production Safe Yield (PSY) in all Subareas and to address the appropriateness of continued reliance on the initial 60-year hydrologic base period of 1931-1990. CDFW has thus reviewed and provided extensive comments on Watermaster's 2024 PSY and Consumptive Use Update, Watermaster's Water Year 2024-25 and 2025-26 Free Production Allowance (FPA) recommendations, and Watermaster's recent "Motion for Determination of Hydrologic Base Period for Production Safe Yield Calculations" (Motion) and supporting Reply Brief. CDFW has also reviewed the "Watermaster Engineer's Statement of Reasons for Recommending the 2001-2020 Base Period" (Statement of Reasons) filed on November 12, 2025.

Despite this extensive review and comment process, significant questions remain on the appropriateness of Watermaster's proposed 2001-2020 hydrologic base period, including whether a change in the current 60-year period is even necessary. To support a productive dialog towards continued implementation of the Physical Solution, CDFW respectfully submits the following questions and comments for Watermaster to address and respond to at its December 12, 2025, base period workshop (Workshop).

WORKSHOP QUESTIONS

1. Quantitatively, how would Watermaster use a different hydrologic base period to improve PSY or FPA estimates for each of the Judgment's Subareas? Please include details on each component of those calculations.

2. Is the proposed hydrologic base period change intended to address climate variations or cultural condition changes? Please provide the technical basis for this distinction.

3. Why is Watermaster presenting the hydrologic base period change as an urgent issue now, for the first time since the entry of the Judgment, when so much is yet unknown? What information is Watermaster relying upon at this time to quantify changes in water supply in each Subarea under the proposed 2001-2020 hydrologic base period relative to the current 1931-1990 hydrologic base period?

    a) Watermaster Engineer states that there is insufficient information to evaluate the water balance in Baja (and other Subareas). (Statement of Reasons, p. 14.) However, there is presently a numerical model in development that purportedly addresses, among other things, water supply for each Subarea. Why not wait to consider a hydrologic base period change when there is adequate information to evaluate water supply in the proposed base period across each Subarea?

    b) Watermaster Engineer states, "Once the hydrologic base period is set, there is no reason to reset it every year, or at any other time unless the conditions upon which it is based change significantly." (Statement of Reasons, p. 12.) However, the Motion concluded that the new model "may suggest a different hydrologic base period for the entire Basin, or even for certain Subareas . . . ." (Motion, p. 6). With the model anticipated in the next year, why not wait for it to be completed, reviewed, and accepted?

    c) Watermaster Engineer has concluded that the proposed base period is 6% drier at the Forks, however this assessment of water supply in the proposed base period is only applicable to the Alto Subarea. How will Watermaster address data deficiencies, when that information is needed to present reliable Subarea water balances (i.e., Table 5-1/ Exhibit C Table C-1) in future PSY calculations using the current or proposed base periods?

4. The Court's September 2022 order required Watermaster to re-evaluate PSY <u>in all Subareas</u>, with specific directions to re-evaluate <u>changes in water supply</u>. Notably, the Court did not order the base period to be changed, just for PSY to be re-evaluated in light of more recent water supply information. As noted above, Watermaster Engineer has since stated that there is not adequate information on

water supply for the Baja Subarea to complete the PSY calculation using the water balance method required by the Judgment.

a) How can stakeholders and interested parties evaluate the impact of the proposed hydrologic base period change on water supply, when no data have been provided for the Subareas other than Alto?

b) How does Watermaster Engineer intend to address these apparent data deficiencies and the PSY determination for Baja going forward?

5. In the September 2022 order, the Court inquired, "At the very least, should not the past 32 years of data be added to the original 60 years?"[1] Did Watermaster consider this extended base period concept? If so, what is the difference in water supply to each Subarea under the extended base period suggested by the Court relative to the current base period?

6. The Department of Water Resources' (DWR) "Handbook for Water Budget Development" (DWR 2020) notes that "selecting a relatively long period for water budget analysis is more likely to include a wide range of hydrological conditions and system responses" and where there has been chronic overdraft it may be necessary for the base period to "capture a time period before overdraft was occurring. Identifying those key, non-overdraft time periods and corresponding water budgets is important for the identification of future water management objectives and actions." (DWR 2020, p. 29).

a) Has consideration been given to using a hydrologic base period that would capture pre-overdraft conditions, ramp down, and more recent data?

b) There can be significant lag time between changes in pumping, depletions, and observed impacts to the larger system. Does the shorter proposed hydrologic base period adequately capture the variation in pumping over time, depletions that can be delayed by many years, and the resulting hydrologic conditions?

7. What is the relationship between cultural conditions in a hydrologic base period and the single year used by Watermaster to represent pumping and consumptive uses?

8. The Mojave River and associated vegetation communities have changed significantly in the past 25 years, including losses of groundwater dependent vegetation in the Baja Subarea compared to what existed in the current 1931-

[1] For example, the Chino Basin Watermaster has moved to a similar extended base period, adding recent years to a base period extending back to 1921.

1990 hydrologic base period due to continued overdraft. How will Watermaster treat that volume of water apportioned for vegetation in each Subarea in 1996 so that sufficient water is available to support phreatophyte vegetation in the subarea and support the future re-establishment of phreatophyte vegetation as the water table recovers?

9. How does Watermaster address the issue of depletions altering the flow of water down the Mojave River in the proposed base period? During the more recent period the Mojave River loses flow volume as it moves through the Alto and Centro Subareas at a higher rate than was experienced in the 1931-1990 base period. (Todd 2013). The natural flow of water down the Mojave River has been altered by patterns of pumping and changes in wastewater and stormwater management occurring in the new proposed base period, resulting in depletions (captured recharge by increased infiltration) in flow, which does not reach the downstream Subareas as flow did in the current original base period.

    a) Please provide calculations showing the change in river depletions between the two hydrologic base periods for each Subarea.

    b) Increases in depletions in one Subarea increase recharge and likely increase PSY for that Subarea. Increased recharge would reduce downstream flow and reduce recharge and water availability in downstream subareas. How will Watermaster address these depletions in evaluating the appropriateness of the new hydrologic base period?

    c) If additional depletions in the new proposed base period are not distinguished from 1931-1990 depletions and natural recharge processes, pumping in the Alto Subarea that results in lower groundwater levels and induces more recharge from the Mojave River would result in a higher PSY. This higher PSY would allow for more pumping, starting a cycle of more depletions and future PSY increases. This would have a negative impact on the water needs of the habitat and species protected under the Judgment as less water would be available to the Baja Subarea due to capture upstream. How will Watermaster address this hydrologic base period issue?

COMMENTS ON PROPOSED HYDROLOGIC BASE PERIOD

CDFW finds that Watermaster's proposal to change the base period is a significant change to the implementation of the Physical Solution and Judgment, which will likely impact public trust resources and lands owned by CDFW for the benefit of wildlife and the public. The Judgment is silent on a change in the hydrologic base period over time. As such, any changes to the hydrologic base period should be done carefully and with consideration of the potential impacts to the ability to meet the original obligations of the

Judgment. CDFW has raised important questions that pertain to this matter that have not yet been addressed.

Reduced Water Supply for Baja

For the past two years, CDFW has highlighted the issue of reduced surface water inflow to the Baja Subarea below the Barstow gage during the new proposed hydrologic base period, and the need to investigate this issue further. This issue was raised in CDFW's April 25, 2025, comment letter to the Watermaster Board, and our representative also summarized these comments in person during the April 23, 2025, public hearing. These issues have been raised by CDFW for the past two years in our comment letters and Court filings and have not yet been fully addressed.

Average annual surface flows from the Centro to the Baja Subarea, as measured at the Barstow gage, have reduced significantly from their historical levels and the levels at the time the Judgment was entered. Watermaster's 2024 PSY Update indicates that during the past decade, the average annual gaged surface water inflow to Baja has decreased from 16,406 acre-feet to just 7,500 acre-feet. This inflow is the primary source of aquifer recharge in the Baja Subarea and is critical to the recovery of shallow groundwater to support public trust resources.

Additionally, CDFW is concerned that Watermaster has recently begun to question the reliability of the flow measurements at the USGS Barstow gage. The Barstow gage plays a key role in the Judgment as the agreed method to estimate the inflow to Baja at the Waterman Fault. CDFW notes that variability is common in gages on river systems that are as dynamic as the Mojave River at Barstow, and there are methods that can be employed to confidently utilize this critical long-term dataset, rather than disregard it. This gage and record remain the best available science for inflows into the Baja Subarea. CDFW urges Watermaster to employ the expertise necessary to continue to use this key dataset and to address any issues that it has identified with the stream gage. The Judgment clearly makes this a responsibly of the Watermaster in Section 24 (e), "Hydrologic Data Collection" and this measurement is central to the fair implementation of the Physical Solution for the Baja Subarea.

Watermaster Engineer states that "Watermaster recognizes that for the Baja Subarea, special circumstances may warrant PSY determination based on limited data. For the Baja Subarea, the only reliable data available is pumping and water level measurements... In 2024, Watermaster recommended Baja PSY of 12,749 acre-feet, which was determined by interpretation of water levels compared to the total pumping." (Statement of Reasons, p. 14). The interpretation of water levels is not a method for the determination of PSY in the Judgment as it ignores a key element of PSY, water supply,[2] and, if applied correctly, is only informative as to changes in groundwater storage. Certainly, the interpretation of hydrographs of representative wells in each Subarea is an important exercise, but without a proper water balance for each Subarea as typically provided by Watermaster Engineer in Table 5-1/ Exhibit C Table C-1, the presumption is that zero change in storage indicates that a Subarea is in balance. In Baja, this ignores evidence showing that the water budget in the Baja Subarea is now reduced by more than 50% than was anticipated using the 1931-1990 base period. Furthermore, as previously expressed, CDFW does not agree with the Watermaster that the leveling off in a subset of Baja wells is indicative of stabilized (or recovering) conditions across the entire Subarea and particularly at Camp Cady, where the Exhibit H habitat areas occur and where severely depressed groundwater levels continue to occur.

Bulletin 84

Watermaster's insistence on using DWR Bulletin 84 as a guideline in the present base period selection discussion is odd considering the volume of pertinent scientific literature that has been produced since 1967. CDFW does not question whether this document played an important role in the selection of the current base period and the crafting of the Judgment. However, Bulletin 84 is outdated and does not properly recognize the interaction of groundwater and surface water.

The understanding of the relationship between surface water and groundwater has advanced substantially, from both a science and policy perspective, since the 1960's. This is evidenced by the extensive analysis of depletions of surface water from groundwater use in USGS Water-Resources Investigation Report 95-4189 titled "Ground-Water and Surface-Water Relations along the Mojave River, Southern California" (Lines 1996) and in the definition of sustainable yield for the Sustainable Groundwater Management Act, which directly incorporates impacts of depletions of interconnected surface water. (See Wat. Code, § 10721).

Riparian Habitat

Finally, CDFW disputes Watermaster's claim in the Reply Brief that "Watermaster estimates of Riparian Habitat use was established by CDFW and agreed to by the Parties at trial. Those same values are used in the PSY calculation." (Reply Br. in Support of Motion, p. 8). CDFW has consistently maintained that the volume of water

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[2] PSY is defined as "The highest average Annual Amount of water that can be produced from a Subarea: (1) over a sequence of years that is representative of long-term average annual natural water supply to the Subarea net of long-term average annual natural outflow from the Subarea, (2) under given patterns of Production, applied water, return flows and Consumptive Use, and (3) without resulting in a long-term net reduction of groundwater in storage in the Subarea." (Judgment, p. 11.)

assigned to phreatophytes in the PSY calculation should remain as established by Lines and Bilhorn (1996). However, because Watermaster has failed to provide a Table 5-1 water balance for the Baja Subarea for the last two years, it is unclear how much water has been allocated to riparian vegetation. In fact, Watermaster's 2024 PSY Update shows a substantial decrease in the water allocation of phreatophytes, from 2,000 acre-feet per year to just 984 acre-feet. In its June 2025 Workshop, the Watermaster had apparently revised that value to 1,581 acre-feet per year, which is still an unacceptable departure from the agreed-to value in the Judgment. Watermaster's recent practice of using an interpretation of water levels in some wells in the Baja Subarea, without a water balance, fails to address water allocation for phreatophytes. As noted above, the wells in the vicinity of CDFW's Camp Cady and the Judgment Exhibit H riparian habitat areas continue to indicate groundwater levels far below the Exhibit H Table H-2 target depths required to maintain riparian vegetation in healthy condition.

CDFW appreciates the opportunity to provide questions and comments regarding Watermaster's proposed hydrologic base period change. We look forward to hearing from Watermaster on these important issues.

Sincerely,

DocuSigned by:
Aaron Johnson
6477ACD4E0DE4DB...

Aaron Johnson
Senior Environmental Scientist
Inland Deserts Region

ec:

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EXHIBIT C

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December 11, 2025

VIA EMAIL

Andrea Hostetter
Mojave Watermaster
13846 Conference Center Drive
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Email: ahostetter@mojavewater.org

Re: Mitsubishi, Robertson's, CalPortland Comment Letter
Mojave Watermaster December 12, 2025 Workshop re Watermaster Recommendations for New Hydrologic Base Period

Dear Ms. Hostetter:

This firm represents Mitsubishi Cement Corporation ("**Mitsubishi**"), Robertson's Ready Mix, Ltd. ("**Robertson's**"), and CalPortland Company ("**CalPortland**"). Collectively, these parties ("**Our Clients**") have facilities located throughout the Mojave Basin Area within the Este, Centro, Alto, and Baja Subareas. This letter is submitted for consideration and discussion at the Mojave Watermaster ("**Watermaster**") Workshop meeting to be held on December 12, 2025. Please distribute this letter to Watermaster Board members and staff.

I. BACKGROUND FOR WATERMASTER WORKSHOP REGARDING CONSIDERATION OF AN UPDATED HYDROLOGIC BASE PERIOD

At the hearing on August 4, 2025, the Court acknowledged the merit of Our Clients' objections to any rubber-stamping of a new hydrologic Base Period. The Court observed that the base hydrologic period is not redetermined annually and might be considered, at most, every 10 or 12 years. The Court directed that the selection of a new hydrologic Base Period should be determined by separate motion "sometime next year" or at least prior to considering next year's updated Production Safe Yield ("**PSY**") or Free Production Allowance ("**FPA**") recommendations.

Watermaster filed a Motion for Determination of hydrologic Base Period just weeks later, on September 3, 2025. Our Clients, and other parties, filed Oppositions to the Motion. Prior to the October 20, 2025, hearing on the Motion, the Court released its tentative decision that the Motion "for the indefinite future is denied." The Court recognized the importance of selecting an appropriate hydrologic Base Period, and the impact that this decision will have on PSY, FPA, and other aspects of the Judgment. A copy of the Court's tentative decision is attached as **Exhibit 1**.

The Court directed the parties to meet and confer and propose a process through which Watermaster would present its analysis and the information on which it is based, and continued the hearing to October 27, 2025. The parties met and conferred with Watermaster counsel to explore, if possible, a mutually agreeable public process for consideration of a new hydrologic Base Period. Though some alignment was reached on certain aspects of the process, the parties did not reach consensus. Attached as **Exhibit 2** is the schedule our office proposed to the Court on October 27, 2025.[1] At the hearing, Judge Reimer expressed his view that any new hydrologic Base Period would need to be both considered *and approved* by the Watermaster Board before being presented to the Court. The Workshop is an early step in this process, but not the only step in the public process.

Given the Court's directives to ensure a robust and transparent public process occurs in evaluating any new hydrologic Base Period, we encourage Watermaster to comply with the attached schedule and process.

On November 12, 2025, Watermaster released a report entitled, "Watermaster Engineer's Statement of Reasons for Recommending 2001-2020 hydrologic Base Period" ("**SOR**")[2] We provide these comments for Watermaster's consideration at the December 12, 2025, Watermaster Workshop, and we request that these comments be included in the record. Additionally, we include comments prepared by our technical consultants, EKI Environment & Water ("**EKI**"). EKI's comments are attached as **Exhibit 3**.

[1] While the Court indicated it would enter an order shortly after the October 27, 2025 hearing, we are not aware of a final Court order as of the date of this letter.

[2] Watermaster Engineer's Statement of Reasons for Recommending 2001-2020 Base Period.

II. COMMENTS REGARDING WATERMASTER SOR

We request Watermaster address the following questions and comments at the Workshop regarding the SOR.

A. Applicability of DWR Bulletin 84

Watermaster SOR Reference	Question/Comment
SOR reliance on Bulletin 84 as the standard and criteria for selecting a new hydrologic Base Period. (See SOR, pg. 2-5)[3]	1. The SOR emphasizes selection of a hydrologic Base Period based primarily upon guidance from the 1967 DWR Bulletin 84 and the 1975 opinion in *City of Los Angeles vs. City of San Fernando, et al., 14 Cal.3d 199 (1975).* 2. Does Watermaster contend that the standards in the above-referenced records reflect the best current methodology for determining a new hydrologic Base Period for the Mojave Basin and each of its Subareas? 3. Has Watermaster considered other guidance materials such as California Department of Water Resources' Sustainable Groundwater Management Best Management Practices for Water Budgets?[4]

[3] Summary of SOR pgs 2-5.

[4] DWR BMP for SGMA, Water Budget, (2016) available at https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/Sustainable-Groundwater-Management/Best-Management-Practices-and-Guidance-Documents/Files/BMP-4-Water-Budget_ay_19.pdf

B. **Initial Hydrologic Base Period 1931-1990**

Watermaster SOR Reference	Question/Comment
"Based upon DWR's guidance in Bulletin 84, the Parties and the Court in City of Barstow determined the initial hydrologic Base Period should be from 1931 to 1990, because it includes both normal and extreme wet and dry years." (SOR 5:25-27).	1. How does Watermaster define "normal" and "extreme" wet and dry years? 2. Is Watermaster's definition of wet and dry years based solely upon flows at the Forks?

C. **Water Supply to the Basin Area**

Watermaster SOR Reference	Question/Comment
"Surface water inflow to the Alto Subarea is measured flow of the Mojave River at the Forks and is the sum of reported values from USGS gage stations at West Fork Mojave River near Hesperia, CA and Deep Creek near Hesperia, CA. This measured USGS gage data provides the best available information regarding the surface water inflow to the Basin Area. There are very few records of surface water inflow to the Este and Oeste Subareas." (SOR 11:17-22)	1. Please identify all records and reports Watermaster is relying upon for surface water inflow to the Este and Oeste Subareas.
"Watermaster reviewed records of precipitation. Although there are several precipitation stations located within the Forks' watershed, the reliability of this data is questionable. The precipitation records are short, inconsistent, and intermittent (see Exhibit M). For these reasons, Watermaster believes the measured flow of the Mojave River at the Forks continues to be the record indicative of the long-term water supply to the Basin Area. Additionally, the flow record at the Forks provides a clear indication of wet and dry periods in the Basin Area." (SOR 11:23-12:2)	2. Has Watermaster considered any third-party data that can provide reliable precipitation records?

D. **Watermaster Proposed Hydrologic Base Period 2001-2020**

Watermaster SOR Reference	Question/Comment
"Once the hydrologic Base Period is set, there is no reason to reset it every year, or at any other time unless the conditions upon which it is based change significantly." (SOR 12:13-15).	1. Does Watermaster intend to present any update to its recommendations for a new hydrologic Base Period once its model update is completed?

E. **Hydrologic Base Period vs. Pumping and Consumptive Uses for purposes of PSY determination**

Watermaster SOR Reference	Question/Comment
"Watermaster needs to clarify that when calculating PSY, the year representative of pumping and consumptive uses does not necessarily need to be strictly contained within the time frame of the hydrologic Base Period." (SOR 12:25-27)	1. This paragraph is unclear. Please provide the legal and technical basis for Watermaster's contention that the representative year for PSY may be outside the hydrologic Base Period. 2. Is it Watermaster's position that the hydrologic Base Period is not foundational to PSY? 3. If PSY can be based upon some "representative year," outside the hydrologic Base Period as Watermaster suggests, what criteria, data, factors, and standards does Watermaster contend would apply in selecting a "representative year" for PSY?[5] 4. Watermaster's interpretation appears to contradict the fact that the first PSY year (1990) was within the hydrologic Base Period sequence (1931-1990). (See

[5] See Judgment sections 4.aa.(1)-(2).

	SOR 12:27-13:2; Table C-1 of the Judgment).
"Even though the hydrologic Base Period of 2001-2020 was recommended by Watermaster for all Subareas, Watermaster recognizes that for the Baja Subarea, special circumstances may warrant PSY determination based on limited data. For the Baja Subarea, the only reliable data available is pumping and water level measurements (which show recent recovery). This is true for the Este Subarea and the Oeste Subarea as well." (SOR 14:4-9)	5. This paragraph is not clear. Please elaborate. 6. What provisions of the Judgment does Watermaster contend would allow PSY determination to be based on limited data? 7. What is Watermaster's plan and timeline to address and fill any known information gaps for Este, Baja, and Oeste? 8. Please clarify whether Watermaster is still considering recommending different hydrologic Base Periods for each Subarea. If so, what data, criteria, or other factors would Watermaster consider in determining whether to recommend a different hydrologic Base Period for a particular Subarea?

F. **Evaluation of Alternative Hydrologic Base Periods**

Watermaster SOR Reference	Question/Comment
"From a water supply perspective, a larger magnitude of average water supply might yield a higher PSY value. On the contrary, a smaller magnitude of water supply might yield a lower PSY value. However, as noted above, the Court previously asked Watermaster to consider a drier and more recent hydrologic Base Period. For these reasons, Watermaster does not recommend the two alternative hydrologic Base Periods of 1991-2022 and 1995-2024." (SOR 17:9-14).	1. The Court asked Watermaster to "consider" a drier and more recent period. Is it Watermaster's position that this direction *requires* Watermaster to *recommend* a drier period? 2. Does Watermaster consider any other potential hydrologic Base Periods would be more technically supportable if not presumed required to select a "drier" period?

	3. How much "drier" does Watermaster project hydrologic conditions for the Basin to become? What studies and data is Watermaster relying on for that projection?
The alternative base period 2002-2022 starts and ends on a dry year and is preceded by a series of dry years. However, because the UMBM is calibrated through the year 2020 only, Watermaster does not consider this to be an appropriate selection. (SOR 17:15-17)	4. Will Watermaster further calibrate the model to capture more recent data (2000-2024)? 5. What impacts does the UMBM not being calibrated past 2020 have on Watermaster's proposal to select 2022? 6. If 2022 was outside the period of model calibration, how were Watermaster 2024 PSY values derived and supported to the extent they relied on 2022 data?
Because the alternative 2002-2022 base period is outside the period of the UMBM calibration, and the magnitude of water supply in the alternative 2002-2022 base period does not "closely approximate" the magnitude of the long-term water supply during the 1931-1990 base period (as indicated by DWR Bulletin 84), Watermaster believes the alternative 2002-2022 base period is not as appropriate as the recommended 2001-2020 base period. (SOR	7. Please explain and quantify the meaning of "closely approximate the magnitude."

G. **Cultural Conditions Evaluation**

Watermaster SOR Reference	Question/Comment
As explained above, Watermaster's data on irrigated acreages show a similar trend of a constant reduction in irrigated land, particularly during recent years. Because the new hydrologic base period should meet the criteria of the DWR Bulletin 84 and include	1. Watermaster states 2001-2020 captures changing land uses, but many of the highlighted cultural changes (Ex. C–H), urbanization, declining agriculture, and increased VVWRA discharges occur

recent cultural conditions, Watermaster determined that the alternative hydrologic base periods that begin in the 1990s do not me[e]t the representation of recent cultural conditions, and therefore, they should not be considered appropriate hydrologic base periods for PSY redetermination. (SOR 18:13-19).	gradually beginning in 1995 and continuing through at least 2024. 2. What statistical basis is Watermaster relying on to conclude that no year in the 1990s should be included? 3. Does Watermaster contend that cultural conditions have evolved uniformly for all Subareas?

III. CONCLUSION

We appreciate Watermaster's release of the SOR, and holding this Workshop to discuss and address stakeholder questions. On behalf of Our Clients, we reserve all rights to comment further on these pending items both at the Workshop and through further proceedings.

We request Watermaster address the issues raised in this letter and the enclosed letter from EKI. We further request Watermaster update its analysis in response to the Workshop, and provide all available and additional information for the updated analysis or updated recommendations for any new hydrologic Base Period selection for each Subarea.

We look forward to participating in further discussion and attending future Watermaster board meetings at which these matters will be discussed and considered for approval and recommendation to the Court.

Sincerely,

FENNEMORE LLP

Derek Hoffman

DHOF

cc: L. McElhany (lmcelhaney@bmklawplc.com)

62797269

EXHIBIT 1

1.

CIV208568	CITY OF BARSTOW VS CITY OF ADELANTO	MOTION FOR DETERMINATION OF HYDROLOGIC BASE PERIOD FOR PRODUCTION SAFE YIELD CALCULATIONS BY THE MOJAVE WATER AGENCY

Tentative Ruling:

The Watermaster's motion to change the hydrologic base period from 1931-1990 to 2001-2020 for the indefinite future is denied. Because of the importance of identifying an appropriate base period, the denial is without prejudice to a more robustly supported motion that addresses the Court's concerns.

The Court is mindful of the timeline facing the Watermaster. To avoid holding up the Watermaster's calculations of PSY and FPA, the Watermaster's annual report, and the annual motion regarding the Watermaster's recommended changes to FPA, the Court will consider the possibility of granting the motion on a temporary basis, i.e., authorizing the propesed base period (2001-2020) to be used in calculating the FPA recommendations for water year 2026-2027. The parties should be prepared to discuss that possibility, as well as the Watermaster's motion to adopt the proposed base period on an on-going basis.

Analysis:

There are two fundamental questions presented by the motion. The first is whether the proposed base period is a more reasonable representation of long-term hydrologic conditions in the basin than the existing base period. The second question is whether the proposed base period is a better representation of those conditions than any of the possible alternative periods. The motion addresses only the former. It does not mention possible alternative periods at all.

In its reply, the Watermaster argues that it would be a waste of scarce resources to evaluate other alternative base periods. (Reply, p. 3.) The Court disagrees. If other alternatives are not considered, there is no way to determine whether the selection of the proposed base period complies with the Judgment's requirement that the Watermaster rely upon the "best available records and data to support implementation of this Judgment."

Similarly, the Watermaster argues that it would be burdensome to evaluate "more than 100 years of data." (Reply, p. 3.) Again, the Court is not persuaded. No one is suggesting that the Watermaster must evaluate potential base periods that include or overlap with portions of the existing base period (1931-1990.) Instead, the question is whether there are other potential base periods since 1990 that would better represent the basin than either 1931-1990 or 2001-2020.

The Watermaster contends that any new base period should meet the criteria specified in DWR Bulletin No. 84. It is unclear, however, whether compliance with the bulletin is required. The very language that the Watermaster quotes is aspirational ("should") rather than mandatory ("shall"). Nevertheless, the Watermaster does not address the issue.

Assuming arguendo that the bulletin is at least persuasive if not mandatory, the proposed base period does not satisfy the bulletin's criteria. One criterion is that "[b]oth the beginning and end of the base period should be preceded by a series of wet years or a series of dry years .... " In addressing the requirement concerning the beginning of the period, the Watermaster asserts that the beginning of the proposed base period was "preceded by a series of dry years, i.e., dry years in 1999 and 2002 precede the 2001 beginning of the base period ... . " (Motion, p. 4.) 2002 did not precede 2001. Therefore, only one dry year, 1999, preceded the beginning of the proposed period in 2001. Because a single dry year does not constitute a "series" of dry years., that criterion is not met. Thus, assuming arguendo that Bulletin No. 84 describes the correct criteria to be used when selecting a new base period, the base period proposed does not meet those criteria.

The motion also argues that "recent cultural conditions" will be better reflected in the proposed base period than in the existing base period. But the Watermaster offers no evidence that those conditions were significantly different in 2001-2020 as compared to 1931-1990. While the Court has little doubt that they are, the Court needs to rely on evidence, not its assumptions. (Even if the evidence had been presented, it is unclear how the "cultural conditions" relate to the selection of the base period as opposed to being later factored into the RMRBM.)

To allow a careful evaluation of the Watermaster's assertions regarding the distribution of normal wet years, extremely wet years, normal dry years, and extremely dry years, the Court needs to know the criteria by which the Watermaster distinguishes normal years from extreme years. Similarly, the Watermaster offers no evidence (as opposed to argument in its Reply) to support the implicit conclusion that water flow at the Forks reasonably represents the water supply for the basin as a whole. It may be, but the motion does not address the issue.

The Watermaster suggests in its Reply that, because the Judgment does not expressly require Court approval of changes in the base period, the Watermaster should be deemed to have the discretion to pick whatever base period it believes is most appropriate. (Reply, pp, 2 & 9.) That reasoning fails, because the Watermaster is required to obtain court approval for changes in FPA The base period is integral to the calculation of PSY and the resulting recommendations regarding changes to FPA If the Watermaster is relying upon a base period that has not been approved, then the Court will be reluctant to approve recommendations based on that base period. Regardless of the express terms of the Judgment, as a practical matter the Watermaster's preferred base period needs judicial endorsement.

EXHIBIT 2

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Attorneys for MITSUBISHI CEMENT CORPORATION, ROBERTSON'S READY MIX, LTD., and CALPORTLAND COMPANY

SUPERIOR COURT OF THE STATE OF CALIFORNIA

COUNTY OF RIVERSIDE – CENTRAL DISTRICT

Coordination Proceeding Special Title (Cal. Rules of Court, Rule 3.550)
MOJAVE BASIN WATER CASES

CITY OF BARSTOW, et al.,

Plaintiff,

v.

CITY OF ADELANTO, et al.,

Defendant.

AND RELATED CROSS-ACTIONS.

Case No. JCCP5265 Mojave Basin Water Cases
Dept. 1, Riverside Superior Court
Hon. Craig G. Reimer

Lead Case CIV208568
Coordinated With San Bernardino Superior Court Case No. CIVSB2218461

MITSUBISHI CEMENT CORPORATION, ROBERTSON'S READY MIX, LTD. AND CALPORTLAND COMPANY PROPOSED SCHEDULE FOR BASE PERIOD AND RELATED MOTIONS

Date: Oct 27, 2025
Time: 10:00 a.m.
Dept: 1

MITSUBISHI CEMENT CORPORATION ("Mitsubishi"), ROBERTSON'S READY MIX, LTD. ("Robertson's"), and CALPORTLAND COMPANY ("CalPortland"), collectively, the "above-captioned parties," by and through their attorneys of record, Fennemore LLP, hereby submit this proposed schedule for stakeholder engagement, Watermaster motion and Court determination of the "base period" and related Watermaster processes. This proposal is made following the October 21, 2025, hearing on Watermaster's Motion for Determination of Hydrologic Base Period for Production Safe Yield Calculations, and consideration of the Court's tentative ruling to deny that Motion.

Pursuant to Court's direction at the hearing on October 21, 2025, counsel for the above-captioned parties initiated and conducted a meet and confer with counsel for the Watermaster, California Department of Fish and Wildlife, Golden State Water Company and Newberry Springs Recreational Lakes Association on October 23, 2025. Though some progress was made, a consensus proposal was not reached and does not appear to be reachable.

The above-captioned parties propose the following schedule for the Court's consideration. As the Court already expressed its willingness to consider, the Court may need to enter an order relieving certain timing obligations under the Judgment and the Watermaster's Rules and Regulations to accommodate the following schedule, pursuant to the Court's authority under Judgment § 19.

The above-captioned parties reserve the right to consider adjustments to the proposed schedule and to present further argument, views and objections to alternative proposals at the continued hearing on October 27, 2025.

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	Description	Date
1	Watermaster releases Base Period Recommendations and supporting materials	November 12, 2025
2	Watermaster Workshop – Base Period	December 12, 2025
3	Watermaster Board Meeting – Base Period	January 28, 2026
4	Watermaster Motion to adopt Base Period	February 11, 2026
5	Opposition(s) to Watermaster Motion to adopt Base Period	March 3, 2026
6	Watermaster Reply ISO Motion to adopt Base Period	March 11, 2026
7	Court Hearing – Base Period	March 18, 2026
8	Watermaster releases FPA Recommendations and draft Annual Report	March 23, 2026
9	Watermaster Workshop – FPA	April 22, 2026
10	Watermaster Board Meeting – FPA Recommendations and draft Annual Report	May 27, 2026
11	Watermaster Motion to adopt FPA Recommendations and draft Annual Report	June 1, 2026
12	Opposition(s) to Watermaster Motion to adopt FPA Recommendations and draft Annual Report	June 22, 2026
13	Watermaster Reply ISO Motion to adopt FPA Recommendations and draft Annual Report	June 30, 2026
14	Court Hearing – FPA Motion	July 8-10, 2026

Dated: October 24, 2025

FENNEMORE LLP

By: ______________________

Derek Hoffman
Darien K. Key
MITSUBISHI CEMENT CORPORATION, ROBERTSON'S READY MIX, LTD., and CALPORTLAND COMPANY

PROOF OF SERVICE

STATE OF CALIFORNIA, COUNTY OF SAN BERNARDINO

Re: City of Barstow v. City of Adelanto, et al.;
Riverside Superior Court Case No.: CIV 208568

I am employed in the County of Fresno, State of California. I am over the age of 18 years and not a party to the within action; my business address is: 8080 North Palm Ave. Third Floor, Fresno, CA 93711. On October 24, 2025, I served copies of the within documents described as **MITSUBISHI CEMENT CORPORATION, ROBERTSON'S READY MIX, LTD. AND CALPORTLAND COMPANY PROPOSED SCHEDULE FOR BASE PERIOD AND RELATED MOTIONS** on the interested parties in this action in a sealed envelope addressed as follows:

See attached Service List

[X] **BY MAIL** - I am "readily familiar" with the firm's practice of collecting and processing correspondence for mailing. Under that practice, it would be deposited with the United States Postal Service on the same day in the ordinary course of business, with postage thereon fully prepaid at San Bernardino, California. I am aware that on motion of the party served, service is presumed invalid if postal cancellation date or postage meter date is more than one day after date of deposit for mailing in affidavit.

[ ] **BY PERSONAL SERVICE** - I caused such envelope to be delivered by hand to the offices of the addressee pursuant to C.C.P. § 1011.

[ ] **BY EXPRESS MAIL/OVERNIGHT DELIVERY** - I caused such envelope to be delivered by hand to the office of the addressee via overnight delivery pursuant to C.C.P. § 1013(c), with delivery fees fully prepaid or provided for.

[ ] **BY FACSIMILE** - I caused such document to be delivered to the office of the addressee via facsimile machine pursuant to C.C.P. § 1013(e). Said document was transmitted to the facsimile number of the office of the addressee from the office of Gresham Savage Nolan & Tilden, in San Bernardino, California, on the date set forth above. The facsimile machine I used complied with California Rules *of Court*, Rule 2003(3) and no error was reported by the machine. Pursuant to California *Rules of Court*, Rule 2009(i), I caused the machine to print a record of the transmittal, a copy of which is attached to this declaration.

[X] **BY ELECTRONIC/EMAIL** - Pursuant to the party's express consent to receive electronic service, I caused such document to be delivered to the office of the addressee via electronic e-mail pursuant to C.C.P. §1010.6(a)(2)(A)(ii). Said document was transmitted to the email address of that office which is listed on the attached Service List. Said document was served electronically and the transmission was reported as complete and without error.

FEDERAL - I am employed in the office of a member of the bar of this court at whose direction the service was made.

I declare under penalty of perjury under the laws of the State of California that the foregoing is true and correct. Executed on October 24, 2025, at Fresno, California.

Kelly Ridenour

KELLY RIDENOUR

SERVICE LIST

Re: City of Barstow v. City of Adelanto, et al.;
Riverside Superior Court Case No.: CIV 208568

William J. Brunick, Esq. Leland P. McElhaney, Esq. Brunick, McElhaney & Kennedy PLC 1839 Commercenter West P.O. Box 13130 San Bernardino, CA 92423-3130 Email: bbrunick@bmklawplc.com lmcelhaney@bmklawplc.com	**Attorneys for Defendant/Cross-Complainant,** **MOJAVE WATER AGENCY**
Mojave Basin Area Watermaster c/o Jeff , Watermaster Services Manager 13846 Conference Center Drive Apple Valley, CA 92307-4377 Email: jruesch@mojavewater.org watermaster@mojavewater.org	MOJAVE BASIN AREA WATERMASTER
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EXHIBIT 3

eki environment & water

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10 December 2025

Derek Hoffman
Fennemore
550 E Hospitality Lane, Suite 350
San Bernardino, CA 92408

Subject: **Comments on the Watermaster Engineer's Statement of Reasons for Recommending a 2001-2020 Base Period**
(EKI 50063.00)

Dear Mr. Hoffman:

EKI Environment & Water, Inc. (EKI) has conducted a review of the *Watermaster Engineer's Statement of Reasons for Recommending a 2001-2020 Base Period* (Statement)[1] filed on 12 November 2025. EKI has conducted this review and provided the comments below to Fennemore in its role as Counsel to Mitsubishi Cement Corporation, Robertson's Ready Mix, Ltd., and CalPortland Company (collectively the "Clients") in the Mojave River Basin Area (Basin).

SUMMARY OF STATEMENT OF REASONS

The Statement provides background information on the Department of Water Resources' (DWR's) Bulletin No. 84 and similar adjudications (e.g., *City of Los Angeles vs. City of San Fernando, et al., 14 Cal.3d 199 (1975)*), discusses the Basin's initial hydrologic base period, changes in land use and pumping since entry of the Judgment, water supply to the Basin, and then provides justification for the proposed hydrologic base period of 2001-2020. The Statement provides greater detail than was originally provided in the Motion to the Court (Motion)[2], including differentiating between selection of the hydrologic base period and evaluation of production safe yield (PSY). The Statement includes a comparison among several other potential hydrologic base periods before ultimately recommending the adoption of 2001-2020 as the new hydrologic base period.

KEY COMMENTS

Parties to the Judgment need visibility into the potential impacts to PSY in all Subareas under the proposed hydrologic base period

The Judgment defines PSY as, *"The highest average Annual Amount of water that can be produced from a Subarea: (1) over a sequence of years that is representative of long-term average annual natural water supply to the Subarea net of long-term average annual natural outflow from the Subarea, (2) under given patterns of Production, applied water, return flows and Consumptive Use, and (3) without resulting in a*

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[1] *Watermaster Engineer's Statement of Reasons for Recommending 2001-2020 Base Period,* November 12, 2025.
[2] Brunick, McElhaney, & Kennedy PLC, 2025. Motion for the Determination of Hydrologic Base Period for Production Safe Yield Calculations; Memorandum of Points and Authorities; Supporting Declaration. September.

long-term net reduction of groundwater in storage in the Subarea." Table C-1 of the Judgment lays out how PSY is calculated – PSY is total production in each Subarea plus the surplus or deficit of water supply, which is the difference between water supply and consumptive use/outflow. The hydrologic base period is used to inform numerous budget terms in this calculation such as surface water inflows and outflows. Each year in the Annual Report, the Watermaster presents a version of Table C-1 as Annual Report Table 5-1. As noted by the Watermaster, 2001-2020 has been temporarily used as the hydrologic base period in the two most recent Annual Reports (i.e., for water years 2022-23 and 2023-24). However, it should be noted that Table 5-1 is currently not available for the 2023-24 Annual Report on the Watermaster's website, and that Table 5-1 for the 2022-23 Annual Report presents PSY calculations for Alto, Centro and Baja, but not Este or Oeste[3]. As such, although the proposed hydrologic base period has been used temporarily by the Watermaster in recent years, and PSY estimates have been provided for all Subareas, the analysis is not fully documented and the impact of the proposed hydrologic base period on the calculation of PSY in each Subarea is unclear.

In the Statement, the Watermaster explains that *"Even though the hydrologic base period of 2001-2020 was recommended by the Watermaster for all Subareas, Watermaster recognizes that for the Baja Subarea, special circumstances may warrant PSY determination based on limited data. For the Baja Subarea, the only reliable data available is pumping and water level measurements (which show recent recovery). This is true for the Este Subarea and the Oeste Subarea as well,"* (page 14). It therefore remains unclear how, if at all, the PSY for Baja, Este and Oeste has changed or may change under the proposed hydrologic base period. Parties to the Judgment need visibility into the potential impacts to PSY in all Subareas before the adoption of a new base period. We request the Watermaster to provide an analysis on estimates of PSY for each Subarea using the potential hydrologic base periods listed in Table 1 of the Statement.

A clear and consistent framework should be used to determine PSY

A complete water budget framework for each Subarea should be established to account for all inflows and outflows, and the water budget terms should not change from year to year as new analyses are conducted, unless revisions to the hydrogeological conceptual model (HCM) are warranted. Further, consideration of a new hydrologic base period should be supported by an evaluation of how that proposed hydrologic base period would impact each term for the PSY calculation for each Subarea.

The Judgment provides an example of a complete water budget framework as Table C-1, which has served as the basis for Table 5-1 (PSY calculation) in the Annual Reports for the Basin. **Table 1** below presents the water budget terms contained in the PSY calculations in recent years' Annual Reports utilizing the 2001-2020 hydrologic base period. Highlighted in yellow in **Table 1** are the water budget terms that are controlled by flow in the Mojave River. As can be seen therein, numerous other water budget terms are not controlled by flow in the Mojave River.

[3] Watermaster Reports - Mojave Water Agency

eki environment & water

Table 1 – Summary of Water Budget Components for PSY Calculation

Budget Term	Alto	Centro	Baja	Este	Oeste
WATER SUPPLY					
Surface Water Inflow	61,635[1]	36,725[1]	-	Unclear[2]	Unclear[2]
Gaged Inflow	-	-	7,500[1]	-	-
Tributary Inflow	-	-	1,568[3]	-	-
Mountain Front Recharge	8,511[4]	0	647[3]	Unclear[5]	Unclear[5]
Groundwater Discharge to the TZ	0	0	-	-	-
Subsurface Inflow	0	2,000[6]	1,751[3]	Unclear[2]	Unclear[2]
Este/Oeste Inflow	4,785[4]	0	-	-	-
Imports	0	0	-	Unclear[5]	Unclear[5]
Deep Percolation of Precipitation	-	-	100[2]	-	-
Total Water Supply	**74,931**	**38,725**	**14,575**	**TBD**	**TBD**
CONSUMPTIVE USE					
Surface Water Outflow	36,725[1]	7,500[1]	-	-	-
Gaged Outflow	-	-	2,554[1]	-	-
Barstow Treatment Plant Discharge	0	2,475[7]	-	-	-
Subsurface Outflow	2,000[2]	1,462[3]	170[3]	Unclear[2,5]	Unclear[2,5]
Consumptive Use - Agriculture	949	5,863	12,749[8]	Unclear[5,9]	Unclear[5,9]
Consumptive Use - Urban	40,171	6,885	(see row above)	-	-
Phreatophytes	11,000[2,10]	3,000[2,10]	984[11]	-	-
Total Consumptive Use	**90,845**	**27,185**	**16,457**	**TBD**	**TBD**
PRODUCTION SAFE YIELD CALCULATION					
Surplus / (Deficit)	(15,914)	11,540	(1,883)	TBD	TBD
Total Estimated Production	78,147	16,995	12,740	TBD	TBD
Potential Return Flow	0	2,885	554	TBD	TBD
Production Safe Yield	**62,233**	**31,420**	**10,866**	**6,582**	**3,634**

Abbreviations:
- = Component not applicable to given Subarea
TBD = To be determined
TZ = Transition Zone

Notes:
Table values taken from Table 5-1 in the WY2022-2023 Annual Report.
Entries labeled unclear are those in which we are aware water budget component estimates have been developed but lack clarity on the value proposed for use in the hydrologic base period going forward.
1 – Value derived from stream gage data 2001-2020.
2 – Value established for the original base period (1931-1990) but not for the proposed hydrologic base period (2001-2020).
3 – Value derived from *USGS, 2001. Simulation of Ground-Water Flow in the Mojave River Basin, California, Water-Resources Investigations Report 01-4002.*
4 – Value derived from Upper Mojave Basin Model.
5 – While estimates are provided in Watermaster's 2024 PSY Update for this Subarea, they have not been included in recent Annual Reports' Table 5-1.
6 – No citation in recent Annual Reports, but the value is consistent with the value in the Judgment.
7 – No citation in Table 5-1 of recent reports.
8 – This value includes Agricultural and Urban Consumptive Use (see Table 5-1 of 2022-23 Annual Report).
9 – Estimates were developed in the Watermaster's 2018 Consumptive Use Analysis but have not been included in recent Annual Reports' Table 5-1.
10 – Value derived from *USGS, 1996.Riparian Vegetation and Its Water Use During 1995 Along the Mojave River, Southern California, Water-Resources Investigations Report 96-4241.*
11 – Value estimated using OpenET for 2019-2022.

Some of the water budget terms shown on **Table 1** have been updated as new data have become available, such as subsurface inflow into Alto (from Este/Oeste) and phreatophyte consumptive use in Baja (calculated using OpenET). Others remain fixed at historical values (e.g., subsurface outflow from Alto and phreatophyte consumptive use in Alto and Centro). Furthermore, while the PSY updates for Este and Oeste provided estimates of some water budget components such as mountain front recharge and consumptive use, ultimately the PSY estimates for these Subareas were based on recent pumping and water level data, and it is unclear if adoption of the proposed hydrologic base period would have any influence over these calculations. Additionally, the Alto water budget term Este/Oeste inflow is not matched by corresponding outflows from Este/Oeste in recent versions of Table 5-1, and this value (4,785 AF) greatly exceeds estimates of subsurface outflows in the PSY updates for Este and Oeste[4,5].

As shown on **Table 1**, the Watermaster currently uses a combination of: (1) budget terms from the Judgment (and therefore the original hydrologic base period of 1931-1990); (2) budget terms updated to reflect the proposed hydrologic base period of 2001-2020 (i.e., mountain front recharge, surface inflow into Alto averaged over the proposed hydrologic base period); and (3) budget terms that have no clear relationship to either base period and are inconsistently applied across Subareas. For example, the PSY calculation for Alto includes subsurface inflow from Este and Oeste, but the corresponding outflow from these Subareas is not considered in their respective PSY calculations. It is therefore not clear how, if at all, the various water budget components in Este and Oeste, as well as those in Alto, Centro, and Baja that are unrelated to surface water flows, would be updated under the proposed hydrologic base period of 2001-2020. We ask that the Watermaster provide an evaluation of how that proposed hydrologic base period would impact each term for the PSY calculation for each Subarea.

Appropriateness of metrics for establishing a hydrologic base period should be demonstrated

The purpose of a hydrologic base period is to represent the long-term patterns of water supply to the Basin. Per the Statement, *"Water supply to the Basin Area includes gaged and ungagged [sic] inflow, subsurface flow, deep percolation of precipitation, and certain imports,"* (page 11). Regarding the availability of hydrologic data on which to establish a base period, the Watermaster notes that *"There are very few records of surface water inflow to the Este and Oeste Subareas,"* (page 11) and that *"Although there are several precipitation stations located within the Fork's watershed, the reliability of this data is questionable. The precipitation records are short, inconsistent, and intermittent (see Exhibit M). For these reasons, Watermaster believes the measured flow of the Mojave River at the Forks continues to be the record indicative of the long-term water supply to the Basin Area,"* (page 11-12).

While it may be that available data are limited, it is not clear that Mojave River flow at the Forks is the appropriate metric upon which to establish a hydrologic base period for all Subareas. Notably, flow at the Forks is not relevant to conditions in Este or Oeste, and some components of the Basin water budget and PSY calculation (Table C-1 of the Judgment and discussed above) are independent of flow at the Forks, such as subsurface inflows and outflows and mountain front recharge (see **Table 1**). While Mojave River flow at the Forks may be a reasonable surrogate for some components of the analysis for some Subareas,

[4] Watermaster, 2024. *Production Safe Yield and Consumptive Use Update, Appendix C: Oeste Subarea Water Supply Update*. February.

[5] Watermaster, 2024. *Production Safe Yield and Consumptive Use Update, Appendix D: Este Subarea Water Supply Update*. February.

as described in the Tentative Ruling, *"the Court needs to rely on evidence, not its assumptions,"* (page 2[6]). The Statement provides no quantitative evaluation to demonstrate the correlation of Mojave River flow at the Forks to other Subarea-specific inflow terms such as subsurface inflows/outflows and mountain front recharge that are part of the PSY calculation, and therefore why it is an appropriate metric.

One hydrologic base period may not reflect "recent cultural conditions" in all Subareas

As described in the Statement, significant changes in "recent cultural conditions" (i.e., land use and groundwater pumping) have occurred in the Basin since entry of the Judgment. Exhibit H to the Statement shows time-series plots of agricultural water production and irrigated acreage in each Subarea. These plots show that irrigation volumes in Alto declined steadily from entry of the Judgment to 2010 when production stabilized, meanwhile Centro exhibits a more gradual and ongoing trend. The Baja Subarea has experienced significant declines in irrigation pumping since 2020, while Este has exhibited a consistent decline since 2015 Irrigation pumping in Oeste has fallen to essentially zero in the last several years. These variable trends demonstrate that "cultural conditions" are evolving in each Subarea on independent timelines, and that the proposed hydrologic base period of 2001-2020 does not capture this variation, or in some cases, the actual current "cultural conditions" in a given Subarea.

In the Statement, Watermaster claims that *"Today's cultural conditions are represented by the new recent hydrologic base period of 2001-2020,"* (page 19). However, elsewhere in the Statement, and as quoted above, Watermaster explains that *"Even though the hydrologic base period of 2001-2020 was recommended by Watermaster for all Subareas, Watermaster recognizes that for the Baja Subarea, special circumstances may warrant PSY determination based on limited data. For the Baja Subarea, the only reliable data available is pumping and water level measurements (which show recent recovery). This is true for the Este Subarea and the Oeste Subarea as well,"* (page 14). While this may be a reasonable approach, it is unclear what criteria and process the Watermaster will use to determine what subset of available data for a given Subarea will be used to estimate PSY.

Additional technical questions should be resolved

While it is understood that the Watermaster operates under both schedule and budget constraints, per the Judgment, technical evaluations must use "sound scientific and engineering estimates" and incorporate the "best available records and data," (Judgment (24(w)). To this end, the following items warrant further consideration and clarification:

- In the Statement, the Motion, and in Annual Reports, the Watermaster discusses the influence of wet and dry years on Basin hydrology. However, it is unclear how water year types for the Basin are determined. In Exhibit I of the Statement, which shows Mojave River flow at the Forks, some water years are shown in red, while others are shown in blue, which may correspond to dry vs. wet. Most red years appear to exhibit below average flow at the Forks; however, not all years with very low flow are shown in red (e.g., 1934 and 1981). The Watermaster should provide details on how this foundational determination of year type is made.

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[6] *City of Barstow vs. City of Adelanto,* No. CIV208568, **tentative ruling** (California Superior Court, Riverside County, 20 October 2025)

- The Watermaster presents available station-based precipitation data and notes that the station data are both temporally and spatially sparse. We offer that the readily-available PRISM[7] data provides daily, monthly, and annual precipitation totals, with annual precipitation totals going back to 1895. The Watermaster may consider supplementing their analysis with PRISM data, especially given PRISM's spatial and temporal coverage. Use of the more complete PRISM dataset may provide for correlation or other analysis to better demonstrate that Mojave River flow at the Forks is, in fact, an appropriate metric upon which to establish a hydrologic base period for all Subareas.
- Estimates of consumptive use of groundwater by phreatophytes in some Subareas appear to be based on a 1996 USGS report (as referenced in the 2022-23 Annual Report). It is not clear if the Watermaster intends to update these estimates for the proposed hydrologic base period.

In EKI's letters to the Watermaster to date, we continue to request opportunities to actively engage in ongoing and forthcoming technical analyses being conducted in the Basin, including RMBM development and other hydrogeological studies, such as hydrologic base period selection, as results of these studies could potentially significantly impact future determinations of PSY, Free Production Allowance, and overall Basin management.

Sincerely,

EKI ENVIRONMENT & WATER, INC.

Anona Dutton, PG, CHg
Vice President

[7] https://prism.oregonstate.edu/

EXHIBIT D

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Peter J. Kiel
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December 12, 2025

Via Email: watermaster@mojavewater.org

Board of Directors
Mojave Basin Area Watermaster
Mojave Water Agency
13846 Conference Center Drive
Apple Valley, CA 92307-4377

Re: **December 12, 2025 Workshop on New Hydrologic Base Period**

The City of Victorville and its subsidiary Victorville Water District (VWD) do not object to the use of the 2001 to 2020 Base Period for Water Year 2025/2026 but request that the Watermaster consider using a longer Base Period in future updates. The omission of the 2021 to 2024 Water Years skews the average, resulting in a much drier, more conservative Base Period. VWD is concerned that an overly conservative Base Period will be hard-wired into the Mojave River Basin Model and not reevaluated, which will lead to significant reductions in modeled Production Safe Yield (PSY) and Free Production Allowance (FPA.) VWD's expert hydrogeologist Pete Leffler offers the following comments and observations:

1. The Court in its September 16, 2022 Order did not expressly direct Watermaster to select a drier Base Period. The Court's comments about using a more "prudent" period were more nuanced:

> For instance, the present calculation of PSY has been based on a 60-year study of flows from 1930 to 1990. The Court questions whether a 60-year period in the middle of the 20th century is still an appropriately representative period from which to measure the long-term averages specified in the definition of PSY, especially given the 32 years that have passed since 1990 and the climatic disruptions that we have been experiencing during that time.
>
> If that is not the most representative period, should a different period be defined? Mr. Wagner has stated that, if the judgment were being negotiated today, it would be more prudent to select "a shorter, drier planning period (hydrologic base period) for local supply ..., resulting in a lower estimated Production Safe Yield and consequently lower annual Free Production Allowance." (Wagner Deel., p. 6, 11. 18-21.) ***Is the Watermaster bound to rely upon what appears at this point in time to be a less-than-prudent period?***
>
> . . .
>
> Thus, the 2019 re-evaluation appears to re-evaluate all of the relevant factors except for supply. Why, with an additional and more recent 30 years of data, should

> the PSY calculation continue to rely upon the prior 60-year period for defining the long-term average? ***At the very least, should not the past 32 years of data be added to the original 60 years?***

(Order at pp. 4-5 (emphasis added).) VWD supports the Court's suggestion to add 1991 to 2024 to the Base Period.

2. We recommend that the long-term reference period be set to 1931 to 2024 for comparison of potential base periods. The average flow at The Forks for this 94-year period is 69,333 AFY, and this represents the best long-term average value available.

3. We recommend that DWR 2018 Climate Change Guidance be reviewed to determine if the expectation for Mojave Basin is a drier future with climate change and, if so, how much drier with respect to streamflow. Review of this climate change guidance for other groundwater basins in California shows that many of them are predicted to have greater future rainfall and/or streamflow that will either offset temperature/ET increase or even result in greater future groundwater recharge. As Watermaster has observed, basin recharge is driven by large storm and Mojave River flow events, not average annual precipitation. It is reasonably possible that climate change may both increase average annual temperature and frequency of drought periods while increasing the frequency and/or magnitude of large storm events that are the primary driver of long-term average annual basin recharge.

4. If the Court desires the new base period to be drier than the long-term average, there is a question of how much drier is reasonable, given that a drier base period has potential to reduce current PSY and FPA once it is applied to the updated Mojave River Basin Model. Compared to the long-term 1931-2024 average, the proposed 2001 to 2020 base period is actually 11% drier than the long-term average as opposed to the 6% drier than average stated in the Watermaster Statement of Reasons for the 2001-2020 period.

5. Comparison of the various alternative base periods to the long-term 1931 – 2024 average reveals how conservative (i.e., dry) a 2001 to 2020 base period is. The alternative 1995-2024 and 1998-2024 base periods are actually 3 to 6% drier than the long-term 1931-2024 average, as opposed to the 2% above to 1% below average as stated in the Watermaster Statement of Reasons.

6. The conclusion that the 1995-2024 and 1998-2024 alternative base periods are not representative of recent cultural conditions due to inclusion of some years from the 1990s compared to the 2001-2020 period does not appear to consider that the 1995-2024 and 1998-2024 alternative base periods include the four most recent years from 2021 to 2024 that are not included in the proposed 2001-2020 base period.

7. Presumably, the new base period selected with serve an important role as the historical calibration period for the basin groundwater model currently being updated. The incorporation of years from the 1990s, even though they may not be representative of current

cultural conditions, is not problematic and likely is beneficial for improving model calibration by incorporating a time frame that simulates different basin stress conditions.

8. Ideally the selection of the new base period would be conducted in conjunction with updating the groundwater model and developing the historical model calibration period. To the extent that a new base period is selected and applied now, it should be revisited one to two years after initial completion of the updated groundwater model by the Mojave Water Agency/Watermaster.

9. Regardless of the base period selected, the same base period should be applied to all Subareas; otherwise, there is potential for overallocation of groundwater pumping for the Basin as a whole.

VWD thanks Watermaster for considering its comments.

Sincerely,

LAW OFFICE OF PETER KIEL PC

Peter J. Kiel
Counsel for the City of Victorville and
Victorville Water District

cc: Leland McElhaney, Watermaster Counsel
Robert Wagner, Watermaster Engineer

EXHIBIT E

1

Mojave Basin Area Watermaster
12/12/2025

Workshop on New Hydrologic Base Period Selection

Wagner Bonsignore
Consulting Civil Engineers, A Corporation

MOJAVE BASIN AREA WATERMASTER

Agenda

- Court's June and September 2022 Orders
- Production Safe Yield
- Appropriate criteria for selection of a hydrologic base period
- Initial hydrologic base period 1931-1990
  - Changes in cultural conditions
  - Changes in pumping
  - Changes in agricultural production and irrigated acreages
  - Changes in return flows based upon VVWRA discharges
- Water Supply to the Basin Area: Precipitation and Streamflow data.
- Watermaster evaluation of alternative hydrologic base periods.
- Any other proposed hydrologic base period(s) from interested Parties?
- Watermaster recommendation for new hydrologic base period 2001-2020
- Next steps

Wagner & Bonsignore
Consulting Civil Engineers, A Corporation

MOJAVE BASIN AREA WATERMASTER

Court's June 2022 Order granting Motion to Adjust FPA for Water Year 2022-2023

- *The Court does not have confidence that, in these times of climate disruption, it is prudent to rely upon the accuracy of those long-term supply assumptions, at least in the short term. As Mr. Wagner states, if the judgment were being negotiated today, it would be more prudent to select 'a shorter, drier planning period (hydrologic base period) for local supply . . . ., resulting in a lower estimated Production Safe Yield and consequently lower annual Free Production Allowance.' (Wagner Decl., p. 6, ll. 18-21.)*

Wagner · Bonsignore
Consulting Civil Engineers, A Corporation

MOJAVE BASIN AREA WATERMASTER

Court's September 2022 Order

- *The Court questions whether a 60-year period in the middle of the 20th century is still an appropriately representative period from which to measure the long-term averages specified in the definition of PSY, especially given the 32 years that have passed since 1990 and the climatic disruptions that we have been experiencing during that time.*
- *If [1931-1990] is not the most representative period, should a different period be defined? . . . Is the Watermaster bound to rely upon what appears at this point in time to be a less-than-prudent period?*
- *. . . Why, with an additional and more recent 30 years of data, should the PSY calculation continue to rely upon the prior 60-year period for defining the long-term average? At the very least, should not the past 32 years of data be added to the original 60 years?*

Wagner & Bonsignore
Consulting Civil Engineers, A Corporation

Mojave Basin Area Watermaster

Production Safe Yield

- The Judgment defines PSY as "The **highest average Annual Amount of water that can be produced from a Subarea**: (1) over a sequence of years that is representative of long-term average annual natural water supply to the Subarea net of long-term average annual natural outflow from the Subarea, (2) under given patterns of Production, applied water, return flows and Consumptive Use, and (3) **without resulting in a long-term net reduction of groundwater in storage in the Subarea**." (Judgment, p. 11.)

Appropriate criteria for selection of a hydrologic base period

- Guidance on base period from the Department of Water Resources Bulletin 84 (1967):

  The base period conditions should be ***reasonably representative of long-time hydrologic conditions*** *and should include both normal and extreme wet and dry years. Both the beginning and the end of the base period should be preceded by a series of wet years or a series of dry years, so that the difference between the amount of water in transit within the zone of aeration at the beginning and end of the base period would be a minimum. The base period should also be within the period of available records and should* ***include recent cultural conditions as an aid for projections under future basin operational studies.***

Appropriate criteria for selection of a hydrologic base period

7

- State Water Rights Board "Report of Referee" (1962) filed in City of Los Angeles v. City of San Fernando.

  The desirable base study period is one during which precipitation characteristics in the Upper Los Angeles River area approximate the 85-year period of record, 1872-73 through 1956-57. A further requirement of such a period is that additional hydrologic information is available sufficient to permit an evaluation of the amount, occurrence and disposal of the normal water supply ***under recent culture conditions****. The desirable base period includes both wet and dry periods similar in magnitude and occurrence to the normal supply, and during which there are sufficient measurements and observations* ***to relate the hydrology to recent culture****.*

Wagner & Bonsignore
Consulting Civil Engineers, A Corporation

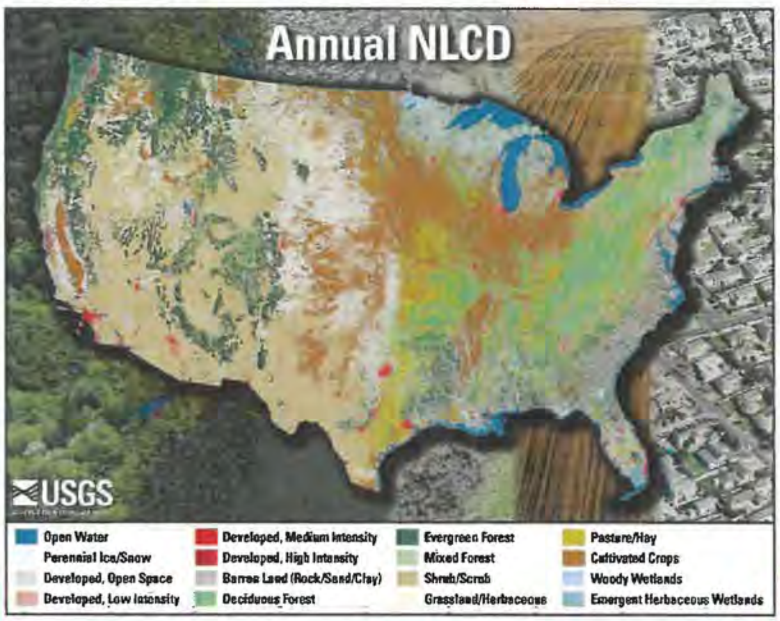
MOJAVE BASIN AREA WATERMASTER

Initial Hydrologic Base Period 1931-1990

- Initial base period 1931-1990 was agreed to by the Parties when the Judgment was entered.
- This base period was consistent with DWR Bulletin 84 guidance.
- However, cultural conditions for water disposal and use have changed since 1990.

Changes in cultural conditions

- Watermaster evaluated changes in land uses since the year 1990 to present.
- USGS Annual NLCD (National Land Cover Database) Land Cover Classification.



Source:
https://usgs.gov/annualnlcd

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Mojave Basin Area Watermaster

Alto

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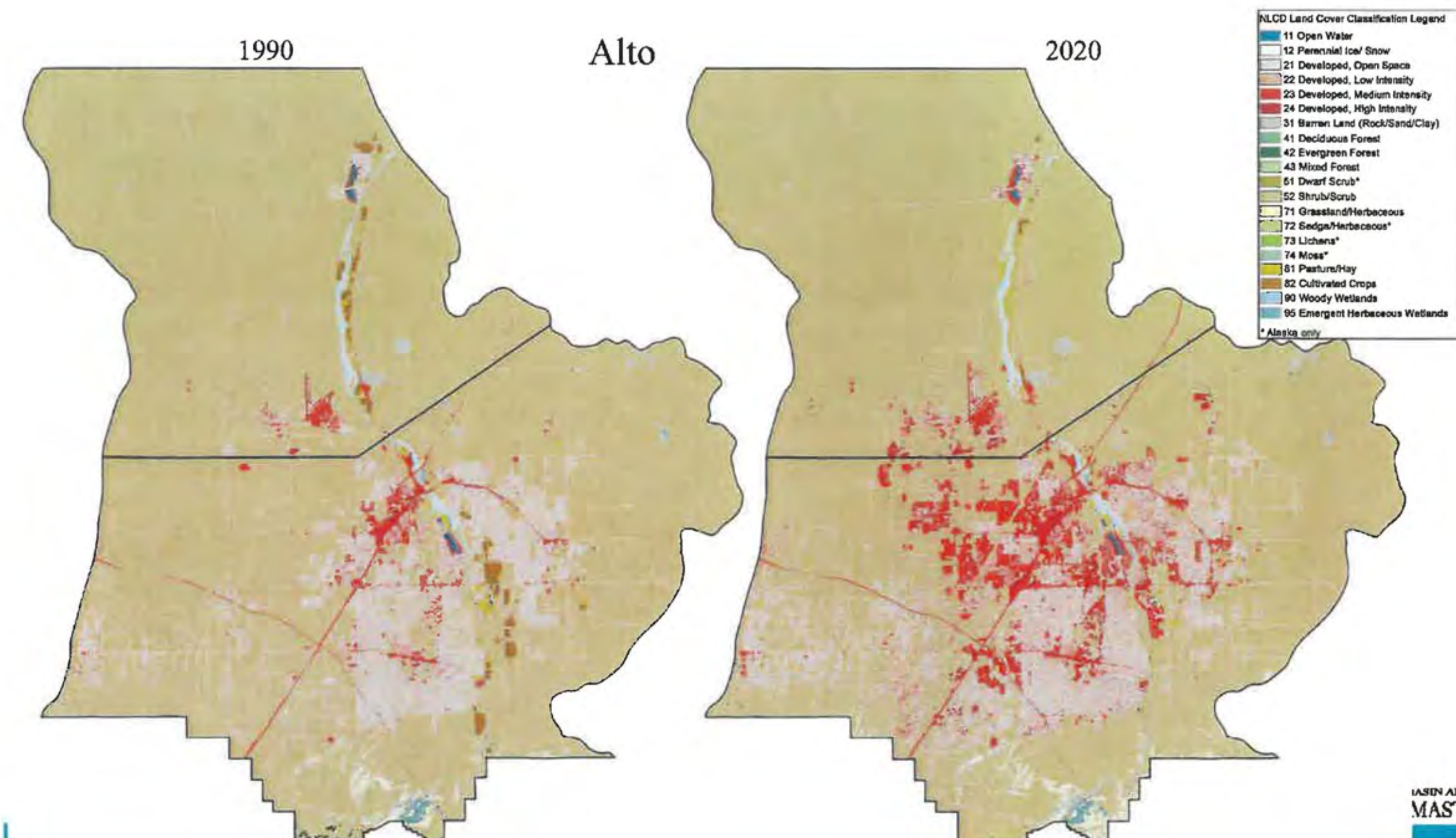
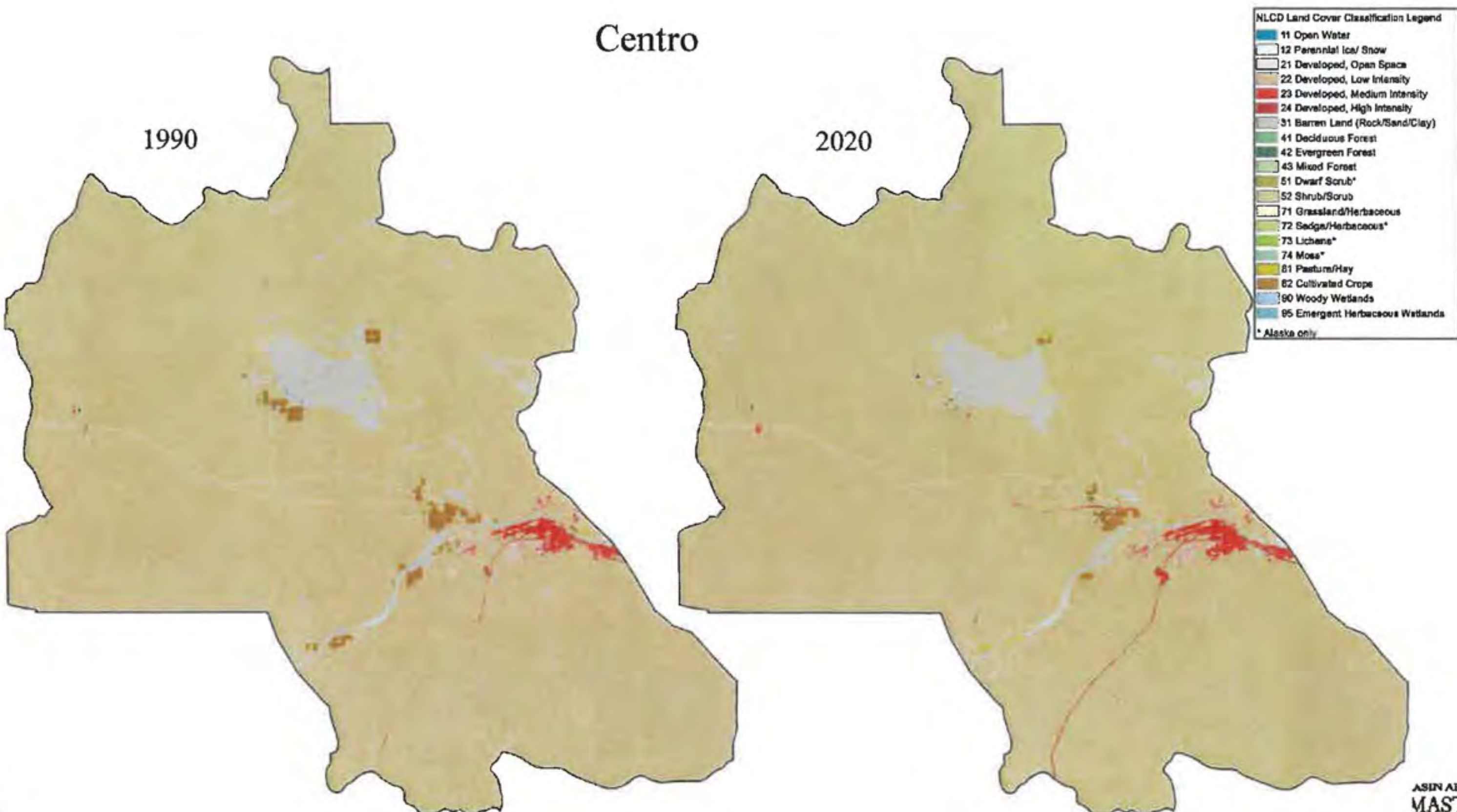

1990
2020
NLCD Land Cover Classification Legend
11 Open Water
12 Perennial Ice/ Snow
21 Developed, Open Space
22 Developed, Low Intensity
23 Developed, Medium Intensity
24 Developed, High Intensity
31 Barren Land (Rock/Sand/Clay)
41 Deciduous Forest
42 Evergreen Forest
43 Mixed Forest
51 Dwarf Scrub*
52 Shrub/Scrub
71 Grassland/Herbaceous
72 Sedge/Herbaceous*
73 Lichens*
74 Moss*
81 Pasture/Hay
82 Cultivated Crops
90 Woody Wetlands
95 Emergent Herbaceous Wetlands
* Alaska only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1990
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NLCD Land Cover Classification Legend
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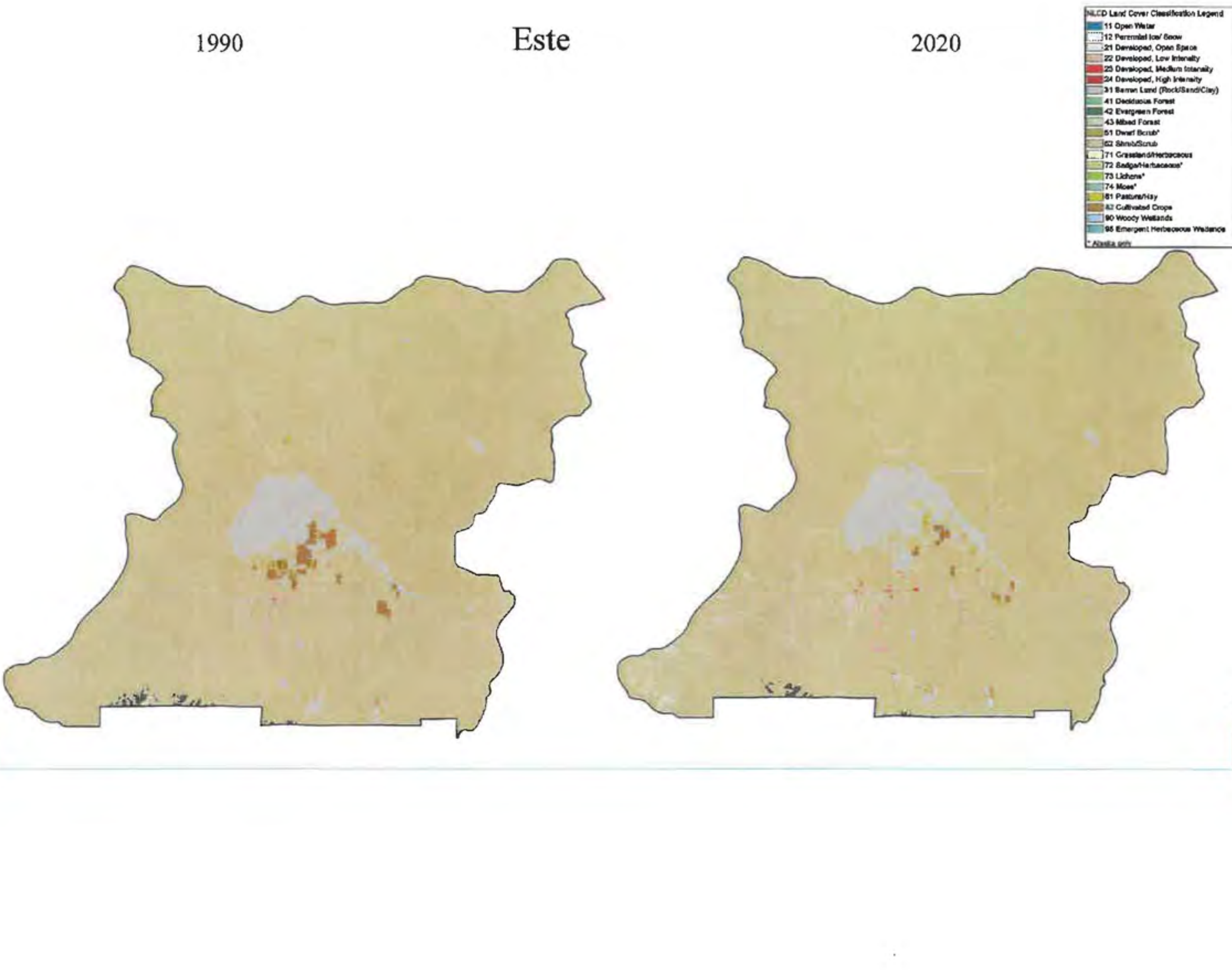
* Alaska only

11


1990
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2020
NLCD Land Cover Classification Legend
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23 Developed, Medium Intensity
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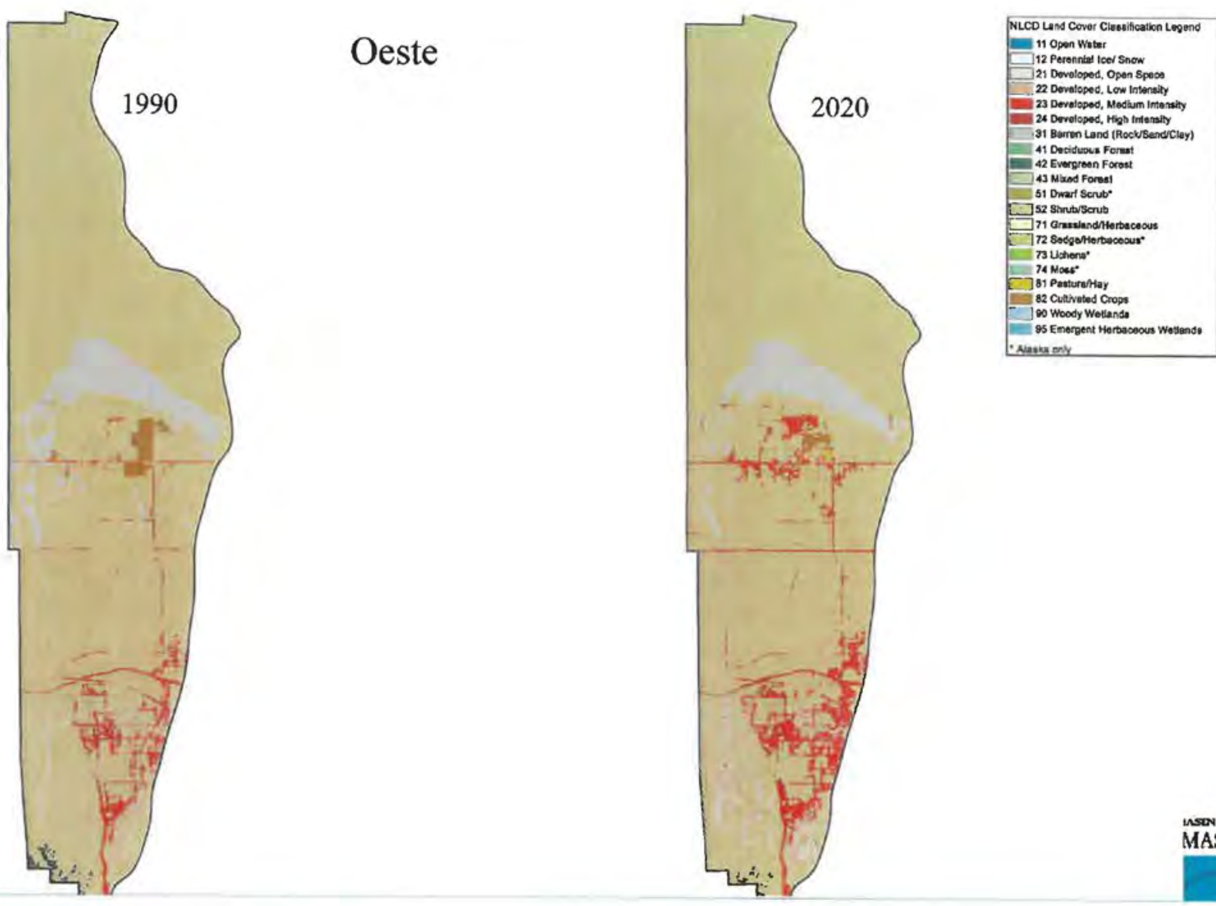
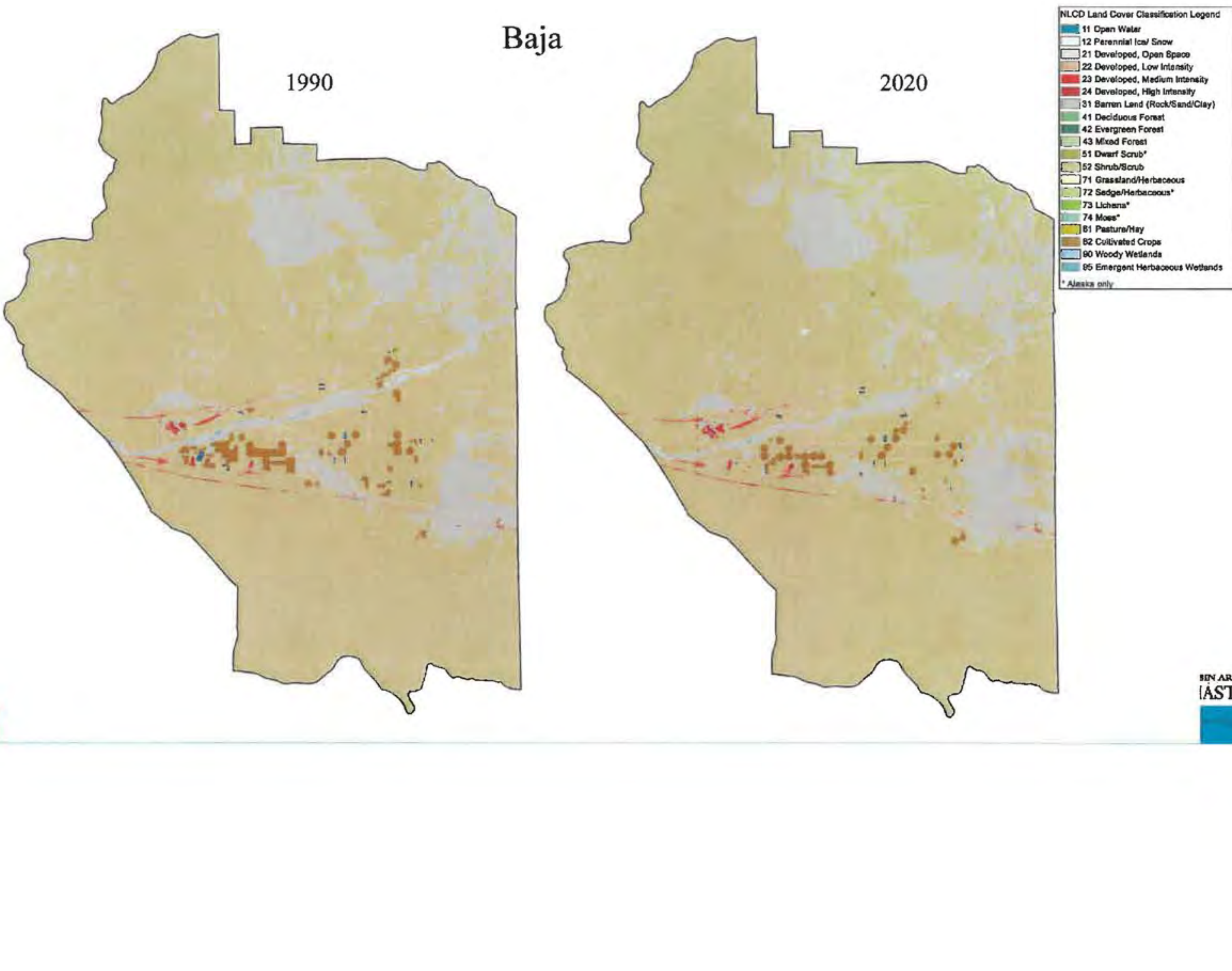


BASIN AREA MASTER


Baja
1990
2020
NLCD Land Cover Classification Legend
11 Open Water
12 Perennial Ice/ Snow
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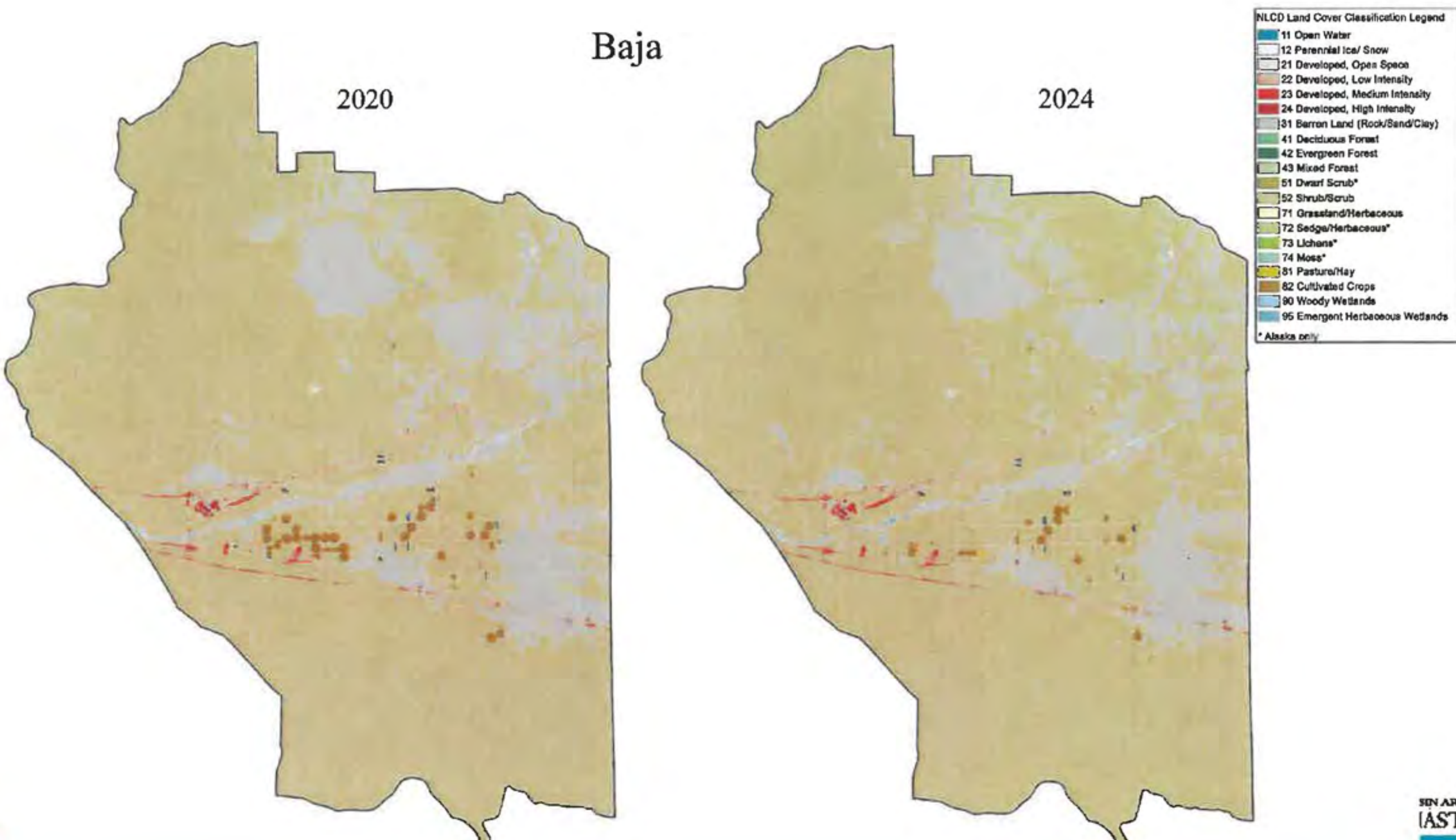
Baja
2020
2024
NLCD Land Cover Classification Legend
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90 Woody Wetlands
95 Emergent Herbaceous Wetlands
* Alaska only

15

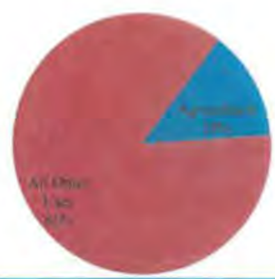
Changes in pumping

1990 Water Uses

2020 Water Uses

2022 Water Uses

2024 Water Uses



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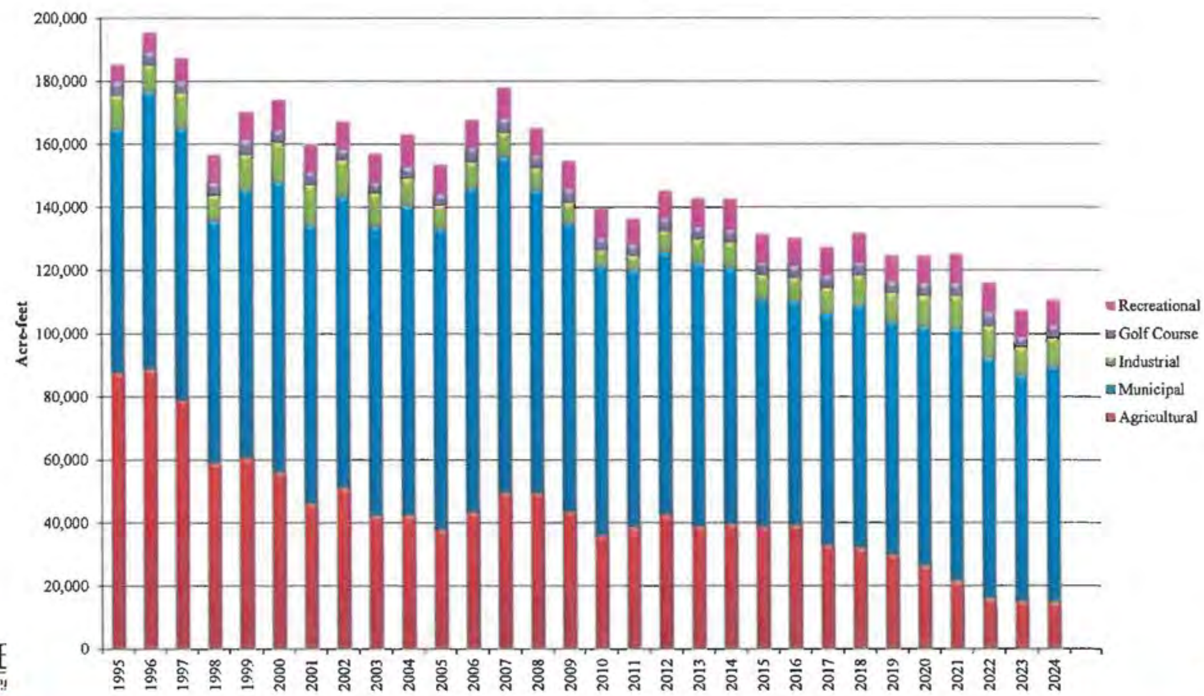
MOJAVE BASIN AREA WATERMASTER

Mojave Basin Area
Estimated Water Production by Type of Use
1994-95 Through 2023-24



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WATERMASTER

Agricultural Water Production and Irrigated Acreage All Subareas

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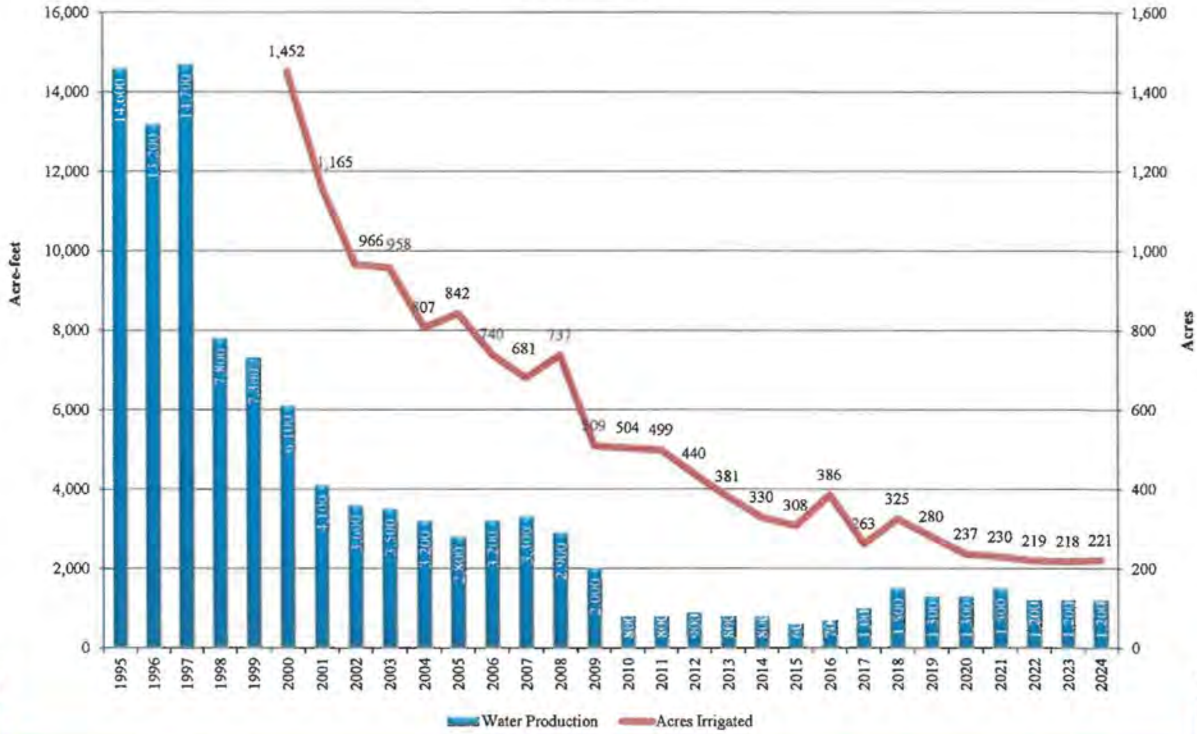
MOJAVE BASIN AREA
ATERMASTER

Agricultural Water Production and Irrigated Acreage Alto Subarea



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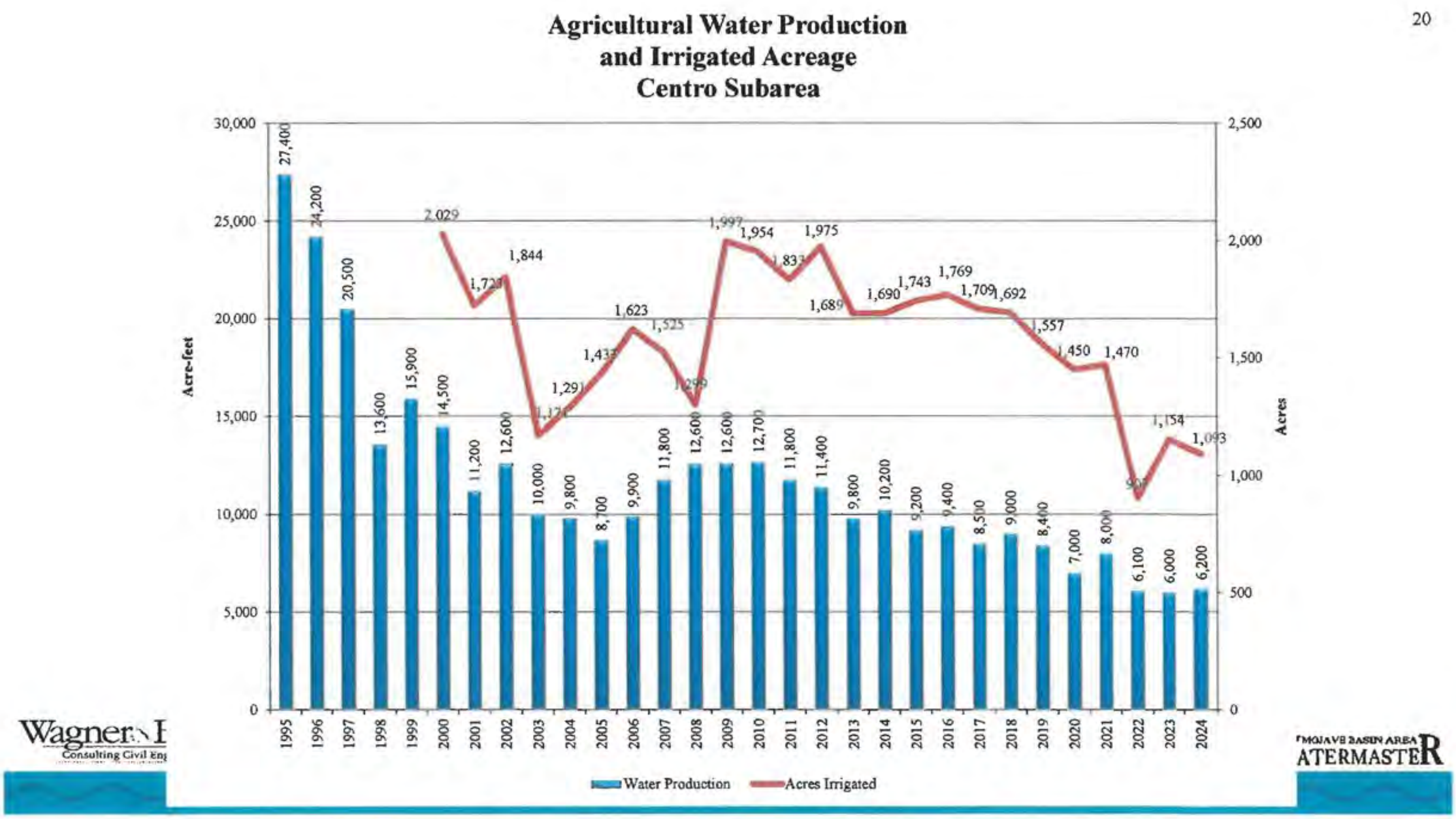
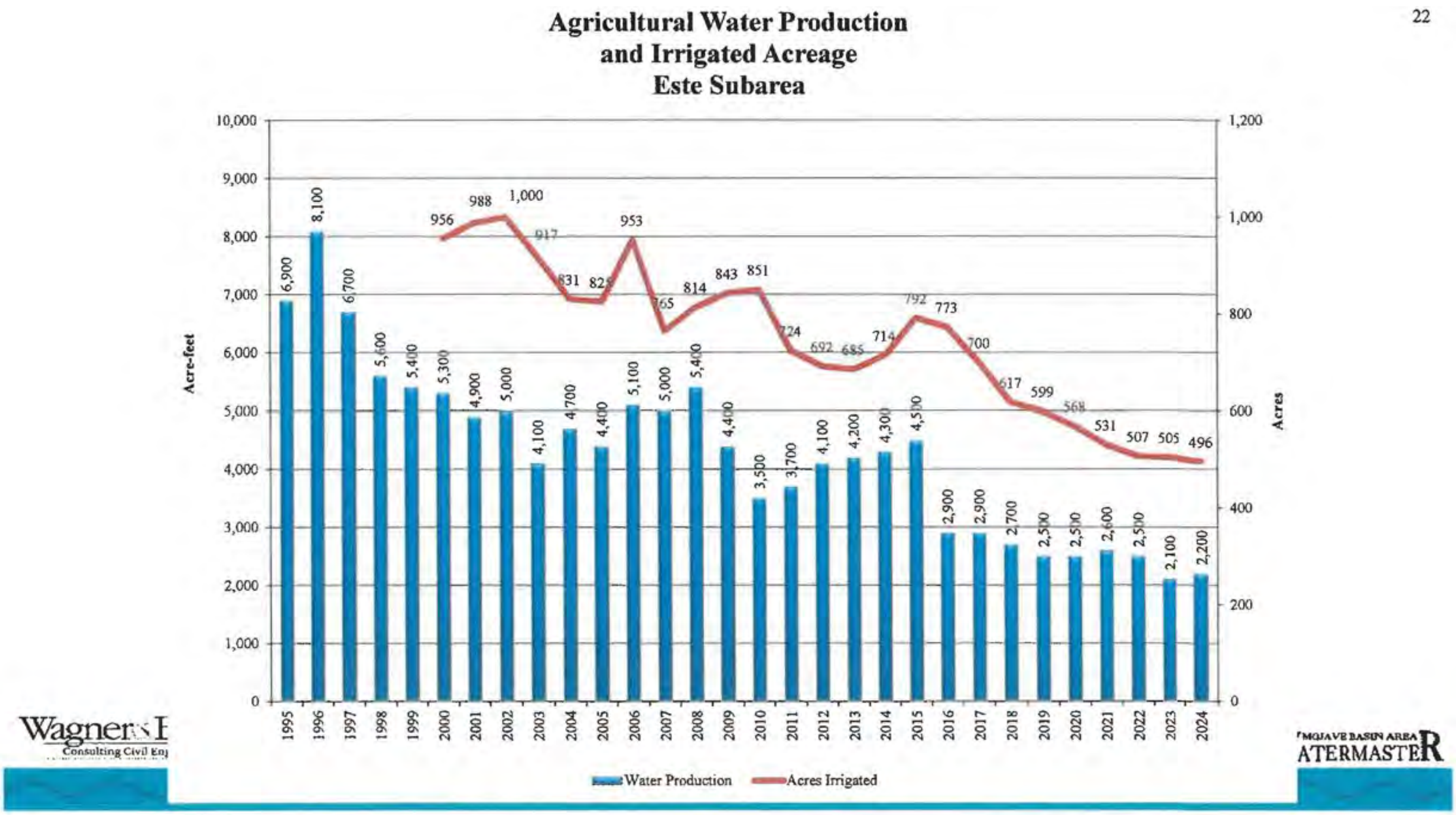
Mojave Basin Area Watermaster


Agricultural Water Production
and Irrigated Acreage
Centro Subarea
Acre-feet
Acres
Water Production
Acres Irrigated
Wagner & Bonsignore Consulting Civil Engineers
MOJAVE BASIN AREA WATERMASTER

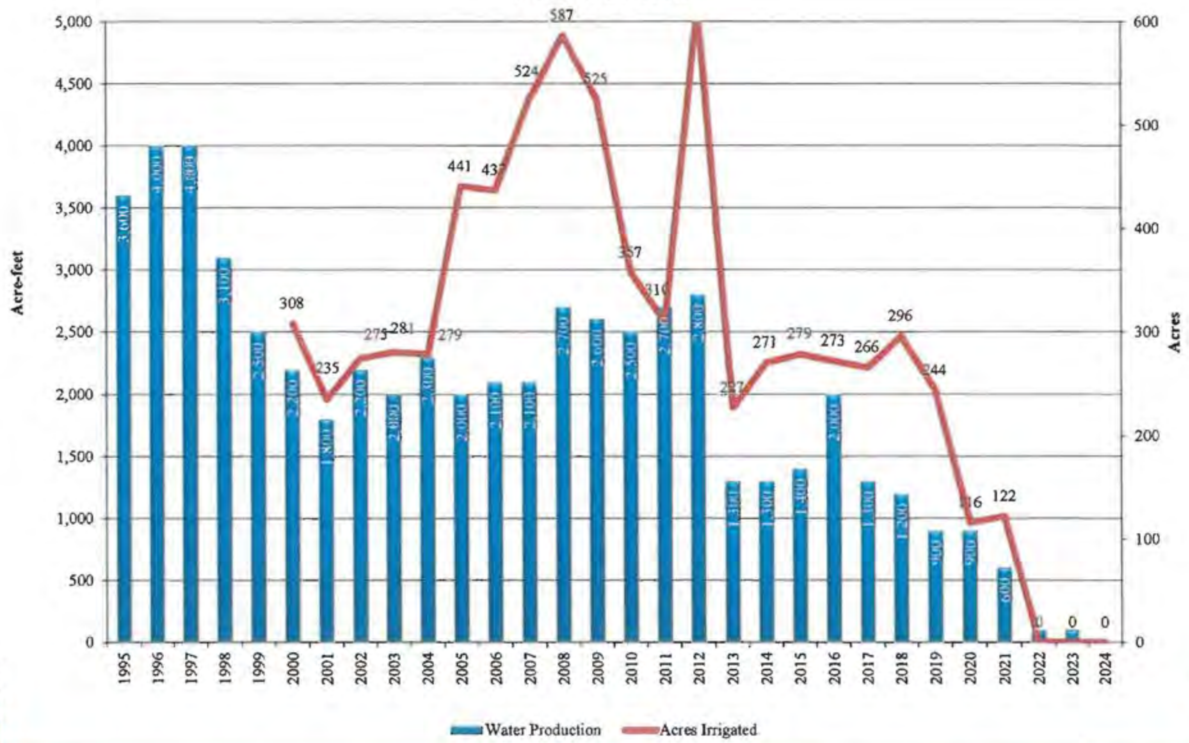
Agricultural Water Production and Irrigated Acreage Baja Subarea

MOJAVE BASIN AREA WATERMASTER

Agricultural Water Production and Irrigated Acreage Este Subarea



Agricultural Water Production and Irrigated Acreage Oeste Subarea



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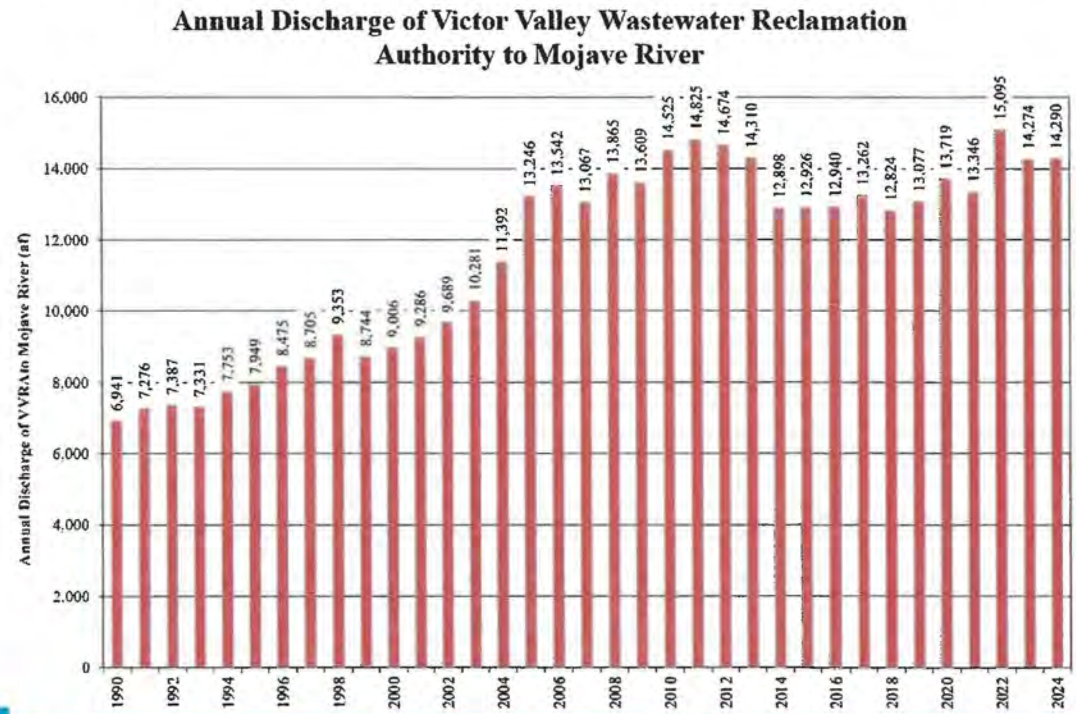
MOJAVE BASIN AREA WATERMASTER

Changes in return flows based upon VVWRA discharges

- Changes in the location of the return flows discharge.
- Changes in magnitude of VVWRA discharges into the TZ.



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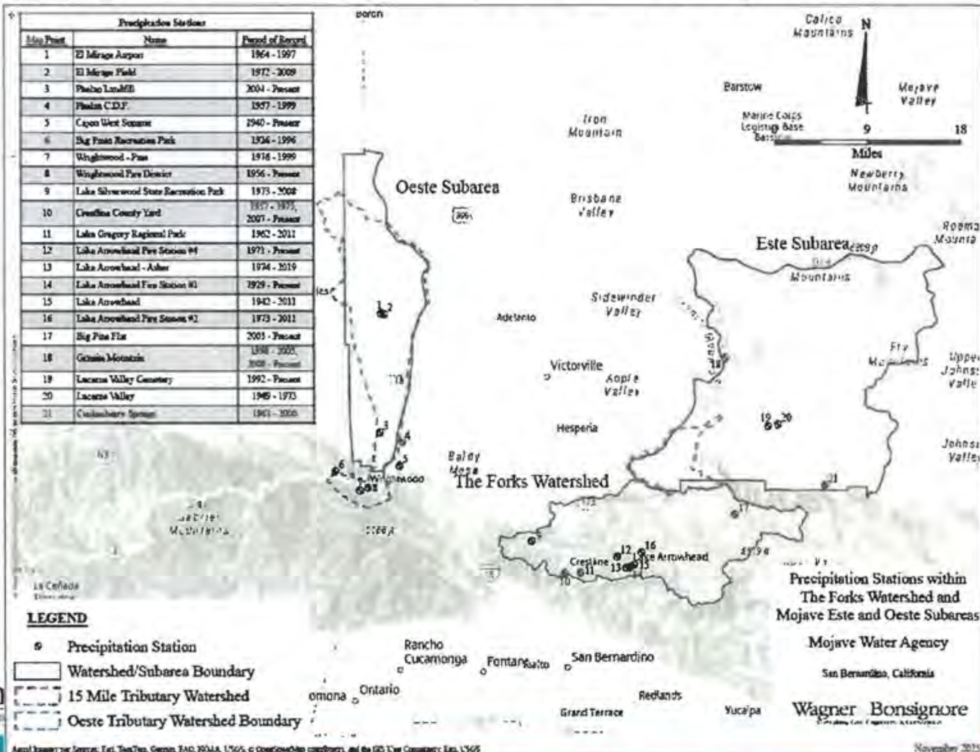
Water Supply to the Basin Area: Precipitation and Streamflow data

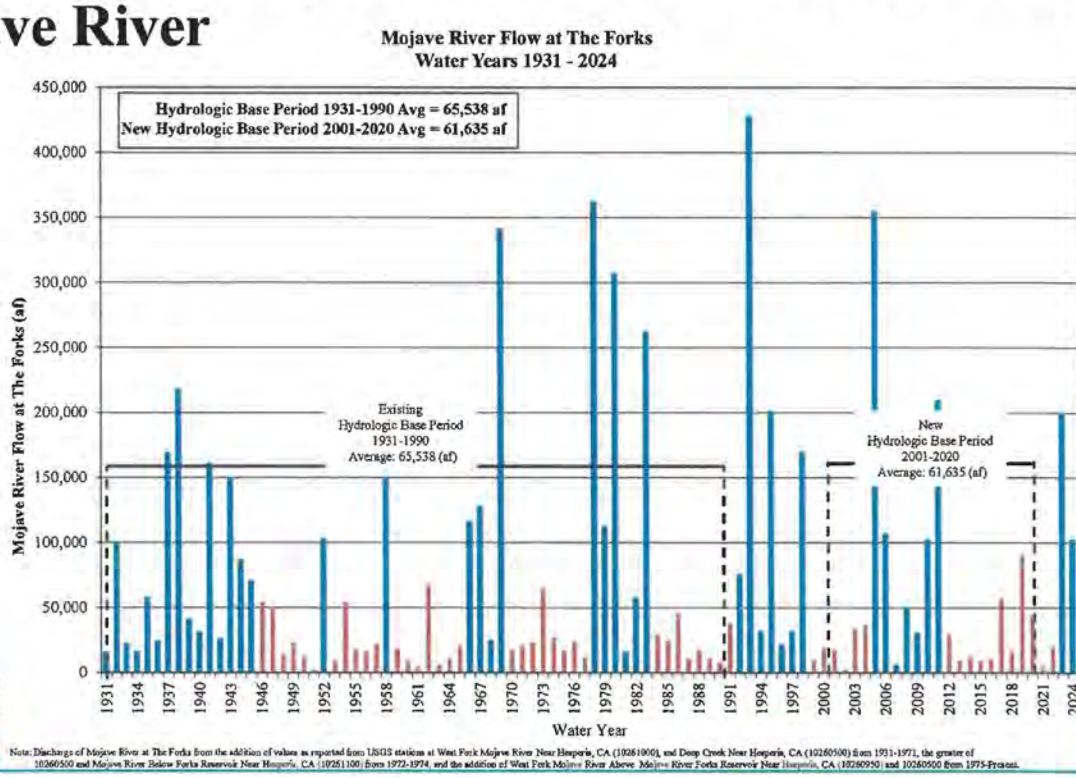
- Although there are several precipitation stations within the Forks watershed, Este and Oeste Subareas, the reliability of this data is questionable.
- Precipitation records are short, inconsistent, and intermittent.
- For these reasons, Watermaster continues to use the **measured streamflow at the Forks as the record indicative of the long-term surface water supply to the Basin Area from the Mojave River**.
- The flow record at the Forks is a clear indicator of patterns of dry and wet periods in the entire Basin Area.
- The UMBM and the Regional Model will use modeled precipitation to estimate rainfall and runoff contributions, however neither of the two models include the Lucerne Valley. We do not have an indicator of wet and dry periods in the Lucerne Valley.

Water Supply to the Basin Area: Precipitation data



Precipitation Stations		
Map Point	Name	Period of Record
1	El Mirage Airport	1964 - 1997
2	El Mirage Field	1972 - 2009
3	Phelan Landfill	2004 - Present
4	Phelan C.D.F.	1957 - 1999
5	Cajon West Summit	1940 - Present
6	Big Pines Recreation Park	1926 - 1996
7	Wrightwood - Pine	1978 - 1999
8	Wrightwood Fire District	1956 - Present
9	Lake Silverwood State Recreation Park	1973 - 2008
10	Crestline County Yard	1957 - 1975, 2007 - Present
11	Lake Gregory Regional Park	1962 - 2011
12	Lake Arrowhead Fire Station #4	1971 - Present
13	Lake Arrowhead - Asher	1974 - 2019
14	Lake Arrowhead Fire Station #1	1929 - Present
15	Lake Arrowhead	1942 - 2011
16	Lake Arrowhead Fire Station #2	1973 - 2011
17	Big Pine Flat	2005 - Present
18	Granite Mountain	[illegible]
19	Lucerne Valley Cemetery	1992 - Present
20	Lucerne Valley	1949 - 1973
21	Cushenbury Springs	[illegible]

Surface Water Supply to the Basin Area from the Mojave River



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Mojave Basin Area Watermaster

Watermaster evaluation of alternative hydrologic base periods

- In 2022, the Court asked Watermaster to consider a drier and more recent hydrologic base period.
- Watermaster evaluated the following hydrologic base periods:

1991-2022
1995-2024
1998-2024
2001-2020
2002-2022
1931-2022

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Mojave Basin Area Watermaster

Watermaster evaluation of alternative hydrologic base periods

Average Flow at the Forks

Alternative Hydrologic Base Periods	Mojave River at the Forks Average (a.f.)	Change relative to the 1931-1990 average (65,538 a.f.)	Criteria
1991-2022	71,344	+8%	Start and end years are dry and are preceded by a series of dry years.
1995-2024	67,057	+2%	Start and end years are wet and are preceded by a wet year/series of wet years.*
1998-2024	65,090	-1%	Start and end years are wet and are preceded by a wet year/series of wet years.
2001-2020	61,635	-6%	Start and end years are dry and are preceded by a series of dry years.
2002-2022	59,009	-11%	Start and end years are severe dry and are preceded by a series of severe dry years.
1931-2022	67,557	+3%	Per Court's Order. Start and end years are dry and are preceding a series of severe dry years.

Notes: The PSY Update prepared by Watermaster in February of 2024 updated the hydrologic base period to be 2001-2020 for purposes of establishing PSY. This selection was based on the information that was available and reliable for Watermaster at the time of the analysis (i.e., flow data up to the year 2023). Also, the PSY Update by Watermaster evaluated the 2001-2020 hydrologic base period also because the Upper Mojave Basin Model was calibrated through the Water Year 2020.

*The water supply at the Forks during the Water Years 1992 through 1995 was about three times the long-term average supply.

Average Precipitation at Lake Arrowhead

Alternative Hydrologic Base Periods	Precipitation Average (inches)	Change Relative to 1931-1990 Average (41.36 inches)	Criteria
1991-2022	39.3	-4.9%	Start and end years are dry and are preceded by a series of dry years.
1995-2024	42.0	+1.5%	Start and end years are wet and are preceded by a wet year/series of wet years.*
1998-2024	41.3	-0.1%	Start and end years are wet and are preceded by a wet year/series of wet years.
2001-2020	37.2	-10.1%	Start and end years are dry and are preceded by a series of dry years.
2002-2022	39.0	-5.8%	Start and end years are severe dry and are preceded by a series of severe dry years.
1931-2022	40.7	-1.7%	Per Court's Order. Start and end years are dry and are preceding a series of severe dry years.

Note: As mentioned by Watermaster, precipitation stations within the Fork's watershed provide precipitation records that are short, inconsistent, and intermittent.

*The water supply at the Forks during the Water Years 1992 through 1995 was about three times the long-term average supply.

MOJAVE BASIN AREA WATERMASTER

Watermaster evaluation of alternative hydrologic base periods

1991-2022

- Average water supply is 8% higher than the average of the initial base period 1931-1990, which might indicate a higher PSY value.
- Water supply at the Forks during the Water Years 1992 to 1995 was about 3 times the long-term average supply.
- Include years that are not representative of recent cultural conditions: agricultural pumping and land uses have greatly changed since the 1990s.
- Court requested consideration of a **drier and more recent hydrologic base period**.

For these reasons, Watermaster does not recommend the hydrologic base period of 1991-2022.

Watermaster evaluation of alternative hydrologic base periods

1995-2024

- Average water supply is 2% higher than the average of the initial base period 1931-1990, which might indicate a higher PSY value.
- It includes years that are not representative of recent cultural conditions: agricultural pumping and land uses have greatly changed since the 1990s.
- Court requested consideration of a **drier and more recent hydrologic base period**.

For these reasons, Watermaster does not recommend the hydrologic base period of 1995-2024.

Watermaster evaluation of alternative hydrologic base periods

1998-2024

- Average water supply is 1% drier than the average of the initial base period 1931-1990.
- It includes years that are not representative of recent cultural conditions: agricultural pumping and land uses have greatly changed since the 1990s.
- Court requested consideration of a drier and **more recent hydrologic base period**.

For these reasons, Watermaster does not recommend the hydrologic base period of 1998-2024.

Watermaster evaluation of alternative hydrologic base periods

2002-2022

- Average water supply is 11% drier than the average of the initial base period 1931-1990; therefore, the indicated water supply does not "closely approximate" the long-term water supply during the 1931-1990 base period.
- The UMBM is calibrated through the year 2020 only, and the alternative 2002-2022 base period is outside the period of the UMBM calibration.

For these reasons, Watermaster believes the alternative 2002-2022 base period is not as appropriate as the recommended 2001-2020.

Watermaster evaluation of alternative hydrologic base periods

1931-2022

- Average water supply is 3% higher than the average of 1931-1990 base period, which might result in higher PSY values.
- It also includes many years that are not representative of current cultural conditions: agricultural pumping and land uses have greatly changed since the 1930s, 1950s and 1990s.
- The Court requested consideration of a **drier and more recent hydrologic base period**.

For these reasons, Watermaster believes the expanded base period 1931-2022 is not as appropriate as the recommended 2001-2020 base period.

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MOJAVE BASIN AREA WATERMASTER

Watermaster justification for recommending new hydrologic base period 2001-2020

- Meets guidance of DWR Bulletin 84.
- Average water supply 6% drier than the average of the initial base period 1931-1990.
- Fits the UMBM model calibration period (ending in 2020).
- Includes and is more representative of current cultural conditions.
- It satisfies the Court's request for a **drier and more recent hydrologic base period**.
- Watermaster seeks to base its **2026 PSY recommendations upon the most appropriate and representative base period**, which Watermaster believes is the 2001-2020 time frame for the reasons indicated.
- Importantly, the base period will not change the actual water supply to the Basin Area going forward. **The selected base period is a management planning tool for future planning purposes!**

Next steps

- Watermaster public hearing on January 14, 2026.

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MOJAVE BASIN AREA WATERMASTER

Response to questions from a stakeholder

- *Why is Watermaster presenting the hydrologic base period change as an urgent issue now, for the first time since the entry of the Judgment, when so much is yet unknown?*

(1) Watermaster is required to recommend PSY values in 2026, and to do so it must select an appropriate base period.
(2) The Court has made clear it wants Watermaster to use a base period more representative of current cultural conditions, including climatic changes.
(3) The Court has ordered Watermaster to file a motion to determine the most appropriate base period, and suggested that a dryer period be considered.

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Mojave Basin Area Watermaster

Response to questions from a stakeholder

- *Has consideration been given to using a hydrologic base period that would capture pre-overdraft conditions, ramp down, and more recent data?*

(1) Watermaster does not believe it is "necessary" to include years predating the significant overdraft that occurred in the 1950s. To do so would distort the water supply that likely will be available to the Basin in the foreseeable future, based upon the dryer conditions that began to manifest in the late 1990s, and have continued during the last 25 years.

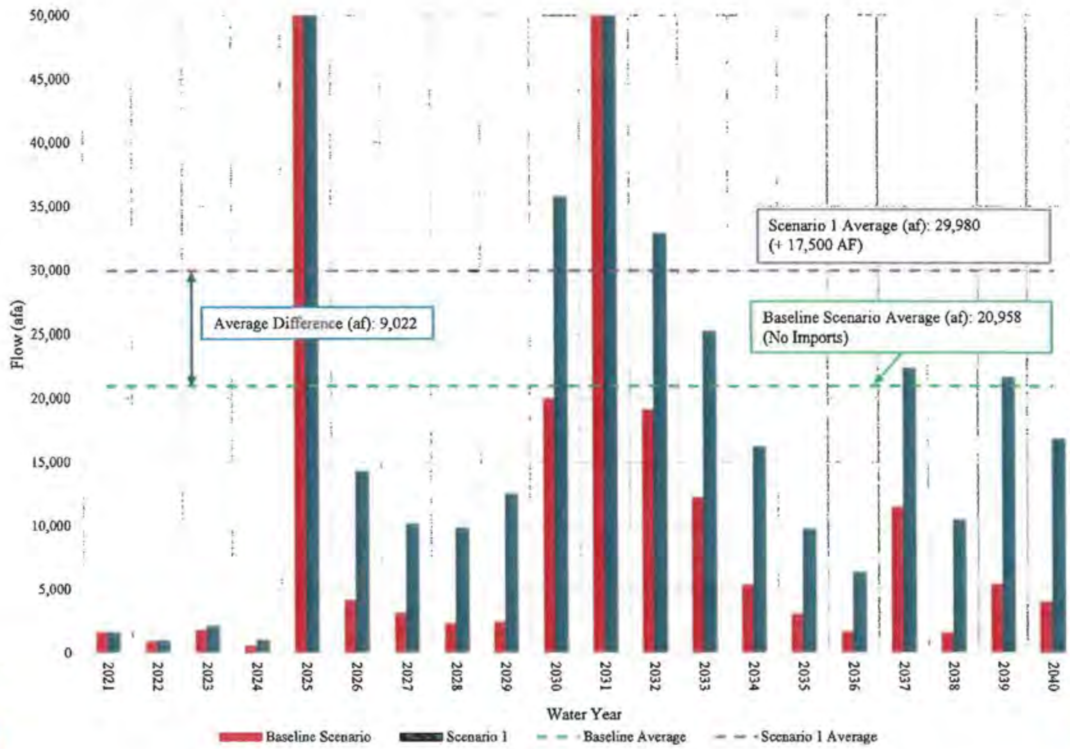
(2) The 2001-2020 proposed base period does capture ramp down and more recent data.

Response to questions from a stakeholder

- *Does the shorter proposed hydrologic base period adequately capture the variation in pumping over time, depletions that can be delayed by many years, and the resulting hydrologic conditions?*

  (1) These issues do not appear to be germane to the selection of an appropriate base period.
  (2) The 2001-2020 base period does capture the variation in pumping during that 20-year period, as well as the depletions and hydrologic conditions during that period.
  (3) Additionally, the shorter and drier base period proposed would produce 17,500 acre-feet per year of imported water that would increase the stream flow at the Lower Narrows by about 9,000 acre-feet per year, thus increasing stream flow in the Mojave River.

Future Scenario: Response to Supplemental Recharge to Alto (17,500 AFY)



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MOJAVE BASIN AREA WATERMASTER

EXHIBIT F

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SAN BERNARDINO, CALIFORNIA 92423-3130

December 31, 2025

Via E-mail (dhoffman@fennemorelaw.com)
Derek Hoffman, Esq.
Fennemore
550 E. Hospitality Lane, Suite 350
San Bernardino, CA 92408

RE: Mitsubishi, Robertson's, CalPortland Comment Letter re Watermaster Recommendations for New Hydrologic Base Period

Dear Mr. Hoffman:

As you know, during the December 12, 2025 Watermaster workshop, we did not have an opportunity or the time necessary to answer all questions presented in your December 11, 2025 comment letter. We attempt to so below.

A. Applicability of DWR Bulletin 84

1. No response required.

2. Yes.

3. Yes, the SGMA BMP does not appear to provide any significantly different criteria for the selection of a base period. Additionally, SGMA provides a definition for the sustainable yield which fully aligns with the Judgment's definition of the PSY. See the following excerpt from the DWR BMP for SGMA, Water Budget, (2016) with the references to a "base period."

> (w) "Sustainable yield" means the maximum quantity of water, calculated over a base period representative of long-term conditions in the basin and including any temporary surplus, that can be withdrawn annually from a groundwater supply without causing an undesirable result.

It also is consistent with the definition of PSY set forth in the Judgment.

B. Initial Hydrologic Base Period 1931-1990

1. Because the Mojave River is the primary source of surface flow to the Basin, this determination is based primarily upon the surface water flows measured at the Forks. Wet

years are years where the surface flow is greater than the average surface flow from 1931-1990; dry years are years where the surface flow is less than the average surface flow from 1931-1990. "Extreme" wet and dry years are those years when surface flows are far above or below the magnitude of the average surface flow from 1931-1990.

2. Yes, because the Mojave River is the main surface water source for the Basin, and the flow at the Forks is the best representation of wet and dry years for the Basin. However, Watermaster also looks at the precipitation records in the various watersheds, gage flows at the Lower Narrows, recycled water contributions in the TZ from VVWRA, calculated flows at the Helendale Fault, gage flows near Hodge, and gage flows at Barstow and Afton.

C. Water Supply to the Basin Area

1. There was a stream flow gage in Este in the Cushenbury Wash that was discontinued for a long period, and was recently re-activated. There also is a new stream flow gage at Sheep Creek Wash in Oeste. Reports Watermaster gives consideration to include, but are not limited to the following: DWR Bulletin 84 (1967), Webb (2000), Hardt (1971), Stamos (2001), the USGS Regional Water Table maps, the Upper Basin Mojave River Model, the Oeste Hydrologic Atlas and Oeste Hydrologic Sub-Area Hydrogeologic Report (2009), Este Hydrologic Atlas (2005), the USGS 2022 report "Hydrogeology and Simulation of Groundwater Flow in the Lucerne Valley Groundwater Basin, California"

2. Yes, Watermaster considers precipitation data provided by NOAA and San Bernardino County.

D. Watermaster Proposed Hydrologic Base Period 2001-2020

1. The model results may provide information that suggests recommending a new hydrologic base period. If so, Watermaster will report that information to the Court and interested parties. When there is a working model it will be used to develop management scenarios to evaluate all various water supply conditions for setting PSY and FPA allowances.

E. Hydrologic Base Period vs. Pumping and Consumptive Uses for purposes of PSY determination

1. The Webb report in 2000 used the 1998 year for pumping and consumptive use, although the Watermaster's base period was then from 1931-1990. Likewise, Watermaster has consistently used the most recent pumping and groundwater level information for PSY calculations.

2. No. Watermaster's position is that the hydrologic base period is foundational to PSY, although it is not the only source of data to be used in determining PSY.

3. See response to number 1. A "representative year" is what we expect would be similar to the future pumping and consumptive use. The base period is the part of the PSY calculation that provides the average water supply to the Basin, with the expectation that

this pattern will repeat itself in the future for planning purposes. For PSY determination, we expect that pumping in the near future approximates the current pumping patterns. The 2024 PSY Update prepared by Watermaster considered the most recently available data of pumping and consumptive use data (2018 to 2022), and water year 2022 was "assumed to represent pumping and consumptive uses on a forward-looking basis." (page 3 of the Watermaster Memorandum titled "Updates for PSY, Consumptive Uses, and Free Production Allowance Recommendations (FPA) for Water Year 2024-25") The factors used for the representative year include the land use, pumping, consumptive uses.

4. There is no contradiction. 1990 was the most recent data available at the time the initial PSY calculation was determined. The fact that 1990 was within the base period 1931-1990 **was not** the criteria for its selection as representative year for cultural conditions.

5. In Watermater's judgment, measured ground water pumping and ground water level measurements are the most reliable information available for PSY calculations in the Baja, Este and Oeste Subareas. The Judgment states that "Where actual records of data are not available, Watermaster shall rely on and use sound scientific and engineering estimates." (paragraph 24 w of the Judgment)

6. Paragraph 24w of the Judgment mandates that Watermaster "rely on and use the best available records of data." Also, expert Dutton notes "PSY is total production in each Subarea plus the surplus or deficit of water supply."

7. For the Baja Subarea, the regional model will help to eliminate data gaps. For Este and Oeste Subareas, recently installed streamflow gages at Cushenbury Wash and Sheep Creek respectively. Also, the new stream flow gage at Kane Wash in the Baja Subarea.

8. Not for the 2026-2027 Water Year.

F. Evaluation of Alternative Hydrologic Base Periods

1. As previously indicated, Watermaster also agrees it is now appropriate to select a more recent and drier base period than 1931-1990.

2. No.

3. 6% drier than in the 1931-1990 base period. This is based on the data available for the Mojave River measured surface flows at the Forks for both the 1931-1990 base period and the 2001-2020 new base period.

4. The modeling is being performed and paid for by the Mojave Water Agency, not the Watermaster. At present, the Mojave Water Agency does not intend to re-calibrate the UMBM to capture data beyond 2020. The UMBM will be replaced by the new Regional Groundwater Model.

5. This question is unclear. The year 2022 was selected as representative of water supply use and disposal for future planning.

6. Watermaster's 2024 PSY values were based upon water supply during the 2001-2020 base period, and water uses based on 2022 data (which does not rely on the model, but is verified measured production), except for the Baja and Este Subareas for which Watermaster used pumping data and interpretation of water levels.

7. The magnitude of the 2002-2022 base period is about 11-percent drier than the average of the 1931-1990 base period; the difference is about 6,529 acre-feet. The magnitude of the 2001-2020 base period is about 6-percent drier than the 1931-1990 base period; the difference between the average 2001-2020 and the 1931-1990 base period is about 3,903 acre-feet.

G. Cultural Conditions Evaluation

1. No response required.

2. The 1990s were abnormally high in terms of surface water supply, as measured at the Forks. See graph of surface flows at the Forks in the 1990s, compared to other time periods. As noted above, Watermaster defines extreme wet years as far above the "normal" average water supply. Any period that would include the 1990s shows a higher average water supply than the 1931-1990 long-term average and, therefore, would not represent the recent drier conditions. Additionally, the land uses in the 1990s are not comparable to current land uses.

3. No.

Response to Comments from EKI Environment & Water, Inc. (EKI)

The EKI report seems to suggest "the impact of the proposed hydrologic base period and the calculation of PSY in each subarea" should be considered in determining an appropriate base period. The solution to this over drafted basin is to require the purchase of replacement water. Accordingly, the "impact" of the proposed hydrologic base period (which is a drier base period than the 1931-1990 base period) may result in lower PSY values which, in turn, would require the purchase of replacement water.

The EKI Comment Letter also states:

In the Statement [of Reasons], Watermaster claims that *"Today's cultural conditions are represented by the new recent hydrologic base period of 2001-2020,"* (page 19). However, elsewhere in the Statement, and as quoted above, Watermaster explains that *"Even though the hydrologic base period of 2001-2020 was recommended by Watermaster for all Subareas, Watermaster recognizes that for the Baja Subarea, special circumstances may warrant PSY determination based on limited data. For the Baja Subarea, the only reliable data available is pumping and water level measurements (which show recent recovery). This is true for the Este Subarea and the Oeste Subarea as well,"* (page 14). While this may be a reasonable approach, it is unclear what criteria and process the Watermaster will use to determine what subset of available data for a given Subarea will be used to estimate PSY. (Italics added.)

Therein, EKI acknowledges that comparison of pumping and water level measurements is "a reasonable approach" where, as here, pumping and water level measurements are the only "reliable data available."

Now that we have had an opportunity to respond to the comments/questions in your letter, we believe a meeting would be useful to further discuss the issues presented. To that end and subject to your availability and that of your expert witness, I propose a remote meeting on either August 8, 2026, from 10:00 a.m. to Noon, or on August 9, 2026, from 9:00 a.m. to 11:00 a.m. Please advise as soon as you are able as to whether those dates and time work for you and your expert.

Very truly yours,

BRUNICK, MCELHANEY & KENNEDY PLC

LELAND P. MCELHANEY

LPM\pjq

cc: Jeffrey Ruesch
Robert C. Wagner

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EXHIBIT G

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January 5, 2026

VIA EMAIL

Andrea Hostetter
Mojave Watermaster
13846 Conference Center Drive
Apple Valley, CA 92307-4377
Email: ahostetter@mojavewater.org

Re: Mitsubishi, Robertson's, CalPortland Comment Letter
Mojave Watermaster Workshop re Watermaster Recommendations for New Hydrologic Base Period

Dear Ms. Hostetter:

This firm represents Mitsubishi Cement Corporation ("**Mitsubishi**"), Robertson's Ready Mix, Ltd. ("**Robertson's**"), and CalPortland Company ("**CalPortland**"). Collectively, these parties ("**Our Clients**") have facilities located throughout the Mojave Basin Area within the Este, Centro, Alto and Baja Subareas. This letter is submitted for consideration and discussion at the Mojave Watermaster ("**Watermaster**") Board meeting to be held on January 14, 2026. Please distribute this letter to Watermaster Board members and staff.

I. BACKGROUND FOR WATERMASTER CONSIDERATION OF AN UPDATED HYDROLOGIC BASE PERIOD

At the hearing on August 4, 2025, the Court acknowledged the merit of Our Clients' objections to any rubber-stamping of a new hydrologic Base Period. The Court observed that the hydrologic Base Period is not redetermined annually and might be considered, at most, every 10 or 12 years. The Court directed that the selection of a new hydrologic Base Period should be determined by separate motion "sometime next year" or at least prior to considering next year's updated Production Safe Yield ("**PSY**") or Free Production Allowance ("**FPA**") recommendations.

Watermaster filed a Motion for Determination of hydrologic Base Period (**"Motion"**) just weeks later, on September 3, 2025. Our Clients, and other parties, filed Oppositions to the Motion. Prior to the October 20, 2025, hearing on the Motion, the Court released its tentative decision that the Motion "for the indefinite future is denied." The Court recognized the importance of selecting an appropriate hydrologic Base Period, and the impact that this decision will have on PSY, FPA, and other aspects of the Judgment. A copy of the Court's tentative decision is attached as **Exhibit 1.**

The Court directed the parties to meet and confer and propose a process through which Watermaster would present its analysis and the information on which it is based, and continued the hearing to October 27, 2025. The parties met and conferred with Watermaster counsel to explore, if possible, a mutually agreeable public process for consideration of a new hydrologic Base Period. Though some alignment was reached on certain aspects of the process, the parties did not reach consensus. Attached as **Exhibit 2** is the schedule our office proposed to the Court on October 27, 2025.[1] At the hearing, Judge Reimer expressed his view that any new hydrologic Base Period would need to be both considered *and approved* by the Watermaster Board before being presented to the Court. Given the Court's directives to ensure a robust and transparent public process occurs in evaluating any new hydrologic Base Period, we encourage Watermaster to comply with the attached schedule and process.

On November 12, 2025, Watermaster released a report entitled, "Watermaster Engineer's Statement of Reasons for Recommending 2001-2020 hydrologic Base Period" ("**SOR**")[2] This office comments for Watermaster's consideration on December 11, 2025, to be addressed at the December 12, 2025, Watermaster Workshop, and we requested that these comments be included in the record. Additionally, we included comments prepared by our technical consultants, EKI Environment & Water ("**EKI**"). See **Exhibit 3.**

At the Watermaster Workshop of December 12, 2025, Watermaster staff requested that further comments on the selection of a hydrologic Base Period be submitted to the Watermaster by January 5, 2026. Currently, the Watermaster has indicated the Watermaster Board will hold a public hearing to consider the Watermaster's recommendation for the hydrologic Base Period at a special board meeting on January 14, 2026. We request that these comments be included in the record and the agenda packet for this meeting. Additionally, we include comments prepared by our technical consultants, EKI. See **Exhibit 4.**

On December 31, 2025, we received correspondence from Watermaster legal counsel providing responses to questions raised in our December 11, 2025 comment letter. Due to the holidays and related scheduling constraints prior to the January 5th timeline to submit this letter, we reserve the right to review and further address Watermaster legal counsel's comments and responses.

[1] While the Court indicated it would enter an order shortly after the October 27, 2025 hearing, we are not aware of a final Court order as of the date of this letter.

[2] Watermaster Engineer's Statement of Reasons for Recommending 2001-2020 Base Period.

II. 1995-2024 IS THE MOST SUPPORTABLE HYDROLOGIC BASE PERIOD AMONG ALTERNATIVES PRESENTED BY THE WATERMASTER

DWR Bulletin 84, *Los Angeles vs. San Fernando*, the Judgment's definition of PSY, the Court's direction to consider "climatic disruption" and utilize the "best available data," and the alternative periods presented by the Watermaster Engineer, 1995-2024 is a more appropriate hydrologic Base Period than the 2001-2020 period proposed by Watermaster staff.

A. DWR Bulletin 84, *Los Angeles vs. San Fernando*, the Judgment's PSY Definition, and Court Directives Provide Criteria in Selecting a New Hydrologic Base Period

To date, the Watermaster's criteria for evaluating and adopting a new hydrologic Base Period are drawn from multiple sources. We address those sources here.

DWR Bulletin 84 provides the following guidance regarding the criteria to be used for selecting a long-term base period:

> The base period conditions should be reasonably representative of long-time hydrologic conditions and **should include both normal and extreme wet and dry years**. Both the beginning and the end of the base period should be preceded by a series of wet years or a series of dry years, so that the difference between the amount of water in transit within the zone of aeration at the beginning and end of the base period would be a minimum. **The base period should also be within the period of available records** and **should include recent cultural conditions** as an aid for projections under future basin operational studies.
>
> (Watermaster SOR Exhibit A [DWR Bulletin 84], pg. 47-48, emphasis added).

In the selection of a base study period, the court in *Los Angeles vs. San Fernando* stated that the base period in that case corresponded to the period with precipitation similar to the long-term period of record 1872-73 through 1956-57. The Report of Referee (1962) stated the following:

> The desirable base study period is one during which precipitation characteristics in the Upper Los Angeles River area approximate the 85-year period of record, 1872-73 through 1956-57. A further requirement of such a period is that additional hydrologic information is available sufficient to permit an evaluation of the amount, occurrence and disposal of the normal water supply under recent culture conditions. **The desirable base period includes both wet and dry periods similar in magnitude and occurrence to the normal supply**, and **during which there are**

> **sufficient measurements** and **observations to relate the hydrology to recent culture**.
>
> (SOR Exhibit B [Report of Referee], pg. 182; emphasis added.)

The Judgment definition of Production Safe Yield is:

> Production Safe Yield - **The highest average Annual Amount of water that can be produced from a Subarea:** (1) **over a sequence of years that is representative of long-term average annual natural water supply to the Subarea net of long-term average annual natural outflow from the Subarea,** (2) under given patterns of Production, applied water, return flows and Consumptive Use, and (3) **without resulting in a long-term net reduction of groundwater in storage in the Subarea.**
>
> (Judgment ¶ 4.aa., emphasis added).

Lastly, the Court in its 2022 Free Production Allowance Order stated:

> For instance, the present calculation of PSY has been based on a 60-year study of flows from 1930 to 1990. The Court questions whether a 60-year period in the middle of the 20th century is still an appropriately representative period from which to measure the long-term averages specified in the definition of PSY, **especially given the 32 years that have passed since 1990 and the climatic disruptions that we have been experiencing during that time**. If that is not the most representative period, should a different period be defined? Mr. Wagner has stated that, if the judgment were being negotiated today, it would be more prudent to select 'a shorter, drier planning period (hydrologic base period) for local supply . . ., resulting in a lower estimated Production Safe Yield and consequently lower annual Free Production Allowance.' (Wagner Decl., p. 6, 11. 18-21.) Is the Watermaster bound to rely upon what appears at this point in time to be a less-than-prudent period?
>
> (Court's September 16, 2022 Order Directing the Watermaster to Re-Evaluate PSY for the Entire Basin, Exhibit A, pg. 4-5, emphasis added.[3])

[3] Court's September 16, 2022 Order Directing the Watermaster to Re-Evaluate PSY for the Entire Basin, Exhibit A, pg 4-5, available here https://www.mojavewater.org/wp-content/uploads/2022/09/20220919_Notice_Serving_Court_Order.pdf#page=7

The sources cited by Watermaster can be distilled into the following criteria in establishing an appropriate hydrologic Base Period:

- Both Normal and Extreme, Wet and Dry Years
- Base Period Must Be From Within Available Records
- Include Recent Cultural Conditions
- Highest Average Annual Amount of Water That Can Be Produced Without Resulting in a Long-term Net Reduction of Groundwater in Storage in the Subarea.
- Consider Climatic Disruption

The following subsections address each of these criteria, in turn, and how they support the selection of 1995-2024 as the most supportable base Hydrologic Period from among the alternatives presented by Watermaster.

B. <u>Both Normal and Extreme, Wet and Dry Years</u>

The Watermaster staff at the Workshop indicated that wet and dry years in the Basin are determined solely by whether Mojave River Flow at the Forks exceeds or falls below the 1931-1990 average of 65,538 af/year.[4] As such, "wet" years resulted in values higher than 65,538 af/year and "dry" years below 65,538 af/year.

The Watermaster has not defined a magnitude above the average that it considers "extreme" for either wet or dry years. Based on the above definitions, however, Watermaster acknowledges that the 1995-2024 hydrologic Base Period would satisfy the applicable criteria. (SOR p. 16:17-18).

The Watermaster did not analyze whether any alternative included "extreme" wet or dry years in any year, though it concluded that, for its 2001-2020 recommendation, such years were present. (See generally SOR section Evaluation of Alternative Hydrologic Base Periods, p. 15:1 to 18:27). The Watermaster states that the 2001-2020 hydrologic Base Period contains "both normal and extreme wet and dry years" without detailing the basis for such extremes. (See SOR p. 12:6-7 and 19:16). EKI finds that 1995-2024 includes "extreme" years of wet and dry because

[4] Our Client's previously disputed whether flow at the Fork is an appropriate basis to determine Basin wide whether a year is hydrologically wet or dry. For purposes of this comment letter that assertion is maintained.

it includes extreme wet years like 2005 and 2023 (which are significantly above 65,538 af/year), and multi-year dry periods like 1999-2002 and 2013-2018 (which are significantly below).[5]

As such, 1995-2024 contains both normal and extreme, wet and dry years, and satisfies this first element.[6]

C. Period of Available Records

The next element is that the hydrologic Base Period must be within the period of available records. The 1995-2024 range falls within the period of available records because the Watermaster began releasing annual reports in 1993-1994 and has collected annual reporting data ever since. The limitation on incorporating 2023-2024 water year data as a justification for Watermaster staff's proposed 2001-2020 hydrologic Base Period is an artificial and unnecessary limitation.

1. The Watermaster Began Releasing Annual Reports in 1993-94

1995-2024 falls within the available record period, as the Watermaster began releasing annual reports in 1993-1994, which include reporting and other measurement data as of that date.[7]

2. Watermaster Alleges that Data from 2023-2024 Cannot be Incorporated due to UMBM Calibration and that 2023-2024 Data was not Available in 2022

The Watermaster discounts multiple alternatives in part because (1) the Upper Mojave Basin Model ("**UMBM**") is only calibrated through 2020 and (2) the data from 2023-2024 water years were not available when the Watermaster originally proposed its 2001-2020 hydrologic Base Period in 2024.

3. The Watermaster does not Explain the Significance of why the UMBM Model Calibration is Required for a New Hydrologic Base Period

First, the Watermaster states 2002-2022 is not an appropriate selection "because the UMBM is calibrated through the year 2020." (SOR p. 17:16). Presumably, the Watermaster

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[5] EKI December 12, 2025 Letter, pg. 4.

[6] *Los Angeles vs. San Fernando* provides that the hydrologic Base Period should be within a "similar magnitude" of the original hydrologic Base Period. The 1995-2024 period is within 2% of the 1931-1990 average currently used under the Judgment, and is much more similar to that standard than the 6% difference using 2001-2020.

[7] See Watermaster First Annual Report for Water Year 1993-94, available at https://www.mojavewater.org/wp-content/uploads/2022/04/1ar9394.pdf

objects to any hydrologic Base Period ending after 2020 on similar bases, despite not stating this in the SOR.

The SOR is the first time the Watermaster has indicated UMBM calibration is a basis for why certain alternatives may be less feasible than others. The Watermaster did not discuss this limitation in the Motion[8], or its Reply[9] to the Motion. Additionally, the Watermaster does not further describe or analyze this calibration issue in the SOR, beyond providing it as a basis to discount the proposed alternatives.

The Watermaster does not describe:

- What effect the UMBM model's ending has on the selection of a hydrologic Base period;
- Whether the UMBM could be extended through 2024 (especially given that the UMBM was recently extended through 2020 in the 2024 PSY Update)[10];
- Whether calibration is a required prerequisite for the selection of a hydrologic Base Period or merely helpful in analyzing options;
- Whether this calibration issue supports waiting on any updated hydrologic Base Period until the full regional Model is released.

When the SOR set forth its criteria for selecting a hydrologic Base Period, it primarily directs readers to Bulletin 84 and *Los Angeles vs. San Fernando.* (SOR pp. 5-6). The SOR did not consider current UMBM calibration as a "critical" element until the analysis started to discount alternatives (SOR p. 17).

If the current UMBM calibration is critical enough to discount a potential hydrologic Base Period, then it is critical enough to delay approval of any hydrologic Base Period until the full

[8] Watermaster Motion for Determination of hydrologic Base Period, available at 20250903a_Motion_for_Determiniation_of_Hydrologic_Base_Period_for_PSY_Calcs.pdf

[9] Watermaster Reply to Motion for Determination of hydrologic Base Period, available at 20251013_Watermaster_Reply_ISO_Determination_HydrologicBasePeriod_for_PSY.pdf

[10] See Watermaster 2024 PSY Update, Appendix G Upper Mojave River Basin Groundwater Model, pg. 1 (The current UMRB model is an expanded and updated version of the 2007 version of the model, which was calibrated from water year 1997 to water year 2005 [...] The model presented in this technical memorandum (TM) extends the spatial boundaries of the original UMRB model to include the upper basin (the watersheds of Deep Creek and West Fork) and is a fully integrated groundwater/surface-water numerical model. **The calibration period was also extended and covers water years from 1951 to water year 2020.**) emphasis added.

Regional model is done, or until the UMBM includes years through 2024. Additionally, without further analysis or explanation by the Watermaster as to the effect of calibration, it is not a proper basis to discount a hydrologic Base Period when the Watermaster has, within the last two years, updated the UMBM to include more recent years. As discussed below, the benefit of including more recent data from 1995-2024 more closely conforms to the criteria above when compared with the Watermaster's claims as to needing a more recently calibrated UMBM.

4. Watermaster Acknowledges that Hydrologic Base Periods with Data from 2023-2024 were not Analyzed in the 2024 PSY Update

The Watermaster notes that "the PSY Update prepared by Watermaster in February of 2024 evaluated a new hydrologic base period based on the information available at that time (up to the end of Water Year 2023). For that reason, Watermaster did not include a base period ending in 2024." (SOR 17:25-27). Watermaster's current assertions imply that because that data was not available *then*, it cannot be used *now*. The Court ordered the Watermaster in 2025 to file future motions for hydrologic Base Periods, not to make recommendations based on data collected as of the 2024 PSY Update. The Watermaster's analysis is unnecessarily limited to data as of the 2024 PSY Update, for no reason other than it appears administratively convenient, since it would not require an update to the UMBM and would support the Watermaster's previous selection of 2001-2020.

D. <u>Recent Cultural Conditions</u>

The SOR includes additional analysis of land-use changes in the Subareas from the 1990s to date. What the SOR fails to demonstrate is why a hydrologic Base Period ending in 2020 is appropriate when, as of the date of this letter, five years will have passed, and every other proposed hydrologic Base Period includes years after 2020.

1. 1995-2024 Includes More Recent Years than 2001-2020

The SOR does not explain why 2020 is an appropriate cutoff for recent cultural conditions, especially since all alternatives analyzed cover years after 2020. (SOR Table 2, p. 16). For hydrologic Base Periods that include the most recent cultural conditions, 2001-2020 is the *least* supportable option analyzed. (SOR Tables 1-2).

A simple textual reading of the requirement "recent culture conditions" would focus on including "recent" years where available. As such, 1995-2024 includes four more recent years of cultural conditions compared to 2001-2020, which weighs in favor of 1995-2024 as a better hydrologic Base Period.

2. Cultural Conditions and Land Use Changes Occur Gradually

Watermaster concludes that "alternative hydrologic base periods that begin in the 1990s do not meet the representation of recent cultural conditions, and therefore, they should not be considered appropriate hydrologic base periods for PSY redetermination," and as such, 1995-2024 and 1998-2024 are discounted by Watermaster. (SOR 18:17-19).

Watermaster states that data from the 1990s is not sufficiently recent, but as discussed above, simultaneously discounts both 1995-2024 and 1998-2024, which include the most recent years of recent cultural conditions and four more years than 2001-2020. Moreover, 1998-2024 includes only two years earlier than 2001-2020, and Watermaster does not identify any dramatic changes that occurred in 1999 and 2000. The Watermaster's analysis suggests that two years of 90s data significantly outweighs the value of the four most recent years. Watermaster's proposed hydrologic Base Period based on this criterion appears to be inconsistent with the criteria set forth in Bulletin 84.

Cultural conditions and land-use changes occur gradually and rarely vary from year to year without a significant intervening event. Accordingly, the hydrologic Base Period should generally include more recent data and exclude older data to capture cultural changes better. What the SOR fails to analyze, however, is that 1996 arguably saw the most significant event affecting land uses in the Mojave Basin in the last century: the entry of the Judgment and the Physical Solution.

As such, 1995-2024 captures the most significant "cultural" change in its entirety because it covers the last year before the implementation of the Physical Solution through the present, and it also meets *the other criteria of Bulletin 84*. 1995-2024 is the only proposed hydrologic Base Period that covers (1) the entry of the Judgment and (2) the most recent cultural conditions.

3. 1995-2024 Includes Watermaster's Proposed PSY Representative Year Within the Hydrologic Base Period

Watermaster states that "that when calculating PSY, the year representative of pumping and consumptive uses does not necessarily need to be strictly contained within the time frame of the hydrologic base period." (SOR 12:25-27). It is unclear on what basis Watermaster considers this to be appropriate under current circumstances or under the Judgment.

Watermaster's assertions are not consistent with the structure of the PSY definition, or the fact that the original "representative year" (1990) was limited to being within the hydrologic Base Period (1931-1990) as set forth in the Stipulated Judgment. The definition of PSY is as follows:

> The highest average Annual Amount of water that can be produced from a Subarea: **(1) over a sequence of years that is representative of long-term average annual natural water supply to the Subarea net of long-term average annual natural outflow from the Subarea,** (2) under given patterns of Production, applied water, return flows and Consumptive Use, and (3) without resulting in a long-term net reduction of groundwater in storage in the Subarea.
>
> (Judgment section 4.aa, emphasis added)

It is unclear from this definition where the Watermaster finds it has authority to select a "representative year" outside of clause (1) *which is the hydrologic Base Period.* Additionally, the Watermaster notes that the original "representative year" (1990) was limited to the original hydrologic Base Period (1931-1990) despite the entry of the Judgment occurring six years after 1990. Why would the Judgment have utilized 1990 when data was available for 1991-1994 by the time the Judgment was entered in 1996? How would a year be "representative of 1931-1990" when it is not included in that data set?

While the Court may have permitted this in the past, the selection of 1995-2024 largely resolves this issue by including the most recent years into the hydrologic Base Period, including 2022.

For this reason, 1995-2024 is more appropriate as a hydrologic Base Period as compared to 2001-2020.

E. <u>Highest Average Annual Amount of Water That Can Be Produced Without Resulting in a Long-term Net Reduction of Groundwater in Storage</u>

As noted above, the PSY definition requires the Watermaster to select values that reflect the "highest average annual amount of water that can be produced from a Subarea," "without resulting in a long-term net reduction of groundwater in storage in the Subarea." Watermaster's analysis does not appear to evaluate the impact of the proposed base Hydrologic Period alternatives on PSY.

The hydrologic Base Period is foundational to PSY. Any proposed new hydrologic Base Period should have analyzed these requirements and impacts. Watermaster's determination to recommend a "drier" hydrologic Base Period contradicts this requirement from the Judgment.

When considering these requirements, 1995-2024 is the most supportable alternative among the periods presented by Watermaster. It yields a 2% increase in total water supply compared to 1931-1990, while meeting all other criteria discussed above. Watermaster has acknowledged that "[f]rom a water supply perspective, a larger magnitude of average water supply might yield a higher PSY value," but then fails to account for the fact that the Judgment requires a base period that supports a maximum—not minimum or unduly conservative—PSY.[11] 2001-2020 specifically fails to meet this requirement and renders a 6% decrease in total water supply relative to 1931-1990.

F. Climatic Disruption

We disagree with Watermaster's implication that "[t]he Court previously asked that we consider a drier and more recent hydrologic planning period" equates to an order to recommend a drier hydrologic Base Period. The full quote from the Court's Order dated September 19, 2022, regarding the 2022 FPA approvals, is as follows:

> For instance, the present calculation of PSY has been based on a 60-year study of flows from 1930 to 1990. The Court questions whether a 60-year period in the middle of the 20th century is still an appropriately representative period from which to measure the long-term averages specified in the definition of PSY, especially given the 32 years that have passed since 1990 **and the climatic disruptions that we have been experiencing during that time.** If that is not the most representative period, should a different period be defined? **Mr. Wagner has stated that**, if the judgment were being negotiated today, it would be more prudent to select "**a shorter, drier** planning period (hydrologic base period) for local supply . . ., resulting in a lower estimated Production Safe Yield and consequently lower annual Free Production Allowance." (Wagner Decl., p. 6, 11. 18-21.) Is the Watermaster

[11] We disagree with Watermaster's characterization that "[t]he Judgment is intended as a funding mechanism so that those that pump more than their FPA will be required to purchase Replacement Water from Watermaster for recharge in a given subarea." (SOR 6:8-10). While the Judgment contains this funding mechanism for parties that need to purchase Replacement Water, the Judgment is intended to "declar[e] and adjudicate[...] the rights to reasonable and beneficial use of water by the Parties in the Mojave Basin Area." (Judgment section II.A.1.a). This is implemented in practice by the definition of PSY, which requires the Highest Average Annual Amount be producible by the Parties, thereby promoting the greatest "reasonable and beneficial use" of water by the Parties. Selecting a hydrologic Base Period to require more Rampdown than necessary for the mere purpose of parties acquiring more Replacement Water is not consistent with the principles of the Judgment.

> bound to rely upon what appears at this point in time to be a less-than-prudent period?
>
> (Emphasis added).

At no time has the Court ordered the Watermaster to recommend a drier hydrologic Base Period, as acknowledged by Watermaster staff at the Workshop. Despite this acknowledgment, multiple alternative hydrologic Base Periods were discounted by Watermaster apparently because they were not "drier" than the 1931-1990 average. (SOR p. 17:12-13).

The Court directed Watermaster to consider "climatic disruption" from 1990 to the present, when considering whether to propose a new hydrologic Base Period. Climate disruption does not reflexively equate to "drier" conditions. Climatic disruption is intended to more accurately capture the volatility between extremely wet years and severe droughts that have occurred since 1990. EKI notes that MWA studies indicate that "extreme flow events are expected to continue into the future," alongside drier years.[12] Climatic disruption should focus on extremes of both ends, since the average water supply in this Basin is calculated by averaging across extreme wet and extreme dry events to reach an "average."

A hydrologic Base Period of 1995-2024 would more accurately include "extreme wet years like 2005 and 2023, and multi-year dry periods like 1999-2002 and 2013-2018," and therefore captures climatic disruption more accurately than 2001-2020.[13]

III. CONCLUSION

We appreciate Watermaster's release of the SOR, holding the December 12, 2025, Workshop, and its intention to hold a public hearing to approve any proposed recommendations relating to the hydrologic Base Period.

We request that, among the alternatives presented by the Watermaster Staff to date, the Watermaster Board adopt the recommendation of 1995-2024 as the hydrologic Base Period, rather than 2001-2020. 1995-2024 more closely meets the requirements in Bulletin 84, *Los Angeles vs. San Fernando*, the Judgment's definition of PSY, and the Court's direction to consider "climatic disruption" and utilize the "best available data." We further request Watermaster update its analysis in response to this comment letter and provide all available and additional information for the updated analysis or updated recommendations for any new hydrologic Base Period selection for each Subarea.

[12] EKI December 12, 2025 Letter, pg. 5.
[13] *Id* at pg. 4.

We reserve the right to further comment on the December 31, 2025, response letter from Watermaster legal counsel, and any further information provided by Watermaster or other parties prior to and at the January 14, 2026, public hearing. We also reserve the opportunity to review and consider any new or different information that might warrant a different recommendation or update.

We look forward to participating in further discussions and attending future Watermaster board meetings, where these matters will be considered for approval and recommendation to the Court.

Sincerely,

FENNEMORE LLP

Derek Hoffman

DHOF
Enclosures
cc/enc: L. McElhany (lmcelhaney@bmklawplc.com)

62865530

EXHIBIT 1

1.

CIV208568	CITY OF BARSTOW VS CITY OF ADELANTO	MOTION FOR DETERMINATION OF HYDROLOGIC BASE PERIOD FOR PRODUCTION SAFE YIELD CALCULATIONS BY THE MOJAVE WATER AGENCY

Tentative Ruling:

The Watermaster's motion to change the hydrologic base period from 1931-1990 to 2001-2020 for the indefinite future is denied. Because of the importance of identifying an appropriate base period, the denial is without prejudice to a more robustly supported motion that addresses the Court's concerns.

The Court is mindful of the timeline facing the Watermaster. To avoid holding up the Watermaster's calculations of PSY and FPA, the Watermaster's annual report, and the annual motion regarding the Watermaster's recommended changes to FPA, the Court will consider the possibility of granting the motion on a temporary basis, i.e., authorizing the propesed base period (2001-2020) to be used in calculating the FPA recommendations for water year 2026-2027. The parties should be prepared to discuss that possibility, as well as the Watermaster's motion to adopt the proposed base period on an on-going basis.

Analysis:

There are two fundamental questions presented by the motion. The first is whether the proposed base period is a more reasonable representation of long-term hydrologic conditions in the basin than the existing base period. The second question is whether the proposed base period is a better representation of those conditions than any of the possible alternative periods. The motion addresses only the former. It does not mention possible alternative periods at all.

In its reply, the Watermaster argues that it would be a waste of scarce resources to evaluate other alternative base periods. (Reply, p. 3.) The Court disagrees. If other alternatives are not considered, there is no way to determine whether the selection of the proposed base period complies with the Judgment's requirement that the Watermaster rely upon the "best available records and data to support implementation of this Judgment."

Similarly, the Watermaster argues that it would be burdensome to evaluate "more than 100 years of data." (Reply, p. 3.) Again, the Court is not persuaded. No one is suggesting that the Watermaster must evaluate potential base periods that include or overlap with portions of the existing base period (1931-1990.) Instead, the question is whether there are other potential base periods since 1990 that would better represent the basin than either 1931-1990 or 2001-2020.

The Watermaster contends that any new base period should meet the criteria specified in DWR Bulletin No. 84. It is unclear, however, whether compliance with the bulletin is required. The very language that the Watermaster quotes is aspirational ("should") rather than mandatory ("shall"). Nevertheless, the Watermaster does not address the issue.

Assuming arguendo that the bulletin is at least persuasive if not mandatory, the proposed base period does not satisfy the bulletin's criteria. One criterion is that "[b]oth the beginning and end of the base period should be preceded by a series of wet years or a series of dry years .... " In addressing the requirement concerning the beginning of the period, the Watermaster asserts that the beginning of the proposed base period was "preceded by a series of dry years, i.e., dry years in 1999 and 2002 precede the 2001 beginning of the base period ... . " (Motion, p. 4.) 2002 did not precede 2001. Therefore, only one dry year, 1999, preceded the beginning of the proposed period in 2001. Because a single dry year does not constitute a "series" of dry years., that criterion is not met. Thus, assuming arguendo that Bulletin No. 84 describes the correct criteria to be used when selecting a new base period, the base period proposed does not meet those criteria. 579

The motion also argues that "recent cultural conditions" will be better reflected in the proposed base period than in the existing base period. But the Watermaster offers no evidence that those conditions were significantly different in 2001-2020 as compared to 1931-1990. While the Court has little doubt that they are, the Court needs to rely on evidence, not its assumptions. (Even if the evidence had been presented, it is unclear how the "cultural conditions" relate to the selection of the base period as opposed to being later factored into the RMRBM.)

To allow a careful evaluation of the Watermaster's assertions regarding the distribution of normal wet years, extremely wet years, normal dry years, and extremely dry years, the Court needs to know the criteria by which the Watermaster distinguishes normal years from extreme years. Similarly, the Watermaster offers no evidence (as opposed to argument in its Reply) to support the implicit conclusion that water flow at the Forks reasonably represents the water supply for the basin as a whole. It may be, but the motion does not address the issue.

The Watermaster suggests in its Reply that, because the Judgment does not expressly require Court approval of changes in the base period, the Watermaster should be deemed to have the discretion to pick whatever base period it believes is most appropriate. (Reply, pp, 2 & 9.) That reasoning fails, because the Watermaster is required to obtain court approval for changes in FPA The base period is integral to the calculation of PSY and the resulting recommendations regarding changes to FPA If the Watermaster is relying upon a base period that has not been approved, then the Court will be reluctant to approve recommendations based on that base period. Regardless of the express terms of the Judgment, as a practical matter the Watermaster's preferred base period needs judicial endorsement.

EXHIBIT 2

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SUPERIOR COURT OF THE STATE OF CALIFORNIA

COUNTY OF RIVERSIDE – CENTRAL DISTRICT

Coordination Proceeding Special Title (Cal. Rules of Court, Rule 3.550) MOJAVE BASIN WATER CASES	Case No. JCCP5265 Mojave Basin Water Cases Dept. 1, Riverside Superior Court Hon. Craig G. Reimer Lead Case CIV208568 Coordinated With San Bernardino Superior Court Case No. CIVSB2218461
CITY OF BARSTOW, et al., Plaintiff, v. CITY OF ADELANTO, et al., Defendant.	**MITSUBISHI CEMENT CORPORATION, ROBERTSON'S READY MIX, LTD. AND CALPORTLAND COMPANY PROPOSED SCHEDULE FOR BASE PERIOD AND RELATED MOTIONS** **Date:** Oct 27, 2025 **Time:** 10:00 a.m. **Dept:** 1
AND RELATED CROSS-ACTIONS.	

582

MITSUBISHI CEMENT CORPORATION ("Mitsubishi"), ROBERTSON'S READY MIX, LTD. ("Robertson's"), and CALPORTLAND COMPANY ("CalPortland"), collectively, the "above-captioned parties," by and through their attorneys of record, Fennemore LLP, hereby submit this proposed schedule for stakeholder engagement, Watermaster motion and Court determination of the "base period" and related Watermaster processes. This proposal is made following the October 21, 2025, hearing on Watermaster's Motion for Determination of Hydrologic Base Period for Production Safe Yield Calculations, and consideration of the Court's tentative ruling to deny that Motion.

Pursuant to Court's direction at the hearing on October 21, 2025, counsel for the above-captioned parties initiated and conducted a meet and confer with counsel for the Watermaster, California Department of Fish and Wildlife, Golden State Water Company and Newberry Springs Recreational Lakes Association on October 23, 2025. Though some progress was made, a consensus proposal was not reached and does not appear to be reachable.

The above-captioned parties propose the following schedule for the Court's consideration. As the Court already expressed its willingness to consider, the Court may need to enter an order relieving certain timing obligations under the Judgment and the Watermaster's Rules and Regulations to accommodate the following schedule, pursuant to the Court's authority under Judgment § 19.

The above-captioned parties reserve the right to consider adjustments to the proposed schedule and to present further argument, views and objections to alternative proposals at the continued hearing on October 27, 2025.

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	Description	Date
1	Watermaster releases Base Period Recommendations and supporting materials	November 12, 2025
2	Watermaster Workshop – Base Period	December 12, 2025
3	Watermaster Board Meeting – Base Period	January 28, 2026
4	Watermaster Motion to adopt Base Period	February 11, 2026
5	Opposition(s) to Watermaster Motion to adopt Base Period	March 3, 2026
6	Watermaster Reply ISO Motion to adopt Base Period	March 11, 2026
7	Court Hearing – Base Period	March 18, 2026
8	Watermaster releases FPA Recommendations and draft Annual Report	March 23, 2026
9	Watermaster Workshop – FPA	April 22, 2026
10	Watermaster Board Meeting – FPA Recommendations and draft Annual Report	May 27, 2026
11	Watermaster Motion to adopt FPA Recommendations and draft Annual Report	June 1, 2026
12	Opposition(s) to Watermaster Motion to adopt FPA Recommendations and draft Annual Report	June 22, 2026
13	Watermaster Reply ISO Motion to adopt FPA Recommendations and draft Annual Report	June 30, 2026
14	Court Hearing – FPA Motion	July 8-10, 2026

Dated: October 24, 2025

FENNEMORE LLP

By: [signature]
Derek Hoffman
Darien K. Key
MITSUBISHI CEMENT CORPORATION, ROBERTSON'S READY MIX, LTD., and CALPORTLAND COMPANY

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PROOF OF SERVICE

STATE OF CALIFORNIA, COUNTY OF SAN BERNARDINO

Re: City of Barstow v. City of Adelanto, et al.;
Riverside Superior Court Case No.: CIV 208568

I am employed in the County of Fresno, State of California. I am over the age of 18 years and not a party to the within action; my business address is: 8080 North Palm Ave. Third Floor, Fresno, CA 93711. On October 24, 2025, I served copies of the within documents described as **MITSUBISHI CEMENT CORPORATION, ROBERTSON'S READY MIX, LTD. AND CALPORTLAND COMPANY PROPOSED SCHEDULE FOR BASE PERIOD AND RELATED MOTIONS** on the interested parties in this action in a sealed envelope addressed as follows:

See attached Service List

[X] **BY MAIL** - I am "readily familiar" with the firm's practice of collecting and processing correspondence for mailing. Under that practice, it would be deposited with the United States Postal Service on the same day in the ordinary course of business, with postage thereon fully prepaid at San Bernardino, California. I am aware that on motion of the party served, service is presumed invalid if postal cancellation date or postage meter date is more than one day after date of deposit for mailing in affidavit.

[ ] **BY PERSONAL SERVICE** - I caused such envelope to be delivered by hand to the offices of the addressee pursuant to C.C.P. § 1011.

[ ] **BY EXPRESS MAIL/OVERNIGHT DELIVERY** - I caused such envelope to be delivered by hand to the office of the addressee via overnight delivery pursuant to C.C.P. § 1013(c), with delivery fees fully prepaid or provided for.

[ ] **BY FACSIMILE** - I caused such document to be delivered to the office of the addressee via facsimile machine pursuant to C.C.P. § 1013(e). Said document was transmitted to the facsimile number of the office of the addressee from the office of Gresham Savage Nolan & Tilden, in San Bernardino, California, on the date set forth above. The facsimile machine I used complied with California Rules *of Court*, Rule 2003(3) and no error was reported by the machine. Pursuant to California *Rules of Court*, Rule 2009(i), I caused the machine to print a record of the transmittal, a copy of which is attached to this declaration.

[X] **BY ELECTRONIC/EMAIL** - Pursuant to the party's express consent to receive electronic service, I caused such document to be delivered to the office of the addressee via electronic e-mail pursuant to C.C.P. §1010.6(a)(2)(A)(ii). Said document was transmitted to the email address of that office which is listed on the attached Service List. Said document was served electronically and the transmission was reported as complete and without error.

FEDERAL - I am employed in the office of a member of the bar of this court at whose direction the service was made.

I declare under penalty of perjury under the laws of the State of California that the foregoing is true and correct. Executed on October 24, 2025, at Fresno, California.

Kelly Ridenour

KELLY RIDENOUR

SERVICE LIST

Re: City of Barstow v. City of Adelanto, et al.;
Riverside Superior Court Case No.: CIV 208568

William J. Brunick, Esq. Leland P. McElhaney, Esq. Brunick, McElhaney & Kennedy PLC 1839 Commercenter West P.O. Box 13130 San Bernardino, CA 92423-3130 Email: bbrunick@bmklawplc.com lmcelhaney@bmklawplc.com	**Attorneys for Defendant/Cross-Complainant, MOJAVE WATER AGENCY**
Mojave Basin Area Watermaster c/o Jeff , Watermaster Services Manager 13846 Conference Center Drive Apple Valley, CA 92307-4377 Email: jruesch@mojavewater.org watermaster@mojavewater.org	MOJAVE BASIN AREA WATERMASTER
Diana J. Carloni 21001 N. Tatum Blvd. Suite 1630.455 Phoenix AZ 85050 Diana@carlonilaw.com	NEWBERRY SPRINGS RECREATIONAL LAKES ASSOCIATION
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Stephanie Osler Hastings Mackenzie W. Carlson BROWNSTEIN HYATT FARBER SCHRECK, LLP 1021 Anacapa Street, 2nd Floor Santa Barbara, CA 93101 SHastings@bhfs.com Mcarlson@bhfs.com	GOLDEN STATE WATER COMPANY

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EXHIBIT 3

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December 11, 2025

VIA EMAIL

Andrea Hostetter
Mojave Watermaster
13846 Conference Center Drive
Apple Valley, CA 92307-4377
Email: ahostetter@mojavewater.org

Re: Mitsubishi, Robertson's, CalPortland Comment Letter
Mojave Watermaster December 12, 2025 Workshop re Watermaster Recommendations for New Hydrologic Base Period

Dear Ms. Hostetter:

This firm represents Mitsubishi Cement Corporation ("**Mitsubishi**"), Robertson's Ready Mix, Ltd. ("**Robertson's**"), and CalPortland Company ("**CalPortland**"). Collectively, these parties ("**Our Clients**") have facilities located throughout the Mojave Basin Area within the Este, Centro, Alto, and Baja Subareas. This letter is submitted for consideration and discussion at the Mojave Watermaster ("**Watermaster**") Workshop meeting to be held on December 12, 2025. Please distribute this letter to Watermaster Board members and staff.

I. BACKGROUND FOR WATERMASTER WORKSHOP REGARDING CONSIDERATION OF AN UPDATED HYDROLOGIC BASE PERIOD

At the hearing on August 4, 2025, the Court acknowledged the merit of Our Clients' objections to any rubber-stamping of a new hydrologic Base Period. The Court observed that the base hydrologic period is not redetermined annually and might be considered, at most, every 10 or 12 years. The Court directed that the selection of a new hydrologic Base Period should be determined by separate motion "sometime next year" or at least prior to considering next year's updated Production Safe Yield ("**PSY**") or Free Production Allowance ("**FPA**") recommendations.

Watermaster filed a Motion for Determination of hydrologic Base Period just weeks later, on September 3, 2025. Our Clients, and other parties, filed Oppositions to the Motion. Prior to the October 20, 2025, hearing on the Motion, the Court released its tentative decision that the Motion "for the indefinite future is denied." The Court recognized the importance of selecting an appropriate hydrologic Base Period, and the impact that this decision will have on PSY, FPA, and other aspects of the Judgment. A copy of the Court's tentative decision is attached as **Exhibit 1**.

The Court directed the parties to meet and confer and propose a process through which Watermaster would present its analysis and the information on which it is based, and continued the hearing to October 27, 2025. The parties met and conferred with Watermaster counsel to explore, if possible, a mutually agreeable public process for consideration of a new hydrologic Base Period. Though some alignment was reached on certain aspects of the process, the parties did not reach consensus. Attached as **Exhibit 2** is the schedule our office proposed to the Court on October 27, 2025.[1] At the hearing, Judge Reimer expressed his view that any new hydrologic Base Period would need to be both considered *and approved* by the Watermaster Board before being presented to the Court. The Workshop is an early step in this process, but not the only step in the public process.

Given the Court's directives to ensure a robust and transparent public process occurs in evaluating any new hydrologic Base Period, we encourage Watermaster to comply with the attached schedule and process.

On November 12, 2025, Watermaster released a report entitled, "Watermaster Engineer's Statement of Reasons for Recommending 2001-2020 hydrologic Base Period" ("**SOR**")[2] We provide these comments for Watermaster's consideration at the December 12, 2025, Watermaster Workshop, and we request that these comments be included in the record. Additionally, we include comments prepared by our technical consultants, EKI Environment & Water ("**EKI**"). EKI's comments are attached as **Exhibit 3**.

[1] While the Court indicated it would enter an order shortly after the October 27, 2025 hearing, we are not aware of a final Court order as of the date of this letter.

[2] Watermaster Engineer's Statement of Reasons for Recommending 2001-2020 Base Period.

II. COMMENTS REGARDING WATERMASTER SOR

We request Watermaster address the following questions and comments at the Workshop regarding the SOR.

A. Applicability of DWR Bulletin 84

Watermaster SOR Reference	Question/Comment
SOR reliance on Bulletin 84 as the standard and criteria for selecting a new hydrologic Base Period. (See SOR, pg. 2-5)[3]	1. The SOR emphasizes selection of a hydrologic Base Period based primarily upon guidance from the 1967 DWR Bulletin 84 and the 1975 opinion in *City of Los Angeles vs. City of San Fernando, et al., 14 Cal.3d 199 (1975).* 2. Does Watermaster contend that the standards in the above-referenced records reflect the best current methodology for determining a new hydrologic Base Period for the Mojave Basin and each of its Subareas? 3. Has Watermaster considered other guidance materials such as California Department of Water Resources' Sustainable Groundwater Management Best Management Practices for Water Budgets?[4]

[3] Summary of SOR pgs 2-5.
[4] DWR BMP for SGMA, Water Budget, (2016) available at https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/Sustainable-Groundwater-Management/Best-Management-Practices-and-Guidance-Documents/Files/BMP-4-Water-Budget_ay_19.pdf

B. **Initial Hydrologic Base Period 1931-1990**

Watermaster SOR Reference	Question/Comment
"Based upon DWR's guidance in Bulletin 84, the Parties and the Court in City of Barstow determined the initial hydrologic Base Period should be from 1931 to 1990, because it includes both normal and extreme wet and dry years." (SOR 5:25-27).	1. How does Watermaster define "normal" and "extreme" wet and dry years? 2. Is Watermaster's definition of wet and dry years based solely upon flows at the Forks?

C. **Water Supply to the Basin Area**

Watermaster SOR Reference	Question/Comment
"Surface water inflow to the Alto Subarea is measured flow of the Mojave River at the Forks and is the sum of reported values from USGS gage stations at West Fork Mojave River near Hesperia, CA and Deep Creek near Hesperia, CA. This measured USGS gage data provides the best available information regarding the surface water inflow to the Basin Area. There are very few records of surface water inflow to the Este and Oeste Subareas." (SOR 11:17-22)	1. Please identify all records and reports Watermaster is relying upon for surface water inflow to the Este and Oeste Subareas.
"Watermaster reviewed records of precipitation. Although there are several precipitation stations located within the Forks' watershed, the reliability of this data is questionable. The precipitation records are short, inconsistent, and intermittent (see Exhibit M). For these reasons, Watermaster believes the measured flow of the Mojave River at the Forks continues to be the record indicative of the long-term water supply to the Basin Area. Additionally, the flow record at the Forks provides a clear indication of wet and dry periods in the Basin Area." (SOR 11:23-12:2)	2. Has Watermaster considered any third-party data that can provide reliable precipitation records?

D. **Watermaster Proposed Hydrologic Base Period 2001-2020**

Watermaster SOR Reference	Question/Comment
"Once the hydrologic Base Period is set, there is no reason to reset it every year, or at any other time unless the conditions upon which it is based change significantly." (SOR 12:13-15).	1. Does Watermaster intend to present any update to its recommendations for a new hydrologic Base Period once its model update is completed?

E. **Hydrologic Base Period vs. Pumping and Consumptive Uses for purposes of PSY determination**

Watermaster SOR Reference	Question/Comment
"Watermaster needs to clarify that when calculating PSY, the year representative of pumping and consumptive uses does not necessarily need to be strictly contained within the time frame of the hydrologic Base Period." (SOR 12:25-27)	1. This paragraph is unclear. Please provide the legal and technical basis for Watermaster's contention that the representative year for PSY may be outside the hydrologic Base Period. 2. Is it Watermaster's position that the hydrologic Base Period is not foundational to PSY? 3. If PSY can be based upon some "representative year," outside the hydrologic Base Period as Watermaster suggests, what criteria, data, factors, and standards does Watermaster contend would apply in selecting a "representative year" for PSY?[5] 4. Watermaster's interpretation appears to contradict the fact that the first PSY year (1990) was within the hydrologic Base Period sequence (1931-1990). (See

[5] See Judgment sections 4.aa.(1)-(2).

	SOR 12:27-13:2; Table C-1 of the Judgment).
"Even though the hydrologic Base Period of 2001-2020 was recommended by Watermaster for all Subareas, Watermaster recognizes that for the Baja Subarea, special circumstances may warrant PSY determination based on limited data. For the Baja Subarea, the only reliable data available is pumping and water level measurements (which show recent recovery). This is true for the Este Subarea and the Oeste Subarea as well." (SOR 14:4-9)	5. This paragraph is not clear. Please elaborate. 6. What provisions of the Judgment does Watermaster contend would allow PSY determination to be based on limited data? 7. What is Watermaster's plan and timeline to address and fill any known information gaps for Este, Baja, and Oeste? 8. Please clarify whether Watermaster is still considering recommending different hydrologic Base Periods for each Subarea. If so, what data, criteria, or other factors would Watermaster consider in determining whether to recommend a different hydrologic Base Period for a particular Subarea?

F. **Evaluation of Alternative Hydrologic Base Periods**

Watermaster SOR Reference	Question/Comment
"From a water supply perspective, a larger magnitude of average water supply might yield a higher PSY value. On the contrary, a smaller magnitude of water supply might yield a lower PSY value. However, as noted above, the Court previously asked Watermaster to consider a drier and more recent hydrologic Base Period. For these reasons, Watermaster does not recommend the two alternative hydrologic Base Periods of 1991-2022 and 1995-2024." (SOR 17:9-14).	1. The Court asked Watermaster to "consider" a drier and more recent period. Is it Watermaster's position that this direction *requires* Watermaster to *recommend* a drier period? 2. Does Watermaster consider any other potential hydrologic Base Periods would be more technically supportable if not presumed required to select a "drier" period?

	3. How much "drier" does Watermaster project hydrologic conditions for the Basin to become? What studies and data is Watermaster relying on for that projection?
The alternative base period 2002-2022 starts and ends on a dry year and is preceded by a series of dry years. However, because the UMBM is calibrated through the year 2020 only, Watermaster does not consider this to be an appropriate selection. (SOR 17:15-17)	4. Will Watermaster further calibrate the model to capture more recent data (2000-2024)? 5. What impacts does the UMBM not being calibrated past 2020 have on Watermaster's proposal to select 2022? 6. If 2022 was outside the period of model calibration, how were Watermaster 2024 PSY values derived and supported to the extent they relied on 2022 data?
Because the alternative 2002-2022 base period is outside the period of the UMBM calibration, and the magnitude of water supply in the alternative 2002-2022 base period does not "closely approximate" the magnitude of the long-term water supply during the 1931-1990 base period (as indicated by DWR Bulletin 84), Watermaster believes the alternative 2002-2022 base period is not as appropriate as the recommended 2001-2020 base period. (SOR	7. Please explain and quantify the meaning of "closely approximate the magnitude."

G. **<u>Cultural Conditions Evaluation</u>**

Watermaster SOR Reference	Question/Comment
As explained above, Watermaster's data on irrigated acreages show a similar trend of a constant reduction in irrigated land, particularly during recent years. Because the new hydrologic base period should meet the criteria of the DWR Bulletin 84 and include	1. Watermaster states 2001-2020 captures changing land uses, but many of the highlighted cultural changes (Ex. C–H), urbanization, declining agriculture, and increased VVWRA discharges occur

recent cultural conditions, Watermaster determined that the alternative hydrologic base periods that begin in the 1990s do not me[e]t the representation of recent cultural conditions, and therefore, they should not be considered appropriate hydrologic base periods for PSY redetermination. (SOR 18:13-19).	gradually beginning in 1995 and continuing through at least 2024. 2. What statistical basis is Watermaster relying on to conclude that no year in the 1990s should be included? 3. Does Watermaster contend that cultural conditions have evolved uniformly for all Subareas?

III. CONCLUSION

We appreciate Watermaster's release of the SOR, and holding this Workshop to discuss and address stakeholder questions. On behalf of Our Clients, we reserve all rights to comment further on these pending items both at the Workshop and through further proceedings.

We request Watermaster address the issues raised in this letter and the enclosed letter from EKI. We further request Watermaster update its analysis in response to the Workshop, and provide all available and additional information for the updated analysis or updated recommendations for any new hydrologic Base Period selection for each Subarea.

We look forward to participating in further discussion and attending future Watermaster board meetings at which these matters will be discussed and considered for approval and recommendation to the Court.

Sincerely,

FENNEMORE LLP

Derek Hoffman

DHOF

cc: L. McElhany (lmcelhaney@bmklawplc.com)

62797269

EXHIBIT 1

1.

CIV208568	CITY OF BARSTOW VS CITY OF ADELANTO	MOTION FOR DETERMINATION OF HYDROLOGIC BASE PERIOD FOR PRODUCTION SAFE YIELD CALCULATIONS BY THE MOJAVE WATER AGENCY

Tentative Ruling:

The Watermaster's motion to change the hydrologic base period from 1931-1990 to 2001-2020 for the indefinite future is denied. Because of the importance of identifying an appropriate base period, the denial is without prejudice to a more robustly supported motion that addresses the Court's concerns.

The Court is mindful of the timeline facing the Watermaster. To avoid holding up the Watermaster's calculations of PSY and FPA, the Watermaster's annual report, and the annual motion regarding the Watermaster's recommended changes to FPA, the Court will consider the possibility of granting the motion on a temporary basis, i.e., authorizing the propesed base period (2001-2020) to be used in calculating the FPA recommendations for water year 2026-2027. The parties should be prepared to discuss that possibility, as well as the Watermaster's motion to adopt the proposed base period on an on-going basis.

Analysis:

There are two fundamental questions presented by the motion. The first is whether the proposed base period is a more reasonable representation of long-term hydrologic conditions in the basin than the existing base period. The second question is whether the proposed base period is a better representation of those conditions than any of the possible alternative periods. The motion addresses only the former. It does not mention possible alternative periods at all.

In its reply, the Watermaster argues that it would be a waste of scarce resources to evaluate other alternative base periods. (Reply, p. 3.) The Court disagrees. If other alternatives are not considered, there is no way to determine whether the selection of the proposed base period complies with the Judgment's requirement that the Watermaster rely upon the "best available records and data to support implementation of this Judgment."

Similarly, the Watermaster argues that it would be burdensome to evaluate "more than 100 years of data." (Reply, p. 3.) Again, the Court is not persuaded. No one is suggesting that the Watermaster must evaluate potential base periods that include or overlap with portions of the existing base period (1931-1990.) Instead, the question is whether there are other potential base periods since 1990 that would better represent the basin than either 1931-1990 or 2001-2020.

The Watermaster contends that any new base period should meet the criteria specified in DWR Bulletin No. 84. It is unclear, however, whether compliance with the bulletin is required. The very language that the Watermaster quotes is aspirational ("should") rather than mandatory ("shall"). Nevertheless, the Watermaster does not address the issue.

Assuming arguendo that the bulletin is at least persuasive if not mandatory, the proposed base period does not satisfy the bulletin's criteria. One criterion is that "[b]oth the beginning and end of the base period should be preceded by a series of wet years or a series of dry years .... " In addressing the requirement concerning the beginning of the period, the Watermaster asserts that the beginning of the proposed base period was "preceded by a series of dry years, i.e., dry years in 1999 and 2002 precede the 2001 beginning of the base period ... . " (Motion, p. 4.) 2002 did not precede 2001. Therefore, only one dry year, 1999, preceded the beginning of the proposed period in 2001. Because a single dry year does not constitute a "series" of dry years., that criterion is not met. Thus, assuming arguendo that Bulletin No. 84 describes the correct criteria to be used when selecting a new base period, the base period proposed does not meet those criteria. 597

The motion also argues that "recent cultural conditions" will be better reflected in the proposed base period than in the existing base period. But the Watermaster offers no evidence that those conditions were significantly different in 2001-2020 as compared to 1931-1990. While the Court has little doubt that they are, the Court needs to rely on evidence, not its assumptions. (Even if the evidence had been presented, it is unclear how the "cultural conditions" relate to the selection of the base period as opposed to being later factored into the RMRBM.)

To allow a careful evaluation of the Watermaster's assertions regarding the distribution of normal wet years, extremely wet years, normal dry years, and extremely dry years, the Court needs to know the criteria by which the Watermaster distinguishes normal years from extreme years. Similarly, the Watermaster offers no evidence (as opposed to argument in its Reply) to support the implicit conclusion that water flow at the Forks reasonably represents the water supply for the basin as a whole. It may be, but the motion does not address the issue.

The Watermaster suggests in its Reply that, because the Judgment does not expressly require Court approval of changes in the base period, the Watermaster should be deemed to have the discretion to pick whatever base period it believes is most appropriate. (Reply, pp, 2 & 9.) That reasoning fails, because the Watermaster is required to obtain court approval for changes in FPA The base period is integral to the calculation of PSY and the resulting recommendations regarding changes to FPA If the Watermaster is relying upon a base period that has not been approved, then the Court will be reluctant to approve recommendations based on that base period. Regardless of the express terms of the Judgment, as a practical matter the Watermaster's preferred base period needs judicial endorsement.

EXHIBIT 2

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SUPERIOR COURT OF THE STATE OF CALIFORNIA

COUNTY OF RIVERSIDE – CENTRAL DISTRICT

Coordination Proceeding Special Title (Cal. Rules of Court, Rule 3.550) MOJAVE BASIN WATER CASES	Case No. JCCP5265 Mojave Basin Water Cases Dept. 1, Riverside Superior Court Hon. Craig G. Reimer Lead Case CIV208568 Coordinated With San Bernardino Superior Court Case No. CIVSB2218461
CITY OF BARSTOW, et al., Plaintiff, v. CITY OF ADELANTO, et al., Defendant.	**MITSUBISHI CEMENT CORPORATION, ROBERTSON'S READY MIX, LTD. AND CALPORTLAND COMPANY PROPOSED SCHEDULE FOR BASE PERIOD AND RELATED MOTIONS** **Date:** Oct 27, 2025 **Time:** 10:00 a.m. **Dept:** 1
AND RELATED CROSS-ACTIONS.	

MITSUBISHI CEMENT CORPORATION ("Mitsubishi"), ROBERTSON'S READY MIX, LTD. ("Robertson's"), and CALPORTLAND COMPANY ("CalPortland"), collectively, the "above-captioned parties," by and through their attorneys of record, Fennemore LLP, hereby submit this proposed schedule for stakeholder engagement, Watermaster motion and Court determination of the "base period" and related Watermaster processes. This proposal is made following the October 21, 2025, hearing on Watermaster's Motion for Determination of Hydrologic Base Period for Production Safe Yield Calculations, and consideration of the Court's tentative ruling to deny that Motion.

Pursuant to Court's direction at the hearing on October 21, 2025, counsel for the above-captioned parties initiated and conducted a meet and confer with counsel for the Watermaster, California Department of Fish and Wildlife, Golden State Water Company and Newberry Springs Recreational Lakes Association on October 23, 2025. Though some progress was made, a consensus proposal was not reached and does not appear to be reachable.

The above-captioned parties propose the following schedule for the Court's consideration. As the Court already expressed its willingness to consider, the Court may need to enter an order relieving certain timing obligations under the Judgment and the Watermaster's Rules and Regulations to accommodate the following schedule, pursuant to the Court's authority under Judgment § 19.

The above-captioned parties reserve the right to consider adjustments to the proposed schedule and to present further argument, views and objections to alternative proposals at the continued hearing on October 27, 2025.

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	Description	Date
1	Watermaster releases Base Period Recommendations and supporting materials	November 12, 2025
2	Watermaster Workshop – Base Period	December 12, 2025
3	Watermaster Board Meeting – Base Period	January 28, 2026
4	Watermaster Motion to adopt Base Period	February 11, 2026
5	Opposition(s) to Watermaster Motion to adopt Base Period	March 3, 2026
6	Watermaster Reply ISO Motion to adopt Base Period	March 11, 2026
7	Court Hearing – Base Period	March 18, 2026
8	Watermaster releases FPA Recommendations and draft Annual Report	March 23, 2026
9	Watermaster Workshop – FPA	April 22, 2026
10	Watermaster Board Meeting – FPA Recommendations and draft Annual Report	May 27, 2026
11	Watermaster Motion to adopt FPA Recommendations and draft Annual Report	June 1, 2026
12	Opposition(s) to Watermaster Motion to adopt FPA Recommendations and draft Annual Report	June 22, 2026
13	Watermaster Reply ISO Motion to adopt FPA Recommendations and draft Annual Report	June 30, 2026
14	Court Hearing – FPA Motion	July 8-10, 2026

Dated: October 24, 2025

FENNEMORE LLP

By: ______________________

Derek Hoffman
Darien K. Key
MITSUBISHI CEMENT CORPORATION, ROBERTSON'S READY MIX, LTD., and CALPORTLAND COMPANY

PROOF OF SERVICE

STATE OF CALIFORNIA, COUNTY OF SAN BERNARDINO

Re: City of Barstow v. City of Adelanto, et al.;
Riverside Superior Court Case No.: CIV 208568

I am employed in the County of Fresno, State of California. I am over the age of 18 years and not a party to the within action; my business address is: 8080 North Palm Ave. Third Floor, Fresno, CA 93711. On October 24, 2025, I served copies of the within documents described as **MITSUBISHI CEMENT CORPORATION, ROBERTSON'S READY MIX, LTD. AND CALPORTLAND COMPANY PROPOSED SCHEDULE FOR BASE PERIOD AND RELATED MOTIONS** on the interested parties in this action in a sealed envelope addressed as follows:

See attached Service List

☒ **BY MAIL** - I am "readily familiar" with the firm's practice of collecting and processing correspondence for mailing. Under that practice, it would be deposited with the United States Postal Service on the same day in the ordinary course of business, with postage thereon fully prepaid at San Bernardino, California. I am aware that on motion of the party served, service is presumed invalid if postal cancellation date or postage meter date is more than one day after date of deposit for mailing in affidavit.

☐ **BY PERSONAL SERVICE** - I caused such envelope to be delivered by hand to the offices of the addressee pursuant to C.C.P. § 1011.

☐ **BY EXPRESS MAIL/OVERNIGHT DELIVERY** - I caused such envelope to be delivered by hand to the office of the addressee via overnight delivery pursuant to C.C.P. § 1013(c), with delivery fees fully prepaid or provided for.

☐ **BY FACSIMILE** - I caused such document to be delivered to the office of the addressee via facsimile machine pursuant to C.C.P. § 1013(e). Said document was transmitted to the facsimile number of the office of the addressee from the office of Gresham Savage Nolan & Tilden, in San Bernardino, California, on the date set forth above. The facsimile machine I used complied with California Rules *of Court*, Rule 2003(3) and no error was reported by the machine. Pursuant to California *Rules of Court*, Rule 2009(i), I caused the machine to print a record of the transmittal, a copy of which is attached to this declaration.

☒ **BY ELECTRONIC/EMAIL** - Pursuant to the party's express consent to receive electronic service, I caused such document to be delivered to the office of the addressee via electronic e-mail pursuant to C.C.P. §1010.6(a)(2)(A)(ii). Said document was transmitted to the email address of that office which is listed on the attached Service List. Said document was served electronically and the transmission was reported as complete and without error.

FEDERAL - I am employed in the office of a member of the bar of this court at whose direction the service was made.

I declare under penalty of perjury under the laws of the State of California that the foregoing is true and correct. Executed on October 24, 2025, at Fresno, California.

Kelly Ridenour

KELLY RIDENOUR

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SERVICE LIST

Re: City of Barstow v. City of Adelanto, et al.; Riverside Superior Court Case No.: CIV 208568

William J. Brunick, Esq. Leland P. McElhaney, Esq. Brunick, McElhaney & Kennedy PLC 1839 Commercenter West P.O. Box 13130 San Bernardino, CA 92423-3130 Email: bbrunick@bmklawplc.com lmcelhaney@bmklawplc.com	**Attorneys for Defendant/Cross-Complainant,** **MOJAVE WATER AGENCY**
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EXHIBIT 3

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10 December 2025

Derek Hoffman
Fennemore
550 E Hospitality Lane, Suite 350
San Bernardino, CA 92408

Subject: **Comments on the Watermaster Engineer's Statement of Reasons for Recommending a 2001-2020 Base Period**
(EKI 50063.00)

Dear Mr. Hoffman:

EKI Environment & Water, Inc. (EKI) has conducted a review of the *Watermaster Engineer's Statement of Reasons for Recommending a 2001-2020 Base Period* (Statement)[1] filed on 12 November 2025. EKI has conducted this review and provided the comments below to Fennemore in its role as Counsel to Mitsubishi Cement Corporation, Robertson's Ready Mix, Ltd., and CalPortland Company (collectively the "Clients") in the Mojave River Basin Area (Basin).

SUMMARY OF STATEMENT OF REASONS

The Statement provides background information on the Department of Water Resources' (DWR's) Bulletin No. 84 and similar adjudications (e.g., *City of Los Angeles vs. City of San Fernando, et al., 14 Cal.3d 199 (1975)*), discusses the Basin's initial hydrologic base period, changes in land use and pumping since entry of the Judgment, water supply to the Basin, and then provides justification for the proposed hydrologic base period of 2001-2020. The Statement provides greater detail than was originally provided in the Motion to the Court (Motion)[2], including differentiating between selection of the hydrologic base period and evaluation of production safe yield (PSY). The Statement includes a comparison among several other potential hydrologic base periods before ultimately recommending the adoption of 2001-2020 as the new hydrologic base period.

KEY COMMENTS

Parties to the Judgment need visibility into the potential impacts to PSY in all Subareas under the proposed hydrologic base period

The Judgment defines PSY as, *"The highest average Annual Amount of water that can be produced from a Subarea: (1) over a sequence of years that is representative of long-term average annual natural water supply to the Subarea net of long-term average annual natural outflow from the Subarea, (2) under given patterns of Production, applied water, return flows and Consumptive Use, and (3) without resulting in a*

[1] *Watermaster Engineer's Statement of Reasons for Recommending 2001-2020 Base Period,* November 12, 2025.
[2] Brunick, McElhaney, & Kennedy PLC, 2025. Motion for the Determination of Hydrologic Base Period for Production Safe Yield Calculations; Memorandum of Points and Authorities; Supporting Declaration. September.

long-term net reduction of groundwater in storage in the Subarea." Table C-1 of the Judgment lays out how PSY is calculated – PSY is total production in each Subarea plus the surplus or deficit of water supply, which is the difference between water supply and consumptive use/outflow. The hydrologic base period is used to inform numerous budget terms in this calculation such as surface water inflows and outflows. Each year in the Annual Report, the Watermaster presents a version of Table C-1 as Annual Report Table 5-1. As noted by the Watermaster, 2001-2020 has been temporarily used as the hydrologic base period in the two most recent Annual Reports (i.e., for water years 2022-23 and 2023-24). However, it should be noted that Table 5-1 is currently not available for the 2023-24 Annual Report on the Watermaster's website, and that Table 5-1 for the 2022-23 Annual Report presents PSY calculations for Alto, Centro and Baja, but not Este or Oeste[3]. As such, although the proposed hydrologic base period has been used temporarily by the Watermaster in recent years, and PSY estimates have been provided for all Subareas, the analysis is not fully documented and the impact of the proposed hydrologic base period on the calculation of PSY in each Subarea is unclear.

In the Statement, the Watermaster explains that *"Even though the hydrologic base period of 2001-2020 was recommended by the Watermaster for all Subareas, Watermaster recognizes that for the Baja Subarea, special circumstances may warrant PSY determination based on limited data. For the Baja Subarea, the only reliable data available is pumping and water level measurements (which show recent recovery). This is true for the Este Subarea and the Oeste Subarea as well,"* (page 14). It therefore remains unclear how, if at all, the PSY for Baja, Este and Oeste has changed or may change under the proposed hydrologic base period. Parties to the Judgment need visibility into the potential impacts to PSY in all Subareas before the adoption of a new base period. We request the Watermaster to provide an analysis on estimates of PSY for each Subarea using the potential hydrologic base periods listed in Table 1 of the Statement.

A clear and consistent framework should be used to determine PSY

A complete water budget framework for each Subarea should be established to account for all inflows and outflows, and the water budget terms should not change from year to year as new analyses are conducted, unless revisions to the hydrogeological conceptual model (HCM) are warranted. Further, consideration of a new hydrologic base period should be supported by an evaluation of how that proposed hydrologic base period would impact each term for the PSY calculation for each Subarea.

The Judgment provides an example of a complete water budget framework as Table C-1, which has served as the basis for Table 5-1 (PSY calculation) in the Annual Reports for the Basin. **Table 1** below presents the water budget terms contained in the PSY calculations in recent years' Annual Reports utilizing the 2001-2020 hydrologic base period. Highlighted in yellow in **Table 1** are the water budget terms that are controlled by flow in the Mojave River. As can be seen therein, numerous other water budget terms are not controlled by flow in the Mojave River.

[3] Watermaster Reports - Mojave Water Agency

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Table 1 – Summary of Water Budget Components for PSY Calculation

Budget Term	Alto	Centro	Baja	Este	Oeste
WATER SUPPLY					
Surface Water Inflow	61,635[1]	36,725[1]	-	Unclear[2]	Unclear[2]
Gaged Inflow	-	-	7,500[1]	-	-
Tributary Inflow	-	-	1,568[3]	-	-
Mountain Front Recharge	8,511[4]	0	647[3]	Unclear[5]	Unclear[5]
Groundwater Discharge to the TZ	0	0	-	-	-
Subsurface Inflow	0	2,000[6]	1,751[3]	Unclear[2]	Unclear[2]
Este/Oeste Inflow	4,785[4]	0	-	-	-
Imports	0	0	-	Unclear[5]	Unclear[5]
Deep Percolation of Precipitation	-	-	100[2]	-	-
Total Water Supply	**74,931**	**38,725**	**14,575**	**TBD**	**TBD**
CONSUMPTIVE USE					
Surface Water Outflow	36,725[1]	7,500[1]	-	-	-
Gaged Outflow	-	-	2,554[1]	-	-
Barstow Treatment Plant Discharge	0	2,475[7]	-	-	-
Subsurface Outflow	2,000[2]	1,462[3]	170[3]	Unclear[2,5]	Unclear[2,5]
Consumptive Use - Agriculture	949	5,863	12,749[8]	Unclear[5,9]	Unclear[5,9]
Consumptive Use - Urban	40,171	6,885	(see row above)	-	-
Phreatophytes	11,000[2,10]	3,000[2,10]	984[11]	-	-
Total Consumptive Use	**90,845**	**27,185**	**16,457**	**TBD**	**TBD**
PRODUCTION SAFE YIELD CALCULATION					
Surplus / (Deficit)	(15,914)	11,540	(1,883)	TBD	TBD
Total Estimated Production	78,147	16,995	12,740	TBD	TBD
Potential Return Flow	0	2,885	554	TBD	TBD
Production Safe Yield	**62,233**	**31,420**	**10,866**	**6,582**	**3,634**

Abbreviations:
- = Component not applicable to given Subarea
TBD = To be determined
TZ = Transition Zone

Notes:
Table values taken from Table 5-1 in the WY2022-2023 Annual Report.
Entries labeled unclear are those in which we are aware water budget component estimates have been developed but lack clarity on the value proposed for use in the hydrologic base period going forward.
1 – Value derived from stream gage data 2001-2020.
2 – Value established for the original base period (1931-1990) but not for the proposed hydrologic base period (2001-2020).
3 – Value derived from *USGS, 2001. Simulation of Ground-Water Flow in the Mojave River Basin, California, Water-Resources Investigations Report 01-4002.*
4 – Value derived from Upper Mojave Basin Model.
5 – While estimates are provided in Watermaster's 2024 PSY Update for this Subarea, they have not been included in recent Annual Reports' Table 5-1.
6 – No citation in recent Annual Reports, but the value is consistent with the value in the Judgment.
7 – No citation in Table 5-1 of recent reports.
8 – This value includes Agricultural and Urban Consumptive Use (see Table 5-1 of 2022-23 Annual Report).
9 – Estimates were developed in the Watermaster's 2018 Consumptive Use Analysis but have not been included in recent Annual Reports' Table 5-1.
10 – Value derived from *USGS, 1996.Riparian Vegetation and Its Water Use During 1995 Along the Mojave River, Southern California, Water-Resources Investigations Report 96-4241.*
11 – Value estimated using OpenET for 2019-2022.

Some of the water budget terms shown on **Table 1** have been updated as new data have become available, such as subsurface inflow into Alto (from Este/Oeste) and phreatophyte consumptive use in Baja (calculated using OpenET). Others remain fixed at historical values (e.g., subsurface outflow from Alto and phreatophyte consumptive use in Alto and Centro). Furthermore, while the PSY updates for Este and Oeste provided estimates of some water budget components such as mountain front recharge and consumptive use, ultimately the PSY estimates for these Subareas were based on recent pumping and water level data, and it is unclear if adoption of the proposed hydrologic base period would have any influence over these calculations. Additionally, the Alto water budget term Este/Oeste inflow is not matched by corresponding outflows from Este/Oeste in recent versions of Table 5-1, and this value (4,785 AF) greatly exceeds estimates of subsurface outflows in the PSY updates for Este and Oeste[4,5].

As shown on **Table 1**, the Watermaster currently uses a combination of: (1) budget terms from the Judgment (and therefore the original hydrologic base period of 1931-1990); (2) budget terms updated to reflect the proposed hydrologic base period of 2001-2020 (i.e., mountain front recharge, surface inflow into Alto averaged over the proposed hydrologic base period); and (3) budget terms that have no clear relationship to either base period and are inconsistently applied across Subareas. For example, the PSY calculation for Alto includes subsurface inflow from Este and Oeste, but the corresponding outflow from these Subareas is not considered in their respective PSY calculations. It is therefore not clear how, if at all, the various water budget components in Este and Oeste, as well as those in Alto, Centro, and Baja that are unrelated to surface water flows, would be updated under the proposed hydrologic base period of 2001-2020. We ask that the Watermaster provide an evaluation of how that proposed hydrologic base period would impact each term for the PSY calculation for each Subarea.

Appropriateness of metrics for establishing a hydrologic base period should be demonstrated

The purpose of a hydrologic base period is to represent the long-term patterns of water supply to the Basin. Per the Statement, *"Water supply to the Basin Area includes gaged and ungagged [sic] inflow, subsurface flow, deep percolation of precipitation, and certain imports,"* (page 11). Regarding the availability of hydrologic data on which to establish a base period, the Watermaster notes that *"There are very few records of surface water inflow to the Este and Oeste Subareas,"* (page 11) and that *"Although there are several precipitation stations located within the Fork's watershed, the reliability of this data is questionable. The precipitation records are short, inconsistent, and intermittent (see Exhibit M). For these reasons, Watermaster believes the measured flow of the Mojave River at the Forks continues to be the record indicative of the long-term water supply to the Basin Area,"* (page 11-12).

While it may be that available data are limited, it is not clear that Mojave River flow at the Forks is the appropriate metric upon which to establish a hydrologic base period for all Subareas. Notably, flow at the Forks is not relevant to conditions in Este or Oeste, and some components of the Basin water budget and PSY calculation (Table C-1 of the Judgment and discussed above) are independent of flow at the Forks, such as subsurface inflows and outflows and mountain front recharge (see **Table 1**). While Mojave River flow at the Forks may be a reasonable surrogate for some components of the analysis for some Subareas,

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[4] Watermaster, 2024. *Production Safe Yield and Consumptive Use Update, Appendix C: Oeste Subarea Water Supply Update.* February.

[5] Watermaster, 2024. *Production Safe Yield and Consumptive Use Update, Appendix D: Este Subarea Water Supply Update.* February.

as described in the Tentative Ruling, *"the Court needs to rely on evidence, not its assumptions,"* (page 2[6]). The Statement provides no quantitative evaluation to demonstrate the correlation of Mojave River flow at the Forks to other Subarea-specific inflow terms such as subsurface inflows/outflows and mountain front recharge that are part of the PSY calculation, and therefore why it is an appropriate metric.

<u>One hydrologic base period may not reflect "recent cultural conditions" in all Subareas</u>

As described in the Statement, significant changes in "recent cultural conditions" (i.e., land use and groundwater pumping) have occurred in the Basin since entry of the Judgment. Exhibit H to the Statement shows time-series plots of agricultural water production and irrigated acreage in each Subarea. These plots show that irrigation volumes in Alto declined steadily from entry of the Judgment to 2010 when production stabilized, meanwhile Centro exhibits a more gradual and ongoing trend. The Baja Subarea has experienced significant declines in irrigation pumping since 2020, while Este has exhibited a consistent decline since 2015 Irrigation pumping in Oeste has fallen to essentially zero in the last several years. These variable trends demonstrate that "cultural conditions" are evolving in each Subarea on independent timelines, and that the proposed hydrologic base period of 2001-2020 does not capture this variation, or in some cases, the actual current "cultural conditions" in a given Subarea.

In the Statement, Watermaster claims that *"Today's cultural conditions are represented by the new recent hydrologic base period of 2001-2020,"* (page 19). However, elsewhere in the Statement, and as quoted above, Watermaster explains that *"Even though the hydrologic base period of 2001-2020 was recommended by Watermaster for all Subareas, Watermaster recognizes that for the Baja Subarea, special circumstances may warrant PSY determination based on limited data. For the Baja Subarea, the only reliable data available is pumping and water level measurements (which show recent recovery). This is true for the Este Subarea and the Oeste Subarea as well,"* (page 14). While this may be a reasonable approach, it is unclear what criteria and process the Watermaster will use to determine what subset of available data for a given Subarea will be used to estimate PSY.

<u>Additional technical questions should be resolved</u>

While it is understood that the Watermaster operates under both schedule and budget constraints, per the Judgment, technical evaluations must use "sound scientific and engineering estimates" and incorporate the "best available records and data," (Judgment (24(w)). To this end, the following items warrant further consideration and clarification:

- In the Statement, the Motion, and in Annual Reports, the Watermaster discusses the influence of wet and dry years on Basin hydrology. However, it is unclear how water year types for the Basin are determined. In Exhibit I of the Statement, which shows Mojave River flow at the Forks, some water years are shown in red, while others are shown in blue, which may correspond to dry vs. wet. Most red years appear to exhibit below average flow at the Forks; however, not all years with very low flow are shown in red (e.g., 1934 and 1981). The Watermaster should provide details on how this foundational determination of year type is made.

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[6] *City of Barstow vs. City of Adelanto,* No. CIV208568, **tentative ruling** (California Superior Court, Riverside County, 20 October 2025)

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- The Watermaster presents available station-based precipitation data and notes that the station data are both temporally and spatially sparse. We offer that the readily-available PRISM[7] data provides daily, monthly, and annual precipitation totals, with annual precipitation totals going back to 1895. The Watermaster may consider supplementing their analysis with PRISM data, especially given PRISM's spatial and temporal coverage. Use of the more complete PRISM dataset may provide for correlation or other analysis to better demonstrate that Mojave River flow at the Forks is, in fact, an appropriate metric upon which to establish a hydrologic base period for all Subareas.
- Estimates of consumptive use of groundwater by phreatophytes in some Subareas appear to be based on a 1996 USGS report (as referenced in the 2022-23 Annual Report). It is not clear if the Watermaster intends to update these estimates for the proposed hydrologic base period.

In EKI's letters to the Watermaster to date, we continue to request opportunities to actively engage in ongoing and forthcoming technical analyses being conducted in the Basin, including RMBM development and other hydrogeological studies, such as hydrologic base period selection, as results of these studies could potentially significantly impact future determinations of PSY, Free Production Allowance, and overall Basin management.

Sincerely,

EKI ENVIRONMENT & WATER, INC.

Anona Dutton, PG, CHg
Vice President

[7] https://prism.oregonstate.edu/

EXHIBIT 4

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19 December 2025

Derek Hoffman
Fennemore
550 E Hospitality Lane, Suite 350
San Bernardino, CA 92408

Subject: **Recommendation for a Hydrologic Base Period**
(EKI 50063.00)

Dear Mr. Hoffman:

EKI Environment & Water, Inc. (EKI) attended the 12 December 2025 Watermaster Workshop on New Hydrologic Base Period Selection and prepared the following comments. Previously, EKI reviewed and provided comments on *Watermaster Engineer's Statement of Reasons for Recommending a 2001-2020 Base Period* (Statement)[1] filed on 12 November 2025. EKI conducted these activities and provided the comments below to Fennemore in its role as Counsel to Mitsubishi Cement Corporation, Robertson's Ready Mix, Ltd., and CalPortland Company (collectively the "Clients") in the Mojave River Basin Area (Basin).

BACKGROUND

The Judgment defines Production Safe Yield (PSY) as, *"The highest average Annual Amount of water that can be produced from a Subarea: (1) over a sequence of years that is representative of long-term average annual natural water supply to the Subarea net of long-term average annual natural outflow from the Subarea, (2) under given patterns of Production, applied water, return flows and Consumptive Use, and (3) without resulting in a long-term net reduction of groundwater in storage in the Subarea."* The hydrologic base period is used to inform numerous budget terms in the calculation of PSY such as surface water inflows and outflows. While many components of natural water supply are highly variable from year to year the Basin, the purpose of the hydrologic base period is to provide reasonable estimates of long-term averages for water supply planning.

KEY COMMENTS

In the Statement, the Watermaster proposed five potential hydrologic base periods that purport to meet the criteria set forth in California Department of Water Resources' (DWR's) Bulletin No. 84, summarized below in **Table 1**. Also included therein is Watermaster's rationale for either recommending or not recommending a given hydrologic base period as presented in the 12 December 2025 workshop for the alternative hydrologic base periods presented in the Statement and the sixth presented at the Workshop.

[1]*Watermaster Engineer's Statement of Reasons for Recommending 2001-2020 Base Period,* November 12, 2025.

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Table 1 - Hydrologic Base Periods Evaluated by Watermaster

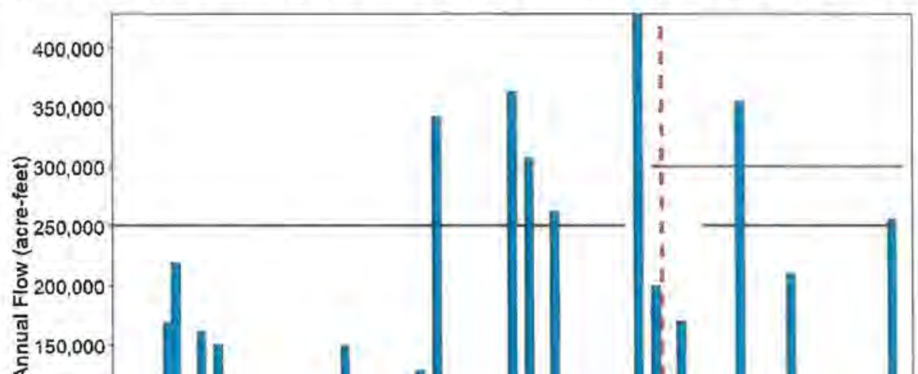
Hydrologic Base Period	Change Relative to 1931-1990	Watermaster Rationale
1991-2022	8%	Watermaster **does not recommend** because: • "Average water supply is 8% higher than the average of the initial base period 1931-1990, which might indicate a higher PSY value." • "Water supply at the Forks during Water Years 1992 to 1995 was about 3 times the long-term average supply." • "Include years that are not representative of recent cultural conditions: agricultural pumping and land uses have greatly changed since the 1990s." • "Court requested consideration of a **drier and more recent hydrologic base period.**"
1995-2024	2%	Watermaster **does not recommend** because: • "Average water supply is 2% higher than the average of the initial base period 1931-1990, which might indicate a higher PSY value." • "It includes years that are not representative of recent cultural conditions: agricultural pumping and land uses have greatly changed since the 1990s." • "Court requested consideration of a **drier and more recent hydrologic base period.**"
1998-2024	-1%	Watermaster **does not recommend** because: • "Average water supply is 1% drier than the average of the initial base period 1931-1990, which might indicate a higher PSY value." • "It includes years that are not representative of recent cultural conditions: agricultural pumping and land uses have greatly changed since the 1990s." • "Court requested consideration of a drier and **more recent hydrologic base period.**"
2002-2022	-11%	Watermaster **does not recommend** because: • "Average water supply is 11% drier than the average of the initial base period 1931-1990; therefore, the indicated water supply does not 'closely approximate' the long-term water supply during the 1931-1990 base period." • "The UMBM is calibrated through year 2020 only, and the alternative 2002-2022 base period is outside the period of UMBM calibration."
1931-2022	3%	Watermaster **does not recommend** because: • "Average water supply is 3% higher than the average of the 1931-1990 base period, which might result in higher PSY values." • "It also includes many years that are not representative of current cultural conditions: agricultural pumping and land uses have greatly changed since the 1930s, 1950s, and 1990s." • "The Court requested consideration of a **drier and more recent hydrologic base period.**"
2001-2020	-6%	Watermaster **recommends** because: • "Meets guidance of DWR Bulletin 84." • "Average water supply is 6% drier than the average of the initial base period 1931-1990." • "Fits the UMBM model calibration period (ending in 2020)." • "Includes and is more representative of current cultural conditions." • "It satisfies the Court's request for a **drier and more recent hydrologic base period.**"

Per Bulletin No. 84, a hydrologic base period should include *"normal and extreme wet and dry years. Both the beginning and the end of the base period should be preceded by a series of wet or a series of dry years... [and the] base period should also be within the period of available records and should include recent cultural conditions,"* (pages 47-48). EKI has reviewed these alternatives and the Watermaster's rationale and has the following comments. These comments are provided based on the limited data available and under a compressed timeline, and while we await the Watermaster's response to questions raised in our previous letter[2]. Our comments and recommendations are subject to revision based on responses from the Watermaster to both our letter and to letters from other parties.

Watermaster should reconsider 1995-2024 as the most appropriate hydrologic base period

Based on a review of the available data, EKI recommends that 1995-2024 be adopted as the hydrologic base period. The 1995-2024 hydrologic base period, the Watermaster's proposed hydrologic base period of 2001-2020, and the original base period of 1931-1990, along with Mojave River flow at the Forks, are shown below on **Figure 1**. The proposed hydrologic base period of 1995-2024 is appropriate because it: (1) best reflects the time period over which the physical solution set forth in the Stipulated Judgment has been adopted; (2) contains recent years during which significant changes in cultural conditions have occurred; and (3) contains both wet and dry hydrologic extremes, or "climatic disruptions" as they are referred to in the Court's September 2022 order.

Figure 1 – Mojave River Flow at the Forks and Potential Hydrologic Base Periods



Note: The original hydrologic base period (1931-1990) and the Watermaster's proposed hydrologic base period (2001-2020) are shown in a horizontal black line, 1995-2024 is shown in purple, and the entry of the Judgment in early 1996 is shown in red.

[2] EKI, 2025. *Comments on Watermaster Engineer's Statement of Reasons for Recommending a 2001-2020 Base Period.* December 10.

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1995-2024 most completely captures the timeframe of the physical solution

Of the viable alternatives identified by the Watermaster, a hydrologic base period of 1995-2024 most completely captures the time period during which the physical solution has been implemented, which represents an over-arching and significant cultural condition in the Basin. This period would capture cultural conditions more thoroughly than any of the other alternative hydrologic base periods proposed by the Watermaster, including 1998-2024, which begins several years after adoption of the physical solution.

1995-2024 most completely captures recent cultural conditions

To the extent that a hydrologic base period should capture "recent cultural conditions", a hydrologic base period extending as close to present as possible is most appropriate. The 1995-2024 period includes recent years where significant land use changes have occurred; these changes are not reflected in the alternative hydrologic base periods ending in 2020 and 2022. For example, as shown in the Exhibit H to the Statement, since 2021, water production for irrigation in Oeste has fallen to essentially zero and water production for irrigation in Baja has dropped significantly since 2020 (from 14,800 acre-feet per year [AFY] in 2020 to 5,500 AFY in 2024).

Further, while we understand that the UMBM, and forthcoming Regional Mojave Basin Model (RMBM) are calibrated through water year 2020, this is not grounds for exclusion of more recent water years from the hydrologic base period as the Watermaster suggests. If needed, a calibrated model can be extended past the period of calibration for the purpose of running future simulations and without the need for further calibration, as is done often in other actively managed groundwater basins.

1995-2024 contains "climatic disruptions", including wet and dry extremes

Climate change is expected to increase the frequency and magnitude of hydrologic extremes including both droughts and storm events[3]. The Court has asked the Watermaster to consider "climatic disruptions" in the selection of a hydrologic base period. Exclusion of hydrologic base periods that include extreme wet years based on slightly elevated average flows at the Forks is not appropriate if the proposed hydrologic base period otherwise captures hydrologic extremes, or "climatic disruptions". The hydrologic base period 1995-2024 includes years of such hydrologic extremes that are anticipated to continue to occur in the Basin, including extreme wet years like 2005 and 2023, and multi-year dry periods like 1999-2002 and 2013-2018.

In 2013, the Bureau of Reclamation (Bureau) published the Mojave River Watershed Climate Change Assessment in cooperation with Mojave Water Agency (MWA)[4]. In this report, the Bureau and MWA present results of hydrologic simulations from 1950 to 1999 using the Variable Infiltration Capacity (VIC) model and analyzed results near three USGS stream gages (Deep Creek, West Fork, and Lower Narrows). Figure 8 from this report is included here as **Figure 2**. This figure presents simulation results at Deep Creek near Hesperia, one of the components of flow at the Forks. Describing this figure, the Bureau states that

[3] Based on Watermaster response at the 12 December Workshop, wet years are characterized by above average flow at the Forks (65,538 AFY), while dry years are characterized by below average flow at the Forks. A formal year-by-year designation of water year type, particularly detailing normal versus extreme, has not been provided to date.
[4] https://www.mojavewater.org/wp-content/uploads/2023/12/appendix-g_all.pdf

"Runoff trends are also consistent between gages. All locations show a nominal decline in annual and December to March, while the uncertainty envelope remains largely constant," (page 26).

Despite nominal decreases in the median, simulation results show future extreme high flow events like those seen in the 1990s, particularly for December-March runoff which constitutes the largest Basin inflow. While the Bureau projects that median flows are likely to decline in the future, especially for April through July runoff (when runoff totals are a fraction of those observed December to March), extreme flow events are expected to continue into the future. As such, exclusion of 1995-2024 because it includes extreme wet years is not appropriate. **Figure 1** shows that flow at the Forks in 1995 is well within the range of flows observed since. Additionally, despite these high flow years in the 1990s, flow at the Forks during 1995-2024 is largely similar to that of the original base period of 1931-1990 (approximately 2% different).

Figure 2 - Figure 8 from U.S. Bureau of Reclamation Mojave River Watershed Climate Change Assessment

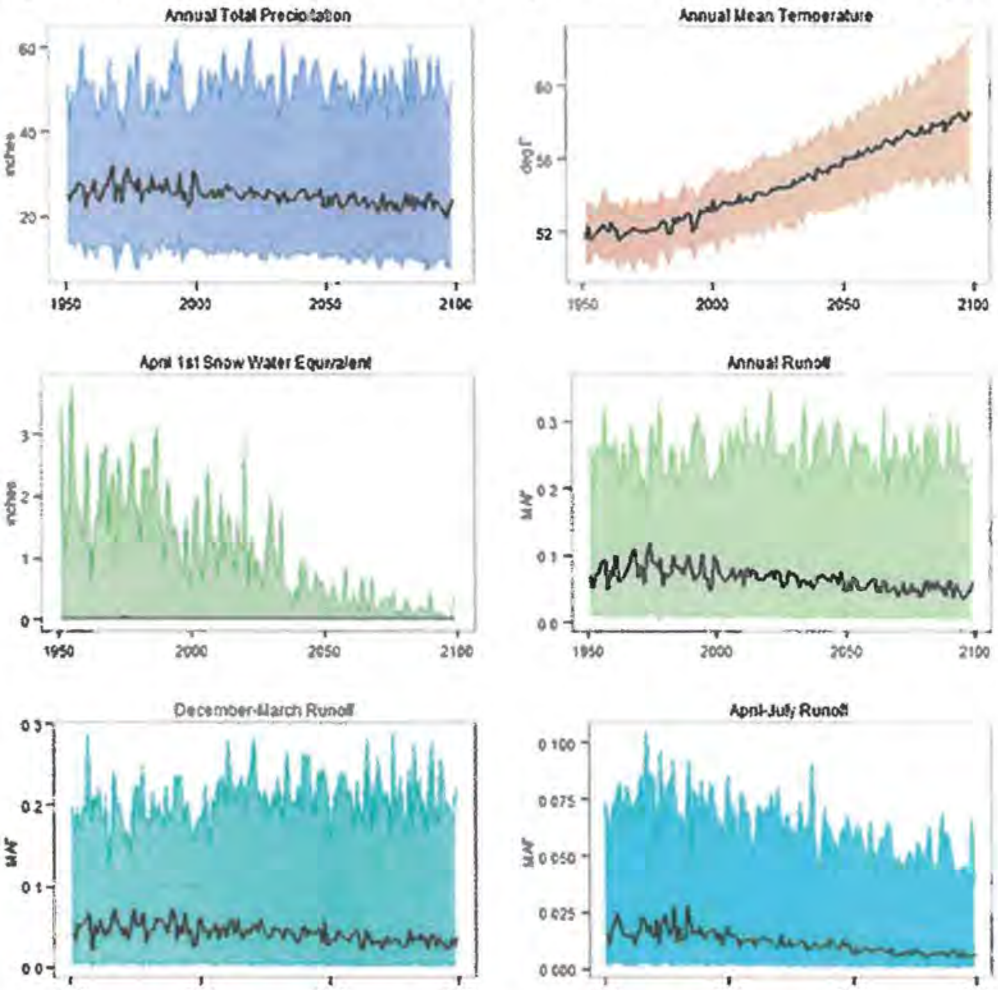

**Figure 8: Deep Creek near Hesperia—
projection ensemble for six hydroclimate indicators
(black line is 50th percentile [ensemble median]).**

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In summary, 1995-2024 appears to be the most appropriate hydrologic base period of the alternatives identified by the Watermaster because it:

- Most fully captures the years during which the physical solution established by the Judgment was in place;
- Contains recent years which best reflect changing cultural conditions in various Subareas; and,
- Exhibits hydrology that captures "climate disruptions" while staying largely similar to averages over the longer period of record and to estimates of future hydrologic conditions.

Ongoing technical questions and transparency

In EKI's letters to the Watermaster to date, we continue to request opportunities to actively engage in ongoing and forthcoming technical analyses being conducted in the Basin, including RMBM development and other hydrogeological studies, such as hydrologic base period selection, as results of these studies could potentially significantly impact future determinations of PSY, Free Production Allowance, and overall Basin management. In our December letter, we also raised clarifying questions to increase transparency for all parties involved and look forward to the Watermaster's response. We appreciate the efforts to date to involve interested parties in these discussions.

Sincerely,

EKI ENVIRONMENT & WATER, INC.

Anona Dutton, PG, CHg
Vice President

EXHIBIT H

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Peter J. Kiel
pkiel@cawaterlaw.com
(707) 387-0060

January 13, 2026

Via Email: watermaster@mojavewater.org

Board of Directors
Mojave Basin Area Watermaster
Mojave Water Agency
13846 Conference Center Drive
Apple Valley, CA 92307-4377

Re: **January 14, 2026 Special Watermaster Meeting**
Items 5 and 6: New Hydrologic Base Period

Victorville Water District (VWD) renews its December 12, 2025 comments. VWD does not object to the use of the 2001 to 2020 Base Period for Water Year 2026/2027 but requests that the Watermaster commit to using a longer Base Period in Water Year 2027/2028 and future updates. The omission of the 2021 to 2024 Water Years from the proposed 2001 to 2020 Base Period does not include most recent cultural conditions and skews the average, resulting in a much drier, more conservative Base Period (especially compared to the more representative long-term average hydrologic period from 1931 to 2024).

VWD is concerned that an overly conservative Base Period will be hard-wired into the updated Mojave River Basin Model and will not be reevaluated, which may lead to significant reductions in modeled Production Safe Yield (PSY) and Free Production Allowance (FPA). VWD's consulting hydrogeologist Peter Leffler asserts that longer hydrologic periods are more representative of future conditions, especially when climate change may both increase average annual temperature and frequency of drought periods while increasing the frequency and/or magnitude of large storm events that are the primary driver of long-term average annual basin recharge best. It is strongly recommended that 1931 to 2024 (as opposed to 1931 to 1990) be used as the reference hydrologic period to evaluate proposed base periods, and that the ultimate base period to be selected be longer than 20 years.

VWD recommends that Watermaster adopt a more comprehensive base period such as 1995-2024 or 1998-2024 starting in Water Year 2027/2028 or as soon as the updated Mojave River Basin Model is completed and ready to inform future PSY and FPA. The two potential base periods starting in the 1990s are close to but slightly drier than the long term reference period of 1931 to 2024, and incorporation of late 1990s cultural conditions are offset by inclusion of more recent cultural conditions from the 2020s.

VWD thanks Watermaster for considering its comments.

Sincerely,

LAW OFFICE OF PETER KIEL PC

Peter J. Kiel
Counsel for the City of Victorville and
Victorville Water District

cc: Leland McElhaney, Watermaster Counsel
Robert Wagner, Watermaster Engineer

EXHIBIT I

DIANA J. CARLONI, ESQ. CASBN 100460
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diana@carlonilaw.com

Attorneys for NEWBERRY SPRINGS RECREATIONAL LAKES ASSOCIATION

SUPEROR COURT FOR THE STATE OF CALIFORNIA

COUNTY OF RIVERSIDE – CENTRAL DISTRICT

CITY OF BARSTOW, et al. Plaintiffs, vs. CITY OF ADELANTO, et al. Defendants, AND RELATED CROSS-ACTIONS.	CASE NO: CIV 208568 NEWBERRY SPRINGS ISSUES AND QUESTIONS FOR DISCUSSION AT WATERMASTER WORKSHOP SET FOR JANUARY 14, 2026. Hearing Information: None Set Date: Time: Dept: Before the Hon. Craig G. Riemer, Judge ISSUES QUESTIONS FOR JAN 14 2026

TO ALL INTERESTED PARTIES AND THEIR ATTORNEYS:

NEWBERRY SPRINGS RECREATIONAL LAKES ASSOCIATION submits the following ISSUES AND QUESTIONS FOR DISCUSSION AT WATERMASTER WORKSHOP SET FOR JANUARY 14, 2026.

Procedural Issues:

It has been stated that the Watermaster attorney was ordered to file a motion to change the base period. Review of relevant orders do not demonstrate such an order.

1. Please identify and clarify such an order, if existing. See excerpts of prior orders attached hereto as Exhibit A.
2. Please articulate in detail, the justification for changing the base period.
3. Will all water experts have a chance to review and provide input to the stated justification?
4. Please detail the procedural process for implementing the change, given the fact that the original judgment had to be reviewed and signed by all stipulating parties. As all parties bound by the judgment stipulated to and relied upon the terms of the original stipulated judgment, does this change occur without full vetting to all parties? Is this a potential denial of due process?
5. Given the discussion necessary, is there a motion already filed and will it be withdrawn?
6. Will base periods be considered by individual subarea or comprehensively. If different for each subarea, should each subarea be considered as a separate motion or new stipulation? If not, and one comprehensive plan is envisioned, why are we not waiting for the release of the new regional (MRBRM) model so this exercise/analysis does not have to be undertaken more than one time?

Substantive Issues:

1. Base Period Selection Process: Will the WM use the Bulletin 84 criteria or create some new formula to determine a new base period? Unless the analysis and reasoning of Bulletin 84 is found to be defective, and substantiated in an evidence-based fashion, should not that be the procedure used by the WM to formulate and propose a new shorter Base Period?

Bulletin 84, page 13, reflects that the years 1904-05 through 1960-61 were used as the Long-Time Hydrologic Condition, upon which the recommended study of a new base period would be based. The original 57-year period was the best representation of long-time hydrologic conditions. The 25-year period then selected as the base period in the study (1936-37-1960-61), when preceded and/or followed by cycles of wet and dry years, best replicated the long-time hydrologic conditions with a difference in findings of approximately one percent. It was considered most reliable and was more current in time for the purposes of the study conducted.

Similar in nature is the long-time period agreed to in our stipulated judgment to the Adjudication. The 1931-1990 time frame can be seen as the Long-Time Hydrological Condition from which to assess and identify a new, more current and shorter Base Period, which replicates the hydrologic conditions of the 1931-1990 time frame.

If Watermaster (WM) is relying on the formulae of Bulletin 84, then the WM proposed 2001-2020 base period is not analogous to the formulae because the difference approximates 6%. Rather, attention should be given to the 1998-2024 base period, as during that time the difference between the conditions in the Long-time period vs this new 25-year period reflects a 1% difference. (similar to Bulletin 84).

2. It does not seem logical to simply add current data onto the current base period, e.g. 1931-2022, as this creates a 3% increase (variance) from long-time conditions. If the data from the 2023-24 water year was added, the difference would be even greater, as those were wet years. If the WM disagrees, please provide evidence-based substantiation of that position.

3. Newberry does not accept the rationale of responding to the Court, by suggesting that the Court asked for a drier and more recent base period. The Court and the Watermaster are (or should be) committed to follow the science. A base period should be a reasonable assumption of precipitation expectation in future years, more likely than not to repeat, and based on the long-time data. If WM does not agree, please provide justification and alternative analysis or explanation.

4. Question, will the new MRBRM conduct analysis similar to Bulletin 84? If so, won't there be sufficient data to support a proposed new Base Period that is grounded in established principles, already relied upon?

Conclusion:

Newberry Springs Recreational Lakes Assn's choice would be to continue with the agreed upon Base Period set forth in the Judgment (1930-1990 base period), since securing consent to a new proposed based period appears cumbersome and unlikely.

In the alternative, Newberry suggests that the WM selects the 1998-2024 base period since it most closely replicates the current one. Watermaster said at the meeting, they did not choose this one, because they only had data up through 2022. Now that the data exists, that is no longer an excuse not to use this period.

The motion to Change or Modify the Base Period should be withdrawn and not refiled until the process, analysis and evidence is completed. A decision of the most efficient and effective use of experts, consultants, time, resources and public funds should be significant factors in adopting a course of action.

Dated: January 6, 2026

Respectfully submitted,

/s/ *Diana J. Carloni*
Electronically signed to Expedite
DIANA J. CARLONI, Esq.
Attorney for Newberry Springs
Recreational Lakes Assn.

Excerpts of prior orders:

October 23, 2024 order.

8. The Judgment requires PSY to be based on" a sequence of years that is representative of the long-term average." In the motion to enforce the judgment, both the Watermaster and Victorville criticized Golden State for cherry-picking a misleadingly short time frame for comparing groundwater levels. Similarly, in its 7-3- 24 order, the Court criticized the Watermaster for relying on short timeframes and inconsistent timeframes. Sometimes the Watermaster has cited to the 1931- 1990 average, but other times the WM has relied on 20-year or even 5-year averages.

a. *Is the 1931- 1990 timeframe representative of the climate in the basin today?*

b. *How long is " long-term?" 20 years? 30 years? 40 years? Longer?*

c. *Is the 1931- 1990 timeframe representative of the climate in the basin How long is " long-term?" 20 years? 30 years? 40 years? Longer? Should the Court establish a different base period to be used when adjusting PSY and FPA and when questioning the accuracy of the Watermaster' s model or recommendations? If so, when should that period begin and end?*

Order of Aug 6th, 2025 – beginning page 4:

Hydrologic base period The Watermaster argued that the base period should be revised to be the period of 2001-2020. However, the motion did not expressly seek approval of that change. Any future motion by the Watermaster seeking approval of that change shall address the following issues:

1. In arguing for the adoption of 2001-2020 as the hydrologic base period, Mr. Wagner states at page 32 of the motion that the proposed base period "is reasonably representative of long-term hydrologic conditions,." citing to Exhibit 25 (at page. 405). Is that conclusion based solely on the similarity between the average Mojave River flow during 1931-1990 (65,538 AF¥) and the flow during 2001-2020 (61,635)? If not, what other factors support the conclusion that the proposed base period is reasonably representative?

2. Mr. Wagner states that in terms of the basin's water Supply, both the 1931-1990 and 2001 2020 periods are representative· of the long-term averages of the basin because the latter period is only 6 percent drier" than the prior period. (Mtn., pp. 74 & 76.) Is a 6 percent difference de minimis? If so, how large would the difference need to be before it would be considered significant?

EXHIBIT J

Mojave Basin Area Watermaster
1/14/2026

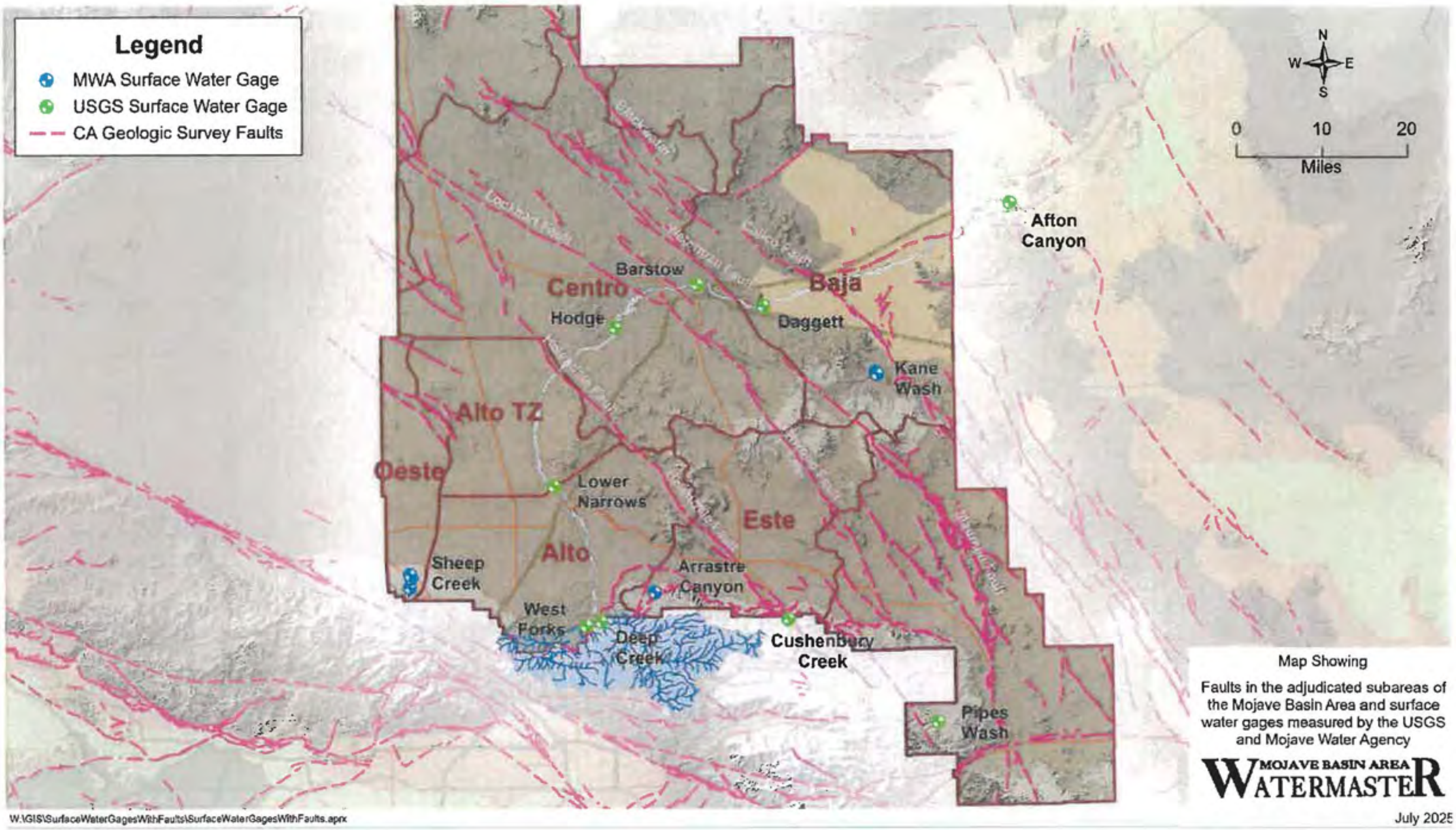
Public Hearing to Receive Comments on Hydrologic Base Period

Wagner Bonsignore
Consulting Civil Engineers, A Corporation

Mojave Basin Area Watermaster

Agenda

- Background and introduction
- Court's June 2022 Order granting Motion to Adjust FPA for Water Year 2022-2023
- Court's September 2022 Order
- Documentation Received Prior to Workshop
- Summary of commentary received prior to Watermaster workshop
- Summary of commentary received after Watermaster workshop
- Summary of interactions with stakeholders to address commentary
- Watermaster's recommendation for new hydrologic base period 2001-2020
- Considerations for Este and Baja Subareas
- Chuck Bell Production and Water Levels
- Cushenbury Canyon Creek near Lucerne Valley
- Next steps
- Staff recommendation


Legend
MWA Surface Water Gage
USGS Surface Water Gage
CA Geologic Survey Faults
N
W
E
S
0
10
20
Miles
Afton Canyon
Barstow
Centro
Baja
Hodge
Daggett
Kane Wash
Alto TZ
Oeste
Lower Narrows
Este
Alto
Sheep Creek
Arrastre Canyon
West Forks
Deep Creek
Cushenbury Creek
Pipes Wash
Map Showing
Faults in the adjudicated subareas of the Mojave Basin Area and surface water gages measured by the USGS and Mojave Water Agency
MOJAVE BASIN AREA WATERMASTER
W:\GIS\SurfaceWaterGagesWithFaults\SurfaceWaterGagesWithFaults.aprx
July 2025

Background and introduction

- In 2022, Court asked Watermaster to consider a shorter and drier base period.
- The 2001-2020 base period was used by Watermaster for PSY/FPA recommendations in water years 2024 and 2025.
- On August 4, 2025 hearing, the Court indicated that we should resolve the base period issue before determination of PSY/FPA.
- On September 3, 2025 Watermaster filed a motion to determine the hydrologic base period with the Court.
- Court hearings were held on October 20, 2025 and October 27, 2025.
- On November 12, 2025, Watermaster submitted to the Court the Watermaster Engineer's Statement of Reasons for Recommending 2001-2020 base period.

Court's June 2022 Order granting Motion to Adjust FPA for Water Year 2022-2023

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- *The Court does not have confidence that, in these times of climate disruption, it is prudent to rely upon the accuracy of those long-term supply assumptions, at least in the short term. As Mr. Wagner states, if the judgment were being negotiated today, it would be more prudent to select 'a shorter, drier planning period (hydrologic base period) for local supply . . ., resulting in a lower estimated Production Safe Yield and consequently lower annual Free Production Allowance.' (Wagner Decl., p. 6, ll. 18-21.)*

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Consulting Civil Engineers, A Corporation

Mojave Basin Area WATERMASTER

Court's September 2022 Order

6

- *The Court questions whether a 60-year period in the middle of the 20th century is still an appropriately representative period from which to measure the long-term averages specified in the definition of PSY, especially given the 32 years that have passed since 1990 and the climatic disruptions that we have been experiencing during that time.*
- *If [1931-1990] is not the most representative period, should a different period be defined? . . . Is the Watermaster bound to rely upon what appears at this point in time to be a less-than-prudent period?*
- *. . . Why, with an additional and more recent 30 years of data, should the PSY calculation continue to rely upon the prior 60-year period for defining the long-term average? At the very least, should not the past 32 years of data be added to the original 60 years?*

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Documentation Received Prior to Workshop

- On November 12, 2025, Watermaster submitted to the Court the Watermaster Engineer's Statement of Reasons for Recommending 2001-2020 base period.
- On December 2, 2025, California Department of Fish and Wildlife (CDFW) provided letter to Watermaster with questions and comments on the proposed hydrologic base period.
- On December 11, 2025 Fennemore LLP (on behalf of Mitsubishi, Robertson, and CalPortland) provided comment letter to Watermaster on the new hydrologic base period.
- On December 12, 2025, City of Victorville submitted commentary letter.
- On December 12, 2025, Watermaster held public workshop on new hydrologic base period selection.

Summary of commentary received prior to Watermaster workshop

Topic	Fennemore LLP	CDFW
Use of DWR Bulletin 84	Questions reliance on guidance from the 1967 DWR Bulletin 84 and the 1975 City of Los Angeles vs. City of San Fernando; asks if Watermaster considered other guidance such as *SGMA Best Management Practices for Water Budgets*.	States DWR Bulletin 84 is outdated; suggests using recent publications that include groundwater-surface water interactions, and definition of sustainable yield from SGMA.
Initial Hydrologic Base Period 1931–1990	Asks how 'normal' and 'extreme' wet/dry years are defined and if based solely on the flow at the Forks.	Notes Court only required PSY re-evaluation, not base period change; asks consideration for extending original period by adding recent years.
Proposed Hydrologic Base Period 2001–2020	Asks if updates will occur after model completion; questions if different base periods are recommended to each Subarea.	Questions urgency of base period change; asks for information to rely upon to quantify water supply for each Subarea; claims proposed period is 6% drier only applicable to Alto. Highlights evaluation of river depletions for each Subarea.

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MOJAVE BASIN AREA WATERMASTER

Summary of commentary received prior to Watermaster workshop

Topic	Fennemore LLP	CDFW
Alternative Hydrologic Base Periods	Asks if Court direction to "consider" a drier and recent period mandates recommendation; asks for how drier hydrologic conditions will become.	Suggests considering a base period that captures pre-overdraft conditions; questions if shorter period adequately captures variations in pumping and depletions lag effects.
Groundwater Modeling in relation to selection of a Hydrologic Base Period	Asks for future calibrations of the UMBM and impacts of the UMBM on the 2022 representative year.	Suggests waiting for completion of the new model to change the base period.
Data Gaps	Requests identification of records for Este and Oeste inflows; asks about plans to fill data gaps for Baja, Este, Oeste.	Asks about data deficiencies for Baja; criticizes reliance on water level interpretation instead of water budget in the form of Tables 5-1 and C-1; urges continued use of Barstow gage data.

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Summary of commentary received prior to Watermaster workshop

Topic	Fennemore LLP	CDFW
Pumping and Consumptive Uses for PSY determination	Asks for legal and technical basis for using representative year outside base period; asks if base period is foundational to PSY.	Asks for relationship between cultural conditions and single representative year; asks how PSY will account for altered river flows and depletions. Asks how new base period would improve PSY and FPA calculations.
Cultural Conditions	Questions exclusion of the 1990s from recent cultural conditions, the statistical basis and uniformity of the changes among Subareas.	Asks for intention of base period change relative to climate or cultural condition changes.
Environmental Concerns	N/A.	Emphasizes impacts on riparian habitat; warns of reduced Baja inflows and ecological harm. Notes major changes in vegetation and river flow in past 25 years; asks how water for riparian habitat will be maintained in the future.

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Summary of commentary received after Watermaster workshop

- Fennemore LLP:
  - The 1995-2024 is the most appropriate hydrologic base period among the alternatives presented by Watermaster.
- City of Victorville (as of December 12, 2025):
  - Does not oppose Watermaster's recommendation for 2001-2020 base period.
  - Asks for consideration of the 1931-2024 period of record for comparison purposes.
  - The same base period selected should be applied to all subareas.

Summary of commentary received after Watermaster workshop

- CDFW:
  - Does not support Watermaster's recommendation for 2001-2020 hydrologic base period. CDFW expressed concern about being locked into a base period that might make matters worse for Camp Cady, and would prefer to delay consideration of this matter until after the completion of the new model
- Newberry Springs Recreational Lakes Association (January 6, 2026):
  - Has proposed stipulating that the PSY/FPA values for Baja that were approved by the Court in August 2025 be the same values for the 2026-2027 Water Year. Alternatively, has suggested a base period from 1998-2024.

Summary of interactions with stakeholders to address commentary

- Watermaster met with CDFW on December 17, 2025 and January 9, 2026.
- Watermaster provided response letter to Fennemore on December 31, 2025 and met on January 8, 2026.
- Watermaster scheduled to meet with Newberry Springs Recreational Lakes Association on January 12, 2026.

Watermaster's recommendation for new hydrologic base period 2001-2020

- Meets guidance of DWR Bulletin 84.
- Average water supply 6% drier than the average of the initial base period 1931-1990.
- Fits the UMBM model calibration period (ending in 2020).
- Includes and is more representative of current cultural conditions.
- It satisfies the *Court's request to consider* a **drier and more recent hydrologic base period**.
- Watermaster seeks to base its **2026 PSY recommendations upon the most appropriate and representative base period**, which Watermaster believes is the 2001-2020 time-frame.
- Importantly, the base period will not change the actual water supply to the Basin Area going forward. The selected base period is a management tool for future planning.

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MOJAVE BASIN AREA WATERMASTER

Watermaster evaluation of alternative hydrologic base periods

Alternative Hydrologic Base Periods	Mojave River at the Forks Average (a.f.)	Change relative to the 1931-1990 average (65,538 a.f.)	Change relative to the 1931-2024 average (69,176 a.f.)	Criteria
1991-2022	71,344	+8%	+3%	Start and end years are dry and are preceded by a series of dry years.
1995-2024	67,057	+2%	-3%	Start and end years are wet and are preceded by a wet year/series of wet years.*
1998-2024	65,090	-1%	-6%	Start and end years are wet and are preceded by a wet year/series of wet years.
2001-2020	61,635	-6%	-12%	Start and end years are dry and are preceded by a series of dry years.
2002-2022	59,009	-11%	-17%	Start and end years are severe dry and are preceded by a series of severe dry years.
1931-2022	67,557	+3%	-2%	Per Court's Order. Start and end years are dry and are preceding a series of severe dry years.

Notes: The PSY Update prepared by Watermaster in February of 2024 updated the hydrologic base period to be 2001-2020 for purposes of establishing PSY. This selection was based on the information that was available and reliable for Watermaster at the time of the analysis (i.e., flow data up to the year 2023).
Also, the PSY Update by Watermaster evaluated the 2001-2020 hydrologic base period also because the Upper Mojave Basin Model was calibrated through the Water Year 2020.
*The water supply at the Forks during the Water Years 1992 through 1995 was about three times the long-term average supply.

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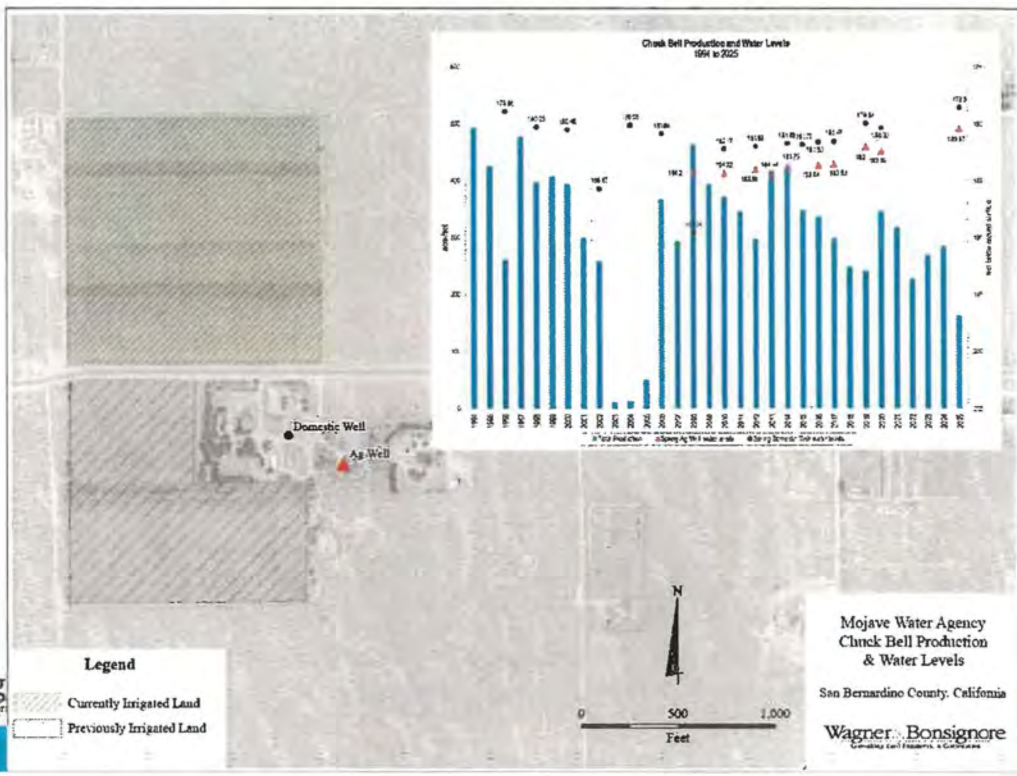
Mojave Basin Area Watermaster

Considerations for Este and Baja Subareas

- The following is an example of a long-time producer in the Este Subarea for which we have metered pumping records and water level measurements.
- This supports how interpretation of water levels and pumping may serve as a proxy for PSY in the Este and Baja Subareas.

Chuck Bell Production and Water Levels



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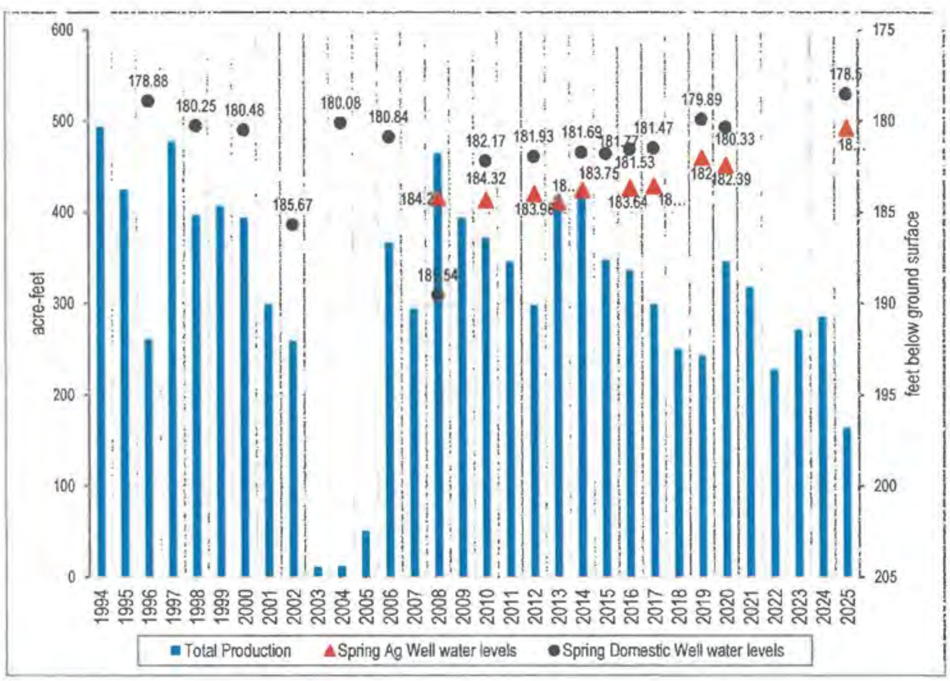
MOJAVE BASIN AREA WATERMASTER

Chuck Bell Production and Water Levels



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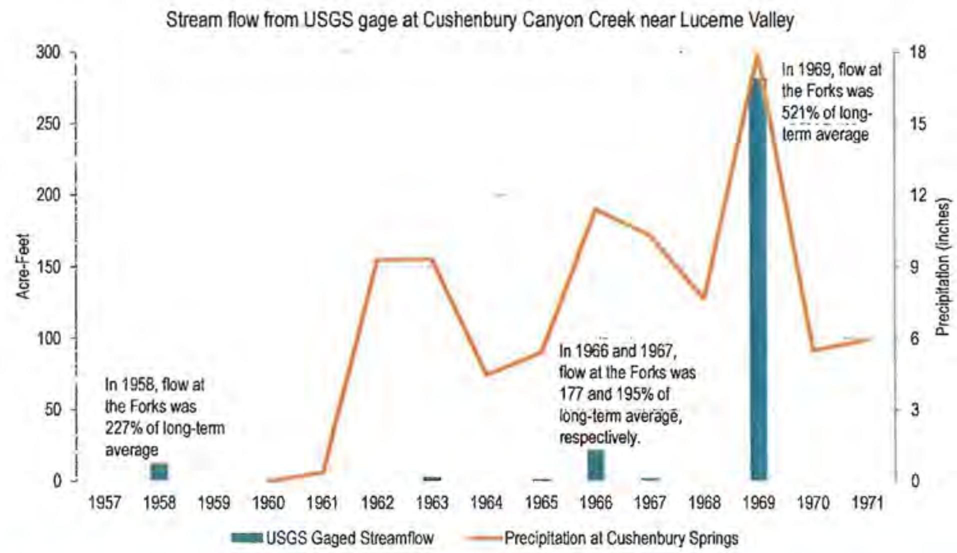
Consulting Civil Engineers, A Corporation

Mojave Basin Area Watermaster

Cushenbury Canyon Creek near Lucerne Valley

- The flow at the Forks as an indicator of wet and dry periods in the Basin Area.



Wagner & Bonsignore
Consulting Civil Engineers, A Corporation

Mojave Basin Area Watermaster

Next steps

- Hold Public Hearing today, January 14, 2026
- Adopt base period recommendation
- File a Motion for Court approval of the new hydrologic base period, and summarize position stated by engaged Parties.
- Prepare analysis for recommending PSY/FPA based on Court approved base period.
- Additional workshops as necessary.
- Watermaster meetings:
  - January 28, 2026.
  - February 25, 2026.
  - March 25, 2026 (potential workshop).
  - April 22, 2026.
  - May 27, 2026.

Staff Recommendation

- Staff recommends that Watermaster conduct a public hearing to receive comments on the hydrologic base period of 2001-2020

EXHIBIT K

Mitsubishi Cement Corporation, Robertson's Ready Mix, Ltd. & CalPortland Company

Public Comment on Hydrologic Base Period Alternative 1995-2024

Watermaster Board Meeting
– January 14, 2026

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Background

- Court denied Watermaster's last attempt to adopt 2001-2020 as a new Hydrologic Base Period

- The Court denied this pending evaluation of alternatives and more robust data and technical support for any Watermaster recommendation

- Court directed a robust and transparent public process prior to Board and Court approval

Bulletin 84 & *Los Angeles v. San Fernando*

The base period conditions [...]**should include both normal and extreme wet and dry years.** [...] **The base period should also be within the period of available records** and **should include recent cultural conditions** as an aid for projections under future basin operational studies.

(Watermaster SOR Exhibit A [DWR Bulletin 84], pg. 47-48, emphasis added).

The desirable base period includes both wet and dry periods similar in magnitude and occurrence to the normal supply, and **during which there are sufficient measurements** and **observations to relate the hydrology to recent culture.**

(Watermaster SOR Exhibit B [Report of Referee], pg. 182; emphasis added.)

PSY Definition & 2022 Court Order

PSY - **The highest average Annual Amount of water that can be produced from a Subarea**: (1) **over a sequence of years that is representative of long-term average annual natural water supply to the Subarea net of long-term average annual natural outflow from the Subarea** [...] **without resulting in a long-term net reduction of groundwater in storage in the Subarea.**

(Judgment ¶ 4.aa., emphasis added).

The Court questions whether a 60-year period in the middle of the 20th century is still an appropriately representative period from which to measure the long-term averages specified in the definition of PSY, **especially given the 32 years that have passed since 1990 and the climatic disruptions that we have been experiencing during that time** [...] **Mr. Wagner has stated** [...] to **select 'a shorter, drier planning period** (hydrologic base period) for local supply . . ., resulting in a lower estimated Production Safe Yield and consequently lower annual Free Production Allowance.

(Court's September 16, 2022 Order Directing the Watermaster to Re-Evaluate PSY for the Entire Basin, Exhibit A, pg. 4-5, emphasis added.)

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Criteria for Selecting a Hydrologic Base Period

- Both normal and extreme wet and dry years
- Must be within the period of available records
- Must include recent cultural conditions
- Must support the highest average annual amount of water without long-term groundwater storage loss
- Must consider climatic disruption

Normal and Extreme Wet and Dry Years

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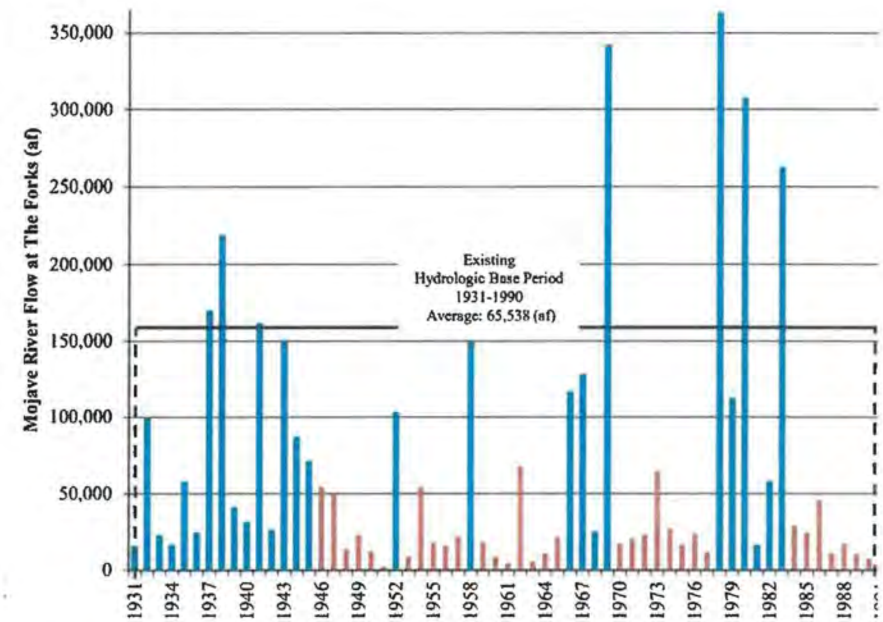
Watermaster Engineer approach identifies wet and dry years using the Mojave River flow at the Forks



Expect **MORE.**

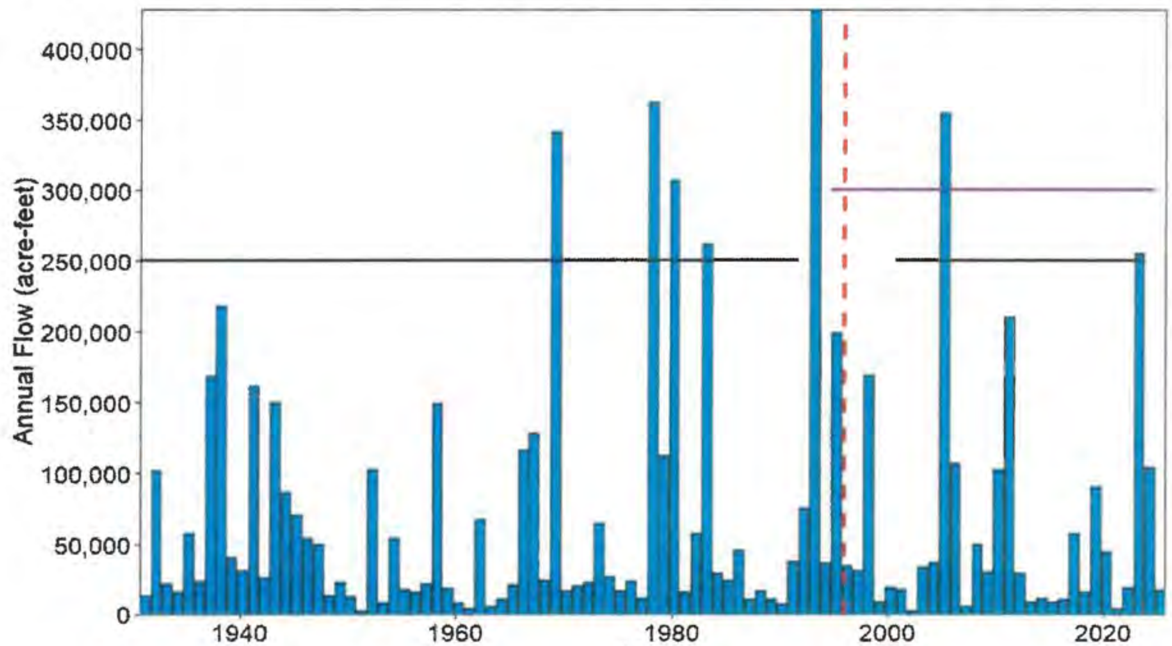
FENNEMORE.

Normal and Extreme Wet and Dry Years

- 1995–2024 includes extreme wet years (e.g., 2005 and 2023)

- 1995–2024 includes multi-year droughts (1999–2002 and 2013–2018)

Figure 1 – Mojave River Flow at the Forks and Potential Hydrologic Base Periods



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Period of Available Records

1993–1994

Watermaster annual reporting begins in 1993–1994

2021–2024

Watermaster exclusion of 2021–2024 data is an artificial restraint

Included entirely within available data record

1995–2024

Expect **MORE.**

FENNEMORE.

UMBM Calibration Is Not a Valid Basis for Rejecting Alternatives

Watermaster staff proposal rejects all other alternatives (which include years after 2020) because the UMBM is calibrated through 2020

No explanation is provided why the model cannot be extended through 2024 (especially when it was recently extended through 2020 for the 2024 PSY Update)

If calibration is critical, it supports delaying approval—not selecting a period that lacks critical data

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Recent Cultural Conditions

- 1995–2024 includes four more recent years than 2001–2020
- **All alternatives evaluated** include post-2020 years **except** the Watermaster staff proposed period of 2001-2020
- Including the most recent years (2021-2024) best satisfies the "recent cultural conditions" requirement

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Cultural Conditions Change Gradually

Watermaster staff does not identify any significant land-use changes to justify 2001-2020 over any other alternative

Judgment and Physical Solution implemented in 1996 which is the most significant land use change in all alternatives analyzed

1995–2024 uniquely captures the last year before the Judgment and the full post-Judgment period

Expect **MORE.**

FENNEMORE.

Representative Year for PSY Selection

Original PSY representative year (1990) was within the hydrologic Base Period

PSY Definition ties representative year to the Base Period

1995–2024 resolves this issue since the Watermaster has been using 2022 as the representative year

PSY Requires Highest Average Annual Amount

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PSY requires selection of the *highest* Annual Average Amount

2001–2020 yields a 6% decrease in total water supply over 1931-1990

1995–2024 yields a 2% increase in total water supply over 1931-1990

FENNEMORE.

"Climatic Disruption" is Not the Same as "Drier"

Court did not order selection of a drier hydrologic Base Period

Climatic disruption reflects volatility, not uniform drying.

MWA expects significant wet years and dry years to continue for the foreseeable future

1995–2024 captures both extreme wet years and severe droughts

FENNEMORE.

Conclusion

DWR Bulletin 84, *Los Angeles v. San Fernando*, the Judgment, and the Court's recent orders support 1995-2024 as a new Hydrologic Base Period, not 2001-2020

EXHIBIT L

Opposition for the Proposed Base Period for Baja

Opening statement
I appreciate the discussion I had with Watermaster on Jan 12th; I want to thank Jeff Ruesch, Lee McElhaney, and Bob Wagner for a frank and long friendly chat. I believe I understand the reasoning behind the proposed base period change a little better, although Baja's issues are unique and should be treated differently than other basins. And that goes for Este also.

1. Baja's PSY calculations, has been treated differently in past years for several reasons, mostly because there is a lack of data. Plus, the lack of storm flow from the Mojave River, which can be attributed to over pumping in the river by upstream users, drought years, and slow releases from the Silverwood dam.
2. Picking a base period that covers all the sub-areas equally may not be the optimal option, especially for Baja. Mr. Wagner even suggested to the court that there could be different base periods for different areas. Here are a few reasons why, that is the case.
    a. Baja only gets recharge from the river on extreme storm flow years
    b. Therefore, a base period for Baja must include those extreme years, like 1992 and 2005
    c. Lack of data on the quantity of water that Baja gets from local storm runoff or other sources
    d. The modeling currently underway could shed light on where our water comes from, and the model must be updated with current year data because of the huge cultural changes that has happened in Baja the last several years.
    e. Based on the ground water level in key wells in Baja, Mr. Wagner has estimated that Baja is at or very close to ground water sustainability
    f. Mr. Wagner has suggested that fact, (Baja has reached sustainability) to the court in the last couple FPA hearings, and has tried to explain to the court why both Baja and Este are treated differently
3. One of the most difficult issues for Baja producers, is trust, that the court will follow the Watermaster's engineers recommendation. In past hearings that has not been the case, Judge Reimer has either ruled against the recommendations because he does not quite understand or because he believes he is following the Judgement. Both of those reasons are hurtful to the producers in Baja, because of continued rampdown, past sustainability.
4. I understand the reasoning behind a more recent base period, for cultural and climate reasons. But that should still be based on the best science available and be more likely than not to repeat in the future.
5. Changing the base period should not have a goal of picking a drier period, based on what the court suggests. It must be based on the long-time record, and in Baja's

case there is no long-time record because of lack of data and not knowing where our water comes from.

6. The Chino basin recently updated their base period and included the more recent years to their long-time average. This is a neighbor basin with similar cultural changes, such as less AG more housing. And could be an option for us that should not be dismissed, just because it would increase supply.
7. If this base period is implemented it would decrease PSY in baja by almost 30%, or 3,678 AF. In Centro the PSY would increase by almost 40%, or 10,332 AF. That is a huge increase of water production for Centro, going from 21,088 AF to 31,420 AF. This will affect storm flow into Baja by reducing the ground water levels in Centro because of more pumping. Heck, you may even see new pivots pop up, farming alfalfa in Centro, if this base period is approved. Why in the world does that sound like a good idea? We need a little common sense here on this issue.

In summery

It would be prudent of Watermaster to take more time to finish and update the model for all sub-areas before you make a recommendation to change the base period. The base period is an essential part of the Judgement, the calculation for PSY and FPA, and should be very carefully picked.

I would recommend that the Watermaster Board vote against the recommendation to change the base period at this time. Let's get more data and make a better-informed decision and allow more time for stakeholders to study this issue.

Or in the alternative, in your recommendation, allow for continued discretion on how Watermaster's Engineer calculates the PSY in both Baja and Este. This may or may not sway the court's decision on FPA, but it may help.

Thank you!

EXHIBIT M

	PSY based on 1931-1990 Base Period	PSY based on 2001-2020 Base Period	Difference	Percent Difference
Este	4,728	5,108	+ 380	+ 7.73%
Oeste	1,712	3,634	+ 1,922	+ 71.90%
Alto	64,406	62,233	- 2,173	- 3.43%
Centro	21,088	31,420	+ 10,332	+ 39.35%
Baja	14,544	10,866	- 3,678	- 28.95%

EXHIBIT 3

Mojave Basin Area Watermaster
12/12/2025

Workshop on New Hydrologic Base Period Selection

Wagner & Bonsignore
Consulting Civil Engineers, A Corporation

Mojave Basin Area
WATERMASTER

Agenda

- Court's June and September 2022 Orders
- Production Safe Yield
- Appropriate criteria for selection of a hydrologic base period
- Initial hydrologic base period 1931-1990
  - Changes in cultural conditions
  - Changes in pumping
  - Changes in agricultural production and irrigated acreages
  - Changes in return flows based upon VVWRA discharges
- Water Supply to the Basin Area: Precipitation and Streamflow data.
- Watermaster evaluation of alternative hydrologic base periods.
- Any other proposed hydrologic base period(s) from interested Parties?
- Watermaster recommendation for new hydrologic base period 2001-2020
- Next steps

Court's June 2022 Order granting Motion to Adjust FPA for Water Year 2022-2023

- *The Court does not have confidence that, in these times of climate disruption, it is prudent to rely upon the accuracy of those long-term supply assumptions, at least in the short term. As Mr. Wagner states, if the judgment were being negotiated today, it would be more prudent to select 'a shorter, drier planning period (hydrologic base period) for local supply . . ., resulting in a lower estimated Production Safe Yield and consequently lower annual Free Production Allowance.' (Wagner Decl., p. 6, ll. 18-21.)*

Court's September 2022 Order

- *The Court questions whether a 60-year period in the middle of the 20th century is still an appropriately representative period from which to measure the long-term averages specified in the definition of PSY, especially given the 32 years that have passed since 1990 and the climatic disruptions that we have been experiencing during that time.*
- *If [1931-1990] is not the most representative period, should a different period be defined? . . . Is the Watermaster bound to rely upon what appears at this point in time to be a less-than-prudent period?*
- *. . . Why, with an additional and more recent 30 years of data, should the PSY calculation continue to rely upon the prior 60-year period for defining the long-term average? At the very least, should not the past 32 years of data be added to the original 60 years?*

Production Safe Yield

- The Judgment defines PSY as "The **highest average Annual Amount of water that can be produced from a Subarea**: (1) over a sequence of years that is representative of long-term average annual natural water supply to the Subarea net of long-term average annual natural outflow from the Subarea, (2) under given patterns of Production, applied water, return flows and Consumptive Use, and (3) **without resulting in a long-term net reduction of groundwater in storage in the Subarea**." (Judgment, p. 11.)

Appropriate criteria for selection of a hydrologic base period

- Guidance on base period from the Department of Water Resources Bulletin 84 (1967):

  The base period conditions should be ***reasonably representative of long-time hydrologic conditions*** *and should include both normal and extreme wet and dry years. Both the beginning and the end of the base period should be preceded by a series of wet years or a series of dry years, so that the difference between the amount of water in transit within the zone of aeration at the beginning and end of the base period would be a minimum. The base period should also be within the period of available records and should* ***include recent cultural conditions as an aid for projections under future basin operational studies****.*

Appropriate criteria for selection of a hydrologic base period

- State Water Rights Board "Report of Referee" (1962) filed in City of Los Angeles v. City of San Fernando.

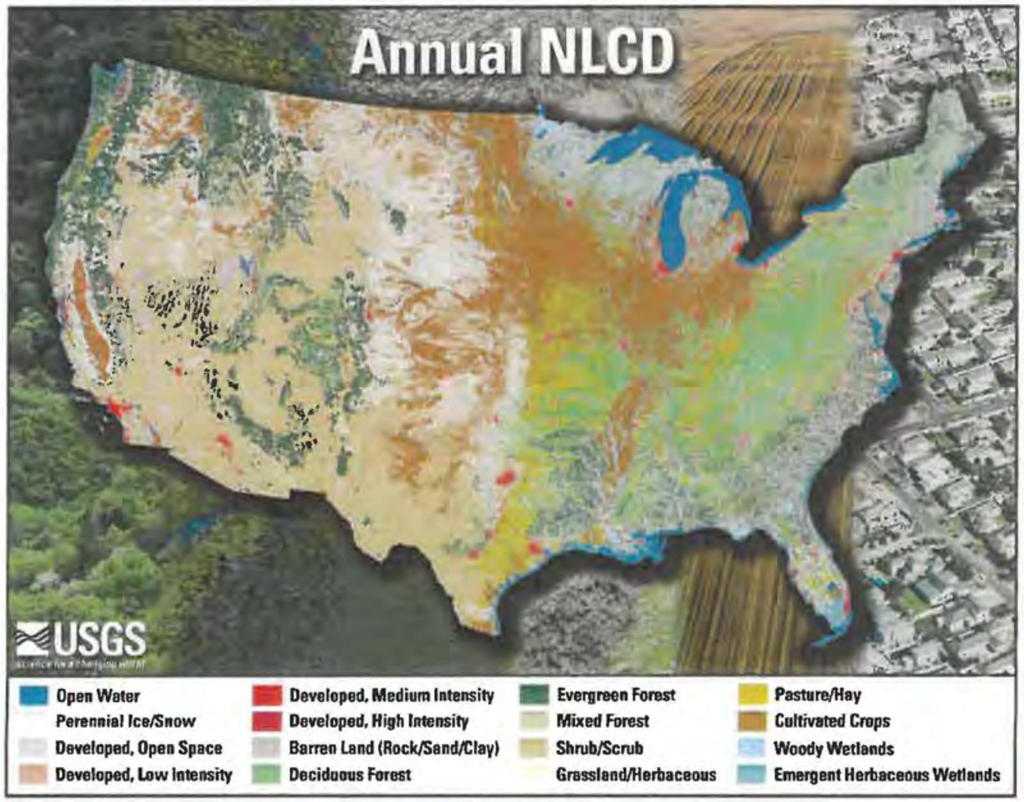
  The desirable base study period is one during which precipitation characteristics in the Upper Los Angeles River area approximate the 85-year period of record, 1872-73 through 1956-57. A further requirement of such a period is that additional hydrologic information is available sufficient to permit an evaluation of the amount, occurrence and disposal of the normal water supply ***under recent culture conditions****. The desirable base period includes both wet and dry periods similar in magnitude and occurrence to the normal supply, and during which there are sufficient measurements and observations* ***to relate the hydrology to recent culture****.*

Initial Hydrologic Base Period 1931-1990

- Initial base period 1931-1990 was agreed to by the Parties when the Judgment was entered.
- This base period was consistent with DWR Bulletin 84 guidance.
- However, cultural conditions for water disposal and use have changed since 1990.

Changes in cultural conditions

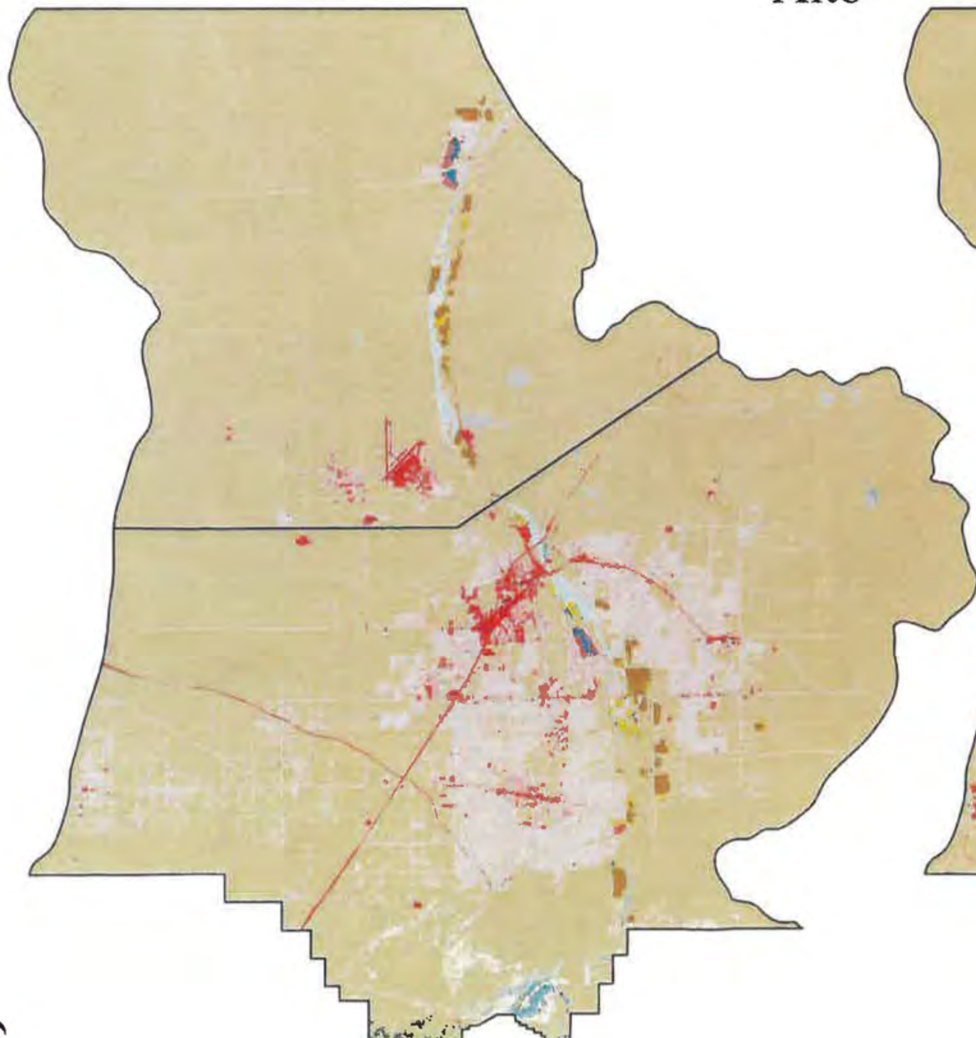
- Watermaster evaluated changes in land uses since the year 1990 to present.
- USGS Annual NLCD (National Land Cover Database) Land Cover Classification.



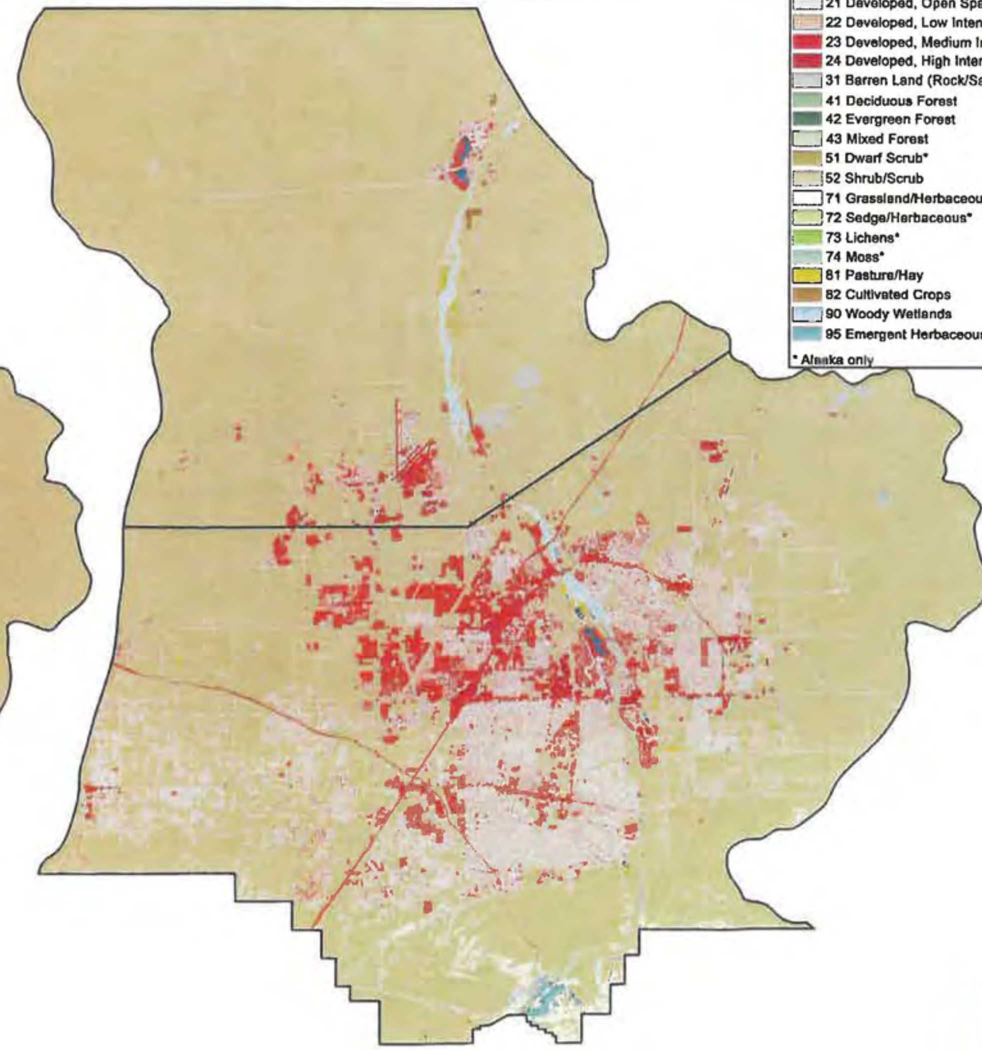
Source: https://usgs.gov/annualnlcd

Alto

1990



2020



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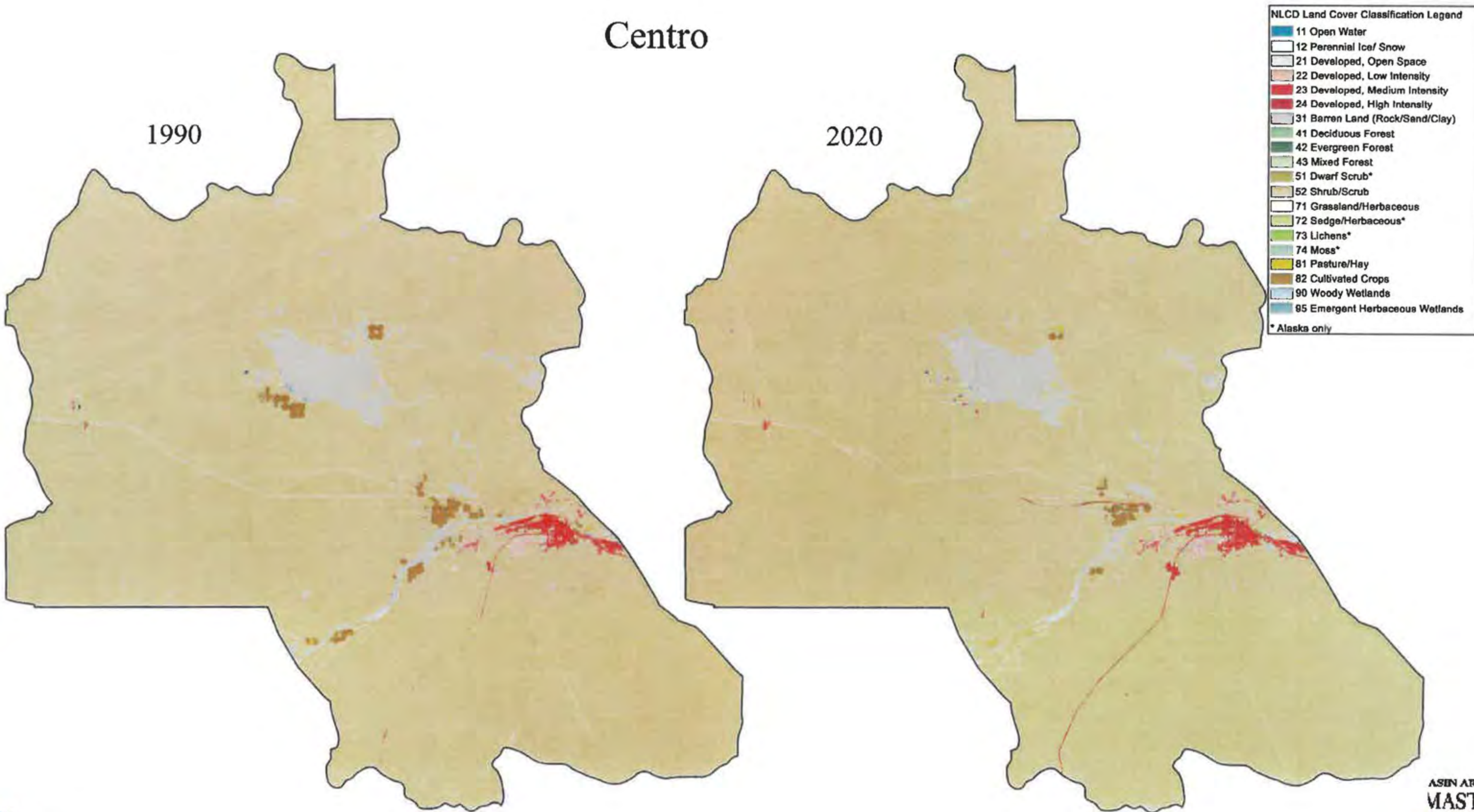
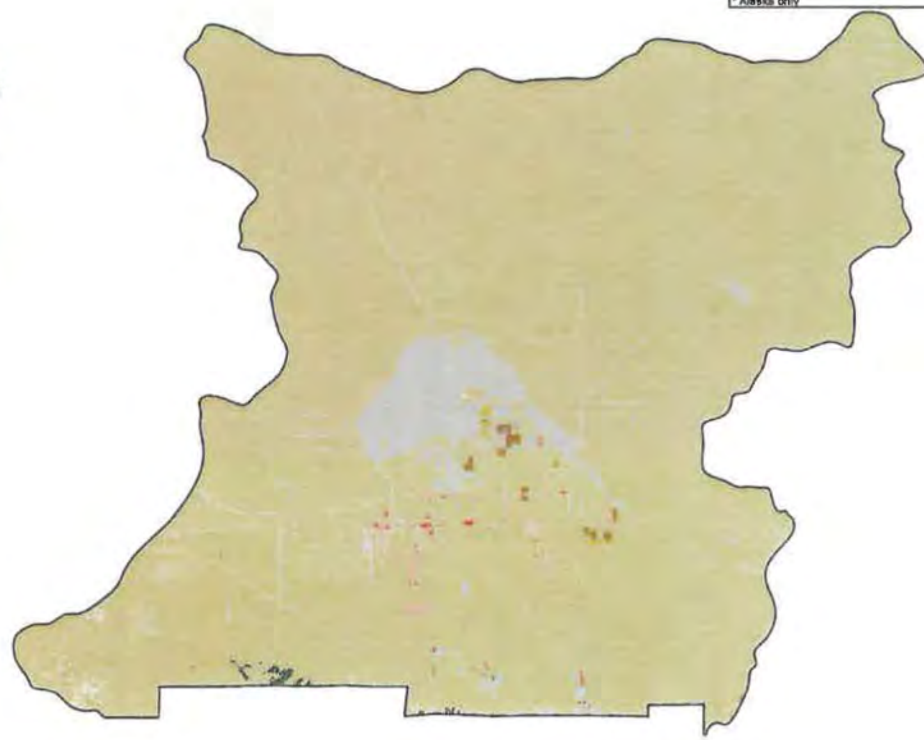
IASIN AREA MASTER

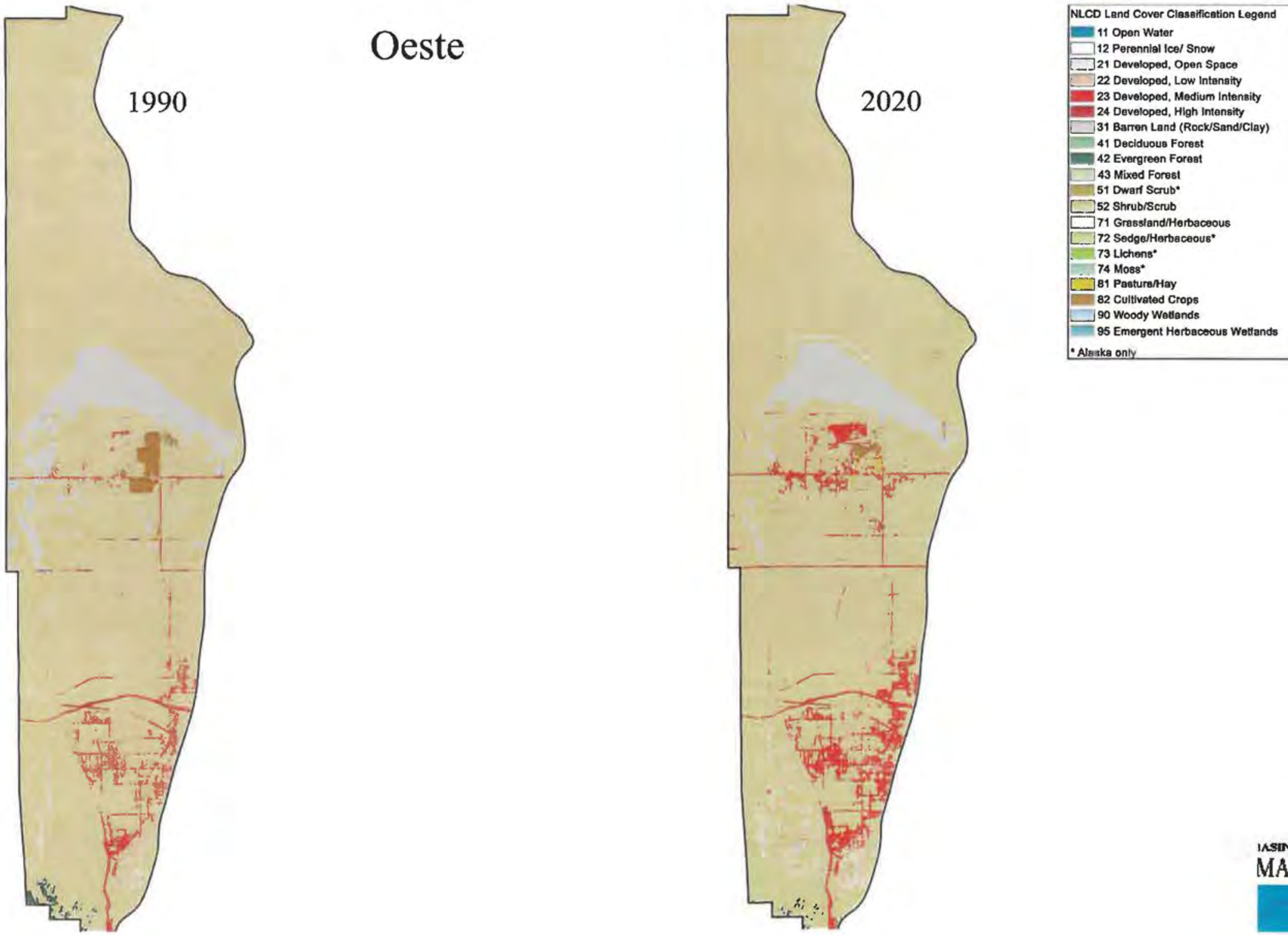

Centro
1990
2020
NLCD Land Cover Classification Legend
11 Open Water
12 Perennial Ice/ Snow
21 Developed, Open Space
22 Developed, Low Intensity
23 Developed, Medium Intensity
24 Developed, High Intensity
31 Barren Land (Rock/Sand/Clay)
41 Deciduous Forest
42 Evergreen Forest
43 Mixed Forest
51 Dwarf Scrub*
52 Shrub/Scrub
71 Grassland/Herbaceous
72 Sedge/Herbaceous*
73 Lichens*
74 Moss*
81 Pasture/Hay
82 Cultivated Crops
90 Woody Wetlands
95 Emergent Herbaceous Wetlands
* Alaska only

Este

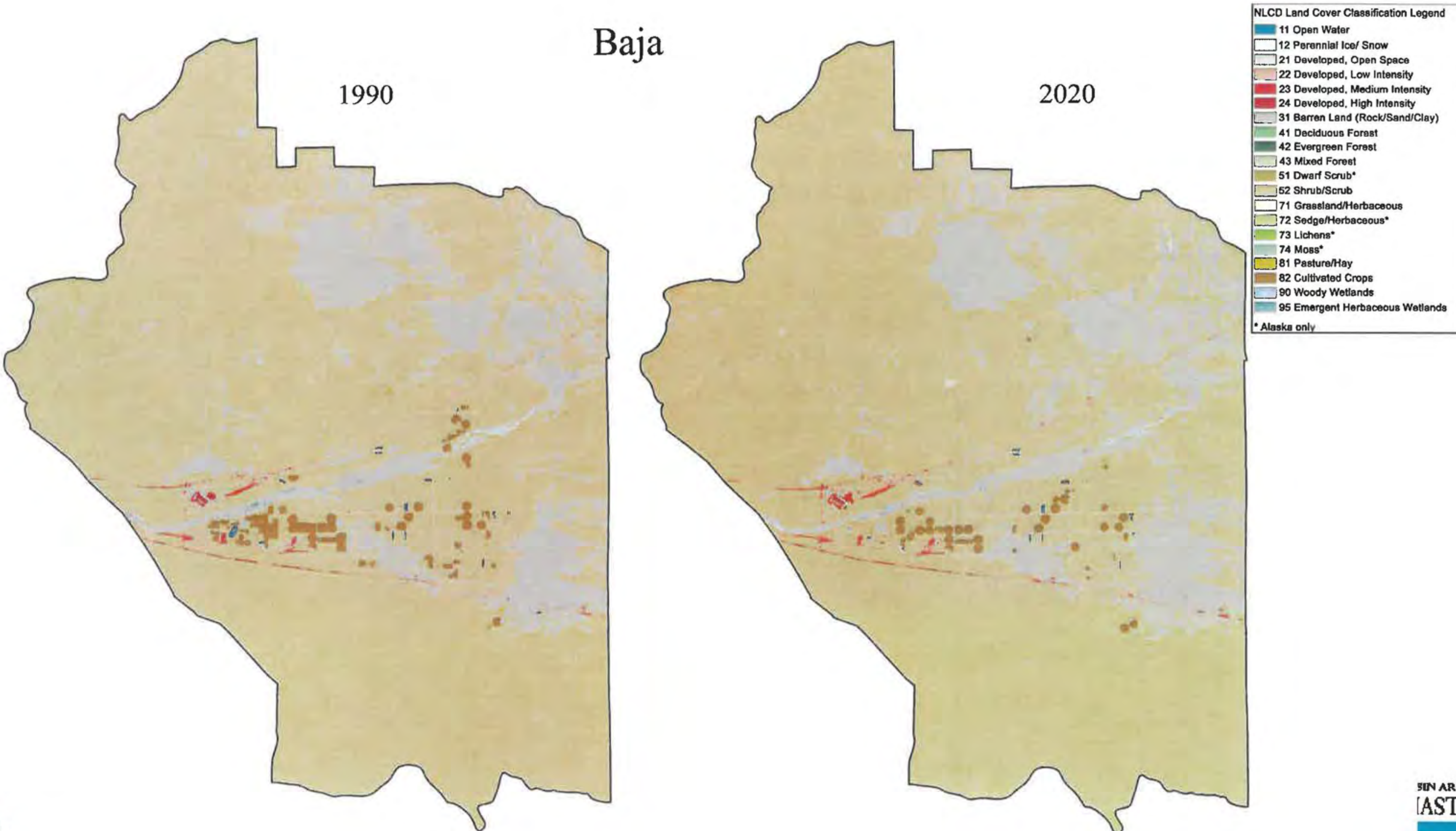
1990

2020





IASIN AREA MASTER


Baja
1990
2020
NLCD Land Cover Classification Legend
11 Open Water
12 Perennial Ice/ Snow
21 Developed, Open Space
22 Developed, Low Intensity
23 Developed, Medium Intensity
24 Developed, High Intensity
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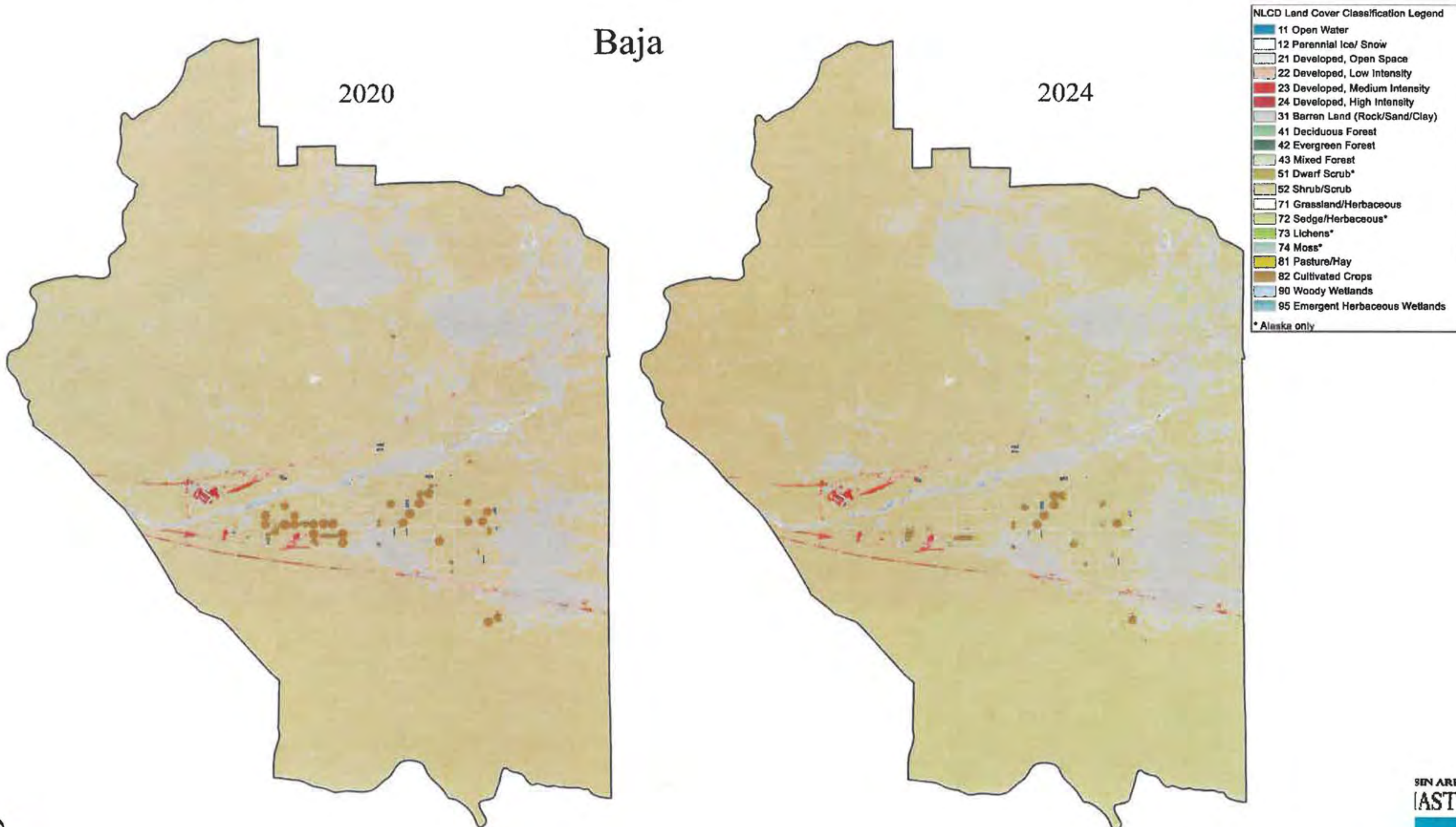
Baja


2020
2024
NLCD Land Cover Classification Legend
11 Open Water
12 Perennial Ice/ Snow
21 Developed, Open Space
22 Developed, Low Intensity
23 Developed, Medium Intensity
24 Developed, High Intensity
31 Barren Land (Rock/Sand/Clay)
41 Deciduous Forest
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71 Grassland/Herbaceous
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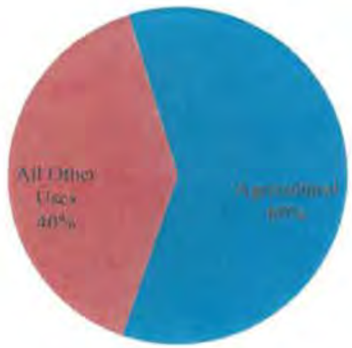
74 Moss*
81 Pasture/Hay
82 Cultivated Crops
90 Woody Wetlands
95 Emergent Herbaceous Wetlands
* Alaska only

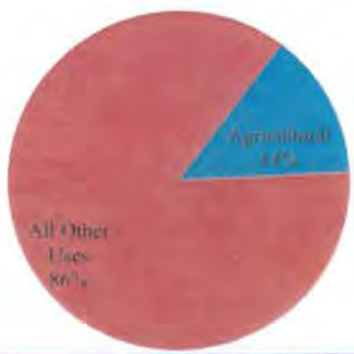
Changes in pumping

1990 Water Uses

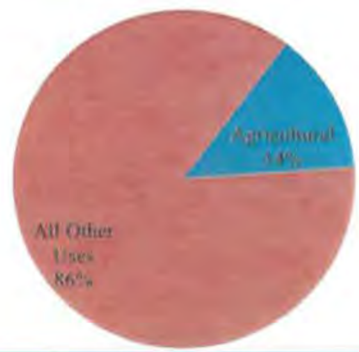


2020 Water Uses

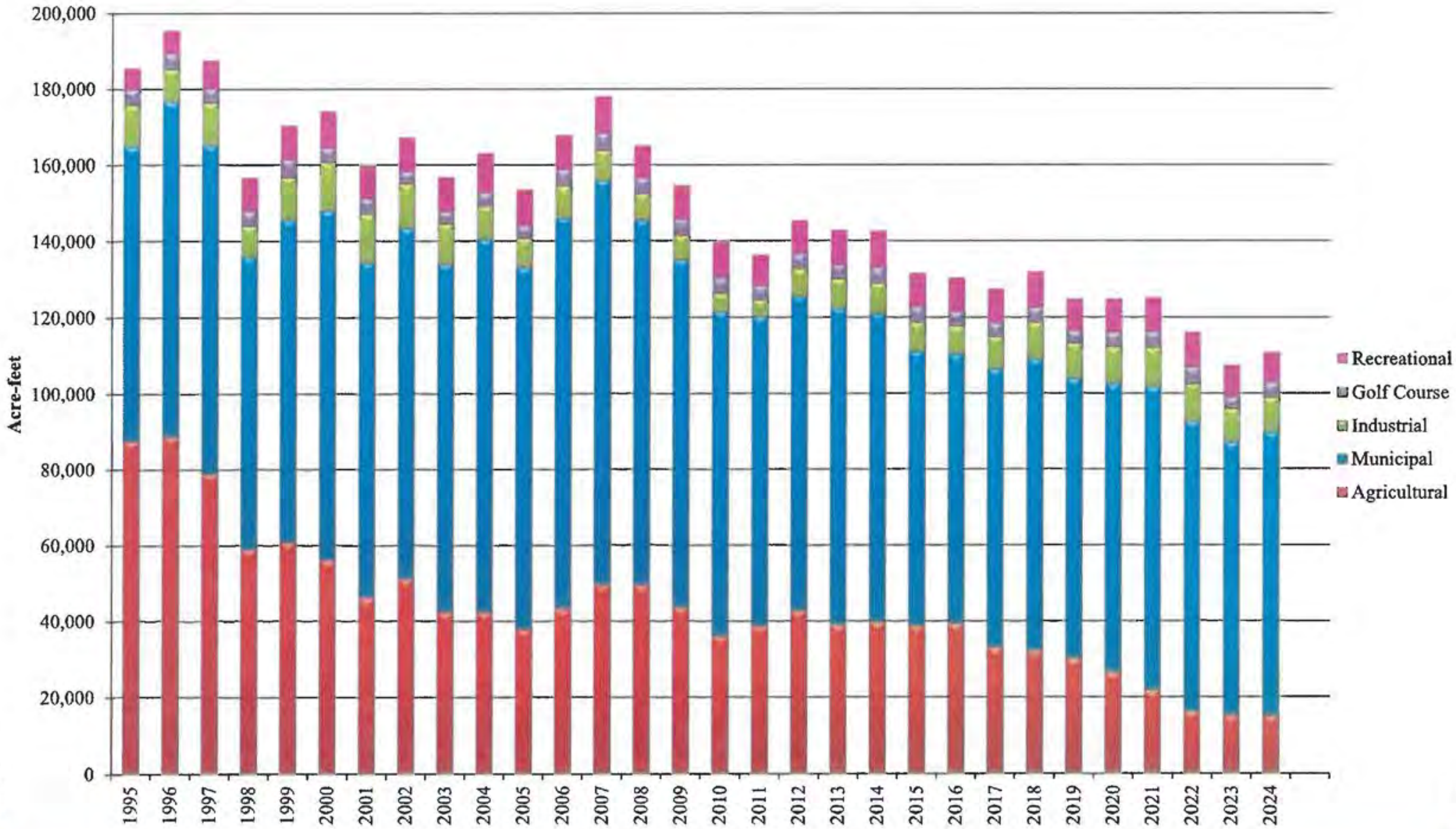
2022 Water Uses



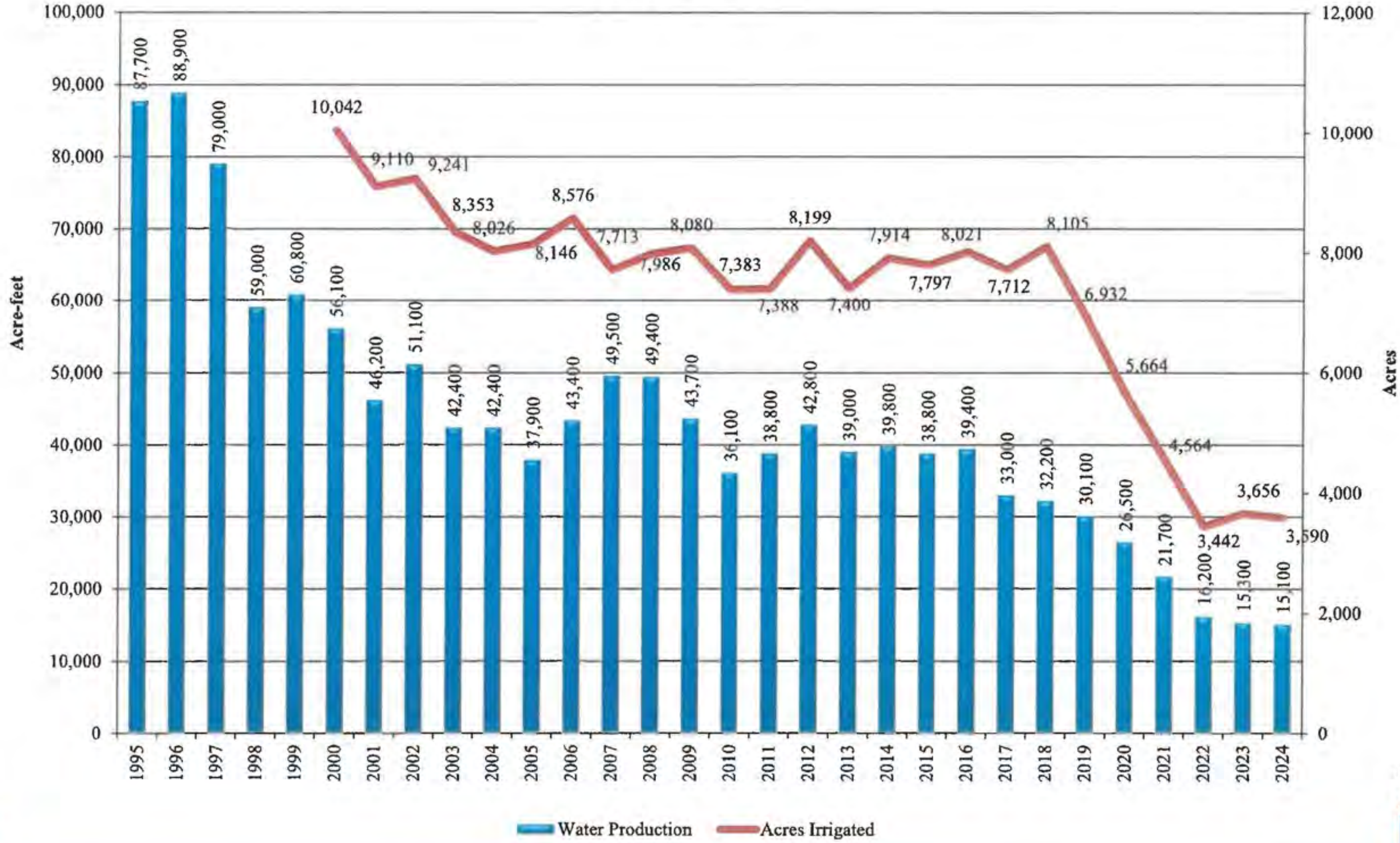
2024 Water Uses



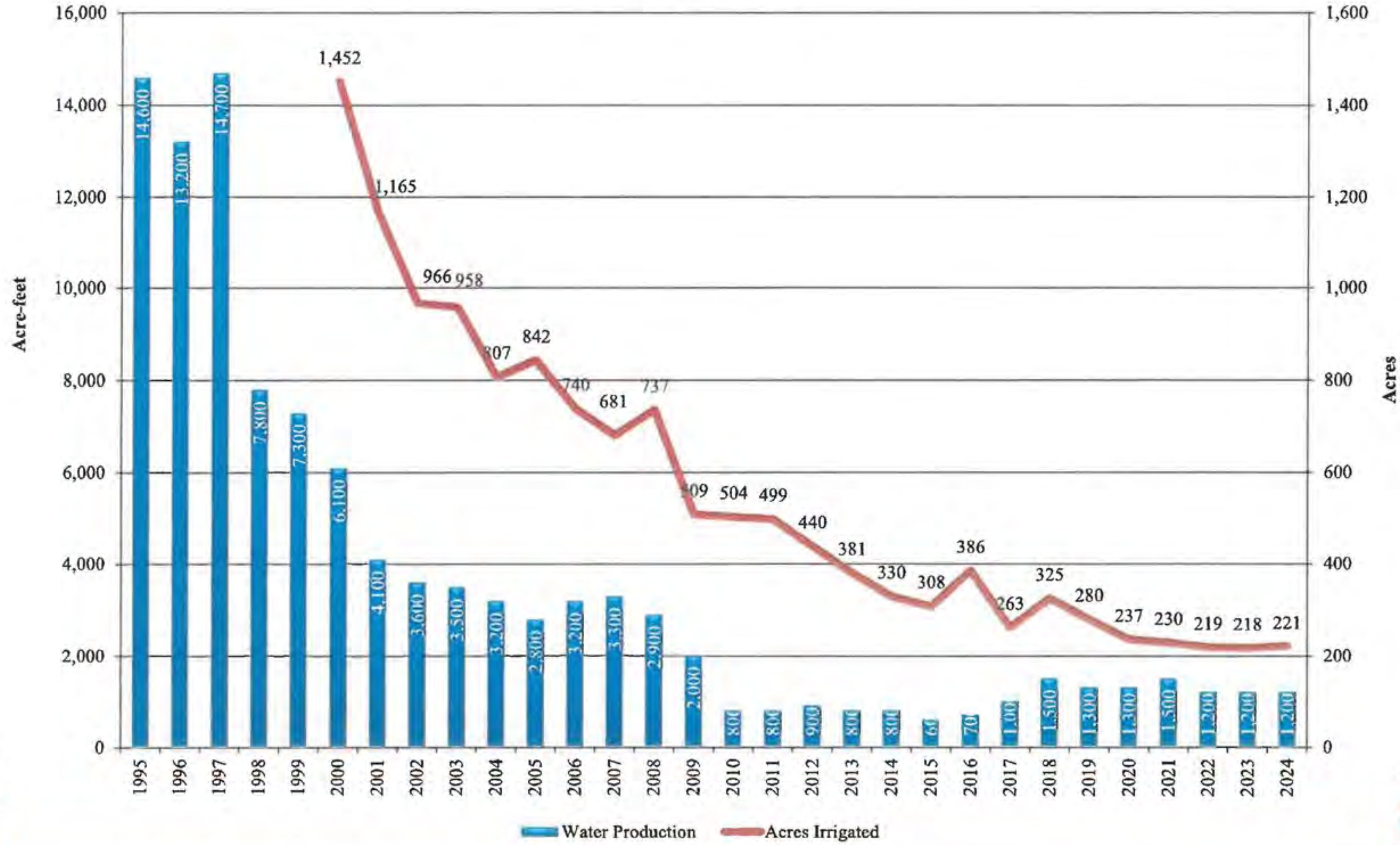
Mojave Basin Area
Estimated Water Production by Type of Use
1994-95 Through 2023-24



Agricultural Water Production and Irrigated Acreage All Subareas



Agricultural Water Production and Irrigated Acreage Alto Subarea



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Consulting Civil Eng

MOJAVE BASIN AREA
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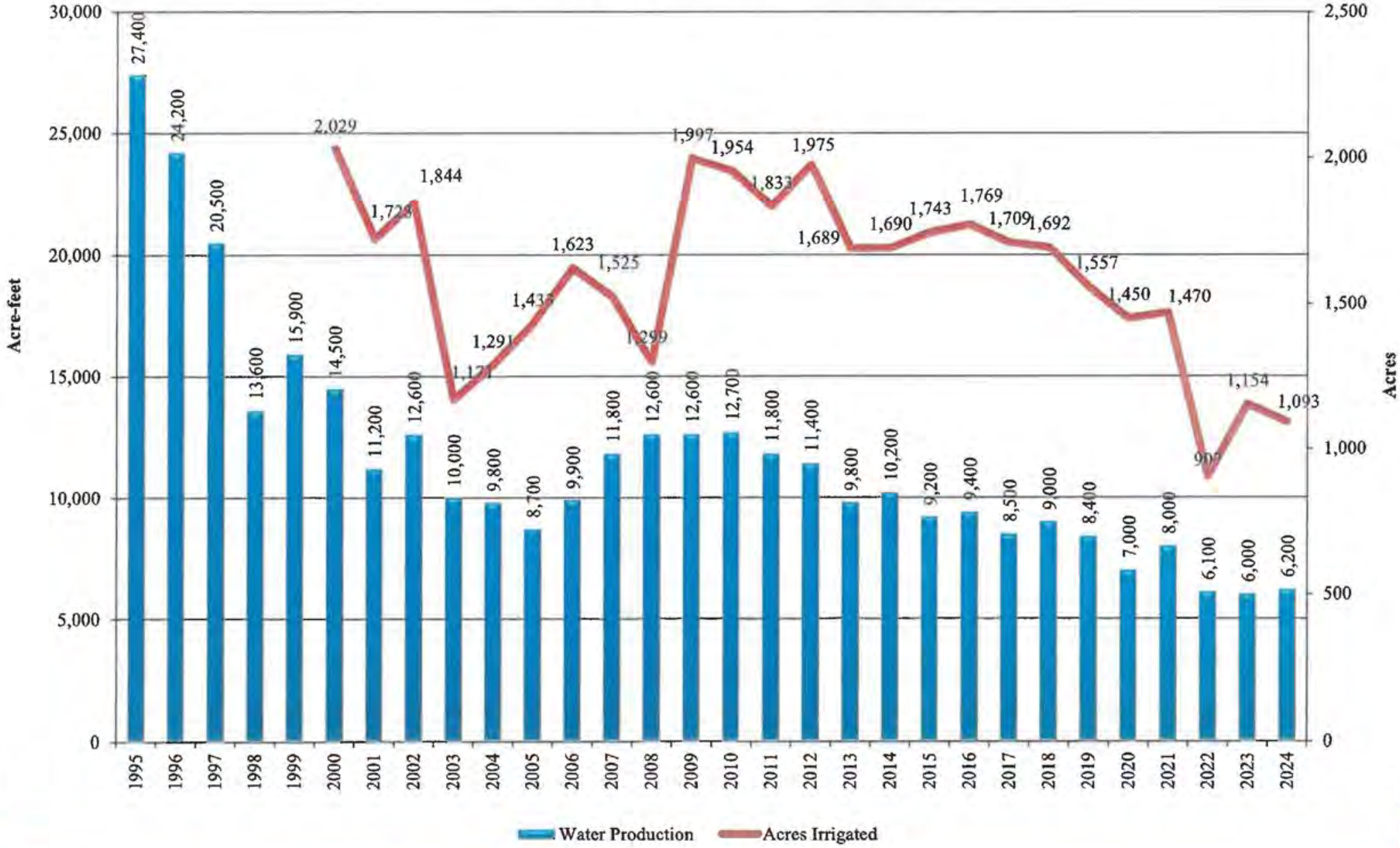
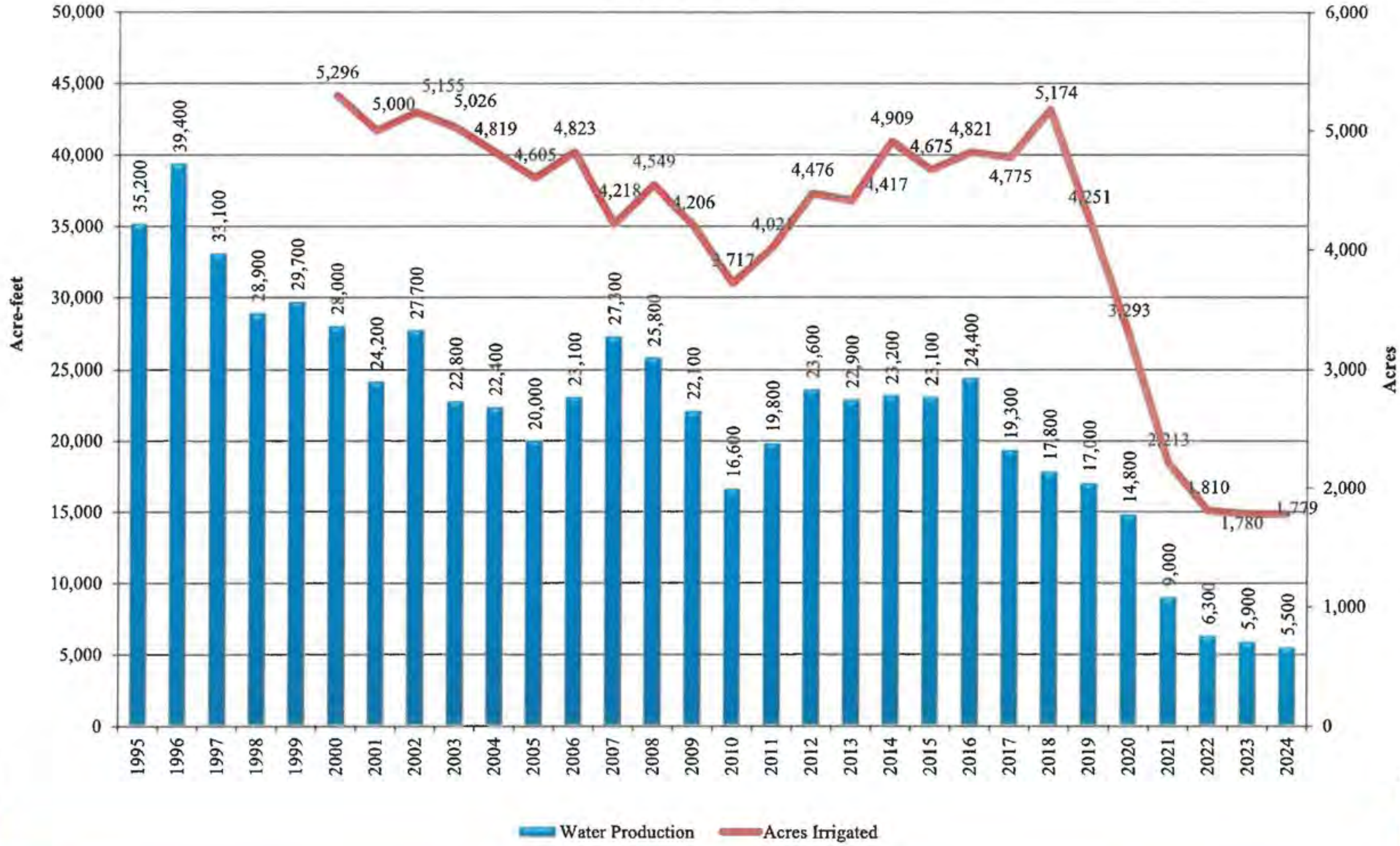
Agricultural Water Production and Irrigated Acreage Centro Subarea



Agricultural Water Production and Irrigated Acreage Baja Subarea



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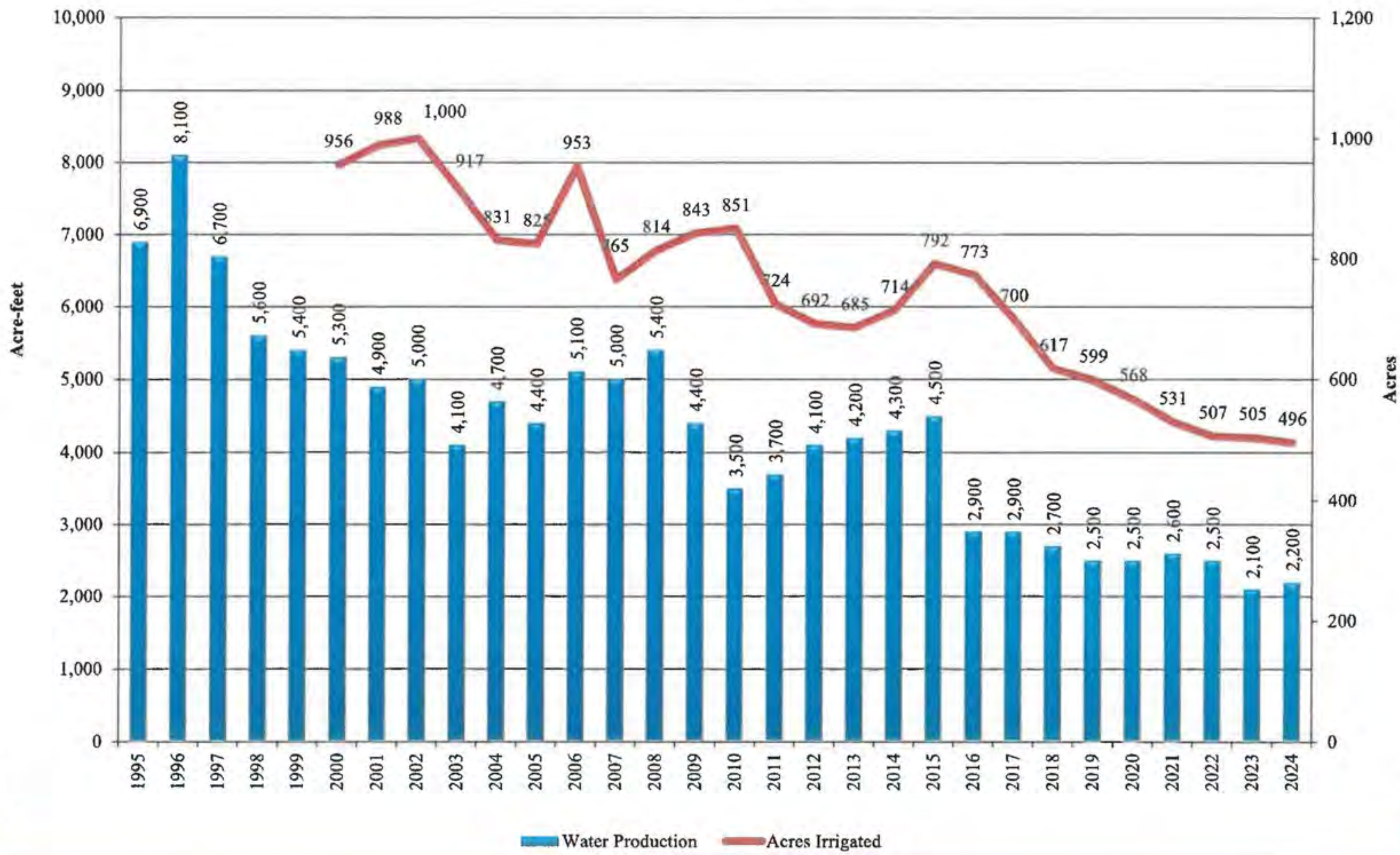
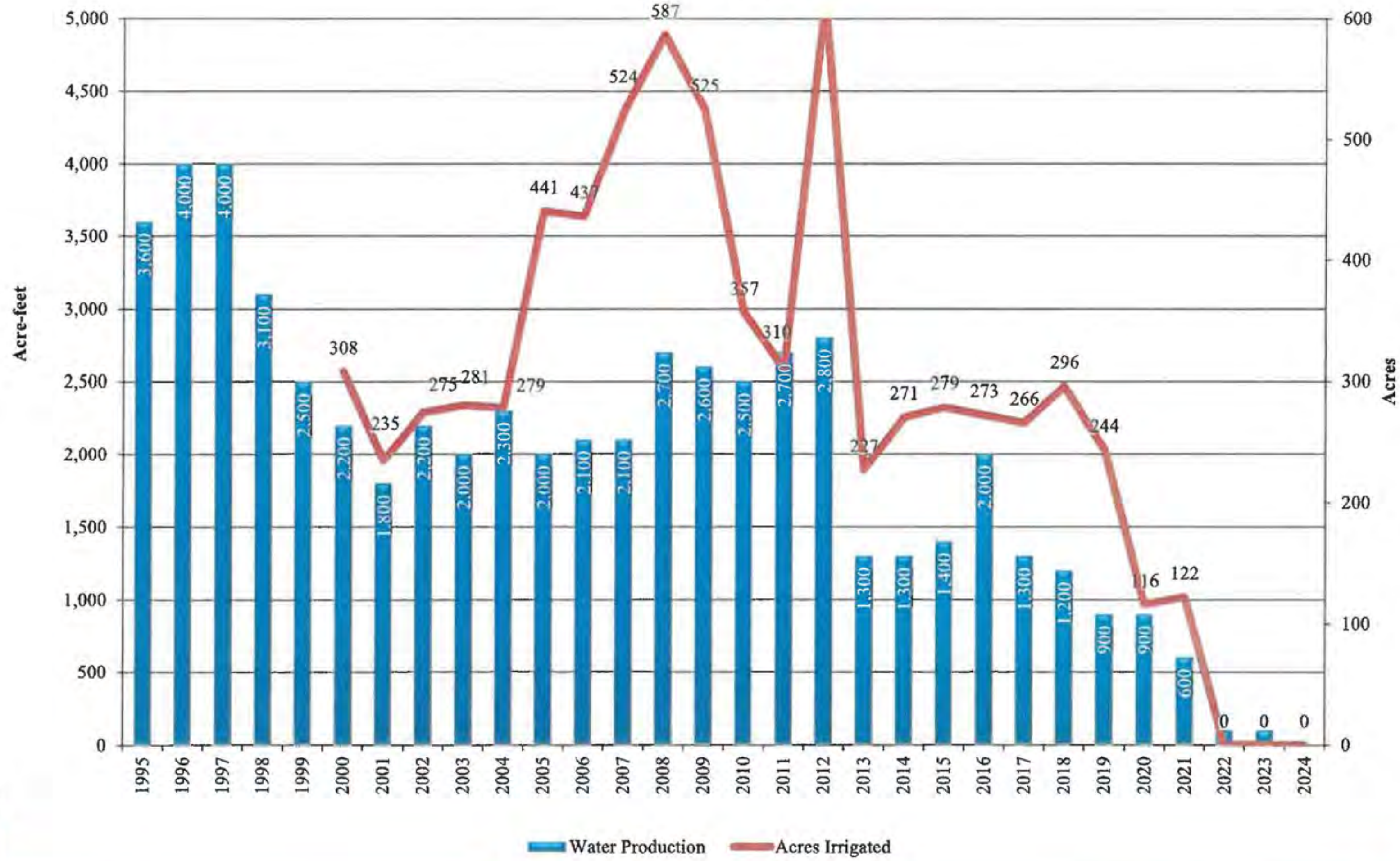
Consulting Civil Engineers

MOJAVE BASIN AREA WATERMASTER

Agricultural Water Production and Irrigated Acreage Este Subarea



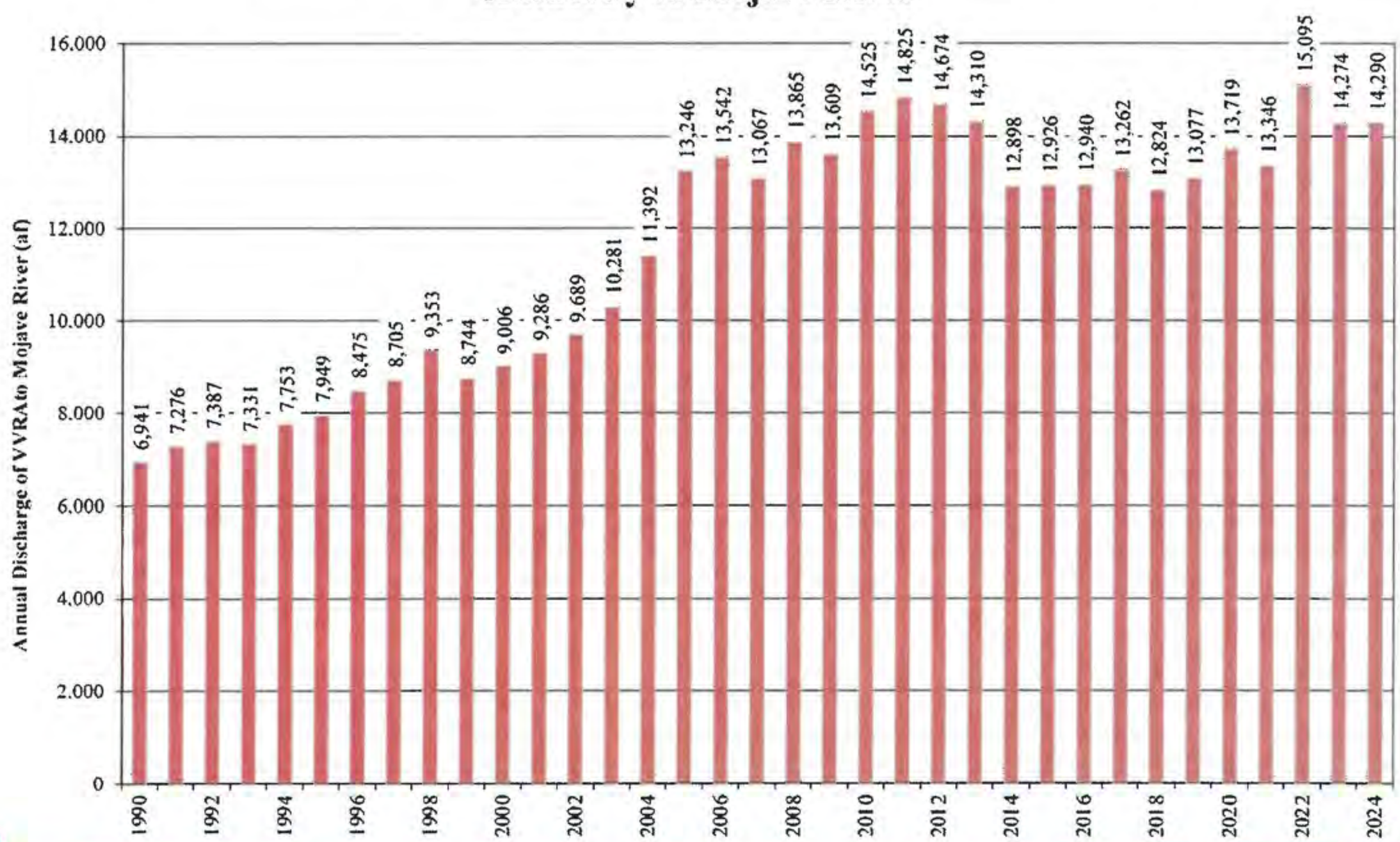
Agricultural Water Production and Irrigated Acreage Oeste Subarea



Changes in return flows based upon VVWRA discharges

- Changes in the location of the return flows discharge.
- Changes in magnitude of VVWRA discharges into the TZ.

Annual Discharge of Victor Valley Wastewater Reclamation Authority to Mojave River



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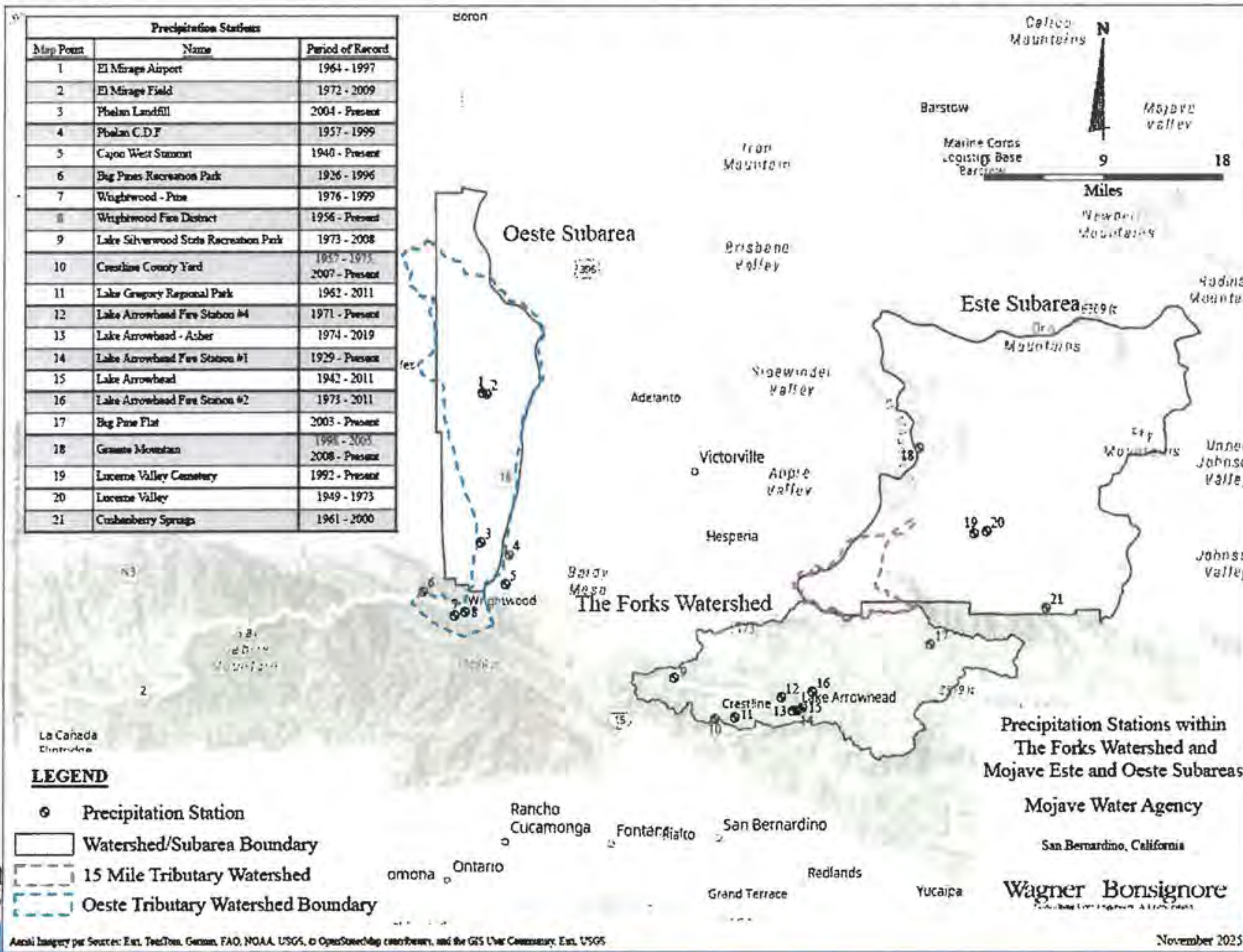
Consulting Civil Engineers, A Corporation

Water Supply to the Basin Area: Precipitation and Streamflow data

- Although there are several precipitation stations within the Forks watershed, Este and Oeste Subareas, the reliability of this data is questionable.
- Precipitation records are short, inconsistent, and intermittent.
- For these reasons, Watermaster continues to use the **measured streamflow at the Forks as the record indicative of the long-term surface water supply to the Basin Area from the Mojave River**.
- The flow record at the Forks is a clear indicator of patterns of dry and wet periods in the entire Basin Area.
- The UMBM and the Regional Model will use modeled precipitation to estimate rainfall and runoff contributions, however neither of the two models include the Lucerne Valley. We do not have an indicator of wet and dry periods in the Lucerne Valley.

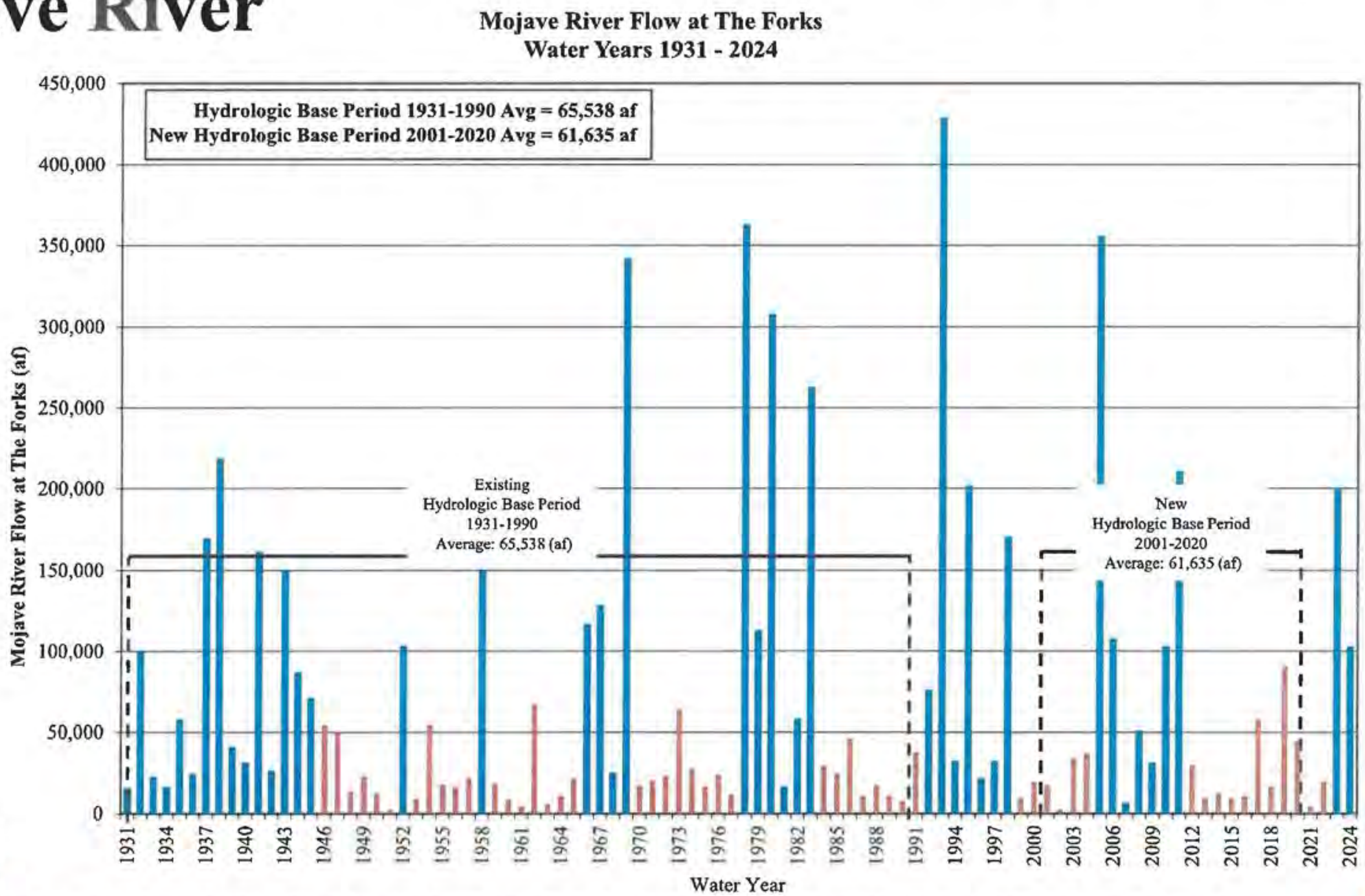
Water Supply to the Basin Area: Precipitation data



Precipitation Stations		
Map Point	Name	Period of Record
1	El Mirage Airport	1964 - 1997
2	El Mirage Field	1972 - 2009
3	Phelan Landfill	2004 - Present
4	Phelan C.D.F	1957 - 1999
5	Cajon West Summit	1940 - Present
6	Big Pines Recreation Park	1926 - 1996
7	Wrightwood - Pine	1976 - 1999
8	Wrightwood Fire District	1956 - Present
9	Lake Silverwood State Recreation Park	1973 - 2008
10	Crestline County Yard	1957 - 1975, 2007 - Present
11	Lake Gregory Regional Park	1962 - 2011
12	Lake Arrowhead Fire Station #4	1971 - Present
13	Lake Arrowhead - Asber	1974 - 2019
14	Lake Arrowhead Fire Station #1	1929 - Present
15	Lake Arrowhead	1942 - 2011
16	Lake Arrowhead Fire Station #2	1973 - 2011
17	Big Pine Flat	2003 - Present
18	Granite Mountain	1998 - 2005, 2008 - Present
19	Lucerne Valley Cemetery	1992 - Present
20	Lucerne Valley	1949 - 1973
21	Cushenberry Springs	1961 - 2000

Aerial Imagery par Source: Esri, TomTom, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community, Esri, USGS

Surface Water Supply to the Basin Area from the Mojave River



Note: Discharge of Mojave River at The Forks from the addition of values as reported from USGS stations at West Fork Mojave River Near Hesperia, CA (10261000), and Deep Creek Near Hesperia, CA (10260500) from 1931-1971, the greater of 10260500 and Mojave River Below Forks Reservoir Near Hesperia, CA (10261100) from 1972-1974, and the addition of West Fork Mojave River Above Mojave River Forks Reservoir Near Hesperia, CA (10260950) and 10260500 from 1975-Present.

Wagner Bc
Consulting Civil Enginee

Mojave Basin Area Watermaster

Watermaster evaluation of alternative hydrologic base periods

- In 2022, the Court asked Watermaster to consider a drier and more recent hydrologic base period.
- Watermaster evaluated the following hydrologic base periods:

1991-2022
1995-2024
1998-2024
2001-2020
2002-2022
1931-2022

Watermaster evaluation of alternative hydrologic base periods

Average Flow at the Forks

Alternative Hydrologic Base Periods	Mojave River at the Forks Average (a.f.)	Change relative to the 1931-1990 average (65,538 a.f.)	Criteria
1991-2022	71,344	+8%	Start and end years are dry and are preceded by a series of dry years.
1995-2024	67,057	+2%	Start and end years are wet and are preceded by a wet year/series of wet years.*
1998-2024	65,090	-1%	Start and end years are wet and are preceded by a wet year/series of wet years.
2001-2020	61,635	-6%	Start and end years are dry and are preceded by a series of dry years.
2002-2022	59,009	-11%	Start and end years are severe dry and are preceded by a series of severe dry years.
1931-2022	67,557	+3%	Per Court's Order. Start and end years are dry and are preceding a series of severe dry years.

Notes: The PSY Update prepared by Watermaster in February of 2024 updated the hydrologic base period to be 2001-2020 for purposes of establishing PSY. This selection was based on the information that was available and reliable for Watermaster at the time of the analysis (i.e., flow data up to the year 2023). Also, the PSY Update by Watermaster evaluated the 2001-2020 hydrologic base period also because the Upper Mojave Basin Model was calibrated through the Water Year 2020.

*The water supply at the Forks during the Water Years 1992 through 1995 was about three times the long-term average supply.

Average Precipitation at Lake Arrowhead

Alternative Hydrologic Base Periods	Precipitation Average (inches)	Change Relative to 1931-1990 Average (41.36 inches)	Criteria
1991-2022	39.3	-4.9%	Start and end years are dry and are preceded by a series of dry years.
1995-2024	42.0	+1.5%	Start and end years are wet and are preceded by a wet year/series of wet years.*
1998-2024	41.3	-0.1%	Start and end years are wet and are preceded by a wet year/series of wet years.
2001-2020	37.2	-10.1%	Start and end years are dry and are preceded by a series of dry years.
2002-2022	39.0	-5.8%	Start and end years are severe dry and are preceded by a series of severe dry years.
1931-2022	40.7	-1.7%	Per Court's Order. Start and end years are dry and are preceding a series of severe dry years.

Note: As mentioned by Watermaster, precipitation stations within the Fork's watershed provide precipitation records that are short, inconsistent, and intermittent.

*The water supply at the Forks during the Water Years 1992 through 1995 was about three times the long-term average supply.

MOJAVE BASIN AREA WATERMASTER

Watermaster evaluation of alternative hydrologic base periods

1991-2022

- Average water supply is 8% higher than the average of the initial base period 1931-1990, which might indicate a higher PSY value.
- Water supply at the Forks during the Water Years 1992 to 1995 was about 3 times the long-term average supply.
- Include years that are not representative of recent cultural conditions: agricultural pumping and land uses have greatly changed since the 1990s.
- Court requested consideration of a **drier and more recent hydrologic base period**.

For these reasons, Watermaster does not recommend the hydrologic base period of 1991-2022.

Watermaster evaluation of alternative hydrologic base periods

1995-2024

- Average water supply is 2% higher than the average of the initial base period 1931-1990, which might indicate a higher PSY value.
- It includes years that are not representative of recent cultural conditions: agricultural pumping and land uses have greatly changed since the 1990s.
- Court requested consideration of a **drier and more recent hydrologic base period**.

For these reasons, Watermaster does not recommend the hydrologic base period of 1995-2024.

Watermaster evaluation of alternative hydrologic base periods

1998-2024

- Average water supply is 1% drier than the average of the initial base period 1931-1990.
- It includes years that are not representative of recent cultural conditions: agricultural pumping and land uses have greatly changed since the 1990s.
- Court requested consideration of a drier and **more recent hydrologic base period**.

For these reasons, Watermaster does not recommend the hydrologic base period of 1998-2024.

Watermaster evaluation of alternative hydrologic base periods

2002-2022

- Average water supply is 11% drier than the average of the initial base period 1931-1990; therefore, the indicated water supply does not "closely approximate" the long-term water supply during the 1931-1990 base period.
- The UMBM is calibrated through the year 2020 only, and the alternative 2002-2022 base period is outside the period of the UMBM calibration.

For these reasons, Watermaster believes the alternative 2002-2022 base period is not as appropriate as the recommended 2001-2020.

Watermaster evaluation of alternative hydrologic base periods

1931-2022

- Average water supply is 3% higher than the average of 1931-1990 base period, which might result in higher PSY values.
- It also includes many years that are not representative of current cultural conditions: agricultural pumping and land uses have greatly changed since the 1930s, 1950s and 1990s.
- The Court requested consideration of a **drier and more recent hydrologic base period**.

For these reasons, Watermaster believes the expanded base period 1931-2022 is not as appropriate as the recommended 2001-2020 base period.

Watermaster justification for recommending new hydrologic base period 2001-2020

- Meets guidance of DWR Bulletin 84.
- Average water supply 6% drier than the average of the initial base period 1931-1990.
- Fits the UMBM model calibration period (ending in 2020).
- Includes and is more representative of current cultural conditions.
- It satisfies the Court's request for a **drier and more recent hydrologic base period**.
- Watermaster seeks to base its **2026 PSY recommendations upon the most appropriate and representative base period**, which Watermaster believes is the 2001-2020 time frame for the reasons indicated.
- Importantly, the base period will not change the actual water supply to the Basin Area going forward. **The selected base period is a management planning tool for future planning purposes!**

Next steps

- Watermaster public hearing on January 14, 2026.

Response to questions from a stakeholder

- *Why is Watermaster presenting the hydrologic base period change as an urgent issue now, for the first time since the entry of the Judgment, when so much is yet unknown?*

(1) Watermaster is required to recommend PSY values in 2026, and to do so it must select an appropriate base period.
(2) The Court has made clear it wants Watermaster to use a base period more representative of current cultural conditions, including climatic changes.
(3) The Court has ordered Watermaster to file a motion to determine the most appropriate base period, and suggested that a dryer period be considered.

Response to questions from a stakeholder

- *Has consideration been given to using a hydrologic base period that would capture pre-overdraft conditions, ramp down, and more recent data?*

(1) Watermaster does not believe it is "necessary" to include years predating the significant overdraft that occurred in the 1950s. To do so would distort the water supply that likely will be available to the Basin in the foreseeable future, based upon the dryer conditions that began to manifest in the late 1990s, and have continued during the last 25 years.

(2) The 2001-2020 proposed base period does capture ramp down and more recent data.

Response to questions from a stakeholder

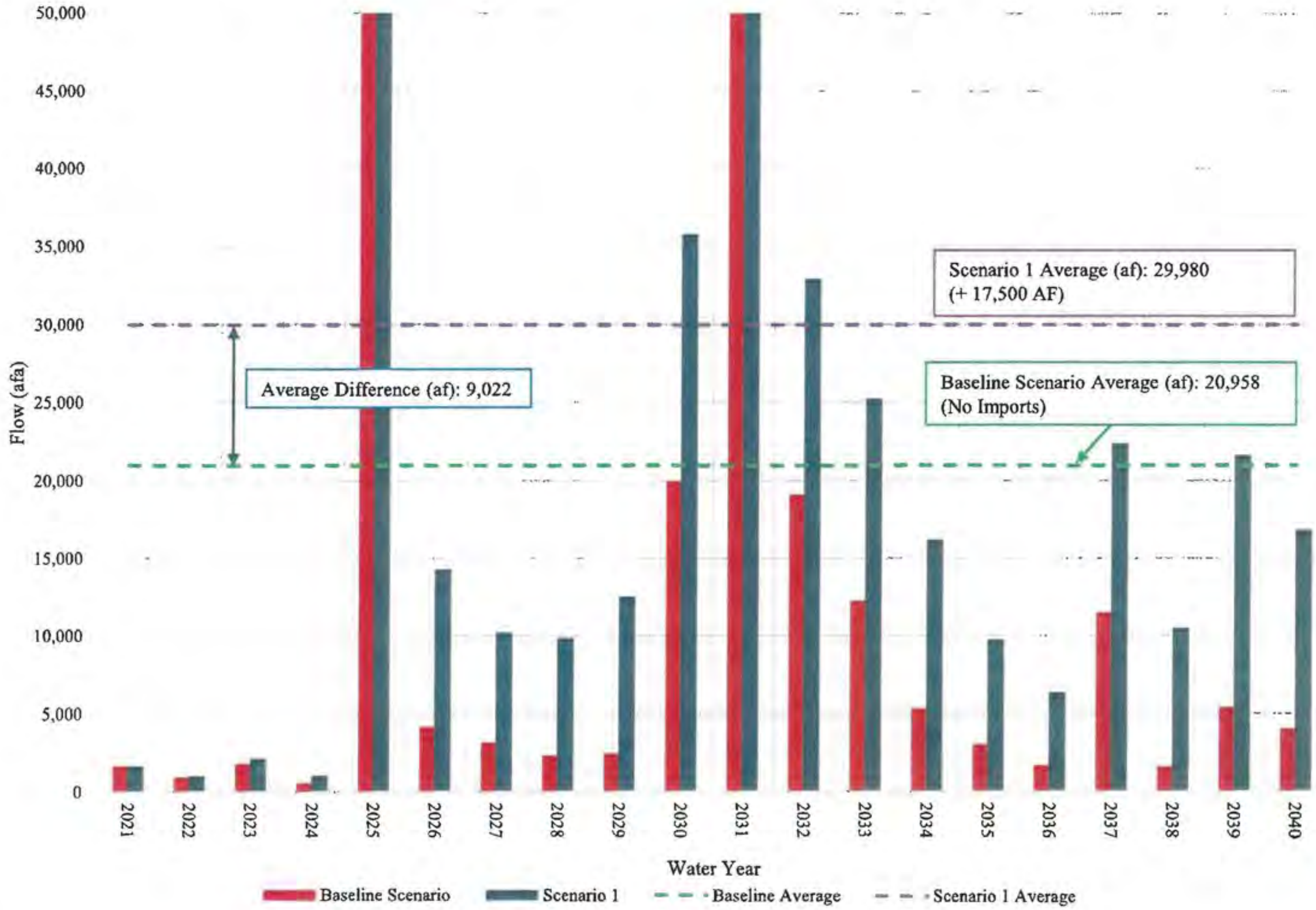
- *Does the shorter proposed hydrologic base period adequately capture the variation in pumping over time, depletions that can be delayed by many years, and the resulting hydrologic conditions?*

  (1) These issues do not appear to be germane to the selection of an appropriate base period.

  (2) The 2001-2020 base period does capture the variation in pumping during that 20-year period, as well as the depletions and hydrologic conditions during that period.

  (3) Additionally, the shorter and drier base period proposed would produce 17,500 acre-feet per year of imported water that would increase the stream flow at the Lower Narrows by about 9,000 acre-feet per year, thus increasing stream flow in the Mojave River.

Future Scenario: Response to Supplemental Recharge to Alto (17,500 AFY)



Wagner Bon
Consulting Civil Engineers, A

MOJAVE BASIN AREA WATERMASTER

EXHIBIT 4

State of California – Natural Resources Agency
DEPARTMENT OF FISH AND WILDLIFE
Inland Deserts Region
787 North Main Street, Suite 220
Bishop, CA 93514
www.wildlife.ca.gov

GAVIN NEWSOM, Governor
CHARLTON H. BONHAM, Director

December 2, 2025

Mojave Basin Area Watermaster
Mojave Water Agency
13846 Conference Center Drive
Apple Valley, CA 92307-4377

Subject: Questions and Comments for Watermaster's December 12, 2025, Proposed Hydrologic Base Period Change Workshop

Dear Watermaster Board, Engineer, and staff,

As you are aware, the California Department of Fish and Wildlife (CDFW) is the trustee agency for the state's fish and wildlife resources and is a party to the January 10, 1996, Judgment After Trial (Judgment). CDFW is also a landowner in two of the Judgment's five Subareas, Baja and Alto. In the Baja Subarea, CDFW owns the Camp Cady Wildlife Area (Camp Cady) and in the Alto Subarea, it owns the Mojave Narrows Regional Park and Mojave River Fish Hatchery. CDFW worked closely with the parties on developing the Judgment and its Exhibit H, which among other things establishes shallow groundwater level criteria necessary to maintain and protect sensitive riparian resources and species (i.e., public trust resources) associated with the Mojave River system.

CDFW has followed the topic of the hydrologic base period with interest since the Court's September 2022 Order directing Watermaster to re-evaluate Production Safe Yield (PSY) in all Subareas and to address the appropriateness of continued reliance on the initial 60-year hydrologic base period of 1931-1990. CDFW has thus reviewed and provided extensive comments on Watermaster's 2024 PSY and Consumptive Use Update, Watermaster's Water Year 2024-25 and 2025-26 Free Production Allowance (FPA) recommendations, and Watermaster's recent "Motion for Determination of Hydrologic Base Period for Production Safe Yield Calculations" (Motion) and supporting Reply Brief. CDFW has also reviewed the "Watermaster Engineer's Statement of Reasons for Recommending the 2001-2020 Base Period" (Statement of Reasons) filed on November 12, 2025.

Despite this extensive review and comment process, significant questions remain on the appropriateness of Watermaster's proposed 2001-2020 hydrologic base period, including whether a change in the current 60-year period is even necessary. To support a productive dialog towards continued implementation of the Physical Solution, CDFW respectfully submits the following questions and comments for Watermaster to address and respond to at its December 12, 2025, base period workshop (Workshop).

Conserving California's Wildlife Since 1870

WORKSHOP QUESTIONS

1. Quantitatively, how would Watermaster use a different hydrologic base period to improve PSY or FPA estimates for each of the Judgment's Subareas? Please include details on each component of those calculations.

2. Is the proposed hydrologic base period change intended to address climate variations or cultural condition changes? Please provide the technical basis for this distinction.

3. Why is Watermaster presenting the hydrologic base period change as an urgent issue now, for the first time since the entry of the Judgment, when so much is yet unknown? What information is Watermaster relying upon at this time to quantify changes in water supply in each Subarea under the proposed 2001-2020 hydrologic base period relative to the current 1931-1990 hydrologic base period?

   a) Watermaster Engineer states that there is insufficient information to evaluate the water balance in Baja (and other Subareas). (Statement of Reasons, p. 14.) However, there is presently a numerical model in development that purportedly addresses, among other things, water supply for each Subarea. Why not wait to consider a hydrologic base period change when there is adequate information to evaluate water supply in the proposed base period across each Subarea?

   b) Watermaster Engineer states, "Once the hydrologic base period is set, there is no reason to reset it every year, or at any other time unless the conditions upon which it is based change significantly." (Statement of Reasons, p. 12.) However, the Motion concluded that the new model "may suggest a different hydrologic base period for the entire Basin, or even for certain Subareas . . . ." (Motion, p. 6). With the model anticipated in the next year, why not wait for it to be completed, reviewed, and accepted?

   c) Watermaster Engineer has concluded that the proposed base period is 6% drier at the Forks, however this assessment of water supply in the proposed base period is only applicable to the Alto Subarea. How will Watermaster address data deficiencies, when that information is needed to present reliable Subarea water balances (i.e., Table 5-1/ Exhibit C Table C-1) in future PSY calculations using the current or proposed base periods?

4. The Court's September 2022 order required Watermaster to re-evaluate PSY in all Subareas, with specific directions to re-evaluate changes in water supply. Notably, the Court did not order the base period to be changed, just for PSY to be re-evaluated in light of more recent water supply information. As noted above, Watermaster Engineer has since stated that there is not adequate information on

water supply for the Baja Subarea to complete the PSY calculation using the water balance method required by the Judgment.

a) How can stakeholders and interested parties evaluate the impact of the proposed hydrologic base period change on water supply, when no data have been provided for the Subareas other than Alto?

b) How does Watermaster Engineer intend to address these apparent data deficiencies and the PSY determination for Baja going forward?

5. In the September 2022 order, the Court inquired, "At the very least, should not the past 32 years of data be added to the original 60 years?"[1] Did Watermaster consider this extended base period concept? If so, what is the difference in water supply to each Subarea under the extended base period suggested by the Court relative to the current base period?

6. The Department of Water Resources' (DWR) "Handbook for Water Budget Development" (DWR 2020) notes that "selecting a relatively long period for water budget analysis is more likely to include a wide range of hydrological conditions and system responses" and where there has been chronic overdraft it may be necessary for the base period to "capture a time period before overdraft was occurring. Identifying those key, non-overdraft time periods and corresponding water budgets is important for the identification of future water management objectives and actions." (DWR 2020, p. 29).

a) Has consideration been given to using a hydrologic base period that would capture pre-overdraft conditions, ramp down, and more recent data?

b) There can be significant lag time between changes in pumping, depletions, and observed impacts to the larger system. Does the shorter proposed hydrologic base period adequately capture the variation in pumping over time, depletions that can be delayed by many years, and the resulting hydrologic conditions?

7. What is the relationship between cultural conditions in a hydrologic base period and the single year used by Watermaster to represent pumping and consumptive uses?

8. The Mojave River and associated vegetation communities have changed significantly in the past 25 years, including losses of groundwater dependent vegetation in the Baja Subarea compared to what existed in the current 1931-

[1] For example, the Chino Basin Watermaster has moved to a similar extended base period, adding recent years to a base period extending back to 1921.

1990 hydrologic base period due to continued overdraft. How will Watermaster treat that volume of water apportioned for vegetation in each Subarea in 1996 so that sufficient water is available to support phreatophyte vegetation in the subarea and support the future re-establishment of phreatophyte vegetation as the water table recovers?

9. How does Watermaster address the issue of depletions altering the flow of water down the Mojave River in the proposed base period? During the more recent period the Mojave River loses flow volume as it moves through the Alto and Centro Subareas at a higher rate than was experienced in the 1931-1990 base period. (Todd 2013). The natural flow of water down the Mojave River has been altered by patterns of pumping and changes in wastewater and stormwater management occurring in the new proposed base period, resulting in depletions (captured recharge by increased infiltration) in flow, which does not reach the downstream Subareas as flow did in the current original base period.

    a) Please provide calculations showing the change in river depletions between the two hydrologic base periods for each Subarea.

    b) Increases in depletions in one Subarea increase recharge and likely increase PSY for that Subarea. Increased recharge would reduce downstream flow and reduce recharge and water availability in downstream subareas. How will Watermaster address these depletions in evaluating the appropriateness of the new hydrologic base period?

    c) If additional depletions in the new proposed base period are not distinguished from 1931-1990 depletions and natural recharge processes, pumping in the Alto Subarea that results in lower groundwater levels and induces more recharge from the Mojave River would result in a higher PSY. This higher PSY would allow for more pumping, starting a cycle of more depletions and future PSY increases. This would have a negative impact on the water needs of the habitat and species protected under the Judgment as less water would be available to the Baja Subarea due to capture upstream. How will Watermaster address this hydrologic base period issue?

COMMENTS ON PROPOSED HYDROLOGIC BASE PERIOD

CDFW finds that Watermaster's proposal to change the base period is a significant change to the implementation of the Physical Solution and Judgment, which will likely impact public trust resources and lands owned by CDFW for the benefit of wildlife and the public. The Judgment is silent on a change in the hydrologic base period over time. As such, any changes to the hydrologic base period should be done carefully and with consideration of the potential impacts to the ability to meet the original obligations of the

Judgment. CDFW has raised important questions that pertain to this matter that have not yet been addressed.

Reduced Water Supply for Baja

For the past two years, CDFW has highlighted the issue of reduced surface water inflow to the Baja Subarea below the Barstow gage during the new proposed hydrologic base period, and the need to investigate this issue further. This issue was raised in CDFW's April 25, 2025, comment letter to the Watermaster Board, and our representative also summarized these comments in person during the April 23, 2025, public hearing. These issues have been raised by CDFW for the past two years in our comment letters and Court filings and have not yet been fully addressed.

Average annual surface flows from the Centro to the Baja Subarea, as measured at the Barstow gage, have reduced significantly from their historical levels and the levels at the time the Judgment was entered. Watermaster's 2024 PSY Update indicates that during the past decade, the average annual gaged surface water inflow to Baja has decreased from 16,406 acre-feet to just 7,500 acre-feet. This inflow is the primary source of aquifer recharge in the Baja Subarea and is critical to the recovery of shallow groundwater to support public trust resources.

Additionally, CDFW is concerned that Watermaster has recently begun to question the reliability of the flow measurements at the USGS Barstow gage. The Barstow gage plays a key role in the Judgment as the agreed method to estimate the inflow to Baja at the Waterman Fault. CDFW notes that variability is common in gages on river systems that are as dynamic as the Mojave River at Barstow, and there are methods that can be employed to confidently utilize this critical long-term dataset, rather than disregard it. This gage and record remain the best available science for inflows into the Baja Subarea. CDFW urges Watermaster to employ the expertise necessary to continue to use this key dataset and to address any issues that it has identified with the stream gage. The Judgment clearly makes this a responsibly of the Watermaster in Section 24 (e), "Hydrologic Data Collection" and this measurement is central to the fair implementation of the Physical Solution for the Baja Subarea.

Watermaster Engineer states that "Watermaster recognizes that for the Baja Subarea, special circumstances may warrant PSY determination based on limited data. For the Baja Subarea, the only reliable data available is pumping and water level measurements...In 2024, Watermaster recommended Baja PSY of 12,749 acre-feet, which was determined by interpretation of water levels compared to the total pumping." (Statement of Reasons, p. 14). The interpretation of water levels is not a method for the determination of PSY in the Judgment as it ignores a key element of PSY, water supply,[2] and, if applied correctly, is only informative as to changes in groundwater storage. Certainly, the interpretation of hydrographs of representative wells in each Subarea is an important exercise, but without a proper water balance for each Subarea as typically provided by Watermaster Engineer in Table 5-1/ Exhibit C Table C-1, the presumption is that zero change in storage indicates that a Subarea is in balance. In Baja, this ignores evidence showing that the water budget in the Baja Subarea is now reduced by more than 50% than was anticipated using the 1931-1990 base period. Furthermore, as previously expressed, CDFW does not agree with the Watermaster that the leveling off in a subset of Baja wells is indicative of stabilized (or recovering) conditions across the entire Subarea and particularly at Camp Cady, where the Exhibit H habitat areas occur and where severely depressed groundwater levels continue to occur.

Bulletin 84

Watermaster's insistence on using DWR Bulletin 84 as a guideline in the present base period selection discussion is odd considering the volume of pertinent scientific literature that has been produced since 1967. CDFW does not question whether this document played an important role in the selection of the current base period and the crafting of the Judgment. However, Bulletin 84 is outdated and does not properly recognize the interaction of groundwater and surface water.

The understanding of the relationship between surface water and groundwater has advanced substantially, from both a science and policy perspective, since the 1960's. This is evidenced by the extensive analysis of depletions of surface water from groundwater use in USGS Water-Resources Investigation Report 95-4189 titled "Ground-Water and Surface-Water Relations along the Mojave River, Southern California" (Lines 1996) and in the definition of sustainable yield for the Sustainable Groundwater Management Act, which directly incorporates impacts of depletions of interconnected surface water. (See Wat. Code, § 10721).

Riparian Habitat

Finally, CDFW disputes Watermaster's claim in the Reply Brief that "Watermaster estimates of Riparian Habitat use was established by CDFW and agreed to by the Parties at trial. Those same values are used in the PSY calculation." (Reply Br. in Support of Motion, p. 8). CDFW has consistently maintained that the volume of water

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[2] PSY is defined as "The highest average Annual Amount of water that can be produced from a Subarea: (1) over a sequence of years that is representative of long-term average annual natural water supply to the Subarea net of long-term average annual natural outflow from the Subarea, (2) under given patterns of Production, applied water, return flows and Consumptive Use, and (3) without resulting in a long-term net reduction of groundwater in storage in the Subarea." (Judgment, p. 11.)

assigned to phreatophytes in the PSY calculation should remain as established by Lines and Bilhorn (1996). However, because Watermaster has failed to provide a Table 5-1 water balance for the Baja Subarea for the last two years, it is unclear how much water has been allocated to riparian vegetation. In fact, Watermaster's 2024 PSY Update shows a substantial decrease in the water allocation of phreatophytes, from 2,000 acre-feet per year to just 984 acre-feet. In its June 2025 Workshop, the Watermaster had apparently revised that value to 1,581 acre-feet per year, which is still an unacceptable departure from the agreed-to value in the Judgment. Watermaster's recent practice of using an interpretation of water levels in some wells in the Baja Subarea, without a water balance, fails to address water allocation for phreatophytes. As noted above, the wells in the vicinity of CDFW's Camp Cady and the Judgment Exhibit H riparian habitat areas continue to indicate groundwater levels far below the Exhibit H Table H-2 target depths required to maintain riparian vegetation in healthy condition.

CDFW appreciates the opportunity to provide questions and comments regarding Watermaster's proposed hydrologic base period change. We look forward to hearing from Watermaster on these important issues.

Sincerely,

DocuSigned by:
Aaron Johnson
6477ACD4E0DE4DB...

Aaron Johnson
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December 11, 2025

VIA EMAIL

Andrea Hostetter
Mojave Watermaster
13846 Conference Center Drive
Apple Valley, CA 92307-4377
Email: ahostetter@mojavewater.org

Re: Mitsubishi, Robertson's, CalPortland Comment Letter
Mojave Watermaster December 12, 2025 Workshop re Watermaster Recommendations for New Hydrologic Base Period

Dear Ms. Hostetter:

This firm represents Mitsubishi Cement Corporation ("**Mitsubishi**"), Robertson's Ready Mix, Ltd. ("**Robertson's**"), and CalPortland Company ("**CalPortland**"). Collectively, these parties ("**Our Clients**") have facilities located throughout the Mojave Basin Area within the Este, Centro, Alto, and Baja Subareas. This letter is submitted for consideration and discussion at the Mojave Watermaster ("**Watermaster**") Workshop meeting to be held on December 12, 2025. Please distribute this letter to Watermaster Board members and staff.

I. BACKGROUND FOR WATERMASTER WORKSHOP REGARDING CONSIDERATION OF AN UPDATED HYDROLOGIC BASE PERIOD

At the hearing on August 4, 2025, the Court acknowledged the merit of Our Clients' objections to any rubber-stamping of a new hydrologic Base Period. The Court observed that the base hydrologic period is not redetermined annually and might be considered, at most, every 10 or 12 years. The Court directed that the selection of a new hydrologic Base Period should be determined by separate motion "sometime next year" or at least prior to considering next year's updated Production Safe Yield ("**PSY**") or Free Production Allowance ("**FPA**") recommendations.

Watermaster filed a Motion for Determination of hydrologic Base Period just weeks later, on September 3, 2025. Our Clients, and other parties, filed Oppositions to the Motion. Prior to the October 20, 2025, hearing on the Motion, the Court released its tentative decision that the Motion "for the indefinite future is denied." The Court recognized the importance of selecting an appropriate hydrologic Base Period, and the impact that this decision will have on PSY, FPA, and other aspects of the Judgment. A copy of the Court's tentative decision is attached as **Exhibit 1**.

The Court directed the parties to meet and confer and propose a process through which Watermaster would present its analysis and the information on which it is based, and continued the hearing to October 27, 2025. The parties met and conferred with Watermaster counsel to explore, if possible, a mutually agreeable public process for consideration of a new hydrologic Base Period. Though some alignment was reached on certain aspects of the process, the parties did not reach consensus. Attached as **Exhibit 2** is the schedule our office proposed to the Court on October 27, 2025.[1] At the hearing, Judge Reimer expressed his view that any new hydrologic Base Period would need to be both considered *and approved* by the Watermaster Board before being presented to the Court. The Workshop is an early step in this process, but not the only step in the public process.

Given the Court's directives to ensure a robust and transparent public process occurs in evaluating any new hydrologic Base Period, we encourage Watermaster to comply with the attached schedule and process.

On November 12, 2025, Watermaster released a report entitled, "Watermaster Engineer's Statement of Reasons for Recommending 2001-2020 hydrologic Base Period" ("**SOR**")[2] We provide these comments for Watermaster's consideration at the December 12, 2025, Watermaster Workshop, and we request that these comments be included in the record. Additionally, we include comments prepared by our technical consultants, EKI Environment & Water ("**EKI**"). EKI's comments are attached as **Exhibit 3**.

[1] While the Court indicated it would enter an order shortly after the October 27, 2025 hearing, we are not aware of a final Court order as of the date of this letter.

[2] Watermaster Engineer's Statement of Reasons for Recommending 2001-2020 Base Period.

II. COMMENTS REGARDING WATERMASTER SOR

We request Watermaster address the following questions and comments at the Workshop regarding the SOR.

A. Applicability of DWR Bulletin 84

Watermaster SOR Reference	Question/Comment
SOR reliance on Bulletin 84 as the standard and criteria for selecting a new hydrologic Base Period. (See SOR, pg. 2-5)[3]	1. The SOR emphasizes selection of a hydrologic Base Period based primarily upon guidance from the 1967 DWR Bulletin 84 and the 1975 opinion in *City of Los Angeles vs. City of San Fernando, et al., 14 Cal.3d 199 (1975).* 2. Does Watermaster contend that the standards in the above-referenced records reflect the best current methodology for determining a new hydrologic Base Period for the Mojave Basin and each of its Subareas? 3. Has Watermaster considered other guidance materials such as California Department of Water Resources' Sustainable Groundwater Management Best Management Practices for Water Budgets?[4]

[3] Summary of SOR pgs 2-5.
[4] DWR BMP for SGMA, Water Budget, (2016) available at https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/Sustainable-Groundwater-Management/Best-Management-Practices-and-Guidance-Documents/Files/BMP-4-Water-Budget_ay_19.pdf

B. **Initial Hydrologic Base Period 1931-1990**

Watermaster SOR Reference	Question/Comment
"Based upon DWR's guidance in Bulletin 84, the Parties and the Court in City of Barstow determined the initial hydrologic Base Period should be from 1931 to 1990, because it includes both normal and extreme wet and dry years." (SOR 5:25-27).	1. How does Watermaster define "normal" and "extreme" wet and dry years? 2. Is Watermaster's definition of wet and dry years based solely upon flows at the Forks?

C. **Water Supply to the Basin Area**

Watermaster SOR Reference	Question/Comment
"Surface water inflow to the Alto Subarea is measured flow of the Mojave River at the Forks and is the sum of reported values from USGS gage stations at West Fork Mojave River near Hesperia, CA and Deep Creek near Hesperia, CA. This measured USGS gage data provides the best available information regarding the surface water inflow to the Basin Area. There are very few records of surface water inflow to the Este and Oeste Subareas." (SOR 11:17-22)	1. Please identify all records and reports Watermaster is relying upon for surface water inflow to the Este and Oeste Subareas.
"Watermaster reviewed records of precipitation. Although there are several precipitation stations located within the Forks' watershed, the reliability of this data is questionable. The precipitation records are short, inconsistent, and intermittent (see Exhibit M). For these reasons, Watermaster believes the measured flow of the Mojave River at the Forks continues to be the record indicative of the long-term water supply to the Basin Area. Additionally, the flow record at the Forks provides a clear indication of wet and dry periods in the Basin Area." (SOR 11:23-12:2)	2. Has Watermaster considered any third-party data that can provide reliable precipitation records?

D. **Watermaster Proposed Hydrologic Base Period 2001-2020**

Watermaster SOR Reference	Question/Comment
"Once the hydrologic Base Period is set, there is no reason to reset it every year, or at any other time unless the conditions upon which it is based change significantly." (SOR 12:13-15).	1. Does Watermaster intend to present any update to its recommendations for a new hydrologic Base Period once its model update is completed?

E. **Hydrologic Base Period vs. Pumping and Consumptive Uses for purposes of PSY determination**

Watermaster SOR Reference	Question/Comment
"Watermaster needs to clarify that when calculating PSY, the year representative of pumping and consumptive uses does not necessarily need to be strictly contained within the time frame of the hydrologic Base Period." (SOR 12:25-27)	1. This paragraph is unclear. Please provide the legal and technical basis for Watermaster's contention that the representative year for PSY may be outside the hydrologic Base Period. 2. Is it Watermaster's position that the hydrologic Base Period is not foundational to PSY? 3. If PSY can be based upon some "representative year," outside the hydrologic Base Period as Watermaster suggests, what criteria, data, factors, and standards does Watermaster contend would apply in selecting a "representative year" for PSY?[5] 4. Watermaster's interpretation appears to contradict the fact that the first PSY year (1990) was within the hydrologic Base Period sequence (1931-1990). (See

[5] See Judgment sections 4.aa.(1)-(2).

	SOR 12:27-13:2; Table C-1 of the Judgment).
"Even though the hydrologic Base Period of 2001-2020 was recommended by Watermaster for all Subareas, Watermaster recognizes that for the Baja Subarea, special circumstances may warrant PSY determination based on limited data. For the Baja Subarea, the only reliable data available is pumping and water level measurements (which show recent recovery). This is true for the Este Subarea and the Oeste Subarea as well." (SOR 14:4-9)	5. This paragraph is not clear. Please elaborate. 6. What provisions of the Judgment does Watermaster contend would allow PSY determination to be based on limited data? 7. What is Watermaster's plan and timeline to address and fill any known information gaps for Este, Baja, and Oeste? 8. Please clarify whether Watermaster is still considering recommending different hydrologic Base Periods for each Subarea. If so, what data, criteria, or other factors would Watermaster consider in determining whether to recommend a different hydrologic Base Period for a particular Subarea?

F. **Evaluation of Alternative Hydrologic Base Periods**

Watermaster SOR Reference	Question/Comment
"From a water supply perspective, a larger magnitude of average water supply might yield a higher PSY value. On the contrary, a smaller magnitude of water supply might yield a lower PSY value. However, as noted above, the Court previously asked Watermaster to consider a drier and more recent hydrologic Base Period. For these reasons, Watermaster does not recommend the two alternative hydrologic Base Periods of 1991-2022 and 1995-2024." (SOR 17:9-14).	1. The Court asked Watermaster to "consider" a drier and more recent period. Is it Watermaster's position that this direction *requires* Watermaster to *recommend* a drier period? 2. Does Watermaster consider any other potential hydrologic Base Periods would be more technically supportable if not presumed required to select a "drier" period?

	3. How much "drier" does Watermaster project hydrologic conditions for the Basin to become? What studies and data is Watermaster relying on for that projection?
The alternative base period 2002-2022 starts and ends on a dry year and is preceded by a series of dry years. However, because the UMBM is calibrated through the year 2020 only, Watermaster does not consider this to be an appropriate selection. (SOR 17:15-17)	4. Will Watermaster further calibrate the model to capture more recent data (2000-2024)? 5. What impacts does the UMBM not being calibrated past 2020 have on Watermaster's proposal to select 2022? 6. If 2022 was outside the period of model calibration, how were Watermaster 2024 PSY values derived and supported to the extent they relied on 2022 data?
Because the alternative 2002-2022 base period is outside the period of the UMBM calibration, and the magnitude of water supply in the alternative 2002-2022 base period does not "closely approximate" the magnitude of the long-term water supply during the 1931-1990 base period (as indicated by DWR Bulletin 84), Watermaster believes the alternative 2002-2022 base period is not as appropriate as the recommended 2001-2020 base period. (SOR	7. Please explain and quantify the meaning of "closely approximate the magnitude."

G. **<u>Cultural Conditions Evaluation</u>**

Watermaster SOR Reference	**Question/Comment**
As explained above, Watermaster's data on irrigated acreages show a similar trend of a constant reduction in irrigated land, particularly during recent years. Because the new hydrologic base period should meet the criteria of the DWR Bulletin 84 and include	1. Watermaster states 2001-2020 captures changing land uses, but many of the highlighted cultural changes (Ex. C–H), urbanization, declining agriculture, and increased VVWRA discharges occur

recent cultural conditions, Watermaster determined that the alternative hydrologic base periods that begin in the 1990s do not me[e]t the representation of recent cultural conditions, and therefore, they should not be considered appropriate hydrologic base periods for PSY redetermination. (SOR 18:13-19).	gradually beginning in 1995 and continuing through at least 2024. 2. What statistical basis is Watermaster relying on to conclude that no year in the 1990s should be included? 3. Does Watermaster contend that cultural conditions have evolved uniformly for all Subareas?

III. CONCLUSION

We appreciate Watermaster's release of the SOR, and holding this Workshop to discuss and address stakeholder questions. On behalf of Our Clients, we reserve all rights to comment further on these pending items both at the Workshop and through further proceedings.

We request Watermaster address the issues raised in this letter and the enclosed letter from EKI. We further request Watermaster update its analysis in response to the Workshop, and provide all available and additional information for the updated analysis or updated recommendations for any new hydrologic Base Period selection for each Subarea.

We look forward to participating in further discussion and attending future Watermaster board meetings at which these matters will be discussed and considered for approval and recommendation to the Court.

Sincerely,

FENNEMORE LLP

Derek Hoffman

DHOF

cc: L. McElhany (lmcelhaney@bmklawplc.com)

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EXHIBIT 1

1.

CIV208568	CITY OF BARSTOW VS CITY OF ADELANTO	MOTION FOR DETERMINATION OF HYDROLOGIC BASE PERIOD FOR PRODUCTION SAFE YIELD CALCULATIONS BY THE MOJAVE WATER AGENCY

Tentative Ruling:

The Watermaster's motion to change the hydrologic base period from 1931-1990 to 2001-2020 for the indefinite future is denied. Because of the importance of identifying an appropriate base period, the denial is without prejudice to a more robustly supported motion that addresses the Court's concerns.

The Court is mindful of the timeline facing the Watermaster. To avoid holding up the Watermaster's calculations of PSY and FPA, the Watermaster's annual report, and the annual motion regarding the Watermaster's recommended changes to FPA, the Court will consider the possibility of granting the motion on a temporary basis, i.e., authorizing the propesed base period (2001-2020) to be used in calculating the FPA recommendations for water year 2026-2027. The parties should be prepared to discuss that possibility, as well as the Watermaster's motion to adopt the proposed base period on an on-going basis.

Analysis:

There are two fundamental questions presented by the motion. The first is whether the proposed base period is a more reasonable representation of long-term hydrologic conditions in the basin than the existing base period. The second question is whether the proposed base period is a better representation of those conditions than any of the possible alternative periods. The motion addresses only the former. It does not mention possible alternative periods at all.

In its reply, the Watermaster argues that it would be a waste of scarce resources to evaluate other alternative base periods. (Reply, p. 3.) The Court disagrees. If other alternatives are not considered, there is no way to determine whether the selection of the proposed base period complies with the Judgment's requirement that the Watermaster rely upon the "best available records and data to support implementation of this Judgment."

Similarly, the Watermaster argues that it would be burdensome to evaluate "more than 100 years of data." (Reply, p. 3.) Again, the Court is not persuaded. No one is suggesting that the Watermaster must evaluate potential base periods that include or overlap with portions of the existing base period (1931-1990.) Instead, the question is whether there are other potential base periods since 1990 that would better represent the basin than either 1931-1990 or 2001-2020.

The Watermaster contends that any new base period should meet the criteria specified in DWR Bulletin No. 84. It is unclear, however, whether compliance with the bulletin is required. The very language that the Watermaster quotes is aspirational ("should") rather than mandatory ("shall"). Nevertheless, the Watermaster does not address the issue.

Assuming arguendo that the bulletin is at least persuasive if not mandatory, the proposed base period does not satisfy the bulletin's criteria. One criterion is that "[b]oth the beginning and end of the base period should be preceded by a series of wet years or a series of dry years .... " In addressing the requirement concerning the beginning of the period, the Watermaster asserts that the beginning of the proposed base period was "preceded by a series of dry years, i.e., dry years in 1999 and 2002 precede the 2001 beginning of the base period ... . " (Motion, p. 4.) 2002 did not precede 2001. Therefore, only one dry year, 1999, preceded the beginning of the proposed period in 2001. Because a single dry year does not constitute a "series" of dry years., that criterion is not met. Thus, assuming arguendo that Bulletin No. 84 describes the correct criteria to be used when selecting a new base period, the base period proposed does not meet those criteria.

The motion also argues that "recent cultural conditions" will be better reflected in the proposed base period than in the existing base period. But the Watermaster offers no evidence that those conditions were significantly different in 2001-2020 as compared to 1931-1990. While the Court has little doubt that they are, the Court needs to rely on evidence, not its assumptions. (Even if the evidence had been presented, it is unclear how the "cultural conditions" relate to the selection of the base period as opposed to being later factored into the RMRBM.)

To allow a careful evaluation of the Watermaster's assertions regarding the distribution of normal wet years, extremely wet years, normal dry years, and extremely dry years, the Court needs to know the criteria by which the Watermaster distinguishes normal years from extreme years. Similarly, the Watermaster offers no evidence (as opposed to argument in its Reply) to support the implicit conclusion that water flow at the Forks reasonably represents the water supply for the basin as a whole. It may be, but the motion does not address the issue.

The Watermaster suggests in its Reply that, because the Judgment does not expressly require Court approval of changes in the base period, the Watermaster should be deemed to have the discretion to pick whatever base period it believes is most appropriate. (Reply, pp, 2 & 9.) That reasoning fails, because the Watermaster is required to obtain court approval for changes in FPA The base period is integral to the calculation of PSY and the resulting recommendations regarding changes to FPA If the Watermaster is relying upon a base period that has not been approved, then the Court will be reluctant to approve recommendations based on that base period. Regardless of the express terms of the Judgment, as a practical matter the Watermaster's preferred base period needs judicial endorsement.

EXHIBIT 2

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Attorneys for MITSUBISHI CEMENT CORPORATION, ROBERTSON'S READY MIX, LTD., and CALPORTLAND COMPANY

SUPERIOR COURT OF THE STATE OF CALIFORNIA

COUNTY OF RIVERSIDE – CENTRAL DISTRICT

Coordination Proceeding Special Title (Cal. Rules of Court, Rule 3.550) MOJAVE BASIN WATER CASES CITY OF BARSTOW, et al., Plaintiff, v. CITY OF ADELANTO, et al., Defendant. AND RELATED CROSS-ACTIONS.	Case No. JCCP5265 Mojave Basin Water Cases Dept. 1, Riverside Superior Court Hon. Craig G. Reimer Lead Case CIV208568 Coordinated With San Bernardino Superior Court Case No. CIVSB2218461 **MITSUBISHI CEMENT CORPORATION, ROBERTSON'S READY MIX, LTD. AND CALPORTLAND COMPANY PROPOSED SCHEDULE FOR BASE PERIOD AND RELATED MOTIONS** **Date:** Oct 27, 2025 **Time:** 10:00 a.m. **Dept:** 1

MITSUBISHI CEMENT CORPORATION ("Mitsubishi"), ROBERTSON'S READY MIX, LTD. ("Robertson's"), and CALPORTLAND COMPANY ("CalPortland"), collectively, the "above-captioned parties," by and through their attorneys of record, Fennemore LLP, hereby submit this proposed schedule for stakeholder engagement, Watermaster motion and Court determination of the "base period" and related Watermaster processes. This proposal is made following the October 21, 2025, hearing on Watermaster's Motion for Determination of Hydrologic Base Period for Production Safe Yield Calculations, and consideration of the Court's tentative ruling to deny that Motion.

Pursuant to Court's direction at the hearing on October 21, 2025, counsel for the above-captioned parties initiated and conducted a meet and confer with counsel for the Watermaster, California Department of Fish and Wildlife, Golden State Water Company and Newberry Springs Recreational Lakes Association on October 23, 2025. Though some progress was made, a consensus proposal was not reached and does not appear to be reachable.

The above-captioned parties propose the following schedule for the Court's consideration. As the Court already expressed its willingness to consider, the Court may need to enter an order relieving certain timing obligations under the Judgment and the Watermaster's Rules and Regulations to accommodate the following schedule, pursuant to the Court's authority under Judgment § 19.

The above-captioned parties reserve the right to consider adjustments to the proposed schedule and to present further argument, views and objections to alternative proposals at the continued hearing on October 27, 2025.

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	Description	Date
1	Watermaster releases Base Period Recommendations and supporting materials	November 12, 2025
2	Watermaster Workshop – Base Period	December 12, 2025
3	Watermaster Board Meeting – Base Period	January 28, 2026
4	Watermaster Motion to adopt Base Period	February 11, 2026
5	Opposition(s) to Watermaster Motion to adopt Base Period	March 3, 2026
6	Watermaster Reply ISO Motion to adopt Base Period	March 11, 2026
7	Court Hearing – Base Period	March 18, 2026
8	Watermaster releases FPA Recommendations and draft Annual Report	March 23, 2026
9	Watermaster Workshop – FPA	April 22, 2026
10	Watermaster Board Meeting – FPA Recommendations and draft Annual Report	May 27, 2026
11	Watermaster Motion to adopt FPA Recommendations and draft Annual Report	June 1, 2026
12	Opposition(s) to Watermaster Motion to adopt FPA Recommendations and draft Annual Report	June 22, 2026
13	Watermaster Reply ISO Motion to adopt FPA Recommendations and draft Annual Report	June 30, 2026
14	Court Hearing – FPA Motion	July 8-10, 2026

Dated: October 24, 2025

FENNEMORE LLP

By: ______________________

Derek Hoffman
Darien K. Key
MITSUBISHI CEMENT CORPORATION, ROBERTSON'S READY MIX, LTD., and CALPORTLAND COMPANY

PROOF OF SERVICE

STATE OF CALIFORNIA, COUNTY OF SAN BERNARDINO

Re: City of Barstow v. City of Adelanto, et al.;
Riverside Superior Court Case No.: CIV 208568

I am employed in the County of Fresno, State of California. I am over the age of 18 years and not a party to the within action; my business address is: 8080 North Palm Ave. Third Floor, Fresno, CA 93711. On October 24, 2025, I served copies of the within documents described as **MITSUBISHI CEMENT CORPORATION, ROBERTSON'S READY MIX, LTD. AND CALPORTLAND COMPANY PROPOSED SCHEDULE FOR BASE PERIOD AND RELATED MOTIONS** on the interested parties in this action in a sealed envelope addressed as follows:

See attached Service List

[X] **BY MAIL** - I am "readily familiar" with the firm's practice of collecting and processing correspondence for mailing. Under that practice, it would be deposited with the United States Postal Service on the same day in the ordinary course of business, with postage thereon fully prepaid at San Bernardino, California. I am aware that on motion of the party served, service is presumed invalid if postal cancellation date or postage meter date is more than one day after date of deposit for mailing in affidavit.

[ ] **BY PERSONAL SERVICE** - I caused such envelope to be delivered by hand to the offices of the addressee pursuant to C.C.P. § 1011.

[ ] **BY EXPRESS MAIL/OVERNIGHT DELIVERY** - I caused such envelope to be delivered by hand to the office of the addressee via overnight delivery pursuant to C.C.P. § 1013(c), with delivery fees fully prepaid or provided for.

[ ] **BY FACSIMILE** - I caused such document to be delivered to the office of the addressee via facsimile machine pursuant to C.C.P. § 1013(e). Said document was transmitted to the facsimile number of the office of the addressee from the office of Gresham Savage Nolan & Tilden, in San Bernardino, California, on the date set forth above. The facsimile machine I used complied with California Rules *of Court*, Rule 2003(3) and no error was reported by the machine. Pursuant to California *Rules of Court*, Rule 2009(i), I caused the machine to print a record of the transmittal, a copy of which is attached to this declaration.

[X] **BY ELECTRONIC/EMAIL** - Pursuant to the party's express consent to receive electronic service, I caused such document to be delivered to the office of the addressee via electronic e-mail pursuant to C.C.P. §1010.6(a)(2)(A)(ii). Said document was transmitted to the email address of that office which is listed on the attached Service List. Said document was served electronically and the transmission was reported as complete and without error.

FEDERAL - I am employed in the office of a member of the bar of this court at whose direction the service was made.

I declare under penalty of perjury under the laws of the State of California that the foregoing is true and correct. Executed on October 24, 2025, at Fresno, California.

Kelly Ridenour

KELLY RIDENOUR

SERVICE LIST

Re: City of Barstow v. City of Adelanto, et al.;
Riverside Superior Court Case No.: CIV 208568

William J. Brunick, Esq. Leland P. McElhaney, Esq. Brunick, McElhaney & Kennedy PLC 1839 Commercenter West P.O. Box 13130 San Bernardino, CA 92423-3130 Email: bbrunick@bmklawplc.com lmcelhaney@bmklawplc.com	**Attorneys for Defendant/Cross-Complainant,** **MOJAVE WATER AGENCY**
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EXHIBIT 3

environment & water

Corporate Office
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10 December 2025

Derek Hoffman
Fennemore
550 E Hospitality Lane, Suite 350
San Bernardino, CA 92408

Subject: **Comments on the Watermaster Engineer's Statement of Reasons for Recommending a 2001-2020 Base Period**
(EKI 50063.00)

Dear Mr. Hoffman:

EKI Environment & Water, Inc. (EKI) has conducted a review of the *Watermaster Engineer's Statement of Reasons for Recommending a 2001-2020 Base Period* (Statement)[1] filed on 12 November 2025. EKI has conducted this review and provided the comments below to Fennemore in its role as Counsel to Mitsubishi Cement Corporation, Robertson's Ready Mix, Ltd., and CalPortland Company (collectively the "Clients") in the Mojave River Basin Area (Basin).

SUMMARY OF STATEMENT OF REASONS

The Statement provides background information on the Department of Water Resources' (DWR's) Bulletin No. 84 and similar adjudications (e.g., *City of Los Angeles vs. City of San Fernando, et al., 14 Cal.3d 199 (1975)*), discusses the Basin's initial hydrologic base period, changes in land use and pumping since entry of the Judgment, water supply to the Basin, and then provides justification for the proposed hydrologic base period of 2001-2020. The Statement provides greater detail than was originally provided in the Motion to the Court (Motion)[2], including differentiating between selection of the hydrologic base period and evaluation of production safe yield (PSY). The Statement includes a comparison among several other potential hydrologic base periods before ultimately recommending the adoption of 2001-2020 as the new hydrologic base period.

KEY COMMENTS

Parties to the Judgment need visibility into the potential impacts to PSY in all Subareas under the proposed hydrologic base period

The Judgment defines PSY as, "*The highest average Annual Amount of water that can be produced from a Subarea: (1) over a sequence of years that is representative of long-term average annual natural water supply to the Subarea net of long-term average annual natural outflow from the Subarea, (2) under given patterns of Production, applied water, return flows and Consumptive Use, and (3) without resulting in a*

[1]*Watermaster Engineer's Statement of Reasons for Recommending 2001-2020 Base Period*, November 12, 2025.
[2] Brunick, McElhaney, & Kennedy PLC, 2025. Motion for the Determination of Hydrologic Base Period for Production Safe Yield Calculations; Memorandum of Points and Authorities; Supporting Declaration. September.

long-term net reduction of groundwater in storage in the Subarea." Table C-1 of the Judgment lays out how PSY is calculated – PSY is total production in each Subarea plus the surplus or deficit of water supply, which is the difference between water supply and consumptive use/outflow. The hydrologic base period is used to inform numerous budget terms in this calculation such as surface water inflows and outflows. Each year in the Annual Report, the Watermaster presents a version of Table C-1 as Annual Report Table 5-1. As noted by the Watermaster, 2001-2020 has been temporarily used as the hydrologic base period in the two most recent Annual Reports (i.e., for water years 2022-23 and 2023-24). However, it should be noted that Table 5-1 is currently not available for the 2023-24 Annual Report on the Watermaster's website, and that Table 5-1 for the 2022-23 Annual Report presents PSY calculations for Alto, Centro and Baja, but not Este or Oeste[3]. As such, although the proposed hydrologic base period has been used temporarily by the Watermaster in recent years, and PSY estimates have been provided for all Subareas, the analysis is not fully documented and the impact of the proposed hydrologic base period on the calculation of PSY in each Subarea is unclear.

In the Statement, the Watermaster explains that *"Even though the hydrologic base period of 2001-2020 was recommended by the Watermaster for all Subareas, Watermaster recognizes that for the Baja Subarea, special circumstances may warrant PSY determination based on limited data. For the Baja Subarea, the only reliable data available is pumping and water level measurements (which show recent recovery). This is true for the Este Subarea and the Oeste Subarea as well,"* (page 14). It therefore remains unclear how, if at all, the PSY for Baja, Este and Oeste has changed or may change under the proposed hydrologic base period. Parties to the Judgment need visibility into the potential impacts to PSY in all Subareas before the adoption of a new base period. We request the Watermaster to provide an analysis on estimates of PSY for each Subarea using the potential hydrologic base periods listed in Table 1 of the Statement.

A clear and consistent framework should be used to determine PSY

A complete water budget framework for each Subarea should be established to account for all inflows and outflows, and the water budget terms should not change from year to year as new analyses are conducted, unless revisions to the hydrogeological conceptual model (HCM) are warranted. Further, consideration of a new hydrologic base period should be supported by an evaluation of how that proposed hydrologic base period would impact each term for the PSY calculation for each Subarea.

The Judgment provides an example of a complete water budget framework as Table C-1, which has served as the basis for Table 5-1 (PSY calculation) in the Annual Reports for the Basin. **Table 1** below presents the water budget terms contained in the PSY calculations in recent years' Annual Reports utilizing the 2001-2020 hydrologic base period. Highlighted in yellow in **Table 1** are the water budget terms that are controlled by flow in the Mojave River. As can be seen therein, numerous other water budget terms are not controlled by flow in the Mojave River.

[3] Watermaster Reports - Mojave Water Agency

Table 1 – Summary of Water Budget Components for PSY Calculation

Budget Term	Alto	Centro	Baja	Este	Oeste
WATER SUPPLY					
Surface Water Inflow	61,635[1]	36,725[1]	-	Unclear[2]	Unclear[2]
Gaged Inflow	-	-	7,500[1]	-	-
Tributary Inflow	-	-	1,568[3]	-	-
Mountain Front Recharge	8,511[4]	0	647[3]	Unclear[5]	Unclear[5]
Groundwater Discharge to the TZ	0	0	-	-	-
Subsurface Inflow	0	2,000[6]	1,751[3]	Unclear[2]	Unclear[2]
Este/Oeste Inflow	4,785[4]	0	-	-	-
Imports	0	0	-	Unclear[5]	Unclear[5]
Deep Percolation of Precipitation	-	-	100[2]	-	-
Total Water Supply	**74,931**	**38,725**	**14,575**	**TBD**	**TBD**
CONSUMPTIVE USE					
Surface Water Outflow	36,725[1]	7,500[1]	-	-	-
Gaged Outflow	-	-	2,554[1]	-	-
Barstow Treatment Plant Discharge	0	2,475[7]	-	-	-
Subsurface Outflow	2,000[2]	1,462[3]	170[3]	Unclear[2,5]	Unclear[2,5]
Consumptive Use - Agriculture	949	5,863	12,749[8]	Unclear[5,9]	Unclear[5,9]
Consumptive Use - Urban	40,171	6,885	(see row above)	-	-
Phreatophytes	11,000[2,10]	3,000[2,10]	984[11]	-	-
Total Consumptive Use	**90,845**	**27,185**	**16,457**	**TBD**	**TBD**
PRODUCTION SAFE YIELD CALCULATION					
Surplus / (Deficit)	(15,914)	11,540	(1,883)	TBD	TBD
Total Estimated Production	78,147	16,995	12,740	TBD	TBD
Potential Return Flow	0	2,885	554	TBD	TBD
Production Safe Yield	**62,233**	**31,420**	**10,866**	**6,582**	**3,634**

Abbreviations:
- = Component not applicable to given Subarea
TBD = To be determined
TZ = Transition Zone

Notes:
Table values taken from Table 5-1 in the WY2022-2023 Annual Report.
Entries labeled unclear are those in which we are aware water budget component estimates have been developed but lack clarity on the value proposed for use in the hydrologic base period going forward.
1 – Value derived from stream gage data 2001-2020.
2 – Value established for the original base period (1931-1990) but not for the proposed hydrologic base period (2001-2020).
3 – Value derived from *USGS, 2001. Simulation of Ground-Water Flow in the Mojave River Basin, California, Water-Resources Investigations Report 01-4002.*
4 – Value derived from Upper Mojave Basin Model.
5 – While estimates are provided in Watermaster's 2024 PSY Update for this Subarea, they have not been included in recent Annual Reports' Table 5-1.
6 – No citation in recent Annual Reports, but the value is consistent with the value in the Judgment.
7 – No citation in Table 5-1 of recent reports.
8 – This value includes Agricultural and Urban Consumptive Use (see Table 5-1 of 2022-23 Annual Report).
9 – Estimates were developed in the Watermaster's 2018 Consumptive Use Analysis but have not been included in recent Annual Reports' Table 5-1.
10 – Value derived from *USGS, 1996.Riparian Vegetation and Its Water Use During 1995 Along the Mojave River, Southern California, Water-Resources Investigations Report 96-4241.*
11 – Value estimated using OpenET for 2019-2022.

eki environment & water

Some of the water budget terms shown on **Table 1** have been updated as new data have become available, such as subsurface inflow into Alto (from Este/Oeste) and phreatophyte consumptive use in Baja (calculated using OpenET). Others remain fixed at historical values (e.g., subsurface outflow from Alto and phreatophyte consumptive use in Alto and Centro). Furthermore, while the PSY updates for Este and Oeste provided estimates of some water budget components such as mountain front recharge and consumptive use, ultimately the PSY estimates for these Subareas were based on recent pumping and water level data, and it is unclear if adoption of the proposed hydrologic base period would have any influence over these calculations. Additionally, the Alto water budget term Este/Oeste inflow is not matched by corresponding outflows from Este/Oeste in recent versions of Table 5-1, and this value (4,785 AF) greatly exceeds estimates of subsurface outflows in the PSY updates for Este and Oeste[4,5].

As shown on **Table 1**, the Watermaster currently uses a combination of: (1) budget terms from the Judgment (and therefore the original hydrologic base period of 1931-1990); (2) budget terms updated to reflect the proposed hydrologic base period of 2001-2020 (i.e., mountain front recharge, surface inflow into Alto averaged over the proposed hydrologic base period); and (3) budget terms that have no clear relationship to either base period and are inconsistently applied across Subareas. For example, the PSY calculation for Alto includes subsurface inflow from Este and Oeste, but the corresponding outflow from these Subareas is not considered in their respective PSY calculations. It is therefore not clear how, if at all, the various water budget components in Este and Oeste, as well as those in Alto, Centro, and Baja that are unrelated to surface water flows, would be updated under the proposed hydrologic base period of 2001-2020. We ask that the Watermaster provide an evaluation of how that proposed hydrologic base period would impact each term for the PSY calculation for each Subarea.

Appropriateness of metrics for establishing a hydrologic base period should be demonstrated

The purpose of a hydrologic base period is to represent the long-term patterns of water supply to the Basin. Per the Statement, *"Water supply to the Basin Area includes gaged and ungagged [sic] inflow, subsurface flow, deep percolation of precipitation, and certain imports,"* (page 11). Regarding the availability of hydrologic data on which to establish a base period, the Watermaster notes that *"There are very few records of surface water inflow to the Este and Oeste Subareas,"* (page 11) and that *"Although there are several precipitation stations located within the Fork's watershed, the reliability of this data is questionable. The precipitation records are short, inconsistent, and intermittent (see Exhibit M). For these reasons, Watermaster believes the measured flow of the Mojave River at the Forks continues to be the record indicative of the long-term water supply to the Basin Area,"* (page 11-12).

While it may be that available data are limited, it is not clear that Mojave River flow at the Forks is the appropriate metric upon which to establish a hydrologic base period for all Subareas. Notably, flow at the Forks is not relevant to conditions in Este or Oeste, and some components of the Basin water budget and PSY calculation (Table C-1 of the Judgment and discussed above) are independent of flow at the Forks, such as subsurface inflows and outflows and mountain front recharge (see **Table 1**). While Mojave River flow at the Forks may be a reasonable surrogate for some components of the analysis for some Subareas,

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[4] Watermaster, 2024. *Production Safe Yield and Consumptive Use Update, Appendix C: Oeste Subarea Water Supply Update.* February.

[5] Watermaster, 2024. *Production Safe Yield and Consumptive Use Update, Appendix D: Este Subarea Water Supply Update.* February.

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as described in the Tentative Ruling, *"the Court needs to rely on evidence, not its assumptions,"* (page 2[6]). The Statement provides no quantitative evaluation to demonstrate the correlation of Mojave River flow at the Forks to other Subarea-specific inflow terms such as subsurface inflows/outflows and mountain front recharge that are part of the PSY calculation, and therefore why it is an appropriate metric.

One hydrologic base period may not reflect "recent cultural conditions" in all Subareas

As described in the Statement, significant changes in "recent cultural conditions" (i.e., land use and groundwater pumping) have occurred in the Basin since entry of the Judgment. Exhibit H to the Statement shows time-series plots of agricultural water production and irrigated acreage in each Subarea. These plots show that irrigation volumes in Alto declined steadily from entry of the Judgment to 2010 when production stabilized, meanwhile Centro exhibits a more gradual and ongoing trend. The Baja Subarea has experienced significant declines in irrigation pumping since 2020, while Este has exhibited a consistent decline since 2015 Irrigation pumping in Oeste has fallen to essentially zero in the last several years. These variable trends demonstrate that "cultural conditions" are evolving in each Subarea on independent timelines, and that the proposed hydrologic base period of 2001-2020 does not capture this variation, or in some cases, the actual current "cultural conditions" in a given Subarea.

In the Statement, Watermaster claims that *"Today's cultural conditions are represented by the new recent hydrologic base period of 2001-2020,"* (page 19). However, elsewhere in the Statement, and as quoted above, Watermaster explains that *"Even though the hydrologic base period of 2001-2020 was recommended by Watermaster for all Subareas, Watermaster recognizes that for the Baja Subarea, special circumstances may warrant PSY determination based on limited data. For the Baja Subarea, the only reliable data available is pumping and water level measurements (which show recent recovery). This is true for the Este Subarea and the Oeste Subarea as well,"* (page 14). While this may be a reasonable approach, it is unclear what criteria and process the Watermaster will use to determine what subset of available data for a given Subarea will be used to estimate PSY.

Additional technical questions should be resolved

While it is understood that the Watermaster operates under both schedule and budget constraints, per the Judgment, technical evaluations must use "sound scientific and engineering estimates" and incorporate the "best available records and data," (Judgment (24(w)). To this end, the following items warrant further consideration and clarification:

- In the Statement, the Motion, and in Annual Reports, the Watermaster discusses the influence of wet and dry years on Basin hydrology. However, it is unclear how water year types for the Basin are determined. In Exhibit I of the Statement, which shows Mojave River flow at the Forks, some water years are shown in red, while others are shown in blue, which may correspond to dry vs. wet. Most red years appear to exhibit below average flow at the Forks; however, not all years with very low flow are shown in red (e.g., 1934 and 1981). The Watermaster should provide details on how this foundational determination of year type is made.

[6] *City of Barstow vs. City of Adelanto,* No. CIV208568, **tentative ruling** (California Superior Court, Riverside County, 20 October 2025)

- The Watermaster presents available station-based precipitation data and notes that the station data are both temporally and spatially sparse. We offer that the readily-available PRISM[7] data provides daily, monthly, and annual precipitation totals, with annual precipitation totals going back to 1895. The Watermaster may consider supplementing their analysis with PRISM data, especially given PRISM's spatial and temporal coverage. Use of the more complete PRISM dataset may provide for correlation or other analysis to better demonstrate that Mojave River flow at the Forks is, in fact, an appropriate metric upon which to establish a hydrologic base period for all Subareas.
- Estimates of consumptive use of groundwater by phreatophytes in some Subareas appear to be based on a 1996 USGS report (as referenced in the 2022-23 Annual Report). It is not clear if the Watermaster intends to update these estimates for the proposed hydrologic base period.

In EKI's letters to the Watermaster to date, we continue to request opportunities to actively engage in ongoing and forthcoming technical analyses being conducted in the Basin, including RMBM development and other hydrogeological studies, such as hydrologic base period selection, as results of these studies could potentially significantly impact future determinations of PSY, Free Production Allowance, and overall Basin management.

Sincerely,

EKI ENVIRONMENT & WATER, INC.

Anona Dutton, PG, CHg
Vice President

[7] https://prism.oregonstate.edu/

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December 12, 2025

Via Email: watermaster@mojavewater.org

Board of Directors
Mojave Basin Area Watermaster
Mojave Water Agency
13846 Conference Center Drive
Apple Valley, CA 92307-4377

Re: **December 12, 2025 Workshop on New Hydrologic Base Period**

The City of Victorville and its subsidiary Victorville Water District (VWD) do not object to the use of the 2001 to 2020 Base Period for Water Year 2025/2026 but request that the Watermaster consider using a longer Base Period in future updates. The omission of the 2021 to 2024 Water Years skews the average, resulting in a much drier, more conservative Base Period. VWD is concerned that an overly conservative Base Period will be hard-wired into the Mojave River Basin Model and not reevaluated, which will lead to significant reductions in modeled Production Safe Yield (PSY) and Free Production Allowance (FPA.) VWD's expert hydrogeologist Pete Leffler offers the following comments and observations:

1. The Court in its September 16, 2022 Order did not expressly direct Watermaster to select a drier Base Period. The Court's comments about using a more "prudent" period were more nuanced:

> For instance, the present calculation of PSY has been based on a 60-year study of flows from 1930 to 1990. The Court questions whether a 60-year period in the middle of the 20th century is still an appropriately representative period from which to measure the long-term averages specified in the definition of PSY, especially given the 32 years that have passed since 1990 and the climatic disruptions that we have been experiencing during that time.
>
> If that is not the most representative period, should a different period be defined? Mr. Wagner has stated that, if the judgment were being negotiated today, it would be more prudent to select "a shorter, drier planning period (hydrologic base period) for local supply ..., resulting in a lower estimated Production Safe Yield and consequently lower annual Free Production Allowance." (Wagner Deel., p. 6, 11. 18-21.) ***Is the Watermaster bound to rely upon what appears at this point in time to be a less-than-prudent period?***
>
> . . .
>
> Thus, the 2019 re-evaluation appears to re-evaluate all of the relevant factors except for supply. Why, with an additional and more recent 30 years of data, should

> the PSY calculation continue to rely upon the prior 60-year period for defining the long-term average? ***At the very least, should not the past 32 years of data be added to the original 60 years?***

(Order at pp. 4-5 (emphasis added).) VWD supports the Court's suggestion to add 1991 to 2024 to the Base Period.

2. We recommend that the long-term reference period be set to 1931 to 2024 for comparison of potential base periods. The average flow at The Forks for this 94-year period is 69,333 AFY, and this represents the best long-term average value available.

3. We recommend that DWR 2018 Climate Change Guidance be reviewed to determine if the expectation for Mojave Basin is a drier future with climate change and, if so, how much drier with respect to streamflow. Review of this climate change guidance for other groundwater basins in California shows that many of them are predicted to have greater future rainfall and/or streamflow that will either offset temperature/ET increase or even result in greater future groundwater recharge. As Watermaster has observed, basin recharge is driven by large storm and Mojave River flow events, not average annual precipitation. It is reasonably possible that climate change may both increase average annual temperature and frequency of drought periods while increasing the frequency and/or magnitude of large storm events that are the primary driver of long-term average annual basin recharge.

4. If the Court desires the new base period to be drier than the long-term average, there is a question of how much drier is reasonable, given that a drier base period has potential to reduce current PSY and FPA once it is applied to the updated Mojave River Basin Model. Compared to the long-term 1931-2024 average, the proposed 2001 to 2020 base period is actually 11% drier than the long-term average as opposed to the 6% drier than average stated in the Watermaster Statement of Reasons for the 2001-2020 period.

5. Comparison of the various alternative base periods to the long-term 1931 – 2024 average reveals how conservative (i.e., dry) a 2001 to 2020 base period is. The alternative 1995-2024 and 1998-2024 base periods are actually 3 to 6% drier than the long-term 1931-2024 average, as opposed to the 2% above to 1% below average as stated in the Watermaster Statement of Reasons.

6. The conclusion that the 1995-2024 and 1998-2024 alternative base periods are not representative of recent cultural conditions due to inclusion of some years from the 1990s compared to the 2001-2020 period does not appear to consider that the 1995-2024 and 1998-2024 alternative base periods include the four most recent years from 2021 to 2024 that are not included in the proposed 2001-2020 base period.

7. Presumably, the new base period selected with serve an important role as the historical calibration period for the basin groundwater model currently being updated. The incorporation of years from the 1990s, even though they may not be representative of current

cultural conditions, is not problematic and likely is beneficial for improving model calibration by incorporating a time frame that simulates different basin stress conditions.

8. Ideally the selection of the new base period would be conducted in conjunction with updating the groundwater model and developing the historical model calibration period. To the extent that a new base period is selected and applied now, it should be revisited one to two years after initial completion of the updated groundwater model by the Mojave Water Agency/Watermaster.

9. Regardless of the base period selected, the same base period should be applied to all Subareas; otherwise, there is potential for overallocation of groundwater pumping for the Basin as a whole.

VWD thanks Watermaster for considering its comments.

Sincerely,

LAW OFFICE OF PETER KIEL PC

Peter J. Kiel
Counsel for the City of Victorville and
Victorville Water District

cc: Leland McElhaney, Watermaster Counsel
Robert Wagner, Watermaster Engineer

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January 5, 2026

VIA EMAIL

Andrea Hostetter
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13846 Conference Center Drive
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Re: Mitsubishi, Robertson's, CalPortland Comment Letter
Mojave Watermaster Workshop re Watermaster Recommendations for New Hydrologic Base Period

Dear Ms. Hostetter:

This firm represents Mitsubishi Cement Corporation ("**Mitsubishi**"), Robertson's Ready Mix, Ltd. ("**Robertson's**"), and CalPortland Company ("**CalPortland**"). Collectively, these parties ("**Our Clients**") have facilities located throughout the Mojave Basin Area within the Este, Centro, Alto and Baja Subareas. This letter is submitted for consideration and discussion at the Mojave Watermaster ("**Watermaster**") Board meeting to be held on January 14, 2026. Please distribute this letter to Watermaster Board members and staff.

I. BACKGROUND FOR WATERMASTER CONSIDERATION OF AN UPDATED HYDROLOGIC BASE PERIOD

At the hearing on August 4, 2025, the Court acknowledged the merit of Our Clients' objections to any rubber-stamping of a new hydrologic Base Period. The Court observed that the hydrologic Base Period is not redetermined annually and might be considered, at most, every 10 or 12 years. The Court directed that the selection of a new hydrologic Base Period should be determined by separate motion "sometime next year" or at least prior to considering next year's updated Production Safe Yield ("**PSY**") or Free Production Allowance ("**FPA**") recommendations.

Watermaster filed a Motion for Determination of hydrologic Base Period (**"Motion"**) just weeks later, on September 3, 2025. Our Clients, and other parties, filed Oppositions to the Motion. Prior to the October 20, 2025, hearing on the Motion, the Court released its tentative decision that the Motion "for the indefinite future is denied." The Court recognized the importance of selecting an appropriate hydrologic Base Period, and the impact that this decision will have on PSY, FPA, and other aspects of the Judgment. A copy of the Court's tentative decision is attached as **Exhibit 1**.

The Court directed the parties to meet and confer and propose a process through which Watermaster would present its analysis and the information on which it is based, and continued the hearing to October 27, 2025. The parties met and conferred with Watermaster counsel to explore, if possible, a mutually agreeable public process for consideration of a new hydrologic Base Period. Though some alignment was reached on certain aspects of the process, the parties did not reach consensus. Attached as **Exhibit 2** is the schedule our office proposed to the Court on October 27, 2025.[1] At the hearing, Judge Reimer expressed his view that any new hydrologic Base Period would need to be both considered *and approved* by the Watermaster Board before being presented to the Court. Given the Court's directives to ensure a robust and transparent public process occurs in evaluating any new hydrologic Base Period, we encourage Watermaster to comply with the attached schedule and process.

On November 12, 2025, Watermaster released a report entitled, "Watermaster Engineer's Statement of Reasons for Recommending 2001-2020 hydrologic Base Period" ("**SOR**")[2] This office comments for Watermaster's consideration on December 11, 2025, to be addressed at the December 12, 2025, Watermaster Workshop, and we requested that these comments be included in the record. Additionally, we included comments prepared by our technical consultants, EKI Environment & Water ("**EKI**"). See **Exhibit 3**.

At the Watermaster Workshop of December 12, 2025, Watermaster staff requested that further comments on the selection of a hydrologic Base Period be submitted to the Watermaster by January 5, 2026. Currently, the Watermaster has indicated the Watermaster Board will hold a public hearing to consider the Watermaster's recommendation for the hydrologic Base Period at a special board meeting on January 14, 2026. We request that these comments be included in the record and the agenda packet for this meeting. Additionally, we include comments prepared by our technical consultants, EKI. See **Exhibit 4.**

On December 31, 2025, we received correspondence from Watermaster legal counsel providing responses to questions raised in our December 11, 2025 comment letter. Due to the holidays and related scheduling constraints prior to the January 5th timeline to submit this letter, we reserve the right to review and further address Watermaster legal counsel's comments and responses.

[1] While the Court indicated it would enter an order shortly after the October 27, 2025 hearing, we are not aware of a final Court order as of the date of this letter.

[2] Watermaster Engineer's Statement of Reasons for Recommending 2001-2020 Base Period.

II. 1995-2024 IS THE MOST SUPPORTABLE HYDROLOGIC BASE PERIOD AMONG ALTERNATIVES PRESENTED BY THE WATERMASTER

DWR Bulletin 84, *Los Angeles vs. San Fernando*, the Judgment's definition of PSY, the Court's direction to consider "climatic disruption" and utilize the "best available data," and the alternative periods presented by the Watermaster Engineer, 1995-2024 is a more appropriate hydrologic Base Period than the 2001-2020 period proposed by Watermaster staff.

A. DWR Bulletin 84, *Los Angeles vs. San Fernando*, the Judgment's PSY Definition, and Court Directives Provide Criteria in Selecting a New Hydrologic Base Period

To date, the Watermaster's criteria for evaluating and adopting a new hydrologic Base Period are drawn from multiple sources. We address those sources here.

DWR Bulletin 84 provides the following guidance regarding the criteria to be used for selecting a long-term base period:

> The base period conditions should be reasonably representative of long-time hydrologic conditions and **should include both normal and extreme wet and dry years**. Both the beginning and the end of the base period should be preceded by a series of wet years or a series of dry years, so that the difference between the amount of water in transit within the zone of aeration at the beginning and end of the base period would be a minimum. **The base period should also be within the period of available records** and **should include recent cultural conditions** as an aid for projections under future basin operational studies.
>
> (Watermaster SOR Exhibit A [DWR Bulletin 84], pg. 47-48, emphasis added).

In the selection of a base study period, the court in *Los Angeles vs. San Fernando* stated that the base period in that case corresponded to the period with precipitation similar to the long-term period of record 1872-73 through 1956-57. The Report of Referee (1962) stated the following:

> The desirable base study period is one during which precipitation characteristics in the Upper Los Angeles River area approximate the 85-year period of record, 1872-73 through 1956-57. A further requirement of such a period is that additional hydrologic information is available sufficient to permit an evaluation of the amount, occurrence and disposal of the normal water supply under recent culture conditions. **The desirable base period includes both wet and dry periods similar in magnitude and occurrence to the normal supply**, and **during which there are**

> **sufficient measurements** and **observations to relate the hydrology to recent culture.**
>
> (SOR Exhibit B [Report of Referee], pg. 182; emphasis added.)

The Judgment definition of Production Safe Yield is:

> Production Safe Yield - **The highest average Annual Amount of water that can be produced from a Subarea:** (1) **over a sequence of years that is representative of long-term average annual natural water supply to the Subarea net of long-term average annual natural outflow from the Subarea**, (2) under given patterns of Production, applied water, return flows and Consumptive Use, and (3) **without resulting in a long-term net reduction of groundwater in storage in the Subarea.**
>
> (Judgment ¶ 4.aa., emphasis added).

Lastly, the Court in its 2022 Free Production Allowance Order stated:

> For instance, the present calculation of PSY has been based on a 60-year study of flows from 1930 to 1990. The Court questions whether a 60-year period in the middle of the 20th century is still an appropriately representative period from which to measure the long-term averages specified in the definition of PSY, **especially given the 32 years that have passed since 1990 and the climatic disruptions that we have been experiencing during that time.** If that is not the most representative period, should a different period be defined? Mr. Wagner has stated that, if the judgment were being negotiated today, it would be more prudent to select 'a shorter, drier planning period (hydrologic base period) for local supply . . ., resulting in a lower estimated Production Safe Yield and consequently lower annual Free Production Allowance.' (Wagner Decl., p. 6, 11. 18-21.) Is the Watermaster bound to rely upon what appears at this point in time to be a less-than-prudent period?
>
> (Court's September 16, 2022 Order Directing the Watermaster to Re-Evaluate PSY for the Entire Basin, Exhibit A, pg. 4-5, emphasis added.[3])

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[3] Court's September 16, 2022 Order Directing the Watermaster to Re-Evaluate PSY for the Entire Basin, Exhibit A, pg 4-5, available here https://www.mojavewater.org/wp-content/uploads/2022/09/20220919_Notice_Serving_Court_Order.pdf#page=7

The sources cited by Watermaster can be distilled into the following criteria in establishing an appropriate hydrologic Base Period:

- Both Normal and Extreme, Wet and Dry Years
- Base Period Must Be From Within Available Records
- Include Recent Cultural Conditions
- Highest Average Annual Amount of Water That Can Be Produced Without Resulting in a Long-term Net Reduction of Groundwater in Storage in the Subarea.
- Consider Climatic Disruption

The following subsections address each of these criteria, in turn, and how they support the selection of 1995-2024 as the most supportable base Hydrologic Period from among the alternatives presented by Watermaster.

B. Both Normal and Extreme, Wet and Dry Years

The Watermaster staff at the Workshop indicated that wet and dry years in the Basin are determined solely by whether Mojave River Flow at the Forks exceeds or falls below the 1931-1990 average of 65,538 af/year.[4] As such, "wet" years resulted in values higher than 65,538 af/year and "dry" years below 65,538 af/year.

The Watermaster has not defined a magnitude above the average that it considers "extreme" for either wet or dry years. Based on the above definitions, however, Watermaster acknowledges that the 1995-2024 hydrologic Base Period would satisfy the applicable criteria. (SOR p. 16:17-18).

The Watermaster did not analyze whether any alternative included "extreme" wet or dry years in any year, though it concluded that, for its 2001-2020 recommendation, such years were present. (See generally SOR section Evaluation of Alternative Hydrologic Base Periods, p. 15:1 to 18:27). The Watermaster states that the 2001-2020 hydrologic Base Period contains "both normal and extreme wet and dry years" without detailing the basis for such extremes. (See SOR p. 12:6-7 and 19:16). EKI finds that 1995-2024 includes "extreme" years of wet and dry because

[4] Our Client's previously disputed whether flow at the Fork is an appropriate basis to determine Basin wide whether a year is hydrologically wet or dry. For purposes of this comment letter that assertion is maintained.

it includes extreme wet years like 2005 and 2023 (which are significantly above 65,538 af/year), and multi-year dry periods like 1999-2002 and 2013-2018 (which are significantly below).[5]

As such, 1995-2024 contains both normal and extreme, wet and dry years, and satisfies this first element.[6]

C. Period of Available Records

The next element is that the hydrologic Base Period must be within the period of available records. The 1995-2024 range falls within the period of available records because the Watermaster began releasing annual reports in 1993-1994 and has collected annual reporting data ever since. The limitation on incorporating 2023-2024 water year data as a justification for Watermaster staff's proposed 2001-2020 hydrologic Base Period is an artificial and unnecessary limitation.

1. The Watermaster Began Releasing Annual Reports in 1993-94

1995-2024 falls within the available record period, as the Watermaster began releasing annual reports in 1993-1994, which include reporting and other measurement data as of that date.[7]

2. Watermaster Alleges that Data from 2023-2024 Cannot be Incorporated due to UMBM Calibration and that 2023-2024 Data was not Available in 2022

The Watermaster discounts multiple alternatives in part because (1) the Upper Mojave Basin Model ("**UMBM**") is only calibrated through 2020 and (2) the data from 2023-2024 water years were not available when the Watermaster originally proposed its 2001-2020 hydrologic Base Period in 2024.

3. The Watermaster does not Explain the Significance of why the UMBM Model Calibration is Required for a New Hydrologic Base Period

First, the Watermaster states 2002-2022 is not an appropriate selection "because the UMBM is calibrated through the year 2020." (SOR p. 17:16). Presumably, the Watermaster

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[5] EKI December 12, 2025 Letter, pg. 4.

[6] *Los Angeles vs. San Fernando* provides that the hydrologic Base Period should be within a "similar magnitude" of the original hydrologic Base Period. The 1995-2024 period is within 2% of the 1931-1990 average currently used under the Judgment, and is much more similar to that standard than the 6% difference using 2001-2020.

[7] See Watermaster First Annual Report for Water Year 1993-94, available at https://www.mojavewater.org/wp-content/uploads/2022/04/1ar9394.pdf

objects to any hydrologic Base Period ending after 2020 on similar bases, despite not stating this in the SOR.

The SOR is the first time the Watermaster has indicated UMBM calibration is a basis for why certain alternatives may be less feasible than others. The Watermaster did not discuss this limitation in the Motion[8], or its Reply[9] to the Motion. Additionally, the Watermaster does not further describe or analyze this calibration issue in the SOR, beyond providing it as a basis to discount the proposed alternatives.

The Watermaster does not describe:

- What effect the UMBM model's ending has on the selection of a hydrologic Base period;
- Whether the UMBM could be extended through 2024 (especially given that the UMBM was recently extended through 2020 in the 2024 PSY Update)[10];
- Whether calibration is a required prerequisite for the selection of a hydrologic Base Period or merely helpful in analyzing options;
- Whether this calibration issue supports waiting on any updated hydrologic Base Period until the full regional Model is released.

When the SOR set forth its criteria for selecting a hydrologic Base Period, it primarily directs readers to Bulletin 84 and *Los Angeles vs. San Fernando.* (SOR pp. 5-6). The SOR did not consider current UMBM calibration as a "critical" element until the analysis started to discount alternatives (SOR p. 17).

If the current UMBM calibration is critical enough to discount a potential hydrologic Base Period, then it is critical enough to delay approval of any hydrologic Base Period until the full

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[8] Watermaster Motion for Determination of hydrologic Base Period, available at 20250903a Motion for Determiniation of Hydrologic Base Period for PSY Calcs.pdf

[9] Watermaster Reply to Motion for Determination of hydrologic Base Period, available at 20251013 Watermaster Reply ISO Determination HydrologicBasePeriod for PSY.pdf

[10] See Watermaster 2024 PSY Update, Appendix G Upper Mojave River Basin Groundwater Model, pg. 1 (The current UMRB model is an expanded and updated version of the 2007 version of the model, which was calibrated from water year 1997 to water year 2005 [...] The model presented in this technical memorandum (TM) extends the spatial boundaries of the original UMRB model to include the upper basin (the watersheds of Deep Creek and West Fork) and is a fully integrated groundwater/surface-water numerical model. **The calibration period was also extended and covers water years from 1951 to water year 2020.**) emphasis added.

Regional model is done, or until the UMBM includes years through 2024. Additionally, without further analysis or explanation by the Watermaster as to the effect of calibration, it is not a proper basis to discount a hydrologic Base Period when the Watermaster has, within the last two years, updated the UMBM to include more recent years. As discussed below, the benefit of including more recent data from 1995-2024 more closely conforms to the criteria above when compared with the Watermaster's claims as to needing a more recently calibrated UMBM.

4. Watermaster Acknowledges that Hydrologic Base Periods with Data from 2023-2024 were not Analyzed in the 2024 PSY Update

The Watermaster notes that "the PSY Update prepared by Watermaster in February of 2024 evaluated a new hydrologic base period based on the information available at that time (up to the end of Water Year 2023). For that reason, Watermaster did not include a base period ending in 2024." (SOR 17:25-27). Watermaster's current assertions imply that because that data was not available *then*, it cannot be used *now*. The Court ordered the Watermaster in 2025 to file future motions for hydrologic Base Periods, not to make recommendations based on data collected as of the 2024 PSY Update. The Watermaster's analysis is unnecessarily limited to data as of the 2024 PSY Update, for no reason other than it appears administratively convenient, since it would not require an update to the UMBM and would support the Watermaster's previous selection of 2001-2020.

D. <u>Recent Cultural Conditions</u>

The SOR includes additional analysis of land-use changes in the Subareas from the 1990s to date. What the SOR fails to demonstrate is why a hydrologic Base Period ending in 2020 is appropriate when, as of the date of this letter, five years will have passed, and every other proposed hydrologic Base Period includes years after 2020.

1. 1995-2024 Includes More Recent Years than 2001-2020

The SOR does not explain why 2020 is an appropriate cutoff for recent cultural conditions, especially since all alternatives analyzed cover years after 2020. (SOR Table 2, p. 16). For hydrologic Base Periods that include the most recent cultural conditions, 2001-2020 is the *least* supportable option analyzed. (SOR Tables 1-2).

A simple textual reading of the requirement "recent culture conditions" would focus on including "recent" years where available. As such, 1995-2024 includes four more recent years of cultural conditions compared to 2001-2020, which weighs in favor of 1995-2024 as a better hydrologic Base Period.

2. Cultural Conditions and Land Use Changes Occur Gradually

Watermaster concludes that "alternative hydrologic base periods that begin in the 1990s do not meet the representation of recent cultural conditions, and therefore, they should not be considered appropriate hydrologic base periods for PSY redetermination," and as such, 1995-2024 and 1998-2024 are discounted by Watermaster. (SOR 18:17-19).

Watermaster states that data from the 1990s is not sufficiently recent, but as discussed above, simultaneously discounts both 1995-2024 and 1998-2024, which include the most recent years of recent cultural conditions and four more years than 2001-2020. Moreover, 1998-2024 includes only two years earlier than 2001-2020, and Watermaster does not identify any dramatic changes that occurred in 1999 and 2000. The Watermaster's analysis suggests that two years of 90s data significantly outweighs the value of the four most recent years. Watermaster's proposed hydrologic Base Period based on this criterion appears to be inconsistent with the criteria set forth in Bulletin 84.

Cultural conditions and land-use changes occur gradually and rarely vary from year to year without a significant intervening event. Accordingly, the hydrologic Base Period should generally include more recent data and exclude older data to capture cultural changes better. What the SOR fails to analyze, however, is that 1996 arguably saw the most significant event affecting land uses in the Mojave Basin in the last century: the entry of the Judgment and the Physical Solution.

As such, 1995-2024 captures the most significant "cultural" change in its entirety because it covers the last year before the implementation of the Physical Solution through the present, and it also meets *the other criteria of Bulletin 84*. 1995-2024 is the only proposed hydrologic Base Period that covers (1) the entry of the Judgment and (2) the most recent cultural conditions.

3. 1995-2024 Includes Watermaster's Proposed PSY Representative Year Within the Hydrologic Base Period

Watermaster states that "that when calculating PSY, the year representative of pumping and consumptive uses does not necessarily need to be strictly contained within the time frame of the hydrologic base period." (SOR 12:25-27). It is unclear on what basis Watermaster considers this to be appropriate under current circumstances or under the Judgment.

Watermaster's assertions are not consistent with the structure of the PSY definition, or the fact that the original "representative year" (1990) was limited to being within the hydrologic Base Period (1931-1990) as set forth in the Stipulated Judgment. The definition of PSY is as follows:

> The highest average Annual Amount of water that can be produced from a Subarea: **(1) over a sequence of years that is representative of long-term average annual natural water supply to the Subarea net of long-term average annual natural outflow from the Subarea,** (2) under given patterns of Production, applied water, return flows and Consumptive Use, and (3) without resulting in a long-term net reduction of groundwater in storage in the Subarea.
>
> (Judgment section 4.aa, emphasis added)

It is unclear from this definition where the Watermaster finds it has authority to select a "representative year" outside of clause (1) *which is the hydrologic Base Period.* Additionally, the Watermaster notes that the original "representative year" (1990) was limited to the original hydrologic Base Period (1931-1990) despite the entry of the Judgment occurring six years after 1990. Why would the Judgment have utilized 1990 when data was available for 1991-1994 by the time the Judgment was entered in 1996? How would a year be "representative of 1931-1990" when it is not included in that data set?

While the Court may have permitted this in the past, the selection of 1995-2024 largely resolves this issue by including the most recent years into the hydrologic Base Period, including 2022.

For this reason, 1995-2024 is more appropriate as a hydrologic Base Period as compared to 2001-2020.

E. Highest Average Annual Amount of Water That Can Be Produced Without Resulting in a Long-term Net Reduction of Groundwater in Storage

As noted above, the PSY definition requires the Watermaster to select values that reflect the "highest average annual amount of water that can be produced from a Subarea," "without resulting in a long-term net reduction of groundwater in storage in the Subarea." Watermaster's analysis does not appear to evaluate the impact of the proposed base Hydrologic Period alternatives on PSY.

The hydrologic Base Period is foundational to PSY. Any proposed new hydrologic Base Period should have analyzed these requirements and impacts. Watermaster's determination to recommend a "drier" hydrologic Base Period contradicts this requirement from the Judgment.

When considering these requirements, 1995-2024 is the most supportable alternative among the periods presented by Watermaster. It yields a 2% increase in total water supply compared to 1931-1990, while meeting all other criteria discussed above. Watermaster has acknowledged that "[f]rom a water supply perspective, a larger magnitude of average water supply might yield a higher PSY value," but then fails to account for the fact that the Judgment requires a base period that supports a maximum—not minimum or unduly conservative—PSY.[11] 2001-2020 specifically fails to meet this requirement and renders a 6% decrease in total water supply relative to 1931-1990.

F. Climatic Disruption

We disagree with Watermaster's implication that "[t]he Court previously asked that we consider a drier and more recent hydrologic planning period" equates to an order to recommend a drier hydrologic Base Period. The full quote from the Court's Order dated September 19, 2022, regarding the 2022 FPA approvals, is as follows:

> For instance, the present calculation of PSY has been based on a 60-year study of flows from 1930 to 1990. The Court questions whether a 60-year period in the middle of the 20th century is still an appropriately representative period from which to measure the long-term averages specified in the definition of PSY, especially given the 32 years that have passed since 1990 **and the climatic disruptions that we have been experiencing during that time.** If that is not the most representative period, should a different period be defined? **Mr. Wagner has stated that,** if the judgment were being negotiated today, it would be more prudent to select "**a shorter, drier** planning period (hydrologic base period) for local supply . . ., resulting in a lower estimated Production Safe Yield and consequently lower annual Free Production Allowance." (Wagner Decl., p. 6, 11. 18-21.) Is the Watermaster

[11] We disagree with Watermaster's characterization that "[t]he Judgment is intended as a funding mechanism so that those that pump more than their FPA will be required to purchase Replacement Water from Watermaster for recharge in a given subarea." (SOR 6:8-10). While the Judgment contains this funding mechanism for parties that need to purchase Replacement Water, the Judgment is intended to "declar[e] and adjudicate[…] the rights to reasonable and beneficial use of water by the Parties in the Mojave Basin Area." (Judgment section II.A.1.a). This is implemented in practice by the definition of PSY, which requires the Highest Average Annual Amount be producible by the Parties, thereby promoting the greatest "reasonable and beneficial use" of water by the Parties. Selecting a hydrologic Base Period to require more Rampdown than necessary for the mere purpose of parties acquiring more Replacement Water is not consistent with the principles of the Judgment.

> bound to rely upon what appears at this point in time to be a less-than-prudent period?
>
> (Emphasis added).

At no time has the Court ordered the Watermaster to recommend a drier hydrologic Base Period, as acknowledged by Watermaster staff at the Workshop. Despite this acknowledgment, multiple alternative hydrologic Base Periods were discounted by Watermaster apparently because they were not "drier" than the 1931-1990 average. (SOR p. 17:12-13).

The Court directed Watermaster to consider "climatic disruption" from 1990 to the present, when considering whether to propose a new hydrologic Base Period. Climate disruption does not reflexively equate to "drier" conditions. Climatic disruption is intended to more accurately capture the volatility between extremely wet years and severe droughts that have occurred since 1990. EKI notes that MWA studies indicate that "extreme flow events are expected to continue into the future," alongside drier years.[12] Climatic disruption should focus on extremes of both ends, since the average water supply in this Basin is calculated by averaging across extreme wet and extreme dry events to reach an "average."

A hydrologic Base Period of 1995-2024 would more accurately include "extreme wet years like 2005 and 2023, and multi-year dry periods like 1999-2002 and 2013-2018," and therefore captures climatic disruption more accurately than 2001-2020.[13]

III. CONCLUSION

We appreciate Watermaster's release of the SOR, holding the December 12, 2025, Workshop, and its intention to hold a public hearing to approve any proposed recommendations relating to the hydrologic Base Period.

We request that, among the alternatives presented by the Watermaster Staff to date, the Watermaster Board adopt the recommendation of 1995-2024 as the hydrologic Base Period, rather than 2001-2020. 1995-2024 more closely meets the requirements in Bulletin 84, *Los Angeles vs. San Fernando*, the Judgment's definition of PSY, and the Court's direction to consider "climatic disruption" and utilize the "best available data." We further request Watermaster update its analysis in response to this comment letter and provide all available and additional information for the updated analysis or updated recommendations for any new hydrologic Base Period selection for each Subarea.

[12] EKI December 12, 2025 Letter, pg. 5.
[13] *Id* at pg. 4.

We reserve the right to further comment on the December 31, 2025, response letter from Watermaster legal counsel, and any further information provided by Watermaster or other parties prior to and at the January 14, 2026, public hearing. We also reserve the opportunity to review and consider any new or different information that might warrant a different recommendation or update.

We look forward to participating in further discussions and attending future Watermaster board meetings, where these matters will be considered for approval and recommendation to the Court.

Sincerely,

FENNEMORE LLP

Derek Hoffman

DHOF
Enclosures
cc/enc: L. McElhany (lmcelhaney@bmklawplc.com)

62865530

EXHIBIT 1

1.

CIV208568	CITY OF BARSTOW VS CITY OF ADELANTO	MOTION FOR DETERMINATION OF HYDROLOGIC BASE PERIOD FOR PRODUCTION SAFE YIELD CALCULATIONS BY THE MOJAVE WATER AGENCY

Tentative Ruling:

The Watermaster's motion to change the hydrologic base period from 1931-1990 to 2001-2020 for the indefinite future is denied. Because of the importance of identifying an appropriate base period, the denial is without prejudice to a more robustly supported motion that addresses the Court's concerns.

The Court is mindful of the timeline facing the Watermaster. To avoid holding up the Watermaster's calculations of PSY and FPA, the Watermaster's annual report, and the annual motion regarding the Watermaster's recommended changes to FPA, the Court will consider the possibility of granting the motion on a temporary basis, i.e., authorizing the propesed base period (2001-2020) to be used in calculating the FPA recommendations for water year 2026-2027. The parties should be prepared to discuss that possibility, as well as the Watermaster's motion to adopt the proposed base period on an on-going basis.

Analysis:

There are two fundamental questions presented by the motion. The first is whether the proposed base period is a more reasonable representation of long-term hydrologic conditions in the basin than the existing base period. The second question is whether the proposed base period is a better representation of those conditions than any of the possible alternative periods. The motion addresses only the former. It does not mention possible alternative periods at all.

In its reply, the Watermaster argues that it would be a waste of scarce resources to evaluate other alternative base periods. (Reply, p. 3.) The Court disagrees. If other alternatives are not considered, there is no way to determine whether the selection of the proposed base period complies with the Judgment's requirement that the Watermaster rely upon the "best available records and data to support implementation of this Judgment."

Similarly, the Watermaster argues that it would be burdensome to evaluate "more than 100 years of data." (Reply, p. 3.) Again, the Court is not persuaded. No one is suggesting that the Watermaster must evaluate potential base periods that include or overlap with portions of the existing base period (1931-1990.) Instead, the question is whether there are other potential base periods since 1990 that would better represent the basin than either 1931-1990 or 2001-2020.

The Watermaster contends that any new base period should meet the criteria specified in DWR Bulletin No. 84. It is unclear, however, whether compliance with the bulletin is required. The very language that the Watermaster quotes is aspirational ("should") rather than mandatory ("shall"). Nevertheless, the Watermaster does not address the issue.

Assuming arguendo that the bulletin is at least persuasive if not mandatory, the proposed base period does not satisfy the bulletin's criteria. One criterion is that "[b]oth the beginning and end of the base period should be preceded by a series of wet years or a series of dry years .... " In addressing the requirement concerning the beginning of the period, the Watermaster asserts that the beginning of the proposed base period was "preceded by a series of dry years, i.e., dry years in 1999 and 2002 precede the 2001 beginning of the base period ... . " (Motion, p. 4.) 2002 did not precede 2001. Therefore, only one dry year, 1999, preceded the beginning of the proposed period in 2001. Because a single dry year does not constitute a "series" of dry years., that criterion is not met. Thus, assuming arguendo that Bulletin No. 84 describes the correct criteria to be used when selecting a new base period, the base period proposed does not meet those criteria.

The motion also argues that "recent cultural conditions" will be better reflected in the proposed base period than in the existing base period. But the Watermaster offers no evidence that those conditions were significantly different in 2001-2020 as compared to 1931-1990. While the Court has little doubt that they are, the Court needs to rely on evidence, not its assumptions. (Even if the evidence had been presented, it is unclear how the "cultural conditions" relate to the selection of the base period as opposed to being later factored into the RMRBM.)

To allow a careful evaluation of the Watermaster's assertions regarding the distribution of normal wet years, extremely wet years, normal dry years, and extremely dry years, the Court needs to know the criteria by which the Watermaster distinguishes normal years from extreme years. Similarly, the Watermaster offers no evidence (as opposed to argument in its Reply) to support the implicit conclusion that water flow at the Forks reasonably represents the water supply for the basin as a whole. It may be, but the motion does not address the issue.

The Watermaster suggests in its Reply that, because the Judgment does not expressly require Court approval of changes in the base period, the Watermaster should be deemed to have the discretion to pick whatever base period it believes is most appropriate. (Reply, pp, 2 & 9.) That reasoning fails, because the Watermaster is required to obtain court approval for changes in FPA The base period is integral to the calculation of PSY and the resulting recommendations regarding changes to FPA If the Watermaster is relying upon a base period that has not been approved, then the Court will be reluctant to approve recommendations based on that base period. Regardless of the express terms of the Judgment, as a practical matter the Watermaster's preferred base period needs judicial endorsement.

EXHIBIT 2

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Attorneys for MITSUBISHI CEMENT CORPORATION, ROBERTSON'S READY MIX, LTD., and CALPORTLAND COMPANY

SUPERIOR COURT OF THE STATE OF CALIFORNIA

COUNTY OF RIVERSIDE – CENTRAL DISTRICT

Coordination Proceeding Special Title (Cal. Rules of Court, Rule 3.550) MOJAVE BASIN WATER CASES	Case No. JCCP5265 Mojave Basin Water Cases Dept. 1, Riverside Superior Court Hon. Craig G. Reimer Lead Case CIV208568 Coordinated With San Bernardino Superior Court Case No. CIVSB2218461
CITY OF BARSTOW, et al., Plaintiff, v. CITY OF ADELANTO, et al., Defendant.	**MITSUBISHI CEMENT CORPORATION, ROBERTSON'S READY MIX, LTD. AND CALPORTLAND COMPANY PROPOSED SCHEDULE FOR BASE PERIOD AND RELATED MOTIONS** **Date:** Oct 27, 2025 **Time:** 10:00 a.m. **Dept:** 1
AND RELATED CROSS-ACTIONS.	

MITSUBISHI CEMENT CORPORATION ("Mitsubishi"), ROBERTSON'S READY MIX, LTD. ("Robertson's"), and CALPORTLAND COMPANY ("CalPortland"), collectively, the "above-captioned parties," by and through their attorneys of record, Fennemore LLP, hereby submit this proposed schedule for stakeholder engagement, Watermaster motion and Court determination of the "base period" and related Watermaster processes. This proposal is made following the October 21, 2025, hearing on Watermaster's Motion for Determination of Hydrologic Base Period for Production Safe Yield Calculations, and consideration of the Court's tentative ruling to deny that Motion.

Pursuant to Court's direction at the hearing on October 21, 2025, counsel for the above-captioned parties initiated and conducted a meet and confer with counsel for the Watermaster, California Department of Fish and Wildlife, Golden State Water Company and Newberry Springs Recreational Lakes Association on October 23, 2025. Though some progress was made, a consensus proposal was not reached and does not appear to be reachable.

The above-captioned parties propose the following schedule for the Court's consideration. As the Court already expressed its willingness to consider, the Court may need to enter an order relieving certain timing obligations under the Judgment and the Watermaster's Rules and Regulations to accommodate the following schedule, pursuant to the Court's authority under Judgment § 19.

The above-captioned parties reserve the right to consider adjustments to the proposed schedule and to present further argument, views and objections to alternative proposals at the continued hearing on October 27, 2025.

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	Description	Date
1	Watermaster releases Base Period Recommendations and supporting materials	November 12, 2025
2	Watermaster Workshop – Base Period	December 12, 2025
3	Watermaster Board Meeting – Base Period	January 28, 2026
4	Watermaster Motion to adopt Base Period	February 11, 2026
5	Opposition(s) to Watermaster Motion to adopt Base Period	March 3, 2026
6	Watermaster Reply ISO Motion to adopt Base Period	March 11, 2026
7	Court Hearing – Base Period	March 18, 2026
8	Watermaster releases FPA Recommendations and draft Annual Report	March 23, 2026
9	Watermaster Workshop – FPA	April 22, 2026
10	Watermaster Board Meeting – FPA Recommendations and draft Annual Report	May 27, 2026
11	Watermaster Motion to adopt FPA Recommendations and draft Annual Report	June 1, 2026
12	Opposition(s) to Watermaster Motion to adopt FPA Recommendations and draft Annual Report	June 22, 2026
13	Watermaster Reply ISO Motion to adopt FPA Recommendations and draft Annual Report	June 30, 2026
14	Court Hearing – FPA Motion	July 8-10, 2026

Dated: October 24, 2025

FENNEMORE LLP

By: ______________________

Derek Hoffman
Darien K. Key
MITSUBISHI CEMENT CORPORATION, ROBERTSON'S READY MIX, LTD., and CALPORTLAND COMPANY

PROOF OF SERVICE

STATE OF CALIFORNIA, COUNTY OF SAN BERNARDINO

Re: City of Barstow v. City of Adelanto, et al.;
Riverside Superior Court Case No.: CIV 208568

I am employed in the County of Fresno, State of California. I am over the age of 18 years and not a party to the within action; my business address is: 8080 North Palm Ave. Third Floor, Fresno, CA 93711. On October 24, 2025, I served copies of the within documents described as **MITSUBISHI CEMENT CORPORATION, ROBERTSON'S READY MIX, LTD. AND CALPORTLAND COMPANY PROPOSED SCHEDULE FOR BASE PERIOD AND RELATED MOTIONS** on the interested parties in this action in a sealed envelope addressed as follows:

See attached Service List

[X] **BY MAIL** - I am "readily familiar" with the firm's practice of collecting and processing correspondence for mailing. Under that practice, it would be deposited with the United States Postal Service on the same day in the ordinary course of business, with postage thereon fully prepaid at San Bernardino, California. I am aware that on motion of the party served, service is presumed invalid if postal cancellation date or postage meter date is more than one day after date of deposit for mailing in affidavit.

[ ] **BY PERSONAL SERVICE** - I caused such envelope to be delivered by hand to the offices of the addressee pursuant to C.C.P. § 1011.

[ ] **BY EXPRESS MAIL/OVERNIGHT DELIVERY** - I caused such envelope to be delivered by hand to the office of the addressee via overnight delivery pursuant to C.C.P. § 1013(c), with delivery fees fully prepaid or provided for.

[ ] **BY FACSIMILE** - I caused such document to be delivered to the office of the addressee via facsimile machine pursuant to C.C.P. § 1013(e). Said document was transmitted to the facsimile number of the office of the addressee from the office of Gresham Savage Nolan & Tilden, in San Bernardino, California, on the date set forth above. The facsimile machine I used complied with California Rules *of Court*, Rule 2003(3) and no error was reported by the machine. Pursuant to California *Rules of Court*, Rule 2009(i), I caused the machine to print a record of the transmittal, a copy of which is attached to this declaration.

[X] **BY ELECTRONIC/EMAIL** - Pursuant to the party's express consent to receive electronic service, I caused such document to be delivered to the office of the addressee via electronic e-mail pursuant to C.C.P. §1010.6(a)(2)(A)(ii). Said document was transmitted to the email address of that office which is listed on the attached Service List. Said document was served electronically and the transmission was reported as complete and without error.

FEDERAL - I am employed in the office of a member of the bar of this court at whose direction the service was made.

I declare under penalty of perjury under the laws of the State of California that the foregoing is true and correct. Executed on October 24, 2025, at Fresno, California.

Kelly Ridenour
KELLY RIDENOUR

SERVICE LIST

Re: City of Barstow v. City of Adelanto, et al.;
Riverside Superior Court Case No.: CIV 208568

William J. Brunick, Esq. Leland P. McElhaney, Esq. Brunick, McElhaney & Kennedy PLC 1839 Commercenter West P.O. Box 13130 San Bernardino, CA 92423-3130 Email: bbrunick@bmklawplc.com lmcelhaney@bmklawplc.com	**Attorneys for Defendant/Cross-Complainant, MOJAVE WATER AGENCY**
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EXHIBIT 3

FENNEMORE.

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December 11, 2025

VIA EMAIL

Andrea Hostetter
Mojave Watermaster
13846 Conference Center Drive
Apple Valley, CA 92307-4377
Email: ahostetter@mojavewater.org

Re: Mitsubishi, Robertson's, CalPortland Comment Letter
Mojave Watermaster December 12, 2025 Workshop re Watermaster Recommendations for New Hydrologic Base Period

Dear Ms. Hostetter:

This firm represents Mitsubishi Cement Corporation ("**Mitsubishi**"), Robertson's Ready Mix, Ltd. ("**Robertson's**"), and CalPortland Company ("**CalPortland**"). Collectively, these parties ("**Our Clients**") have facilities located throughout the Mojave Basin Area within the Este, Centro, Alto, and Baja Subareas. This letter is submitted for consideration and discussion at the Mojave Watermaster ("**Watermaster**") Workshop meeting to be held on December 12, 2025. Please distribute this letter to Watermaster Board members and staff.

I. BACKGROUND FOR WATERMASTER WORKSHOP REGARDING CONSIDERATION OF AN UPDATED HYDROLOGIC BASE PERIOD

At the hearing on August 4, 2025, the Court acknowledged the merit of Our Clients' objections to any rubber-stamping of a new hydrologic Base Period. The Court observed that the base hydrologic period is not redetermined annually and might be considered, at most, every 10 or 12 years. The Court directed that the selection of a new hydrologic Base Period should be determined by separate motion "sometime next year" or at least prior to considering next year's updated Production Safe Yield ("**PSY**") or Free Production Allowance ("**FPA**") recommendations.

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Watermaster filed a Motion for Determination of hydrologic Base Period just weeks later, on September 3, 2025. Our Clients, and other parties, filed Oppositions to the Motion. Prior to the October 20, 2025, hearing on the Motion, the Court released its tentative decision that the Motion "for the indefinite future is denied." The Court recognized the importance of selecting an appropriate hydrologic Base Period, and the impact that this decision will have on PSY, FPA, and other aspects of the Judgment. A copy of the Court's tentative decision is attached as **Exhibit 1.**

The Court directed the parties to meet and confer and propose a process through which Watermaster would present its analysis and the information on which it is based, and continued the hearing to October 27, 2025. The parties met and conferred with Watermaster counsel to explore, if possible, a mutually agreeable public process for consideration of a new hydrologic Base Period. Though some alignment was reached on certain aspects of the process, the parties did not reach consensus. Attached as **Exhibit 2** is the schedule our office proposed to the Court on October 27, 2025.[1] At the hearing, Judge Reimer expressed his view that any new hydrologic Base Period would need to be both considered *and approved* by the Watermaster Board before being presented to the Court. The Workshop is an early step in this process, but not the only step in the public process.

Given the Court's directives to ensure a robust and transparent public process occurs in evaluating any new hydrologic Base Period, we encourage Watermaster to comply with the attached schedule and process.

On November 12, 2025, Watermaster released a report entitled, "Watermaster Engineer's Statement of Reasons for Recommending 2001-2020 hydrologic Base Period" ("**SOR**")[2] We provide these comments for Watermaster's consideration at the December 12, 2025, Watermaster Workshop, and we request that these comments be included in the record. Additionally, we include comments prepared by our technical consultants, EKI Environment & Water ("**EKI**"). EKI's comments are attached as **Exhibit 3.**

[1] While the Court indicated it would enter an order shortly after the October 27, 2025 hearing, we are not aware of a final Court order as of the date of this letter.

[2] Watermaster Engineer's Statement of Reasons for Recommending 2001-2020 Base Period.

II. COMMENTS REGARDING WATERMASTER SOR

We request Watermaster address the following questions and comments at the Workshop regarding the SOR.

A. Applicability of DWR Bulletin 84

Watermaster SOR Reference	Question/Comment
SOR reliance on Bulletin 84 as the standard and criteria for selecting a new hydrologic Base Period. (See SOR, pg. 2-5)[3]	1. The SOR emphasizes selection of a hydrologic Base Period based primarily upon guidance from the 1967 DWR Bulletin 84 and the 1975 opinion in *City of Los Angeles vs. City of San Fernando, et al., 14 Cal.3d 199 (1975).* 2. Does Watermaster contend that the standards in the above-referenced records reflect the best current methodology for determining a new hydrologic Base Period for the Mojave Basin and each of its Subareas? 3. Has Watermaster considered other guidance materials such as California Department of Water Resources' Sustainable Groundwater Management Best Management Practices for Water Budgets?[4]

[3] Summary of SOR pgs 2-5.

[4] DWR BMP for SGMA, Water Budget, (2016) available at https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/Sustainable-Groundwater-Management/Best-Management-Practices-and-Guidance-Documents/Files/BMP-4-Water-Budget_ay_19.pdf

B. Initial Hydrologic Base Period 1931-1990

Watermaster SOR Reference	Question/Comment
"Based upon DWR's guidance in Bulletin 84, the Parties and the Court in City of Barstow determined the initial hydrologic Base Period should be from 1931 to 1990, because it includes both normal and extreme wet and dry years." (SOR 5:25-27).	1. How does Watermaster define "normal" and "extreme" wet and dry years? 2. Is Watermaster's definition of wet and dry years based solely upon flows at the Forks?

C. Water Supply to the Basin Area

Watermaster SOR Reference	Question/Comment
"Surface water inflow to the Alto Subarea is measured flow of the Mojave River at the Forks and is the sum of reported values from USGS gage stations at West Fork Mojave River near Hesperia, CA and Deep Creek near Hesperia, CA. This measured USGS gage data provides the best available information regarding the surface water inflow to the Basin Area. There are very few records of surface water inflow to the Este and Oeste Subareas." (SOR 11:17-22)	1. Please identify all records and reports Watermaster is relying upon for surface water inflow to the Este and Oeste Subareas.
"Watermaster reviewed records of precipitation. Although there are several precipitation stations located within the Forks' watershed, the reliability of this data is questionable. The precipitation records are short, inconsistent, and intermittent (see Exhibit M). For these reasons, Watermaster believes the measured flow of the Mojave River at the Forks continues to be the record indicative of the long-term water supply to the Basin Area. Additionally, the flow record at the Forks provides a clear indication of wet and dry periods in the Basin Area." (SOR 11:23-12:2)	2. Has Watermaster considered any third-party data that can provide reliable precipitation records?

D. **Watermaster Proposed Hydrologic Base Period 2001-2020**

Watermaster SOR Reference	Question/Comment
"Once the hydrologic Base Period is set, there is no reason to reset it every year, or at any other time unless the conditions upon which it is based change significantly." (SOR 12:13-15).	1. Does Watermaster intend to present any update to its recommendations for a new hydrologic Base Period once its model update is completed?

E. **Hydrologic Base Period vs. Pumping and Consumptive Uses for purposes of PSY determination**

Watermaster SOR Reference	Question/Comment
"Watermaster needs to clarify that when calculating PSY, the year representative of pumping and consumptive uses does not necessarily need to be strictly contained within the time frame of the hydrologic Base Period." (SOR 12:25-27)	1. This paragraph is unclear. Please provide the legal and technical basis for Watermaster's contention that the representative year for PSY may be outside the hydrologic Base Period. 2. Is it Watermaster's position that the hydrologic Base Period is not foundational to PSY? 3. If PSY can be based upon some "representative year," outside the hydrologic Base Period as Watermaster suggests, what criteria, data, factors, and standards does Watermaster contend would apply in selecting a "representative year" for PSY?[5] 4. Watermaster's interpretation appears to contradict the fact that the first PSY year (1990) was within the hydrologic Base Period sequence (1931-1990). (See

[5] See Judgment sections 4.aa.(1)-(2).

	SOR 12:27-13:2; Table C-1 of the Judgment).
"Even though the hydrologic Base Period of 2001-2020 was recommended by Watermaster for all Subareas, Watermaster recognizes that for the Baja Subarea, special circumstances may warrant PSY determination based on limited data. For the Baja Subarea, the only reliable data available is pumping and water level measurements (which show recent recovery). This is true for the Este Subarea and the Oeste Subarea as well." (SOR 14:4-9)	5. This paragraph is not clear. Please elaborate. 6. What provisions of the Judgment does Watermaster contend would allow PSY determination to be based on limited data? 7. What is Watermaster's plan and timeline to address and fill any known information gaps for Este, Baja, and Oeste? 8. Please clarify whether Watermaster is still considering recommending different hydrologic Base Periods for each Subarea. If so, what data, criteria, or other factors would Watermaster consider in determining whether to recommend a different hydrologic Base Period for a particular Subarea?

F. **Evaluation of Alternative Hydrologic Base Periods**

Watermaster SOR Reference	**Question/Comment**
"From a water supply perspective, a larger magnitude of average water supply might yield a higher PSY value. On the contrary, a smaller magnitude of water supply might yield a lower PSY value. However, as noted above, the Court previously asked Watermaster to consider a drier and more recent hydrologic Base Period. For these reasons, Watermaster does not recommend the two alternative hydrologic Base Periods of 1991-2022 and 1995-2024." (SOR 17:9-14).	1. The Court asked Watermaster to "consider" a drier and more recent period. Is it Watermaster's position that this direction *requires* Watermaster to *recommend* a drier period? 2. Does Watermaster consider any other potential hydrologic Base Periods would be more technically supportable if not presumed required to select a "drier" period?

	3. How much "drier" does Watermaster project hydrologic conditions for the Basin to become? What studies and data is Watermaster relying on for that projection?
The alternative base period 2002-2022 starts and ends on a dry year and is preceded by a series of dry years. However, because the UMBM is calibrated through the year 2020 only, Watermaster does not consider this to be an appropriate selection. (SOR 17:15-17)	4. Will Watermaster further calibrate the model to capture more recent data (2000-2024)? 5. What impacts does the UMBM not being calibrated past 2020 have on Watermaster's proposal to select 2022? 6. If 2022 was outside the period of model calibration, how were Watermaster 2024 PSY values derived and supported to the extent they relied on 2022 data?
Because the alternative 2002-2022 base period is outside the period of the UMBM calibration, and the magnitude of water supply in the alternative 2002-2022 base period does not "closely approximate" the magnitude of the long-term water supply during the 1931-1990 base period (as indicated by DWR Bulletin 84), Watermaster believes the alternative 2002-2022 base period is not as appropriate as the recommended 2001-2020 base period. (SOR	7. Please explain and quantify the meaning of "closely approximate the magnitude."

G. **Cultural Conditions Evaluation**

Watermaster SOR Reference	Question/Comment
As explained above, Watermaster's data on irrigated acreages show a similar trend of a constant reduction in irrigated land, particularly during recent years. Because the new hydrologic base period should meet the criteria of the DWR Bulletin 84 and include	1. Watermaster states 2001-2020 captures changing land uses, but many of the highlighted cultural changes (Ex. C–H), urbanization, declining agriculture, and increased VVWRA discharges occur

recent cultural conditions, Watermaster determined that the alternative hydrologic base periods that begin in the 1990s do not me[e]t the representation of recent cultural conditions, and therefore, they should not be considered appropriate hydrologic base periods for PSY redetermination. (SOR 18:13-19).	gradually beginning in 1995 and continuing through at least 2024. 2. What statistical basis is Watermaster relying on to conclude that no year in the 1990s should be included? 3. Does Watermaster contend that cultural conditions have evolved uniformly for all Subareas?

III. CONCLUSION

We appreciate Watermaster's release of the SOR, and holding this Workshop to discuss and address stakeholder questions. On behalf of Our Clients, we reserve all rights to comment further on these pending items both at the Workshop and through further proceedings.

We request Watermaster address the issues raised in this letter and the enclosed letter from EKI. We further request Watermaster update its analysis in response to the Workshop, and provide all available and additional information for the updated analysis or updated recommendations for any new hydrologic Base Period selection for each Subarea.

We look forward to participating in further discussion and attending future Watermaster board meetings at which these matters will be discussed and considered for approval and recommendation to the Court.

Sincerely,

FENNEMORE LLP

Derek Hoffman

DHOF

cc: L. McElhany (lmcelhaney@bmklawplc.com)

62797269

EXHIBIT 1

1.

CIV208568	CITY OF BARSTOW VS CITY OF ADELANTO	MOTION FOR DETERMINATION OF HYDROLOGIC BASE PERIOD FOR PRODUCTION SAFE YIELD CALCULATIONS BY THE MOJAVE WATER AGENCY

Tentative Ruling:

The Watermaster's motion to change the hydrologic base period from 1931-1990 to 2001-2020 for the indefinite future is denied. Because of the importance of identifying an appropriate base period, the denial is without prejudice to a more robustly supported motion that addresses the Court's concerns.

The Court is mindful of the timeline facing the Watermaster. To avoid holding up the Watermaster's calculations of PSY and FPA, the Watermaster's annual report, and the annual motion regarding the Watermaster's recommended changes to FPA, the Court will consider the possibility of granting the motion on a temporary basis, i.e., authorizing the propesed base period (2001-2020) to be used in calculating the FPA recommendations for water year 2026-2027. The parties should be prepared to discuss that possibility, as well as the Watermaster's motion to adopt the proposed base period on an on-going basis.

Analysis:

There are two fundamental questions presented by the motion. The first is whether the proposed base period is a more reasonable representation of long-term hydrologic conditions in the basin than the existing base period. The second question is whether the proposed base period is a better representation of those conditions than any of the possible alternative periods. The motion addresses only the former. It does not mention possible alternative periods at all.

In its reply, the Watermaster argues that it would be a waste of scarce resources to evaluate other alternative base periods. (Reply, p. 3.) The Court disagrees. If other alternatives are not considered, there is no way to determine whether the selection of the proposed base period complies with the Judgment's requirement that the Watermaster rely upon the "best available records and data to support implementation of this Judgment."

Similarly, the Watermaster argues that it would be burdensome to evaluate "more than 100 years of data." (Reply, p. 3.) Again, the Court is not persuaded. No one is suggesting that the Watermaster must evaluate potential base periods that include or overlap with portions of the existing base period (1931-1990.) Instead, the question is whether there are other potential base periods since 1990 that would better represent the basin than either 1931-1990 or 2001-2020.

The Watermaster contends that any new base period should meet the criteria specified in DWR Bulletin No. 84. It is unclear, however, whether compliance with the bulletin is required. The very language that the Watermaster quotes is aspirational ("should") rather than mandatory ("shall"). Nevertheless, the Watermaster does not address the issue.

Assuming arguendo that the bulletin is at least persuasive if not mandatory, the proposed base period does not satisfy the bulletin's criteria. One criterion is that "[b]oth the beginning and end of the base period should be preceded by a series of wet years or a series of dry years .... " In addressing the requirement concerning the beginning of the period, the Watermaster asserts that the beginning of the proposed base period was "preceded by a series of dry years, i.e., dry years in 1999 and 2002 precede the 2001 beginning of the base period ... . " (Motion, p. 4.) 2002 did not precede 2001. Therefore, only one dry year, 1999, preceded the beginning of the proposed period in 2001. Because a single dry year does not constitute a "series" of dry years., that criterion is not met. Thus, assuming arguendo that Bulletin No. 84 describes the correct criteria to be used when selecting a new base period, the base period proposed does not meet those criteria.

The motion also argues that "recent cultural conditions" will be better reflected in the proposed base period than in the existing base period. But the Watermaster offers no evidence that those conditions were significantly different in 2001-2020 as compared to 1931-1990. While the Court has little doubt that they are, the Court needs to rely on evidence, not its assumptions. (Even if the evidence had been presented, it is unclear how the "cultural conditions" relate to the selection of the base period as opposed to being later factored into the RMRBM.)

To allow a careful evaluation of the Watermaster's assertions regarding the distribution of normal wet years, extremely wet years, normal dry years, and extremely dry years, the Court needs to know the criteria by which the Watermaster distinguishes normal years from extreme years. Similarly, the Watermaster offers no evidence (as opposed to argument in its Reply) to support the implicit conclusion that water flow at the Forks reasonably represents the water supply for the basin as a whole. It may be, but the motion does not address the issue.

The Watermaster suggests in its Reply that, because the Judgment does not expressly require Court approval of changes in the base period, the Watermaster should be deemed to have the discretion to pick whatever base period it believes is most appropriate. (Reply, pp, 2 & 9.) That reasoning fails, because the Watermaster is required to obtain court approval for changes in FPA The base period is integral to the calculation of PSY and the resulting recommendations regarding changes to FPA If the Watermaster is relying upon a base period that has not been approved, then the Court will be reluctant to approve recommendations based on that base period. Regardless of the express terms of the Judgment, as a practical matter the Watermaster's preferred base period needs judicial endorsement.

EXHIBIT 2

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Attorneys for MITSUBISHI CEMENT CORPORATION, ROBERTSON'S READY MIX, LTD., and CALPORTLAND COMPANY

SUPERIOR COURT OF THE STATE OF CALIFORNIA

COUNTY OF RIVERSIDE – CENTRAL DISTRICT

Coordination Proceeding Special Title (Cal. Rules of Court, Rule 3.550) MOJAVE BASIN WATER CASES	Case No. JCCP5265 Mojave Basin Water Cases Dept. 1, Riverside Superior Court Hon. Craig G. Reimer
CITY OF BARSTOW, et al., Plaintiff, v. CITY OF ADELANTO, et al., Defendant.	Lead Case CIV208568 Coordinated With San Bernardino Superior Court Case No. CIVSB2218461 **MITSUBISHI CEMENT CORPORATION, ROBERTSON'S READY MIX, LTD. AND CALPORTLAND COMPANY PROPOSED SCHEDULE FOR BASE PERIOD AND RELATED MOTIONS** **Date:** Oct 27, 2025 **Time:** 10:00 a.m. **Dept:** 1
AND RELATED CROSS-ACTIONS.	

MITSUBISHI CEMENT CORPORATION ("Mitsubishi"), ROBERTSON'S READY MIX, LTD. ("Robertson's"), and CALPORTLAND COMPANY ("CalPortland"), collectively, the "above-captioned parties," by and through their attorneys of record, Fennemore LLP, hereby submit this proposed schedule for stakeholder engagement, Watermaster motion and Court determination of the "base period" and related Watermaster processes. This proposal is made following the October 21, 2025, hearing on Watermaster's Motion for Determination of Hydrologic Base Period for Production Safe Yield Calculations, and consideration of the Court's tentative ruling to deny that Motion.

Pursuant to Court's direction at the hearing on October 21, 2025, counsel for the above-captioned parties initiated and conducted a meet and confer with counsel for the Watermaster, California Department of Fish and Wildlife, Golden State Water Company and Newberry Springs Recreational Lakes Association on October 23, 2025. Though some progress was made, a consensus proposal was not reached and does not appear to be reachable.

The above-captioned parties propose the following schedule for the Court's consideration. As the Court already expressed its willingness to consider, the Court may need to enter an order relieving certain timing obligations under the Judgment and the Watermaster's Rules and Regulations to accommodate the following schedule, pursuant to the Court's authority under Judgment § 19.

The above-captioned parties reserve the right to consider adjustments to the proposed schedule and to present further argument, views and objections to alternative proposals at the continued hearing on October 27, 2025.

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	Description	Date
1	Watermaster releases Base Period Recommendations and supporting materials	November 12, 2025
2	Watermaster Workshop – Base Period	December 12, 2025
3	Watermaster Board Meeting – Base Period	January 28, 2026
4	Watermaster Motion to adopt Base Period	February 11, 2026
5	Opposition(s) to Watermaster Motion to adopt Base Period	March 3, 2026
6	Watermaster Reply ISO Motion to adopt Base Period	March 11, 2026
7	Court Hearing – Base Period	March 18, 2026
8	Watermaster releases FPA Recommendations and draft Annual Report	March 23, 2026
9	Watermaster Workshop – FPA	April 22, 2026
10	Watermaster Board Meeting – FPA Recommendations and draft Annual Report	May 27, 2026
11	Watermaster Motion to adopt FPA Recommendations and draft Annual Report	June 1, 2026
12	Opposition(s) to Watermaster Motion to adopt FPA Recommendations and draft Annual Report	June 22, 2026
13	Watermaster Reply ISO Motion to adopt FPA Recommendations and draft Annual Report	June 30, 2026
14	Court Hearing – FPA Motion	July 8-10, 2026

Dated: October 24, 2025

FENNEMORE LLP

By: [signature]

Derek Hoffman
Darien K. Key
MITSUBISHI CEMENT CORPORATION, ROBERTSON'S READY MIX, LTD., and CALPORTLAND COMPANY

PROOF OF SERVICE

STATE OF CALIFORNIA, COUNTY OF SAN BERNARDINO

Re: City of Barstow v. City of Adelanto, et al.;
Riverside Superior Court Case No.: CIV 208568

I am employed in the County of Fresno, State of California. I am over the age of 18 years and not a party to the within action; my business address is: 8080 North Palm Ave. Third Floor, Fresno, CA 93711. On October 24, 2025, I served copies of the within documents described as **MITSUBISHI CEMENT CORPORATION, ROBERTSON'S READY MIX, LTD. AND CALPORTLAND COMPANY PROPOSED SCHEDULE FOR BASE PERIOD AND RELATED MOTIONS** on the interested parties in this action in a sealed envelope addressed as follows:

See attached Service List

[X] **BY MAIL** - I am "readily familiar" with the firm's practice of collecting and processing correspondence for mailing. Under that practice, it would be deposited with the United States Postal Service on the same day in the ordinary course of business, with postage thereon fully prepaid at San Bernardino, California. I am aware that on motion of the party served, service is presumed invalid if postal cancellation date or postage meter date is more than one day after date of deposit for mailing in affidavit.

[ ] **BY PERSONAL SERVICE** - I caused such envelope to be delivered by hand to the offices of the addressee pursuant to C.C.P. § 1011.

[ ] **BY EXPRESS MAIL/OVERNIGHT DELIVERY** - I caused such envelope to be delivered by hand to the office of the addressee via overnight delivery pursuant to C.C.P. § 1013(c), with delivery fees fully prepaid or provided for.

[ ] **BY FACSIMILE** - I caused such document to be delivered to the office of the addressee via facsimile machine pursuant to C.C.P. § 1013(e). Said document was transmitted to the facsimile number of the office of the addressee from the office of Gresham Savage Nolan & Tilden, in San Bernardino, California, on the date set forth above. The facsimile machine I used complied with California Rules *of Court*, Rule 2003(3) and no error was reported by the machine. Pursuant to California *Rules of Court*, Rule 2009(i), I caused the machine to print a record of the transmittal, a copy of which is attached to this declaration.

[X] **BY ELECTRONIC/EMAIL** - Pursuant to the party's express consent to receive electronic service, I caused such document to be delivered to the office of the addressee via electronic e-mail pursuant to C.C.P. §1010.6(a)(2)(A)(ii). Said document was transmitted to the email address of that office which is listed on the attached Service List. Said document was served electronically and the transmission was reported as complete and without error.

FEDERAL - I am employed in the office of a member of the bar of this court at whose direction the service was made.

I declare under penalty of perjury under the laws of the State of California that the foregoing is true and correct. Executed on October 24, 2025, at Fresno, California.

Kelly Ridenour
KELLY RIDENOUR

SERVICE LIST

Re: City of Barstow v. City of Adelanto, et al.; Riverside Superior Court Case No.: CIV 208568

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EXHIBIT 3

eki environment & water

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(650) 292-9100
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10 December 2025

Derek Hoffman
Fennemore
550 E Hospitality Lane, Suite 350
San Bernardino, CA 92408

Subject: **Comments on the Watermaster Engineer's Statement of Reasons for Recommending a 2001-2020 Base Period**
(EKI 50063.00)

Dear Mr. Hoffman:

EKI Environment & Water, Inc. (EKI) has conducted a review of the *Watermaster Engineer's Statement of Reasons for Recommending a 2001-2020 Base Period* (Statement)[1] filed on 12 November 2025. EKI has conducted this review and provided the comments below to Fennemore in its role as Counsel to Mitsubishi Cement Corporation, Robertson's Ready Mix, Ltd., and CalPortland Company (collectively the "Clients") in the Mojave River Basin Area (Basin).

SUMMARY OF STATEMENT OF REASONS

The Statement provides background information on the Department of Water Resources' (DWR's) Bulletin No. 84 and similar adjudications (e.g., *City of Los Angeles vs. City of San Fernando, et al., 14 Cal.3d 199 (1975)*), discusses the Basin's initial hydrologic base period, changes in land use and pumping since entry of the Judgment, water supply to the Basin, and then provides justification for the proposed hydrologic base period of 2001-2020. The Statement provides greater detail than was originally provided in the Motion to the Court (Motion)[2], including differentiating between selection of the hydrologic base period and evaluation of production safe yield (PSY). The Statement includes a comparison among several other potential hydrologic base periods before ultimately recommending the adoption of 2001-2020 as the new hydrologic base period.

KEY COMMENTS

Parties to the Judgment need visibility into the potential impacts to PSY in all Subareas under the proposed hydrologic base period

The Judgment defines PSY as, *"The highest average Annual Amount of water that can be produced from a Subarea: (1) over a sequence of years that is representative of long-term average annual natural water supply to the Subarea net of long-term average annual natural outflow from the Subarea, (2) under given patterns of Production, applied water, return flows and Consumptive Use, and (3) without resulting in a*

[1] *Watermaster Engineer's Statement of Reasons for Recommending 2001-2020 Base Period,* November 12, 2025.
[2] Brunick, McElhaney, & Kennedy PLC, 2025. Motion for the Determination of Hydrologic Base Period for Production Safe Yield Calculations; Memorandum of Points and Authorities; Supporting Declaration. September.

long-term net reduction of groundwater in storage in the Subarea." Table C-1 of the Judgment lays out how PSY is calculated – PSY is total production in each Subarea plus the surplus or deficit of water supply, which is the difference between water supply and consumptive use/outflow. The hydrologic base period is used to inform numerous budget terms in this calculation such as surface water inflows and outflows. Each year in the Annual Report, the Watermaster presents a version of Table C-1 as Annual Report Table 5-1. As noted by the Watermaster, 2001-2020 has been temporarily used as the hydrologic base period in the two most recent Annual Reports (i.e., for water years 2022-23 and 2023-24). However, it should be noted that Table 5-1 is currently not available for the 2023-24 Annual Report on the Watermaster's website, and that Table 5-1 for the 2022-23 Annual Report presents PSY calculations for Alto, Centro and Baja, but not Este or Oeste[3]. As such, although the proposed hydrologic base period has been used temporarily by the Watermaster in recent years, and PSY estimates have been provided for all Subareas, the analysis is not fully documented and the impact of the proposed hydrologic base period on the calculation of PSY in each Subarea is unclear.

In the Statement, the Watermaster explains that *"Even though the hydrologic base period of 2001-2020 was recommended by the Watermaster for all Subareas, Watermaster recognizes that for the Baja Subarea, special circumstances may warrant PSY determination based on limited data. For the Baja Subarea, the only reliable data available is pumping and water level measurements (which show recent recovery). This is true for the Este Subarea and the Oeste Subarea as well,"* (page 14). It therefore remains unclear how, if at all, the PSY for Baja, Este and Oeste has changed or may change under the proposed hydrologic base period. Parties to the Judgment need visibility into the potential impacts to PSY in all Subareas before the adoption of a new base period. We request the Watermaster to provide an analysis on estimates of PSY for each Subarea using the potential hydrologic base periods listed in Table 1 of the Statement.

A clear and consistent framework should be used to determine PSY

A complete water budget framework for each Subarea should be established to account for all inflows and outflows, and the water budget terms should not change from year to year as new analyses are conducted, unless revisions to the hydrogeological conceptual model (HCM) are warranted. Further, consideration of a new hydrologic base period should be supported by an evaluation of how that proposed hydrologic base period would impact each term for the PSY calculation for each Subarea.

The Judgment provides an example of a complete water budget framework as Table C-1, which has served as the basis for Table 5-1 (PSY calculation) in the Annual Reports for the Basin. **Table 1** below presents the water budget terms contained in the PSY calculations in recent years' Annual Reports utilizing the 2001-2020 hydrologic base period. Highlighted in yellow in **Table 1** are the water budget terms that are controlled by flow in the Mojave River. As can be seen therein, numerous other water budget terms are not controlled by flow in the Mojave River.

[3] Watermaster Reports - Mojave Water Agency

Table 1 – Summary of Water Budget Components for PSY Calculation

Budget Term	Alto	Centro	Baja	Este	Oeste
WATER SUPPLY					
Surface Water Inflow	61,635[1]	36,725[1]	-	Unclear[2]	Unclear[2]
Gaged Inflow	-	-	7,500[1]	-	-
Tributary Inflow	-	-	1,568[3]	-	-
Mountain Front Recharge	8,511[4]	0	647[3]	Unclear[5]	Unclear[5]
Groundwater Discharge to the TZ	0	0	-	-	-
Subsurface Inflow	0	2,000[6]	1,751[3]	Unclear[2]	Unclear[2]
Este/Oeste Inflow	4,785[4]	0	-	-	-
Imports	0	0	-	Unclear[5]	Unclear[5]
Deep Percolation of Precipitation	-	-	100[2]	-	-
Total Water Supply	**74,931**	**38,725**	**14,575**	**TBD**	**TBD**
CONSUMPTIVE USE					
Surface Water Outflow	36,725[1]	7,500[1]	-	-	-
Gaged Outflow	-	-	2,554[1]	-	-
Barstow Treatment Plant Discharge	0	2,475[7]	-	-	-
Subsurface Outflow	2,000[2]	1,462[3]	170[3]	Unclear[2,5]	Unclear[2,5]
Consumptive Use - Agriculture	949	5,863	12,749[8]	Unclear[5,9]	Unclear[5,9]
Consumptive Use - Urban	40,171	6,885	(see row above)	-	-
Phreatophytes	11,000[2,10]	3,000[2,10]	984[11]	-	-
Total Consumptive Use	**90,845**	**27,185**	**16,457**	**TBD**	**TBD**
PRODUCTION SAFE YIELD CALCULATION					
Surplus / (Deficit)	(15,914)	11,540	(1,883)	TBD	TBD
Total Estimated Production	78,147	16,995	12,740	TBD	TBD
Potential Return Flow	0	2,885	554	TBD	TBD
Production Safe Yield	**62,233**	**31,420**	**10,866**	**6,582**	**3,634**

Abbreviations:
- = Component not applicable to given Subarea
TBD = To be determined
TZ = Transition Zone

Notes:
Table values taken from Table 5-1 in the WY2022-2023 Annual Report.
Entries labeled unclear are those in which we are aware water budget component estimates have been developed but lack clarity on the value proposed for use in the hydrologic base period going forward.
1 – Value derived from stream gage data 2001-2020.
2 – Value established for the original base period (1931-1990) but not for the proposed hydrologic base period (2001-2020).
3 – Value derived from *USGS, 2001. Simulation of Ground-Water Flow in the Mojave River Basin, California, Water-Resources Investigations Report 01-4002.*
4 – Value derived from Upper Mojave Basin Model.
5 – While estimates are provided in Watermaster's 2024 PSY Update for this Subarea, they have not been included in recent Annual Reports' Table 5-1.
6 – No citation in recent Annual Reports, but the value is consistent with the value in the Judgment.
7 – No citation in Table 5-1 of recent reports.
8 – This value includes Agricultural and Urban Consumptive Use (see Table 5-1 of 2022-23 Annual Report).
9 – Estimates were developed in the Watermaster's 2018 Consumptive Use Analysis but have not been included in recent Annual Reports' Table 5-1.
10 – Value derived from *USGS, 1996. Riparian Vegetation and Its Water Use During 1995 Along the Mojave River, Southern California, Water-Resources Investigations Report 96-4241.*
11 – Value estimated using OpenET for 2019-2022.

Some of the water budget terms shown on **Table 1** have been updated as new data have become available, such as subsurface inflow into Alto (from Este/Oeste) and phreatophyte consumptive use in Baja (calculated using OpenET). Others remain fixed at historical values (e.g., subsurface outflow from Alto and phreatophyte consumptive use in Alto and Centro). Furthermore, while the PSY updates for Este and Oeste provided estimates of some water budget components such as mountain front recharge and consumptive use, ultimately the PSY estimates for these Subareas were based on recent pumping and water level data, and it is unclear if adoption of the proposed hydrologic base period would have any influence over these calculations. Additionally, the Alto water budget term Este/Oeste inflow is not matched by corresponding outflows from Este/Oeste in recent versions of Table 5-1, and this value (4,785 AF) greatly exceeds estimates of subsurface outflows in the PSY updates for Este and Oeste[4,5].

As shown on **Table 1**, the Watermaster currently uses a combination of: (1) budget terms from the Judgment (and therefore the original hydrologic base period of 1931-1990); (2) budget terms updated to reflect the proposed hydrologic base period of 2001-2020 (i.e., mountain front recharge, surface inflow into Alto averaged over the proposed hydrologic base period); and (3) budget terms that have no clear relationship to either base period and are inconsistently applied across Subareas. For example, the PSY calculation for Alto includes subsurface inflow from Este and Oeste, but the corresponding outflow from these Subareas is not considered in their respective PSY calculations. It is therefore not clear how, if at all, the various water budget components in Este and Oeste, as well as those in Alto, Centro, and Baja that are unrelated to surface water flows, would be updated under the proposed hydrologic base period of 2001-2020. We ask that the Watermaster provide an evaluation of how that proposed hydrologic base period would impact each term for the PSY calculation for each Subarea.

Appropriateness of metrics for establishing a hydrologic base period should be demonstrated

The purpose of a hydrologic base period is to represent the long-term patterns of water supply to the Basin. Per the Statement, *"Water supply to the Basin Area includes gaged and ungagged [sic] inflow, subsurface flow, deep percolation of precipitation, and certain imports,"* (page 11). Regarding the availability of hydrologic data on which to establish a base period, the Watermaster notes that *"There are very few records of surface water inflow to the Este and Oeste Subareas,"* (page 11) and that *"Although there are several precipitation stations located within the Fork's watershed, the reliability of this data is questionable. The precipitation records are short, inconsistent, and intermittent (see Exhibit M). For these reasons, Watermaster believes the measured flow of the Mojave River at the Forks continues to be the record indicative of the long-term water supply to the Basin Area,"* (page 11-12).

While it may be that available data are limited, it is not clear that Mojave River flow at the Forks is the appropriate metric upon which to establish a hydrologic base period for all Subareas. Notably, flow at the Forks is not relevant to conditions in Este or Oeste, and some components of the Basin water budget and PSY calculation (Table C-1 of the Judgment and discussed above) are independent of flow at the Forks, such as subsurface inflows and outflows and mountain front recharge (see **Table 1**). While Mojave River flow at the Forks may be a reasonable surrogate for some components of the analysis for some Subareas,

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[4] Watermaster, 2024. *Production Safe Yield and Consumptive Use Update, Appendix C: Oeste Subarea Water Supply Update*. February.
[5] Watermaster, 2024. *Production Safe Yield and Consumptive Use Update, Appendix D: Este Subarea Water Supply Update*. February.

as described in the Tentative Ruling, *"the Court needs to rely on evidence, not its assumptions,"* (page 2[6]). The Statement provides no quantitative evaluation to demonstrate the correlation of Mojave River flow at the Forks to other Subarea-specific inflow terms such as subsurface inflows/outflows and mountain front recharge that are part of the PSY calculation, and therefore why it is an appropriate metric.

One hydrologic base period may not reflect "recent cultural conditions" in all Subareas

As described in the Statement, significant changes in "recent cultural conditions" (i.e., land use and groundwater pumping) have occurred in the Basin since entry of the Judgment. Exhibit H to the Statement shows time-series plots of agricultural water production and irrigated acreage in each Subarea. These plots show that irrigation volumes in Alto declined steadily from entry of the Judgment to 2010 when production stabilized, meanwhile Centro exhibits a more gradual and ongoing trend. The Baja Subarea has experienced significant declines in irrigation pumping since 2020, while Este has exhibited a consistent decline since 2015 Irrigation pumping in Oeste has fallen to essentially zero in the last several years. These variable trends demonstrate that "cultural conditions" are evolving in each Subarea on independent timelines, and that the proposed hydrologic base period of 2001-2020 does not capture this variation, or in some cases, the actual current "cultural conditions" in a given Subarea.

In the Statement, Watermaster claims that *"Today's cultural conditions are represented by the new recent hydrologic base period of 2001-2020,"* (page 19). However, elsewhere in the Statement, and as quoted above, Watermaster explains that *"Even though the hydrologic base period of 2001-2020 was recommended by Watermaster for all Subareas, Watermaster recognizes that for the Baja Subarea, special circumstances may warrant PSY determination based on limited data. For the Baja Subarea, the only reliable data available is pumping and water level measurements (which show recent recovery). This is true for the Este Subarea and the Oeste Subarea as well,"* (page 14). While this may be a reasonable approach, it is unclear what criteria and process the Watermaster will use to determine what subset of available data for a given Subarea will be used to estimate PSY.

Additional technical questions should be resolved

While it is understood that the Watermaster operates under both schedule and budget constraints, per the Judgment, technical evaluations must use "sound scientific and engineering estimates" and incorporate the "best available records and data," (Judgment (24(w)). To this end, the following items warrant further consideration and clarification:

- In the Statement, the Motion, and in Annual Reports, the Watermaster discusses the influence of wet and dry years on Basin hydrology. However, it is unclear how water year types for the Basin are determined. In Exhibit I of the Statement, which shows Mojave River flow at the Forks, some water years are shown in red, while others are shown in blue, which may correspond to dry vs. wet. Most red years appear to exhibit below average flow at the Forks; however, not all years with very low flow are shown in red (e.g., 1934 and 1981). The Watermaster should provide details on how this foundational determination of year type is made.

[6] *City of Barstow vs. City of Adelanto,* No. CIV208568, **tentative ruling** (California Superior Court, Riverside County, 20 October 2025)

- The Watermaster presents available station-based precipitation data and notes that the station data are both temporally and spatially sparse. We offer that the readily-available PRISM[7] data provides daily, monthly, and annual precipitation totals, with annual precipitation totals going back to 1895. The Watermaster may consider supplementing their analysis with PRISM data, especially given PRISM's spatial and temporal coverage. Use of the more complete PRISM dataset may provide for correlation or other analysis to better demonstrate that Mojave River flow at the Forks is, in fact, an appropriate metric upon which to establish a hydrologic base period for all Subareas.
- Estimates of consumptive use of groundwater by phreatophytes in some Subareas appear to be based on a 1996 USGS report (as referenced in the 2022-23 Annual Report). It is not clear if the Watermaster intends to update these estimates for the proposed hydrologic base period.

In EKI's letters to the Watermaster to date, we continue to request opportunities to actively engage in ongoing and forthcoming technical analyses being conducted in the Basin, including RMBM development and other hydrogeological studies, such as hydrologic base period selection, as results of these studies could potentially significantly impact future determinations of PSY, Free Production Allowance, and overall Basin management.

Sincerely,

EKI ENVIRONMENT & WATER, INC.

Anona Dutton, PG, CHg
Vice President

[7] https://prism.oregonstate.edu/

EXHIBIT 4

eki environment & water

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19 December 2025

Derek Hoffman
Fennemore
550 E Hospitality Lane, Suite 350
San Bernardino, CA 92408

Subject: **Recommendation for a Hydrologic Base Period**
(EKI 50063.00)

Dear Mr. Hoffman:

EKI Environment & Water, Inc. (EKI) attended the 12 December 2025 Watermaster Workshop on New Hydrologic Base Period Selection and prepared the following comments. Previously, EKI reviewed and provided comments on *Watermaster Engineer's Statement of Reasons for Recommending a 2001-2020 Base Period* (Statement)[1] filed on 12 November 2025. EKI conducted these activities and provided the comments below to Fennemore in its role as Counsel to Mitsubishi Cement Corporation, Robertson's Ready Mix, Ltd., and CalPortland Company (collectively the "Clients") in the Mojave River Basin Area (Basin).

BACKGROUND

The Judgment defines Production Safe Yield (PSY) as, *"The highest average Annual Amount of water that can be produced from a Subarea: (1) over a sequence of years that is representative of long-term average annual natural water supply to the Subarea net of long-term average annual natural outflow from the Subarea, (2) under given patterns of Production, applied water, return flows and Consumptive Use, and (3) without resulting in a long-term net reduction of groundwater in storage in the Subarea."* The hydrologic base period is used to inform numerous budget terms in the calculation of PSY such as surface water inflows and outflows. While many components of natural water supply are highly variable from year to year the Basin, the purpose of the hydrologic base period is to provide reasonable estimates of long-term averages for water supply planning.

KEY COMMENTS

In the Statement, the Watermaster proposed five potential hydrologic base periods that purport to meet the criteria set forth in California Department of Water Resources' (DWR's) Bulletin No. 84, summarized below in **Table 1**. Also included therein is Watermaster's rationale for either recommending or not recommending a given hydrologic base period as presented in the 12 December 2025 workshop for the alternative hydrologic base periods presented in the Statement and the sixth presented at the Workshop.

[1] *Watermaster Engineer's Statement of Reasons for Recommending 2001-2020 Base Period,* November 12, 2025.

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Table 1 - Hydrologic Base Periods Evaluated by Watermaster

Hydrologic Base Period	Change Relative to 1931-1990	Watermaster Rationale
1991-2022	8%	Watermaster **does not recommend** because: • "Average water supply is 8% higher than the average of the initial base period 1931-1990, which might indicate a higher PSY value." • "Water supply at the Forks during Water Years 1992 to 1995 was about 3 times the long-term average supply." • "Include years that are not representative of recent cultural conditions: agricultural pumping and land uses have greatly changed since the 1990s." • "Court requested consideration of a **drier and more recent hydrologic base period.**"
1995-2024	2%	Watermaster **does not recommend** because: • "Average water supply is 2% higher than the average of the initial base period 1931-1990, which might indicate a higher PSY value." • "It includes years that are not representative of recent cultural conditions: agricultural pumping and land uses have greatly changed since the 1990s." • "Court requested consideration of a **drier and more recent hydrologic base period.**"
1998-2024	-1%	Watermaster **does not recommend** because: • "Average water supply is 1% drier than the average of the initial base period 1931-1990, which might indicate a higher PSY value." • "It includes years that are not representative of recent cultural conditions: agricultural pumping and land uses have greatly changed since the 1990s." • "Court requested consideration of a drier and **more recent hydrologic base period.**"
2002-2022	-11%	Watermaster **does not recommend** because: • "Average water supply is 11% drier than the average of the initial base period 1931-1990; therefore, the indicated water supply does not 'closely approximate' the long-term water supply during the 1931-1990 base period." • "The UMBM is calibrated through year 2020 only, and the alternative 2002-2022 base period is outside the period of UMBM calibration."
1931-2022	3%	Watermaster **does not recommend** because: • "Average water supply is 3% higher than the average of the 1931-1990 base period, which might result in higher PSY values." • "It also includes many years that are not representative of current cultural conditions: agricultural pumping and land uses have greatly changed since the 1930s, 1950s, and 1990s." • "The Court requested consideration of a **drier and more recent hydrologic base period.**"
2001-2020	-6%	Watermaster **recommends** because: • "Meets guidance of DWR Bulletin 84." • "Average water supply is 6% drier than the average of the initial base period 1931-1990." • "Fits the UMBM model calibration period (ending in 2020)." • "Includes and is more representative of current cultural conditions." • "It satisfies the Court's request for a **drier and more recent hydrologic base period.**"

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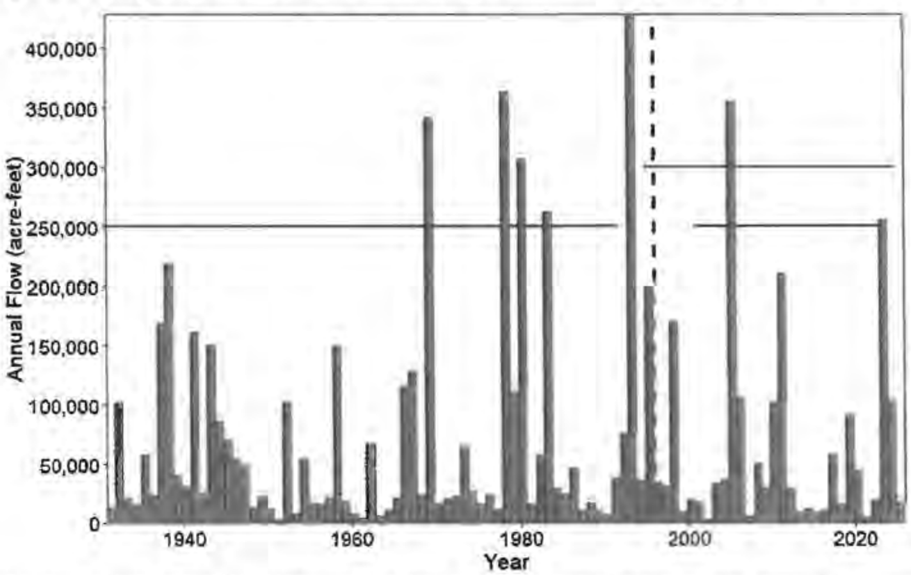
Per Bulletin No. 84, a hydrologic base period should include *"normal and extreme wet and dry years. Both the beginning and the end of the base period should be preceded by a series of wet or a series of dry years... [and the] base period should also be within the period of available records and should include recent cultural conditions,"* (pages 47-48). EKI has reviewed these alternatives and the Watermaster's rationale and has the following comments. These comments are provided based on the limited data available and under a compressed timeline, and while we await the Watermaster's response to questions raised in our previous letter[2]. Our comments and recommendations are subject to revision based on responses from the Watermaster to both our letter and to letters from other parties.

Watermaster should reconsider 1995-2024 as the most appropriate hydrologic base period

Based on a review of the available data, EKI recommends that 1995-2024 be adopted as the hydrologic base period. The 1995-2024 hydrologic base period, the Watermaster's proposed hydrologic base period of 2001-2020, and the original base period of 1931-1990, along with Mojave River flow at the Forks, are shown below on **Figure 1**. The proposed hydrologic base period of 1995-2024 is appropriate because it: (1) best reflects the time period over which the physical solution set forth in the Stipulated Judgment has been adopted; (2) contains recent years during which significant changes in cultural conditions have occurred; and (3) contains both wet and dry hydrologic extremes, or "climatic disruptions" as they are referred to in the Court's September 2022 order.

Figure 1 – Mojave River Flow at the Forks and Potential Hydrologic Base Periods



Note: The original hydrologic base period (1931-1990) and the Watermaster's proposed hydrologic base period (2001-2020) are shown in a horizontal black line, 1995-2024 is shown in purple, and the entry of the Judgment in early 1996 is shown in red.

[2] EKI, 2025. *Comments on Watermaster Engineer's Statement of Reasons for Recommending a 2001-2020 Base Period.* December 10.

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1995-2024 most completely captures the timeframe of the physical solution

Of the viable alternatives identified by the Watermaster, a hydrologic base period of 1995-2024 most completely captures the time period during which the physical solution has been implemented, which represents an over-arching and significant cultural condition in the Basin. This period would capture cultural conditions more thoroughly than any of the other alternative hydrologic base periods proposed by the Watermaster, including 1998-2024, which begins several years after adoption of the physical solution.

1995-2024 most completely captures recent cultural conditions

To the extent that a hydrologic base period should capture "recent cultural conditions", a hydrologic base period extending as close to present as possible is most appropriate. The 1995-2024 period includes recent years where significant land use changes have occurred; these changes are not reflected in the alternative hydrologic base periods ending in 2020 and 2022. For example, as shown in the Exhibit H to the Statement, since 2021, water production for irrigation in Oeste has fallen to essentially zero and water production for irrigation in Baja has dropped significantly since 2020 (from 14,800 acre-feet per year [AFY] in 2020 to 5,500 AFY in 2024).

Further, while we understand that the UMBM, and forthcoming Regional Mojave Basin Model (RMBM) are calibrated through water year 2020, this is not grounds for exclusion of more recent water years from the hydrologic base period as the Watermaster suggests. If needed, a calibrated model can be extended past the period of calibration for the purpose of running future simulations and without the need for further calibration, as is done often in other actively managed groundwater basins.

1995-2024 contains "climatic disruptions", including wet and dry extremes

Climate change is expected to increase the frequency and magnitude of hydrologic extremes including both droughts and storm events[3]. The Court has asked the Watermaster to consider "climatic disruptions" in the selection of a hydrologic base period. Exclusion of hydrologic base periods that include extreme wet years based on slightly elevated average flows at the Forks is not appropriate if the proposed hydrologic base period otherwise captures hydrologic extremes, or "climatic disruptions". The hydrologic base period 1995-2024 includes years of such hydrologic extremes that are anticipated to continue to occur in the Basin, including extreme wet years like 2005 and 2023, and multi-year dry periods like 1999-2002 and 2013-2018.

In 2013, the Bureau of Reclamation (Bureau) published the Mojave River Watershed Climate Change Assessment in cooperation with Mojave Water Agency (MWA)[4]. In this report, the Bureau and MWA present results of hydrologic simulations from 1950 to 1999 using the Variable Infiltration Capacity (VIC) model and analyzed results near three USGS stream gages (Deep Creek, West Fork, and Lower Narrows). Figure 8 from this report is included here as **Figure 2.** This figure presents simulation results at Deep Creek near Hesperia, one of the components of flow at the Forks. Describing this figure, the Bureau states that

[3] Based on Watermaster response at the 12 December Workshop, wet years are characterized by above average flow at the Forks (65,538 AFY), while dry years are characterized by below average flow at the Forks. A formal year-by-year designation of water year type, particularly detailing normal versus extreme, has not been provided to date.
[4] https://www.mojavewater.org/wp-content/uploads/2023/12/appendix-g_all.pdf

"Runoff trends are also consistent between gages. All locations show a nominal decline in annual and December to March, while the uncertainty envelope remains largely constant," (page 26).

Despite nominal decreases in the median, simulation results show future extreme high flow events like those seen in the 1990s, particularly for December-March runoff which constitutes the largest Basin inflow. While the Bureau projects that median flows are likely to decline in the future, especially for April through July runoff (when runoff totals are a fraction of those observed December to March), extreme flow events are expected to continue into the future. As such, exclusion of 1995-2024 because it includes extreme wet years is not appropriate. **Figure 1** shows that flow at the Forks in 1995 is well within the range of flows observed since. Additionally, despite these high flow years in the 1990s, flow at the Forks during 1995-2024 is largely similar to that of the original base period of 1931-1990 (approximately 2% different).

Figure 2 - Figure 8 from U.S. Bureau of Reclamation Mojave River Watershed Climate Change Assessment

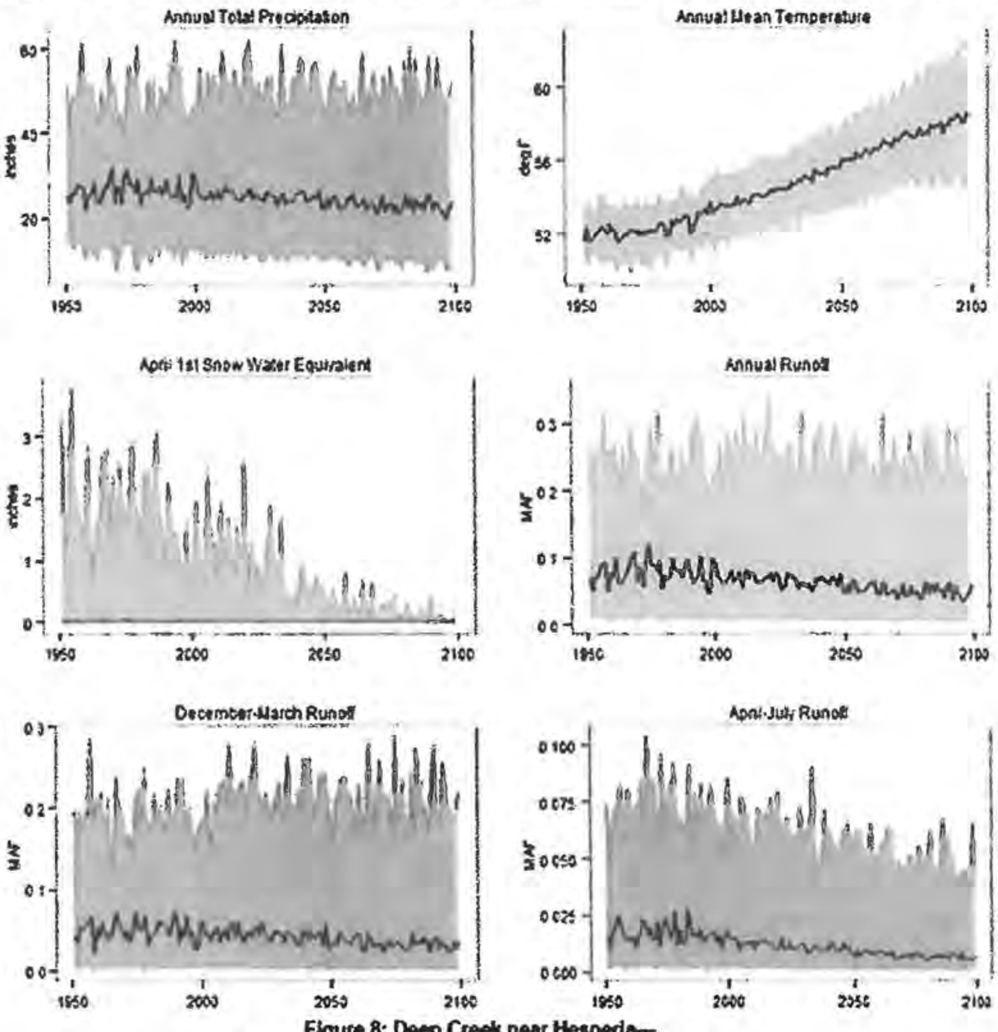

**Figure 8: Deep Creek near Hesperia—
projection ensemble for six hydroclimate indicators
(black line is 50th percentile [ensemble median]).**

In summary, 1995-2024 appears to be the most appropriate hydrologic base period of the alternatives identified by the Watermaster because it:

- Most fully captures the years during which the physical solution established by the Judgment was in place;
- Contains recent years which best reflect changing cultural conditions in various Subareas; and,
- Exhibits hydrology that captures "climate disruptions" while staying largely similar to averages over the longer period of record and to estimates of future hydrologic conditions.

Ongoing technical questions and transparency

In EKI's letters to the Watermaster to date, we continue to request opportunities to actively engage in ongoing and forthcoming technical analyses being conducted in the Basin, including RMBM development and other hydrogeological studies, such as hydrologic base period selection, as results of these studies could potentially significantly impact future determinations of PSY, Free Production Allowance, and overall Basin management. In our December letter, we also raised clarifying questions to increase transparency for all parties involved and look forward to the Watermaster's response. We appreciate the efforts to date to involve interested parties in these discussions.

Sincerely,

EKI ENVIRONMENT & WATER, INC.

Anona Dutton, PG, CHg
Vice President

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January 13, 2026

Via Email: watermaster@mojavewater.org

Board of Directors
Mojave Basin Area Watermaster
Mojave Water Agency
13846 Conference Center Drive
Apple Valley, CA 92307-4377

Re: **January 14, 2026 Special Watermaster Meeting**
Items 5 and 6: New Hydrologic Base Period

Victorville Water District (VWD) renews its December 12, 2025 comments. VWD does not object to the use of the 2001 to 2020 Base Period for Water Year 2026/2027 but requests that the Watermaster commit to using a longer Base Period in Water Year 2027/2028 and future updates. The omission of the 2021 to 2024 Water Years from the proposed 2001 to 2020 Base Period does not include most recent cultural conditions and skews the average, resulting in a much drier, more conservative Base Period (especially compared to the more representative long-term average hydrologic period from 1931 to 2024).

VWD is concerned that an overly conservative Base Period will be hard-wired into the updated Mojave River Basin Model and will not be reevaluated, which may lead to significant reductions in modeled Production Safe Yield (PSY) and Free Production Allowance (FPA). VWD's consulting hydrogeologist Peter Leffler asserts that longer hydrologic periods are more representative of future conditions, especially when climate change may both increase average annual temperature and frequency of drought periods while increasing the frequency and/or magnitude of large storm events that are the primary driver of long-term average annual basin recharge best. It is strongly recommended that 1931 to 2024 (as opposed to 1931 to 1990) be used as the reference hydrologic period to evaluate proposed base periods, and that the ultimate base period to be selected be longer than 20 years.

VWD recommends that Watermaster adopt a more comprehensive base period such as 1995-2024 or 1998-2024 starting in Water Year 2027/2028 or as soon as the updated Mojave River Basin Model is completed and ready to inform future PSY and FPA. The two potential base periods starting in the 1990s are close to but slightly drier than the long term reference period of 1931 to 2024, and incorporation of late 1990s cultural conditions are offset by inclusion of more recent cultural conditions from the 2020s.

VWD thanks Watermaster for considering its comments.

Sincerely,

LAW OFFICE OF PETER KIEL PC

Peter J. Kiel
Counsel for the City of Victorville and
Victorville Water District

cc: Leland McElhaney, Watermaster Counsel
Robert Wagner, Watermaster Engineer

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January 13, 2026

Via Email: watermaster@mojavewater.org

Board of Directors
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Re: **January 14, 2026 Special Watermaster Meeting**
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VWD thanks Watermaster for considering its comments.

Sincerely,

LAW OFFICE OF PETER KIEL PC

Peter J. Kiel
Counsel for the City of Victorville and
Victorville Water District

cc: Leland McElhaney, Watermaster Counsel
Robert Wagner, Watermaster Engineer

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Attorneys for NEWBERRY SPRINGS RECREATIONAL LAKES ASSOCIATION

SUPEROR COURT FOR THE STATE OF CALIFORNIA

COUNTY OF RIVERSIDE – CENTRAL DISTRICT

CITY OF BARSTOW, et al. Plaintiffs, vs. CITY OF ADELANTO, et al. Defendants, AND RELATED CROSS-ACTIONS.	CASE NO: CIV 208568 NEWBERRY SPRINGS ISSUES AND QUESTIONS FOR DISCUSSION AT WATERMASTER WORKSHOP SET FOR JANUARY 14, 2026. Hearing Information: None Set Date: Time: Dept: Before the Hon. Craig G. Riemer, Judge ISSUES QUESTIONS FOR JAN 14 2026

TO ALL INTERESTED PARTIES AND THEIR ATTORNEYS:

NEWBERRY SPRINGS RECREATIONAL LAKES ASSOCIATION submits the following ISSUES AND QUESTIONS FOR DISCUSSION AT WATERMASTER WORKSHOP SET FOR JANUARY 14, 2026.

Procedural Issues:

It has been stated that the Watermaster attorney was ordered to file a motion to change the base period. Review of relevant orders do not demonstrate such an order.

1. Please identify and clarify such an order, if existing. See excerpts of prior orders attached hereto as Exhibit A.
2. Please articulate in detail, the justification for changing the base period.
3. Will all water experts have a chance to review and provide input to the stated justification?
4. Please detail the procedural process for implementing the change, given the fact that the original judgment had to be reviewed and signed by all stipulating parties. As all parties bound by the judgment stipulated to and relied upon the terms of the original stipulated judgment, does this change occur without full vetting to all parties? Is this a potential denial of due process?
5. Given the discussion necessary, is there a motion already filed and will it be withdrawn?
6. Will base periods be considered by individual subarea or comprehensively. If different for each subarea, should each subarea be considered as a separate motion or new stipulation? If not, and one comprehensive plan is envisioned, why are we not waiting for the release of the new regional (MRBRM) model so this exercise/analysis does not have to be undertaken more than one time?

Substantive Issues:

1. Base Period Selection Process: Will the WM use the Bulletin 84 criteria or create some new formula to determine a new base period? Unless the analysis and reasoning of Bulletin 84 is found to be defective, and substantiated in an evidence-based fashion, should not that be the procedure used by the WM to formulate and propose a new shorter Base Period?

Bulletin 84, page 13, reflects that the years 1904-05 through 1960-61 were used as the Long-Time Hydrologic Condition, upon which the recommended study of a new base period would be based. The original 57-year period was the best representation of long-time hydrologic conditions. The 25-year period then selected as the base period in the study (1936-37-1960-61), when preceded and/or followed by cycles of wet and dry years, best replicated the long-time hydrologic conditions with a difference in findings of approximately one percent. It was considered most reliable and was more current in time for the purposes of the study conducted.

Similar in nature is the long-time period agreed to in our stipulated judgment to the Adjudication. The 1931-1990 time frame can be seen as the Long-Time Hydrological Condition from which to assess and identify a new, more current and shorter Base Period, which replicates the hydrologic conditions of the 1931-1990 time frame.

If Watermaster (WM) is relying on the formulae of Bulletin 84, then the WM proposed 2001-2020 base period is not analogous to the formulae because the difference approximates 6%. Rather, attention should be given to the 1998-2024 base period, as during that time the difference between the conditions in the Long-time period vs this new 25-year period reflects a 1% difference. (similar to Bulletin 84).

2. It does not seem logical to simply add current data onto the current base period, e.g. 1931-2022, as this creates a 3% increase (variance) from long-time conditions. If the data from the 2023-24 water year was added, the difference would be even greater, as those were wet years. If the WM disagrees, please provide evidence-based substantiation of that position.

3. Newberry does not accept the rationale of responding to the Court, by suggesting that the Court asked for a drier and more recent base period. The Court and the Watermaster are (or should be) committed to follow the science. A base period should be a reasonable assumption of precipitation expectation in future years, more likely than not to repeat, and based on the long-time data. If WM does not agree, please provide justification and alternative analysis or explanation.

4. Question, will the new MRBRM conduct analysis similar to Bulletin 84? If so, won't there be sufficient data to support a proposed new Base Period that is grounded in established principles, already relied upon?

Conclusion:

Newberry Springs Recreational Lakes Assn's choice would be to continue with the agreed upon Base Period set forth in the Judgment (1930-1990 base period), since securing consent to a new proposed based period appears cumbersome and unlikely.

In the alternative, Newberry suggests that the WM selects the 1998-2024 base period since it most closely replicates the current one. Watermaster said at the meeting, they did not choose this one, because they only had data up through 2022. Now that the data exists, that is no longer an excuse not to use this period.

The motion to Change or Modify the Base Period should be withdrawn and not refiled until the process, analysis and evidence is completed. A decision of the most efficient and effective use of experts, consultants, time, resources and public funds should be significant factors in adopting a course of action.

Dated: January 6, 2026

Respectfully submitted,

/s/ *Diana J. Carloni*
Electronically signed to Expedite
DIANA J. CARLONI, Esq.
Attorney for Newberry Springs
Recreational Lakes Assn.

Excerpts of prior orders:

October 23, 2024 order.

8. The Judgment requires PSY to be based on" a sequence of years that is representative of the long-term average." In the motion to enforce the judgment, both the Watermaster and Victorville criticized Golden State for cherry-picking a misleadingly short time frame for comparing groundwater levels. Similarly, in its 7-3- 24 order, the Court criticized the Watermaster for relying on short timeframes and inconsistent timeframes. Sometimes the Watermaster has cited to the 1931- 1990 average, but other times the WM has relied on 20-year or even 5-year averages.

a. *Is the 1931- 1990 timeframe representative of the climate in the basin today?*

b. *How long is " long-term?" 20 years? 30 years? 40 years? Longer?*

c. *Is the 1931- 1990 timeframe representative of the climate in the basin How long is " long-term?" 20 years? 30 years? 40 years? Longer? Should the Court establish a different base period to be used when adjusting PSY and FPA and when questioning the accuracy of the Watermaster' s model or recommendations? If so, when should that period begin and end?*

Order of Aug 6th, 2025 – beginning page 4:

Hydrologic base period The Watermaster argued that the base period should be revised to be the period of 2001-2020. However, the motion did not expressly seek approval of that change. Any future motion by the Watermaster seeking approval of that change shall address the following issues:

1. In arguing for the adoption of 2001-2020 as the hydrologic base period, Mr. Wagner states at page 32 of the motion that the proposed base period "is reasonably representative of long-term hydrologic conditions,." citing to Exhibit 25 (at page. 405). Is that conclusion based solely on the similarity between the average Mojave River flow during 1931-1990 (65,538 AF¥) and the flow during 2001-2020 (61,635)? If not, what other factors support the conclusion that the proposed base period is reasonably representative?

2. Mr. Wagner states that in terms of the basin's water Supply, both the 1931-1990 and 2001 2020 periods are representative· of the long-term averages of the basin because the latter period is only 6 percent drier" than the prior period. (Mtn., pp. 74 & 76.) Is a 6 percent difference de minimis? If so, how large would the difference need to be before it would be considered significant?

EXHIBIT 5

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December 31, 2025

Via E-mail (dhoffman@fennemorelaw.com)
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RE: Mitsubishi, Robertson's, CalPortland Comment Letter re Watermaster Recommendations for New Hydrologic Base Period

Dear Mr. Hoffman:

As you know, during the December 12, 2025 Watermaster workshop, we did not have an opportunity or the time necessary to answer all questions presented in your December 11, 2025 comment letter. We attempt to so below.

A. Applicability of DWR Bulletin 84

1. No response required.

2. Yes.

3. Yes, the SGMA BMP does not appear to provide any significantly different criteria for the selection of a base period. Additionally, SGMA provides a definition for the sustainable yield which fully aligns with the Judgment's definition of the PSY. See the following excerpt from the DWR BMP for SGMA, Water Budget, (2016) with the references to a "base period."

> (w) "Sustainable yield" means the maximum quantity of water, calculated over a base period representative of long-term conditions in the basin and including any temporary surplus, that can be withdrawn annually from a groundwater supply without causing an undesirable result.
>
> It also is consistent with the definition of PSY set forth in the Judgment.

B. Initial Hydrologic Base Period 1931-1990

1. Because the Mojave River is the primary source of surface flow to the Basin, this determination is based primarily upon the surface water flows measured at the Forks. Wet

years are years where the surface flow is greater than the average surface flow from 1931-1990; dry years are years where the surface flow is less than the average surface flow from 1931-1990. "Extreme" wet and dry years are those years when surface flows are far above or below the magnitude of the average surface flow from 1931-1990.

2. Yes, because the Mojave River is the main surface water source for the Basin, and the flow at the Forks is the best representation of wet and dry years for the Basin. However, Watermaster also looks at the precipitation records in the various watersheds, gage flows at the Lower Narrows, recycled water contributions in the TZ from VVWRA, calculated flows at the Helendale Fault, gage flows near Hodge, and gage flows at Barstow and Afton.

C. Water Supply to the Basin Area

1. There was a stream flow gage in Este in the Cushenbury Wash that was discontinued for a long period, and was recently re-activated. There also is a new stream flow gage at Sheep Creek Wash in Oeste. Reports Watermaster gives consideration to include, but are not limited to the following: DWR Bulletin 84 (1967), Webb (2000), Hardt (1971), Stamos (2001), the USGS Regional Water Table maps, the Upper Basin Mojave River Model, the Oeste Hydrologic Atlas and Oeste Hydrologic Sub-Area Hydrogeologic Report (2009), Este Hydrologic Atlas (2005), the USGS 2022 report "Hydrogeology and Simulation of Groundwater Flow in the Lucerne Valley Groundwater Basin, California"

2. Yes, Watermaster considers precipitation data provided by NOAA and San Bernardino County.

D. Watermaster Proposed Hydrologic Base Period 2001-2020

1. The model results may provide information that suggests recommending a new hydrologic base period. If so, Watermaster will report that information to the Court and interested parties. When there is a working model it will be used to develop management scenarios to evaluate all various water supply conditions for setting PSY and FPA allowances.

E. Hydrologic Base Period vs. Pumping and Consumptive Uses for purposes of PSY determination

1. The Webb report in 2000 used the 1998 year for pumping and consumptive use, although the Watermaster's base period was then from 1931-1990. Likewise, Watermaster has consistently used the most recent pumping and groundwater level information for PSY calculations.

2. No. Watermaster's position is that the hydrologic base period is foundational to PSY, although it is not the only source of data to be used in determining PSY.

3. See response to number 1. A "representative year" is what we expect would be similar to the future pumping and consumptive use. The base period is the part of the PSY calculation that provides the average water supply to the Basin, with the expectation that

this pattern will repeat itself in the future for planning purposes. For PSY determination, we expect that pumping in the near future approximates the current pumping patterns. The 2024 PSY Update prepared by Watermaster considered the most recently available data of pumping and consumptive use data (2018 to 2022), and water year 2022 was "assumed to represent pumping and consumptive uses on a forward-looking basis." (page 3 of the Watermaster Memorandum titled "Updates for PSY, Consumptive Uses, and Free Production Allowance Recommendations (FPA) for Water Year 2024-25") The factors used for the representative year include the land use, pumping, consumptive uses.

4. There is no contradiction. 1990 was the most recent data available at the time the initial PSY calculation was determined. The fact that 1990 was within the base period 1931-1990 **was not** the criteria for its selection as representative year for cultural conditions.

5. In Watermater's judgment, measured ground water pumping and ground water level measurements are the most reliable information available for PSY calculations in the Baja, Este and Oeste Subareas. The Judgment states that "Where actual records of data are not available, Watermaster shall rely on and use sound scientific and engineering estimates." (paragraph 24 w of the Judgment)

6. Paragraph 24w of the Judgment mandates that Watermaster "rely on and use the best available records of data." Also, expert Dutton notes "PSY is total production in each Subarea plus the surplus or deficit of water supply."

7. For the Baja Subarea, the regional model will help to eliminate data gaps. For Este and Oeste Subareas, recently installed streamflow gages at Cushenbury Wash and Sheep Creek respectively. Also, the new stream flow gage at Kane Wash in the Baja Subarea.

8. Not for the 2026-2027 Water Year.

F. Evaluation of Alternative Hydrologic Base Periods

1. As previously indicated, Watermaster also agrees it is now appropriate to select a more recent and drier base period than 1931-1990.

2. No.

3. 6% drier than in the 1931-1990 base period. This is based on the data available for the Mojave River measured surface flows at the Forks for both the 1931-1990 base period and the 2001-2020 new base period.

4. The modeling is being performed and paid for by the Mojave Water Agency, not the Watermaster. At present, the Mojave Water Agency does not intend to re-calibrate the UMBM to capture data beyond 2020. The UMBM will be replaced by the new Regional Groundwater Model.

5. This question is unclear. The year 2022 was selected as representative of water supply use and disposal for future planning.

6. Watermaster's 2024 PSY values were based upon water supply during the 2001-2020 base period, and water uses based on 2022 data (which does not rely on the model, but is verified measured production), except for the Baja and Este Subareas for which Watermaster used pumping data and interpretation of water levels.

7. The magnitude of the 2002-2022 base period is about 11-percent drier than the average of the 1931-1990 base period; the difference is about 6,529 acre-feet. The magnitude of the 2001-2020 base period is about 6-percent drier than the 1931-1990 base period; the difference between the average 2001-2020 and the 1931-1990 base period is about 3,903 acre-feet.

G. Cultural Conditions Evaluation

1. No response required.

2. The 1990s were abnormally high in terms of surface water supply, as measured at the Forks. See graph of surface flows at the Forks in the 1990s, compared to other time periods. As noted above, Watermaster defines extreme wet years as far above the "normal" average water supply. Any period that would include the 1990s shows a higher average water supply than the 1931-1990 long-term average and, therefore, would not represent the recent drier conditions. Additionally, the land uses in the 1990s are not comparable to current land uses.

3. No.

Response to Comments from EKI Environment & Water, Inc. (EKI)

The EKI report seems to suggest "the impact of the proposed hydrologic base period and the calculation of PSY in each subarea" should be considered in determining an appropriate base period. The solution to this over drafted basin is to require the purchase of replacement water. Accordingly, the "impact" of the proposed hydrologic base period (which is a drier base period than the 1931-1990 base period) may result in lower PSY values which, in turn, would require the purchase of replacement water.

The EKI Comment Letter also states:

In the Statement [of Reasons], Watermaster claims that *"Today's cultural conditions are represented by the new recent hydrologic base period of 2001-2020,"* (page 19). However, elsewhere in the Statement, and as quoted above, Watermaster explains that *"Even though the hydrologic base period of 2001-2020 was recommended by Watermaster for all Subareas, Watermaster recognizes that for the Baja Subarea, special circumstances may warrant PSY determination based on limited data. For the Baja Subarea, the only reliable data available is pumping and water level measurements (which show recent recovery). This is true for the Este Subarea and the Oeste Subarea as well,"* (page 14). While this may be a reasonable approach, it is unclear what criteria and process the Watermaster will use to determine what subset of available data for a given Subarea will be used to estimate PSY. (Italics added.)

Therein, EKI acknowledges that comparison of pumping and water level measurements is "a reasonable approach" where, as here, pumping and water level measurements are the only "reliable data available."

Now that we have had an opportunity to respond to the comments/questions in your letter, we believe a meeting would be useful to further discuss the issues presented. To that end and subject to your availability and that of your expert witness, I propose a remote meeting on either August 8, 2026, from 10:00 a.m. to Noon, or on August 9, 2026, from 9:00 a.m. to 11:00 a.m. Please advise as soon as you are able as to whether those dates and time work for you and your expert.

Very truly yours,

BRUNICK, McELHANEY & KENNEDY PLC

LELAND P. McELHANEY

LPM\pjq

cc: Jeffrey Ruesch
Robert C. Wagner

u:\MWA\HoffmanDerekLtr12.31.25

PROOF OF SERVICE

STATE OF CALIFORNIA }
COUNTY OF SAN BERNARDINO}

I am employed in the County of the San Bernardino, State of California. I am over the age of 18 and not a party to the within action; my business address is 13846 Conference Center Drive, Apple Valley, California 92307.

On February 24, 2026, the document(s) described below were served pursuant to the Mojave Basin Area Watermaster's Rules and Regulations paragraph 8.B.2 which provides for service by electronic mail upon election by the Party or paragraph 10.D, which provides that Watermaster shall mail a postcard describing each document being served, to each Party or its designee according to the official service list, a copy of which is attached hereto, and which shall be maintained by the Mojave Basin Area Watermaster pursuant to Paragraph 37 of the Judgment. Served documents will be posted to and maintained on the Mojave Water Agency's internet website for printing and/or download by Parties wishing to do so.

Document(s) filed with the court and served herein are described as follows:

Watermaster's Renewed Motion for Determination of Hydrologic Base Period for Calculation of Production Safe Yield Values; Memorandum of Points and Authorities; Supporting Declaration

_X_ (STATE) I declare under penalty of perjury under the laws of the State of California that the above is true and correct.

Executed on February 24, 2026 at Apple Valley, California.

____
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Mojave Basin Area Watermaster Service List as of February 24, 2026

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Mojave Basin Area Watermaster Service List as of February 24, 2026

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