Mojave Basin Area Watermaster

Appendix E

Baja Subarea

Water Supply Update

Prepared by:

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February 28, 2024

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MEMORANDUM

To: Mojave Basin Area Watermaster

From: Robert C. Wagner, P.E.

Date: February 28, 2024

Re: **Production Safe Yield and Water Supply Update for Baja Subarea**
Recommendation for Free Production Allowance for Water Year 2024-25
Evaluation of Water Levels as indicator of Change in Storage

This memorandum sets forth findings from our review of water supply conditions in the Baja subarea and makes a recommendation for Production Safe Yield (PSY) based on significant reduction in pumping since 2015-2016 (-60%), and evaluation of changing water levels. In addition, we discuss two different approaches to the Baja Subarea water balance, changes to the estimate of phreatophyte usage, assumptions of ungaged tributary inflow, and the need to change the estimated production by minimal producers. While the water balances included herein serves as a coarse crosscheck for the PSY recommendation, we are using the water level hydrographs to form the basis for our recommendation.

The Baja Subarea is one of the five subareas within the Mojave Basin Area Adjudication (**Figure 1**). The boundaries along the Mojave River are generally downstream of the Waterman Fault area, near Nebo and continuing to Afton. There are no gages for measuring inflow to Baja, as the USGS gaging station at Barstow is about 5 miles upstream from the Waterman Fault. The gage at Barstow, adjusted for Waterman Fault, is considered the inflow to Baja. There is also no measurement for ungaged inflow (tributaries and desert washes) or mountain front recharge. Estimates of subsurface inflow were determined by USGS, Stamos, 2001, and are assumed representative of the subsurface inflow currently, as water levels near the subarea boundary between Centro and Baja are reasonably stable over time.

The USGS gaging station, Mojave River, Afton has been considered to represent outflow from the Baja subarea, and in general when the river carries sufficient flow to reach Afton this assumption is reasonable. However, storms occur that produce flow at Afton and are not measured at Barstow, understating the recharge potential to Baja.

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Water Balances
Baja Table 5-1 (1931-1990), attached as Table 1, shows an estimate of long-term average water supply for the period 1931-1990 (17,358 acre feet), and an estimate of average outflow at Afton of 6,066 acre feet for the 1953-1990 (based on published records). For this analysis we have included an estimate of tributary inflow, (3,571 acre feet) based on the method described by Stamos, 2001. In this analysis, we have included the ungaged tributary inflow on the supply side (Table 1), assuming it is measured as outflow and recorded at Afton.

Baja Table 5-1 (2001-2020), attached as Table 2, shows an estimate of supply for the period 2001-2020, based on USGS measurements at Barstow, wastewater discharge at Barstow, and the elements shown on Table 2. Outflow is based on USGS measurements at Afton, adjusted to account for seasonal measurements where no flow is measured at Barstow. Phreatophytes use is shown as the average of the last 4 years, based on satellite imagery and earth surface energy balance to compute evapotranspiration.

Table 1 indicates a surplus based on long term average supply and outflow and current year consumptive uses of 1,795 acre feet. Table 1 also assumes that phreatophyte use is consistent with past estimates (2,000 acre feet). Table 2 indicates a deficit of 1,883 acre feet. Table 2 is based on estimate of supply for the 20 years (2001-2020), and current consumptive by phreatophytes and beneficial uses.

The PSY estimate based on long term supply is 14,544 acre feet (Table 1) and based on the 2001-2020 is 10,866 acre feet (Table 2). The average of PSY for two periods based on current consumptive uses is 12,705.

Phreatophytes
We estimated the current water use (evapotranspiration, ET) by phreatophytes in the Baja riparian habitat zone near Camp Cady. Exhibit H of the Judgment defines the "Harvard/Eastern Baja Riparian Zone" as the reach of the Mojave River that flows west to east from Harvard Road to Iron Ranch/Iron Mountain area. The Baja riparian area is about 1,389 acres (**Figure 2**). In 1996, Lines and Bilhorn estimated long term average water use by riparian plant communities to be about 2,000 acre feet per year (AFY) in this area.[1] In 2011, a study by the U.S. Bureau of Reclamation (USBR) and Utah State University (USU) estimated riparian ET for Baja to be about 2,000 AFY for 2007 and 2,500 AFY for 2010.[2]

The Watermaster has annually reported the amount of riparian use in the Baja subarea water balance. For this analysis the Watermaster Engineer relied on ET values computed from satellite-

[1] The estimate by Lines and Bilhorn (1996) relied on mapping using false-color infrared and low-level oblique photographs, vegetation and areal-density classification, and application of water-use rates from other studies.
[2] USBR and USU (2011) relied on mapping using airborne lidar, multispectral and thermal infrared data, vegetation and surface classification using multispectral imagery, and application of an ET model involving energy fluxes for soil and canopy components.

based imagery tools, which are publicly available from the online platform OpenET which provides ET data from multiple satellite-driven models. We estimated an average ET for the Baja riparian area of 984 AFY (see **Table 3**). The satellite-based model METRIC (Mapping EvapoTranspiration at high Resolution with Internalized Calibration) was selected for this calculation; the METRIC method computes ET as the residual of an energy balance applied at the earth's surface. We note that the method described to compute ET of riparian plant communities by remote sensing is less reliable than the same method applied to agricultural ET estimates.[3] Further, we understand and expect the California Department of Fish and Wildlife may have a better understanding of the riparian water use in Baja; we welcome their input and collaboration to establish a reliable value to include for the habitat elements of Exhibit H.

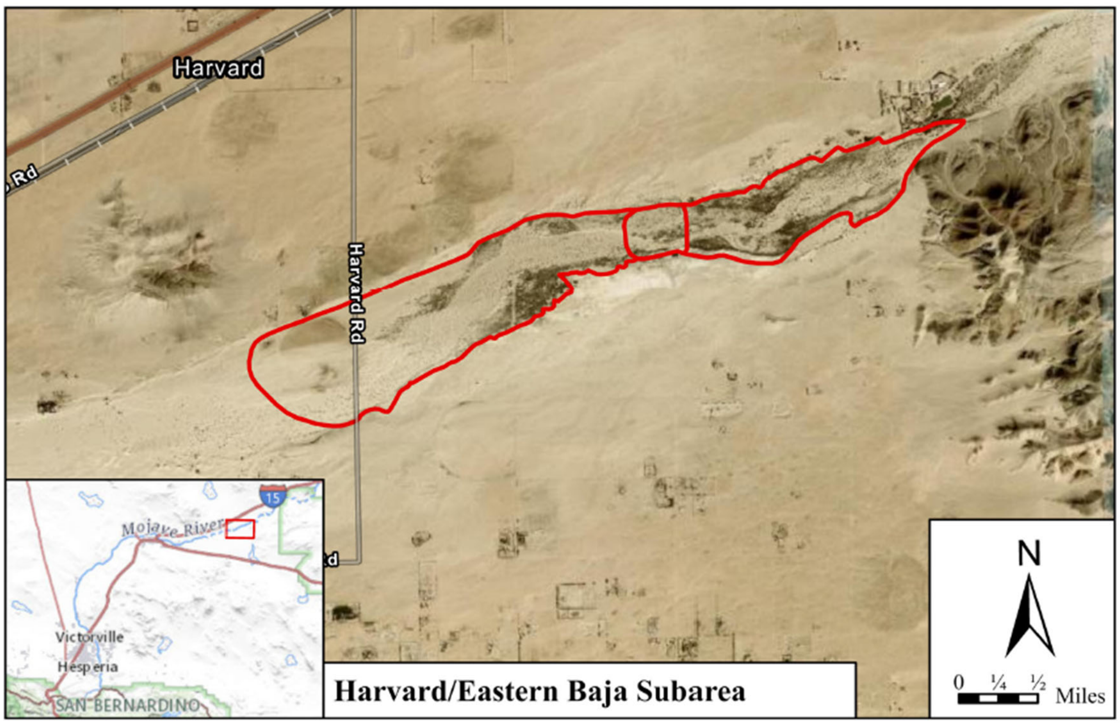


Figure 2. Harvard/Eastern Baja Riparian Zone.

[3] OpenET data is not a reliable method for ET estimates over open water bodies.

Table 3. Total ET for Baja riparian zone.

Water Year	Total ET (AFY)
2019	822.6
2020	694.8
2021	1,144.7
2022	1,275.6
4-year average	984.4

Minimal Producers

Minimal Producers, those pumpers not subject to the Judgment, have been estimated to pump 2,228 acre feet in the Baja subarea. This value has not been updated in several years, and likely overstates the actual water use by minimal producers. For example, the total population of Baja is about 4,000 residents, and assuming 57.5 gpdc, the total indoor water use would be only 258 acre feet, suggesting almost 2,000 acre feet of outdoor water use by minimal producers. We question this value. Total pumping in Baja has declined from more than 30,000 acre feet in 2015 to less than 13,000 acre feet in 2022, including the estimate for minimal producers. MWA will be undertaking the task to update minimal producer use in Baja in the next two years. We have included the current estimate, although we believe this overstates actual minimal producer use by about 50%.

Total Pumping and Water Level Response

Water production in Baja has been declining since before entry of Judgment (1996), from about 50,000 acre feet in 1996 to about 12,500 acre feet in 2023 (-75%). Historical water pumping in Baja is shown in **Figure 3**. Since 2016, pumping has further declined about 60%. The significance of this decline is apparent in the water level hydrographs that show changes in water levels throughout Baja over time (**Figure 4**). For many decades, most of the wells show a long term decline, meaning a depletion of groundwater in storage. However, consistent with the rapid reduction in pumping in the past 9-10 years, and the magnitude of the reduction in pumping over the past 30 years, water levels in some wells seem to be "flattening", meaning either having reached a low point, or will soon. Some wells show a rebound in water level, and some still are declining. Wells indicating flattening or recovery are in areas where pumping has declined significantly in recent years. Water level hydrographs are attached for inspection.

Production Safe Yield for Baja Subarea

The definition of production safe yield as used in the Judgment compares long term average supply to near term consumptive use. The base period for long term supply from the Judgment is 1931-1990, and the near term consumptive use has been considered to be 2017-2018 water year conditions. For this analysis we considered two base periods 1931-1990 and 2001-2020 with certain adjustments based on published values. The PSY calculation as shown on Tables 1 and 2 add the elements of supply and subtracts the elements of outflow to determine a surplus or a deficit. The surplus/deficit is added to the Total Production to determine the PSY. In effect, the PSY can be described as Pumping (P) plus Change in Storage equals PSY; P=PSY if change in storage is zero for some finite period.

As noted above, we calculate a small surplus under long term (1,795 acre feet) conditions and a similar deficit (1,883 acre feet) under shorter term conditions. The water level hydrographs for Baja suggest that the actual value is somewhere between the two. Assuming the water levels will continue to behave as shown for the past several years, and assuming that pumping does not increase, the PSY for Baja is likely about equal to or slightly greater than the current pumping for 2022, or about 12,749-acre feet. Based on the foregoing, we recommend PSY be set at 12,749 acre feet.

References

Allen, R., Irmak, A., Trezza, R., Hendrickx, JMH., Bastiaanssen, WGM., & Kjaersgaard, J. (2011). Satellite-based ET estimation in agriculture using SEBAL and METRIC. Hydrological Processes: an international journal, 25(26), 4011-4027. https://doi.org/10.1002/hyp.8408

Todd Engineers (2013). Final Report Hydrogeologic Investigation of Camp Cady Wildlife Area Newberry Springs, CA.

Simulation of Ground-Water Flow in the Mojave River Basin, California, Water Resources Investigations Report, 01-4002, Stamos, 2001

Lines, G.C., and Bilhorn, T.W., 1996, Riparian vegetation and its water use during 1995, along the Mojave River, southern California: USGS

Lines, G.C., 1996, Ground-water Surface water relations along the Mojave River, southern California

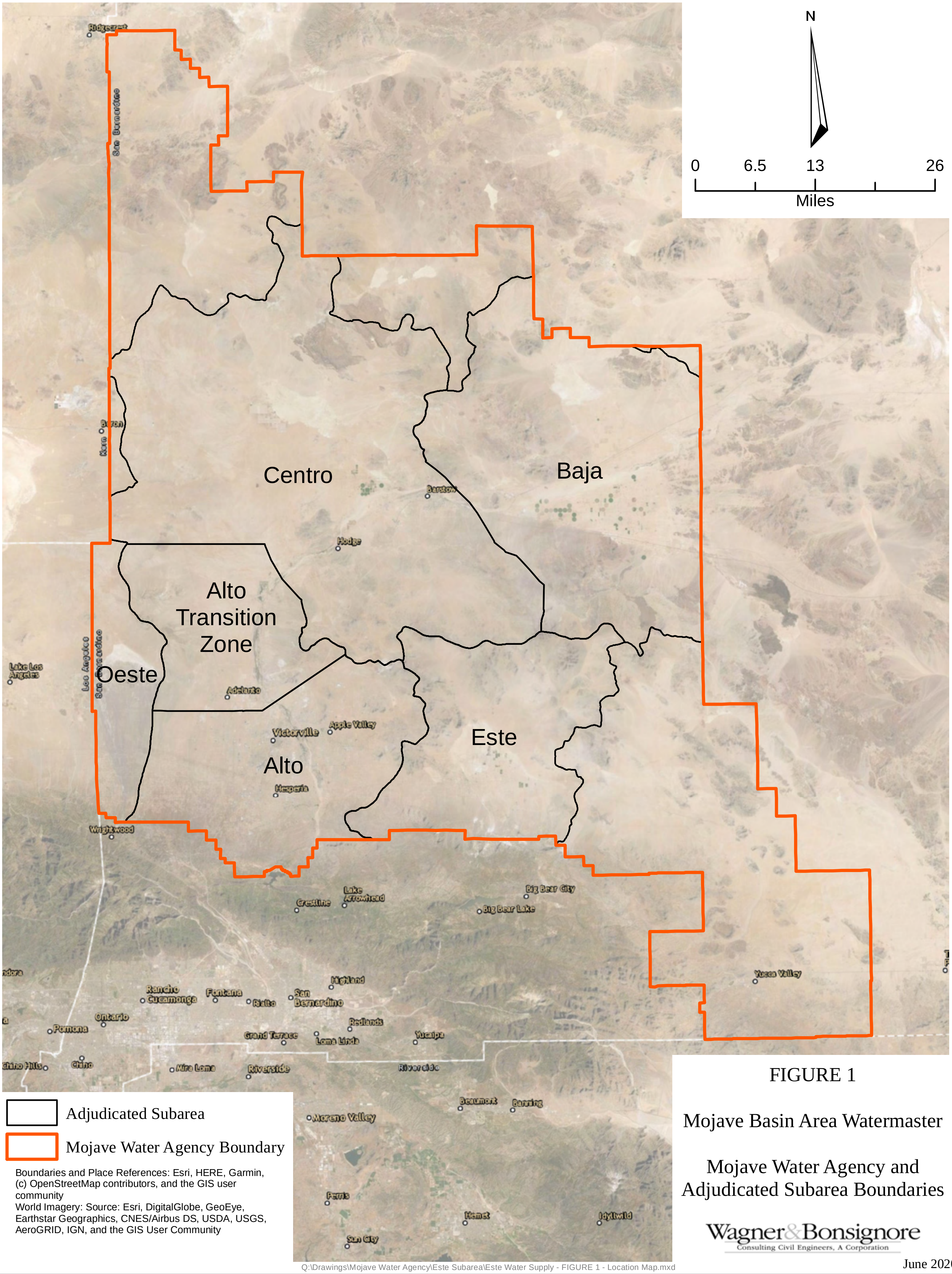


FIGURE 1

Mojave Basin Area Watermaster

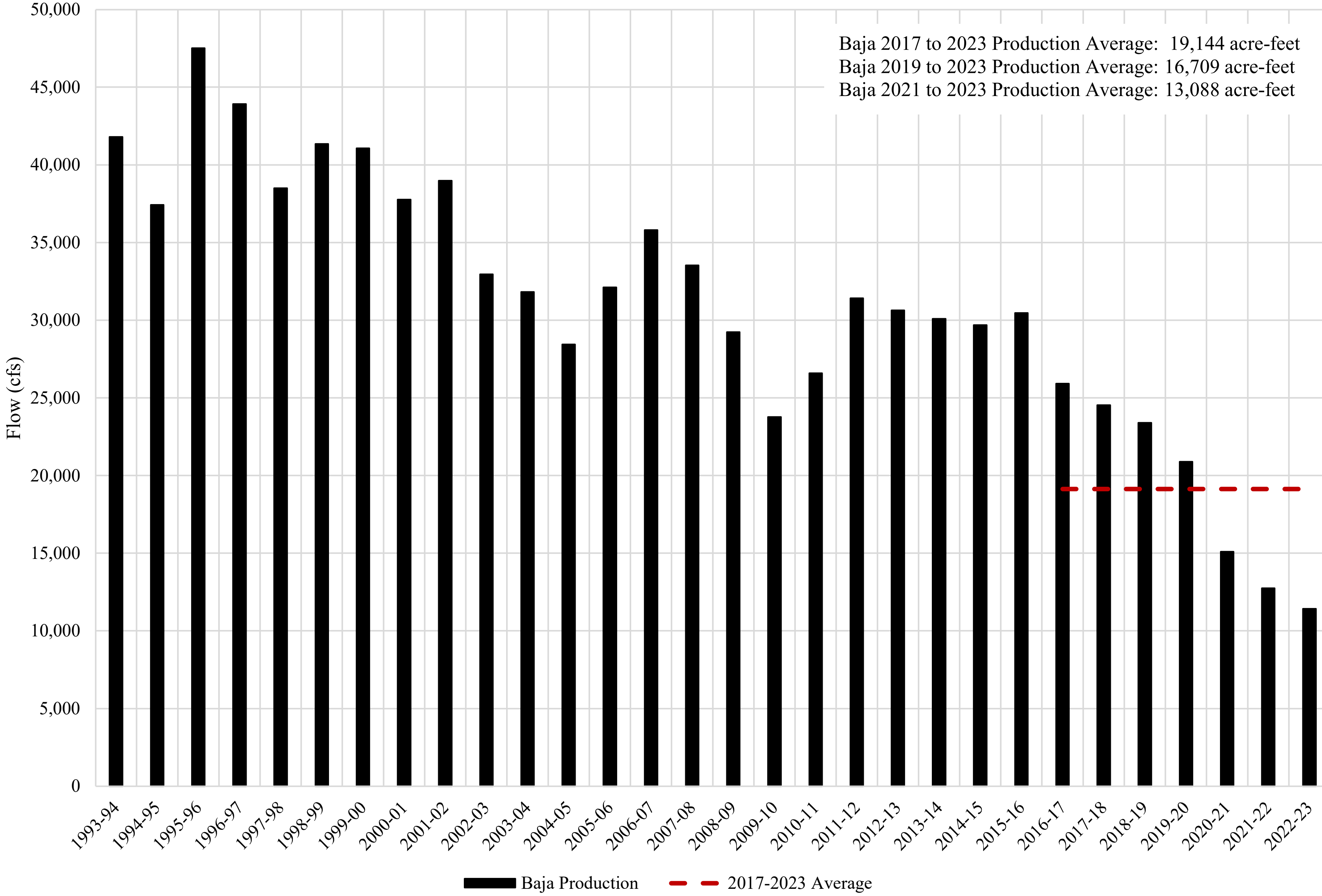
Mojave Water Agency and Adjudicated Subarea Boundaries

Wagner & Bonsignore
Consulting Civil Engineers, A Corporation

June 2020

Q:\Drawings\Mojave Water Agency\Este Subarea\Este Water Supply - FIGURE 1 - Location Map.mxd

FIGURE 3
Baja Production
2016 to 2023



G:\MOJAVE ADJUDICATION - 3020\Analysis\Groundwater Modeling\3020-033M-Baja Este and Oeste Pumping History Through 2023.xlsx

12N01E35A01
11N02E07A01 and 12N02E32G02 Composite
12N02E19K01 and 16A01 Composite
11N02E26R01
10N03E07R01
10N03E15Q01 and Q02 Composite
10N02E35A01
10N03E12F01
09N02E03K05-09
10N03E27J01-05
09N02E03E01
10N04E19M02
10N02E31L03
10N04E11C01
10N01E20M01-02
11N05E16J01
10N01E28G03
09N03E03D01, 03N02, 04K01, 10N03E34F02, 34L02 Composite
09N01E06H02
09N02E12F04
09N01W12L02-05
09N04E30E01
09N01E04K01-03, 10L01 Composite
09N03E22R04-07
09N01E16F01- 04
08N04E18Q03
09N01E10Q02-04
08N03E02M06
09N01E15H01,14M01, and 13E02 Composite
09N01E23J01
09N02E07Q01 and Q03 Composite
09N02E20Q01, K01, and G03 Composite
09N02E14N02 and Q02 Composite
09N03E34D01, N01, and 35D03 Composite
Groundwater Elevation (feet amsl)
Depth to Water (feet bgs)
NOTE: Water levels potentially influenced by pumping of well or wells in the vicinity.
Coyote Dry Lake
Yermo
Daggett
Barstow
Newberry Springs
Troy Dry Lake
Daggett / Yermo Recharge Site
Newberry Springs Recharge Site
Mojave River Pipeline
15
40
66
The Mojave Water Agency and U.S. Geological Survey are working together in a comprehensive program to monitor water levels and maintain historic records throughout the Regional Basin. The graphed wells are selected based on spatial and temporal representation of the Subarea. All wells on the Hydrograph Map are a part of the MWA Monitoring Program, and have data available to the public from either the Mojave Water Agency Website, the USGS National Water Information System or the California Statewide Groundwater Elevation Monitoring (CASGEM) Website.
For more information please contact Mojave Water Agency.
Mojave Water Agency
Data Sources:
MWA, US Census,
USGS/ NWIS,
DWR Bulletin 84 1967
Date: January 2024
Mojave Water Agency
Water Resources Department
Graphed Wells
MWA Monitoring Program Wells
Exhibit H Riparian Habitat Area
CA Geologic Faults (CGS, USGS)
MWA Recharge Pipeline
MWA Recharge Site
Baja Subarea
Hydrographs 2024
Recent record
Long-term record (begins ~1950 to ~ 1980)
Very long-term record (begins ~1920)
0
2
4
Miles
N

FIGURE 4

TABLE 1

TABLE 5-1 (1931-1990)
BAJA SUBAREA HYDROLOGICAL INVENTORY BASED ON LONG TERM AVERAGE NATURAL WATER SUPPLY AND OUTFLOW AND 2021-22 IMPORTS AND CONSUMPTIVE USE

(ALL AMOUNTS IN ACRE-FEET)

		Baja
WATER SUPPLY		
Surface Water Inflow		17,358 [1]
Subsurface Inflow		1,581 [2]
Deep Percolation of Precipitation		100
Tributary Inflow		3,571 [3]
	TOTAL	**22,610**
CONSUMPTIVE USE AND OUTFLOW		
Surface Water Outflow		6,066 [4]
Subsurface Outflow		0
Consumptive use		
Agriculture		6,092 [5]
Urban		6,657
Phreatophytes		2,000
	TOTAL	**20,815**
Surplus / (Deficit)		1,795
Total Estimated Production		12,749
PRODUCTION SAFE YIELD		**14,544**

[1] Estimated from reported flows at USGS gaging station, Mojave River at Barstow. Includes 16,406 af of Mojave River surface flow across the Waterman Fault estimated by "Evaluations of Potential Mojave River Recharge Losses between Barstow and Waterman Fault", Wagner & Bonsignore, 2012 (see Appendix A, Table 6), and 747 af of local surface inflow from Kane Wash and Boom Creek, and 205 af from washes (Wagner, 2011).

[2] Stamos, 2001 (USGS).

[3] Stamos page 15, 2001 (USGS).

[4] Based on USGS station Mojave River at Afton, CA (10263000) reported discharge for 1953-1990. Water Years 1979 and 1980 estimated by Mojave Basin Area Watermaster. Water year 1932-1952 estimated by Hardt, William, USGS

[5] 2022 Consumptive Use Analysis, Watermaster.

TABLE 2

TABLE 5-1 (Based on 2001-2020)

BAJA SUBAREA HYDROLOGICAL INVENTORY BASED ON VARIOUS SUPPLY ASSUMPTIONS AND 2021-22 CONSUMPTIVE USE, RETURN FLOW AND IMPORTS

(ALL AMOUNTS IN ACRE-FEET)

Water Supply	**Baja**
Gaged Inflow(1)	7,500
Tributary Inflow(2)	1,568
Subsurface Inflow(3)	1,751
Mountain Front Recharge(4)	647
Barstow Treatment Plan (5)	2,455
Return Flow(6)	554
Deep Percolation of Precipitation(7)	100
Total	**14,575**
Production and Outflow	
Gaged Outflow (8)	2,554
Subsurface Outflow(3)	170
Phreatophytes(9)	984
Production(10)(11)	12,749
Total	**16,457**
Surplus / (Deficit)	(1,883)
Total Estimated Production	12,749
Production Safe Yield	**10,866**

1 Estimated from reported flows at USGS gaging station, Mojave River at Barstow. (2001 - 2020).
2 2001 USGS Stamos, Page 15-16.
3 2001 USGS Stamos, Figure 34.
4 2001 USGS Stamos, Table 11 Page 96.
5 Percolation Pond + Return Flow from Irrigation. Barstow data per Barstow Water Treatment Plan Matthew Franklin Lead Operator.
6 2022 Consumptive Use Analysis.
7 City of Barstow et al, v. City of Adelanto et al, Judgment. (1996)
8 Estimated from reported flows at USGS gaging station, Mojave River at Afton. (2001-2020) minus stream flows at Afton when Barstow was zero.
9 Area of Camp Cady * Evapotranspiration (Open ET eeMetric yearly average 2019-22).
10 2022 Watermaster.
11 Includes consumptive use of "Minimals Pool" (estimated Minimal's production is 2,228 acre-feet)