GEOSCIENCE

The First Name in Groundwater

May 1, 2025

Technical Review Panel **DRAFT**
Cadiz Mojave Groundwater Bank Project

Re: PRISM Precipitation Data and Precipitation Trends in the Greater Fenner Watershed

Dear TRP Members:

This letter provides a compilation of precipitation data for the groundwater basins within the Greater Fenner Watershed, including Bristol, Fenner, and Cadiz Groundwater Basins. These data include recent PRISM precipitation data and are summarized briefly in the following sections.

Precipitation Volume for the Sub-Watersheds Surrounding the Mojave Groundwater Bank

In their 2024 review of the Groundwater Hydrology of the Mojave Water Bank, aquilogic calculated the volume of precipitation falling in the Fenner Watershed by sub-watershed based on monthly and annual PRISM precipitation data (1971-2000). These estimates are reproduced below.

Table 1. Total Volume of Annual Average Precipitation by Watershed for Period 1971-2000 (Source: Table 4 from aquilogic, 2024)

Watershed	Area (ft^2)	Precipitation Volume AFY
Bristol	22,141,717,000	170,541
Orange Blossom Wash	4,736,693,394	46,232
Fenner (West)	13,700,280,036	173,716
Fenner (East)	16,625,535,879	234,753
Lanfair	7,831,938,617	123,806
Cadiz	16,482,012,982	131,042
Total	**81,518,177,907**	**880,090**

Notes:
Based upon PRISM Annual Average Precipitation for Period 1971-2000
ft^2: square feet
AFY: acre-feet per year
Source: PRISM Climate Group at Oregon State University. United States Average Monthly or Annual Precipitation, 1971 - 2000. http://www.prismclimate.org. Retreived October 9, 2013.
Environmental Science Associates (ESA). (2012a). Final Environmental Impact Report (FEIR) for the Cadiz Valley Water Conservation, Recovery, and Storage Project. SCH# 2011031002. July. Appendix A in Vol. 2, Appendix H1b.
Aquilogic, Inc. (2013). Review of The Groundwater Hydrology of the Cadiz Project, San Bernardino County, California. October. Table 4.1

Using updated PRISM precipitation data, Geoscience recalculated the precipitation volumes for the periods from 1981-2010 and 1991-2020. These volumes are summarized in Table 2 below in comparison with previous estimates by aquilogic (from Table 1 above). Please note that the sub-watershed areas vary

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slightly between aquilogic and Geoscience estimates due to minor differences in the Shapefile used to calculate the areas.

Table 2. Updated Estimates of Annual Average Precipitation Volumes by Sub-Watershed

aquilogic, 2024 Estimates				Geoscience Updated Estimates					
Watershed	Area (ft^2)	Precipitation Volume for Period 1971-2000 (AFY)	Average Annual Precipitation (in)	Watershed	Area (ft^2)	Precipitation Volume for Period 1981-2010 (AFY)	Average Annual Precipitation (in)	Precipitation Volume for Period 1991-2020 (AFY)	Average Annual Precipitation (in)
Bristol	22,141,717,000	170,541	4.03	Bristol	22,003,405,066	162,578	3.86	158,849	3.77
Orange Blossom Wash	4,736,693,394	46,232	5.10	Orange Blossom Wash	4,865,114,719	45,384	4.88	44,702	4.80
Fenner West	13,700,280,036	173,716	6.63	Fenner West	13,746,000,651	159,520	6.07	156,245	5.94
Fenner East	16,625,535,879	234,753	7.38	Fenner East	16,789,286,412	219,453	6.83	210,950	6.57
Lanfair	7,831,938,617	123,806	8.26	Lanfair	7,048,687,732	108,306	8.03	104,582	7.76
Cadiz	16,482,012,982	131,042	4.16	Cadiz	16,474,293,529	132,373	4.20	137,211	4.35
Total	**81,518,177,907**	**880,090**	**5.64**	**Total**	**80,926,788,108**	**827,614**	**5.35**	**812,539**	**5.25**

As shown, average annual precipitation within the Fenner Watershed ranges between 5.25 and 5.64 inches per year, with variability by sub-watershed ranging from 3.77 to 8.26 inches per year, depending on the period of reference. This amounts to an average volume of precipitation falling over the Fenner Watershed area of between 812,500 and 880,100 acre-ft/yr. Figure 1 below illustrates this variability spatially.

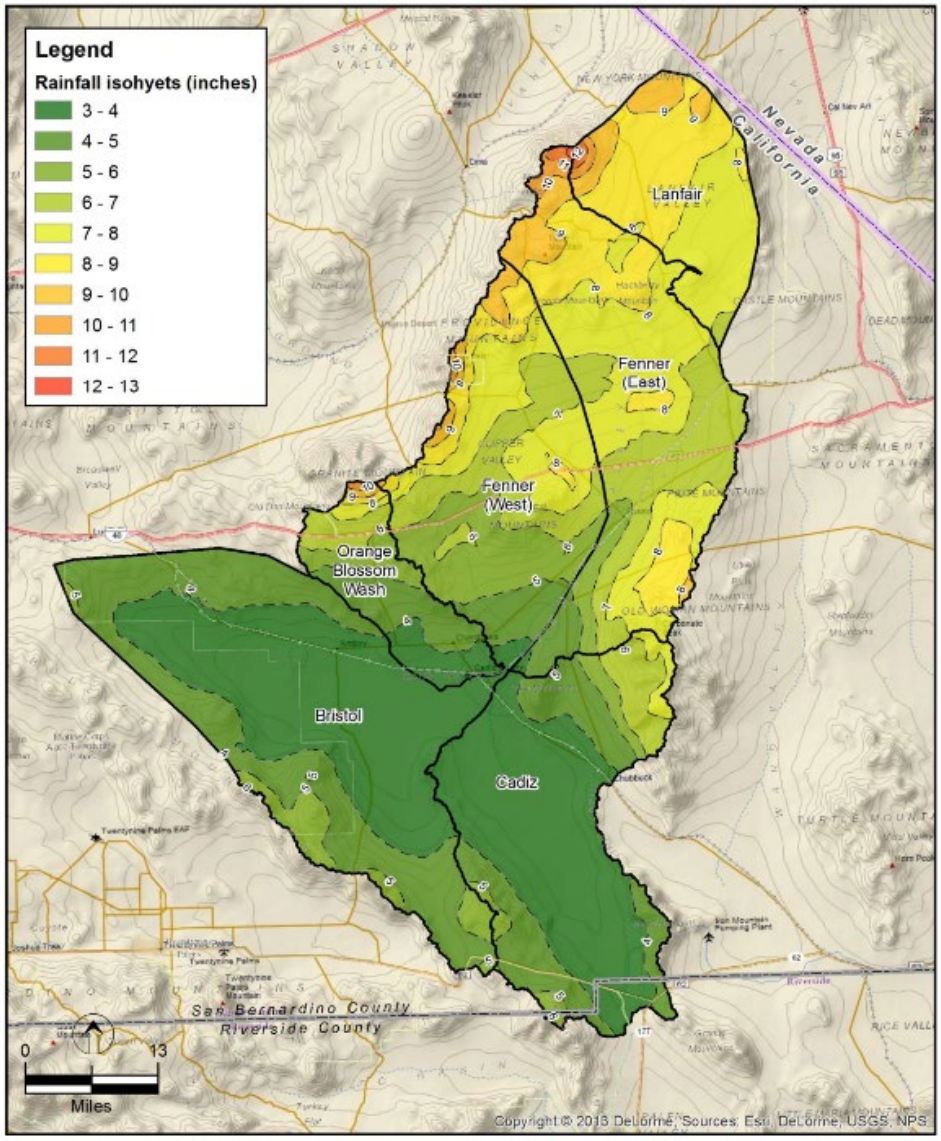

Figure 1. Average Annual Precipitation in Fenner Watershed (Source: Figure 7 from aquilogic, 2024)

Rain Shadow Effect

The Fenner Watershed, located in the southeastern portion Mojave Desert, exhibits less rain shadow effect than other areas of the Mojave Desert – such as Death Valley and Western Mojave. This is reflected by the relative average annual precipitation volumes (see Figure 2) and local precipitation-elevation curves developed for the area using the Maxey-Eakin Model (see Figure 3).

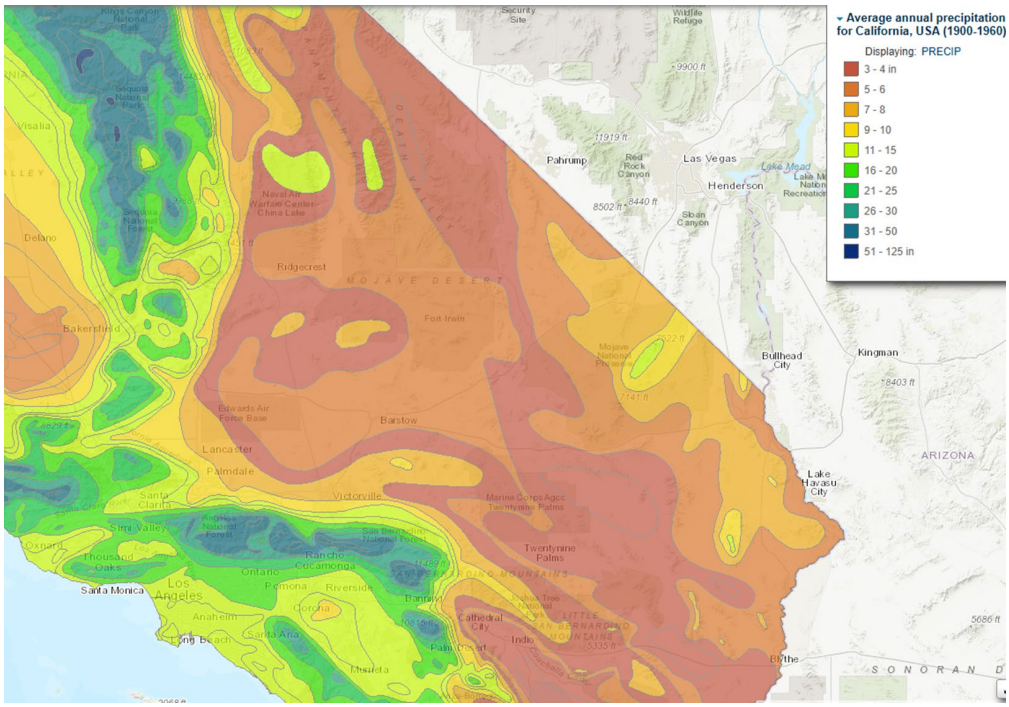

Figure 2. Average Annual Precipitation for California, 1900-1960 (Source: USGS, DWR, and CDM, 2014)

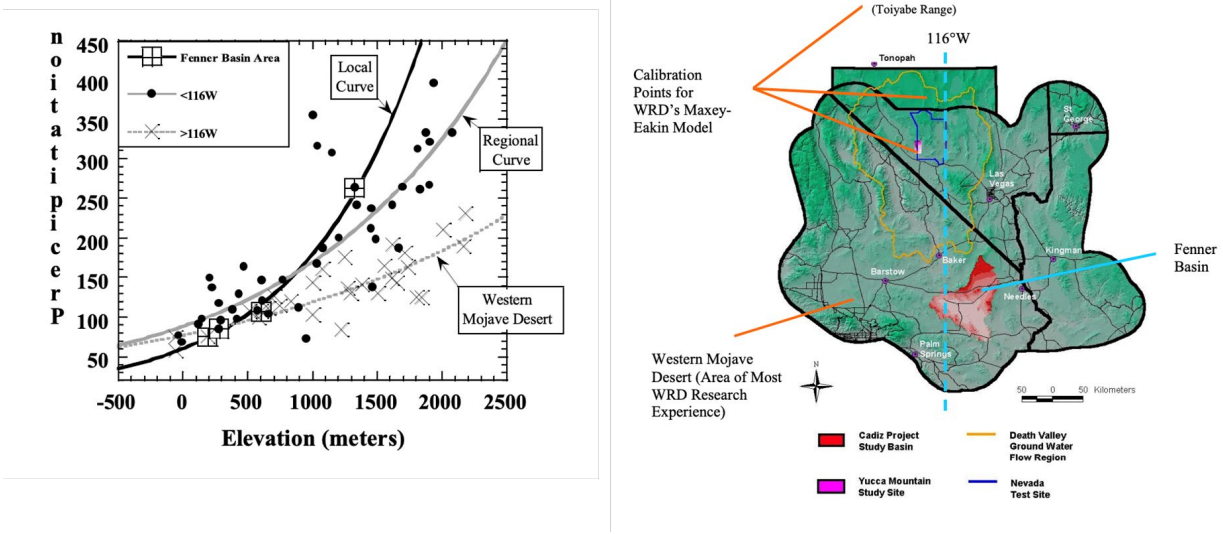

Figure 3. Precipitation-Elevation Curves using Maxey-Eakin Model (Source: Figures 3 and 1 from Davisson and Rose, 2000)

Precipitation Variability

Long-term records of statewide annual precipitation (Figure 4) show a marked shift in annual precipitation variability starting around the drought in Water Year 1976-1977. Prior to this precipitation was comparatively stable, with generally similar amounts of precipitation year-to-year. After this period

annual precipitation shows much more variability year-to-year, switching often between dry and wet years.

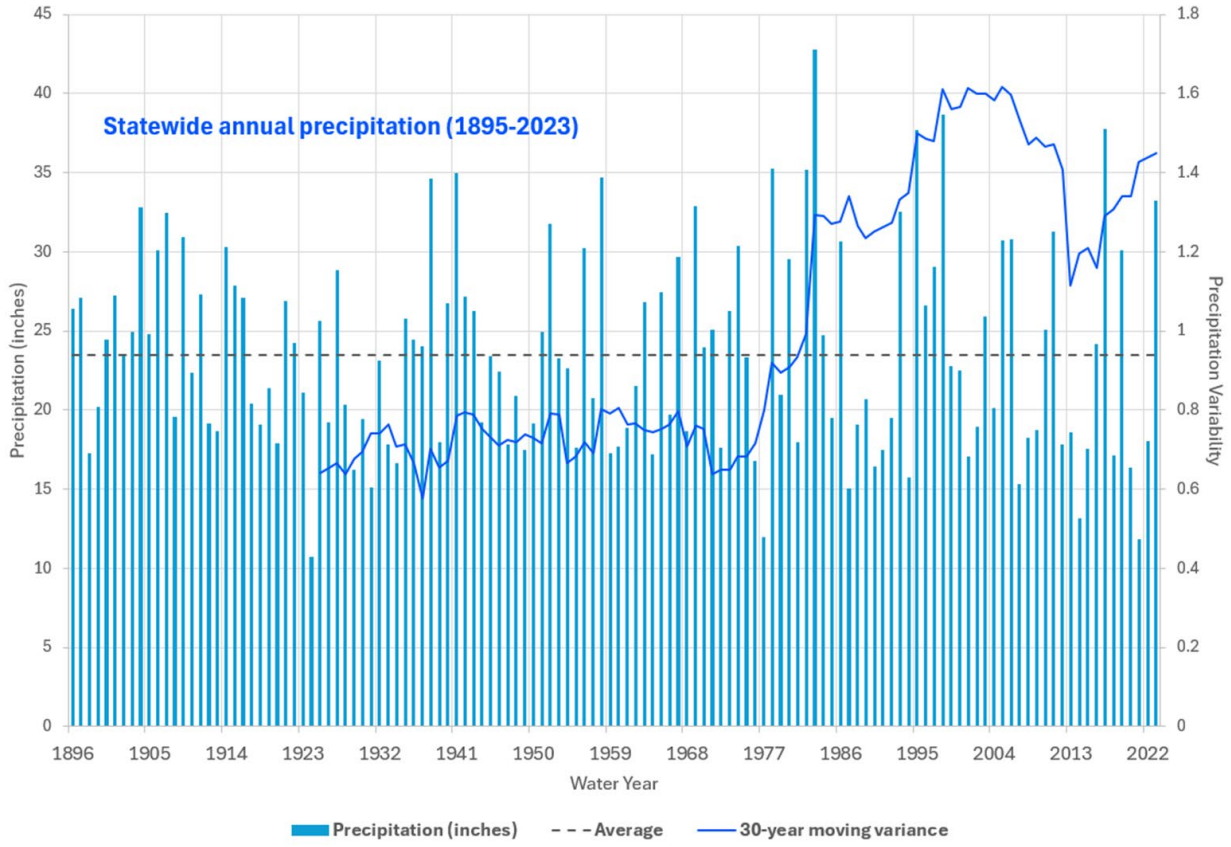

Figure 4. Climate "Whiplash" Pattern with Increased Variability in Precipitation Beginning in the 1970s (Source: OEHHA, 2022)

Cumulative Departures from Mean Annual Precipitation and Recent Trends in Precipitation

Cumulative departure from mean annual precipitation curves for PRSIM precipitation stations in the New York Mountains and Providence Mountains (Figures 5 and 6, respectively) show similar trends in precipitation, with generally average precipitation from the early 1900s to 1940, a dry period from 1940 to 1980, a wet period from 1980 to 2010, and a recent dry period since 2010. Long-term precipitation (1896-2024) ranges from 8.36 to 9.62 inches per year. Prior to the start of the wet period, which coincides with the period of increased precipitation variability, average annual precipitation (1896-1976) ranged from 7.57 to 8.76 inches per year. After this, average annual precipitation (1977-2024) has averaged 9.69 to 11.07 inches per year at these two stations.

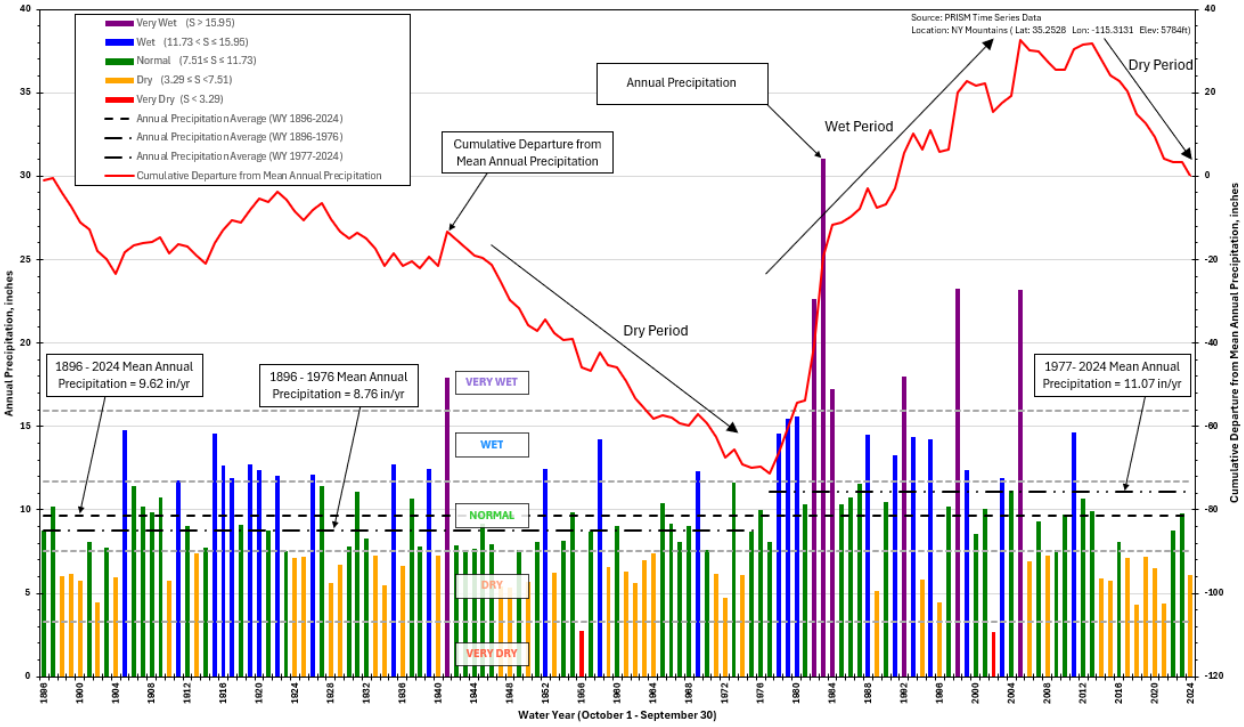

Figure 5. Annual Precipitation and Cumulative Departure from Mean Annual Precipitation in the New York Mountains (1896-2024)

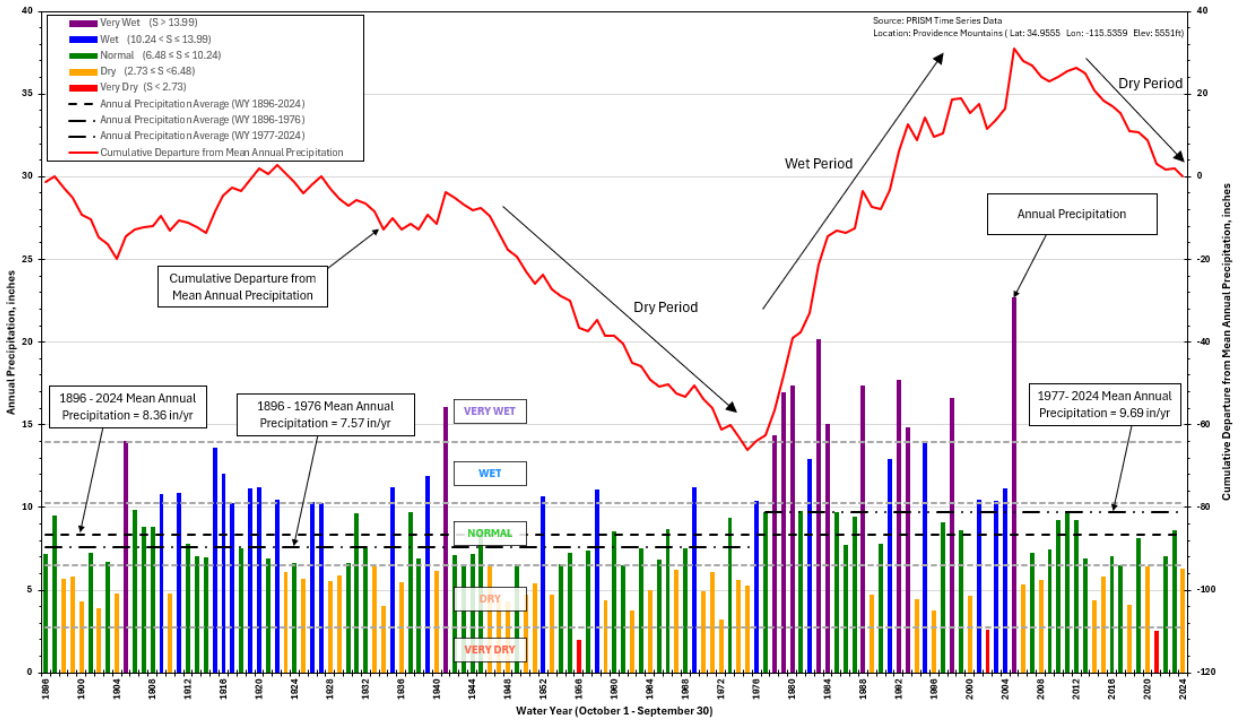

Figure 6. Annual Precipitation and Cumulative Departure from Mean Annual Precipitation in the Providence Mountains (1896-2024)

Rough Estimates of Recharge to Groundwater from Precipitation

According to previous conversations with W. David Nichols[1], groundwater recharge typically ranges from 3% to 8% of the total precipitation. This general rule of thumb can be used to evaluate initial rough estimates of recharge from precipitation data that can later be substantiated through more rigorous methods and verified with groundwater modeling. Using this range of potential groundwater recharge rates and estimated precipitation volumes (Tables 1 and 2), a range of potential groundwater recharge for Greater Fenner Watershed may be approximated. Table 3 indicates a range of groundwater recharge for the Greater Fenner Watershed that ranges from 24,400 to 70,400 acre-ft/yr depending on assumed percentage of recharge and time period. These recharge volumes have not been verified.

Table 3. Rough Estimates of Groundwater Recharge within Fenner Watershed, in acre-ft/year

Precipitation Volume (AFY)	1971-2000	1981-2010	1991-2020
	880,090	827,614	812,539
Estimated Recharge @ 3%	26,403	24,828	24,376
Estimated Recharge @ 5%	44,005	41,381	40,627
Estimated Recharge @ 8%	70,407	66,209	65,003

Fenner Watershed Area and Groundwater Storage Volume

Watershed size is an important consideration for groundwater recharge; the larger the watershed area, the more precipitation is generally available for capture, even in desert environments. Watershed elevation is also an important factor for the availability of precipitation for groundwater recharge, such as those present in the Providence and New York Mountains surrounding Fenner Watershed. In turn, groundwater recharge and groundwater storage capacity affect the ability of a groundwater basin to be managed for groundwater production. As shown in Table 4 (taken from the 2024 aquilogic report), the combined Fenner, Bristol, and Cadiz Groundwater Basins are an order of magnitude larger than other Southern California basins and have on the order of 17,000,000 to 34,000,000 acre-ft of groundwater in storge.

[1] W. David Nichols is a well-respected, retired hydrogeologist from the USGS with substantial experience in methods associated with the estimation of recharge from precipitation.

Table 4. Southern California Groundwater Basin Comparison (Source: Table 1 from aquilogic, 2024)

Groundwater Basin	Basin Size	Depth of Basin	Groundwater Storage	Groundwater Production
	mile^2	feet bgs	AF	AFY
Fenner, Bristol and Cadiz Watersheds	2700	1,000	17,000,000 – 34,000,000	50,000 (proposed)
San Gabriel Valley	255	4,100	10,740,000	269,448 (2001)
Orange County Coastal Plain	350	2,000	37,700,000	259,861 (2010-2011)
Chino Basin	240	700	5,325,000 (2000)	161,475 (2000)
San Fernando Valley (Upper Los Angeles River Area [ULARA])	226	900	3,049,000 (1998)	108,500 (1998)
Bunker Hill, Riverside	120	1,000	5,890,300	188,296 (2001)
West Coast Basin, Los Angeles	142	2,200	6,500,000	42,068 (2013)
Central Basin, Los Angeles	277	2,200	13,800,000	196,261 (2013)

Notes:
mile^2: square miles
feet bgs: feet below ground surface
AF: acre-feet
AFY: acre-feet per year
Sources: Department of Water Resources, 2003; 2013a; 2013b.

References

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Davisson, M.L. and T.P. Rose, 2000. Maxey-Eakin methods for Estimating Groundwater Recharge in the Fenner Watershed, Southeastern, California. Lawrence Livermore National Laboratory, dated May 15, 2000.

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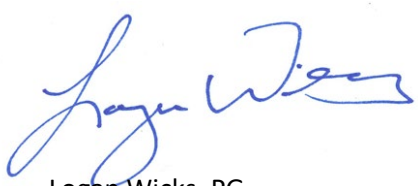
PRISM (PRISM Climate Group at Oregon State University), 2024. PRISM Time Series Data AN91m, 1895-2024. http://www.prism.oregonstate.edu. Accessed December 18, 2024.

USGS (United States Geological Survey), DWR (California Department of Water Resources), and CDM (California Division of Mines), 2014. Average Annual Precipitation for California, USA (1900-1960). Available at: https://databasin.org/maps/new/#datasets=3fac6542263d4972af2f55dc13737f36.

Geoscience appreciates the opportunity to provide these groundwater recharge considerations.

Respectfully submitted,



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CC: Fenner Valley Water Authority
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