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CHINO BASIN WATERMASTER

SUPERIOR COURT OF THE STATE OF CALIFORNIA

FOR THE COUNTY OF SAN BERNARDINO

CHINO BASIN MUNICIPAL WATER DISTRICT,

Plaintiff,

v.

CITY OF CHINO, ET AL.,

Defendants.

**Case No. RCVRS51010**

[Assigned for All Purposes to the Honorable Carlos M. Cabrera]

**EXHIBIT A - PART 3 OF 4 TO DECLARATION OF GARRETT RAPP IN SUPPORT OF MOTION REGARDING 2025 SAFE YIELD REEVALUATION, AMENDMENT OF RESTATED JUDGMENT, PARAGRAPH 6**

Date: November 13, 2026
Time: 10:00 a.m.
Dept.: S24

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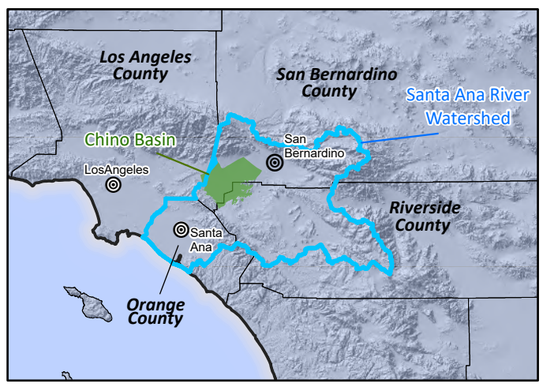
# Exhibit A

HSPF Model Domain
R4 Model Domain
2025 CVM Domain
Gaging Stations

Rivers and Streams
Flood Control and/or Conservation Basins

**Faults**

Location Certain
Location Approximate
Approximate Location of Groundwater Barrier
Location Concealed
Location Uncertain




Prepared by:

WEST YOST
Water. Engineered.

N

0 3 6 Miles
0 4 8 Km

Prepared for:

**Chino Basin Watermaster**
2025 Safe Yield Reevaluation

**Location Map for Gaging Stations and Flood Control and Conservation Basins Used to Calibrate the HSPF and R4 Models**

**Figure 4-1**

Table 4-1 below documents the $R^2$ and NSE statistics for simulated streamflow data at each of the gaging stations for the 2020 CVM and the 2025 CVM. These statistics are calculated for monthly streamflow over the period from July 1980 through the end of the model's respective calibration period (June 2018 for the 2020 CVM and June 2022 for the 2025 CVM).

**Table 4-1. R4 Model Calibration Statistics for Streamflow in the 2020 CVM and 2025 CVM**

| Gaging Station | $R^2$ | | NSE | |
|---|---|---|---|---|
| | 2020 CVM[(a)] | 2025 CVM[(b)] | 2020 CVM | 2025 CVM |
| Chino Creek at Schaefer Avenue (USGS 11073360) | 0.91 | 0.91 | 0.95 | 0.89 |
| Cucamonga Creek near Mira Loma (USGS 11073495) | 0.81 | 0.79 | 0.77 | 0.75 |

(a) The 2020 CVM was calibrated to monthly streamflow over the period of FY 1981 through FY 2018
(b) The 2025 CVM was calibrated to monthly streamflow over the period of FY 1981 through FY 2022

For Chino Creek at Schaefer Avenue (USGS 11073360), the R4 model achieved an $R^2$ of 0.91 and an NSE index of 0.95 in the 2020 CVM, indicating a very good[2] calibration match. With the inclusion of the additional years of data in the 2025 CVM, the $R^2$ statistic remained at 0.91 and the NSE index slightly decreased to 0.89. The match between R4-simulated streamflow and the measured data on Chino Creek at Schaefer Avenue remained good to very good for the R4 model in the 2025 CVM.

For Cucamonga Creek near Mira Loma (USGS 11073495), the R4 model achieved an $R^2$ of 0.81 and an NSE index of 0.77 for the 2020 CVM, indicating a very good calibration match. With the inclusion of the additional years of data in the 2025 CVM, the $R^2$ statistic decreased to 0.77 and the NSE index decreased to 0.75. These statistics for the R4 model in the 2025 CVM, though slightly lower, still indicate a good match between R4-simulated streamflow and the measured data on Cucamonga Creek near Mira Loma.

Figures 4-2 and 4-3 present scatter plots that illustrate the goodness of fit between measured and R4-simulated estimates of monthly surface water discharge on Chino Creek and Cucamonga Creek, respectively. These figures highlight the four additional years of data that were added for the R4 model validation and illustrate the successful validation of the R4 model in the 2025 CVM.

### *4.1.2.2 Simulated Urban Outdoor Water Use*

The R4 rootzone module estimates irrigation demand by simulating a soil moisture balance that accounts for vegetation type, land use, precipitation, and irrigation practices. For the 2020 CVM, UOWU estimated by the R4 model was calibrated to match irrigation demand within the IEUA sewersheds, where urban irrigation demand is assumed to be equivalent to UOWU.

[2] Moriasi et al. (2007) classify model performance based on the Nash–Sutcliffe Efficiency (NSE) such that values greater than 0.75 are considered "very good," and values between 0.65 and 0.75 are considered "good" for monthly time-step simulations, based on a review of a range of hydrologic models.

IEUA provides monthly records of total water supply and wastewater flows, which are used to independently estimate UOWU across its service area. The monthly urban irrigation demand for each sewershed is calculated as the total potable water supply minus the combined outflows of wastewater treatment plant influent, onsite wastewater disposal system (OWDS) discharge, and dry-weather flows.

Table 4-2 below documents the $R^2$ and NSE statistics for simulated UOWU data in each of the sewersheds for the 2020 CVM and the 2025 CVM. These statistics are calculated for monthly simulated UOWU over the period of available data from January 1991 through the end of the model's respective calibration period (June 2018 for the 2020 CVM and June 2022 for the 2025 CVM).

**Figure 4-2. Scatter Plot of R4-Estimated Monthly Discharge and USGS-Estimated Discharge for Chino Creek at Schaefer Avenue**

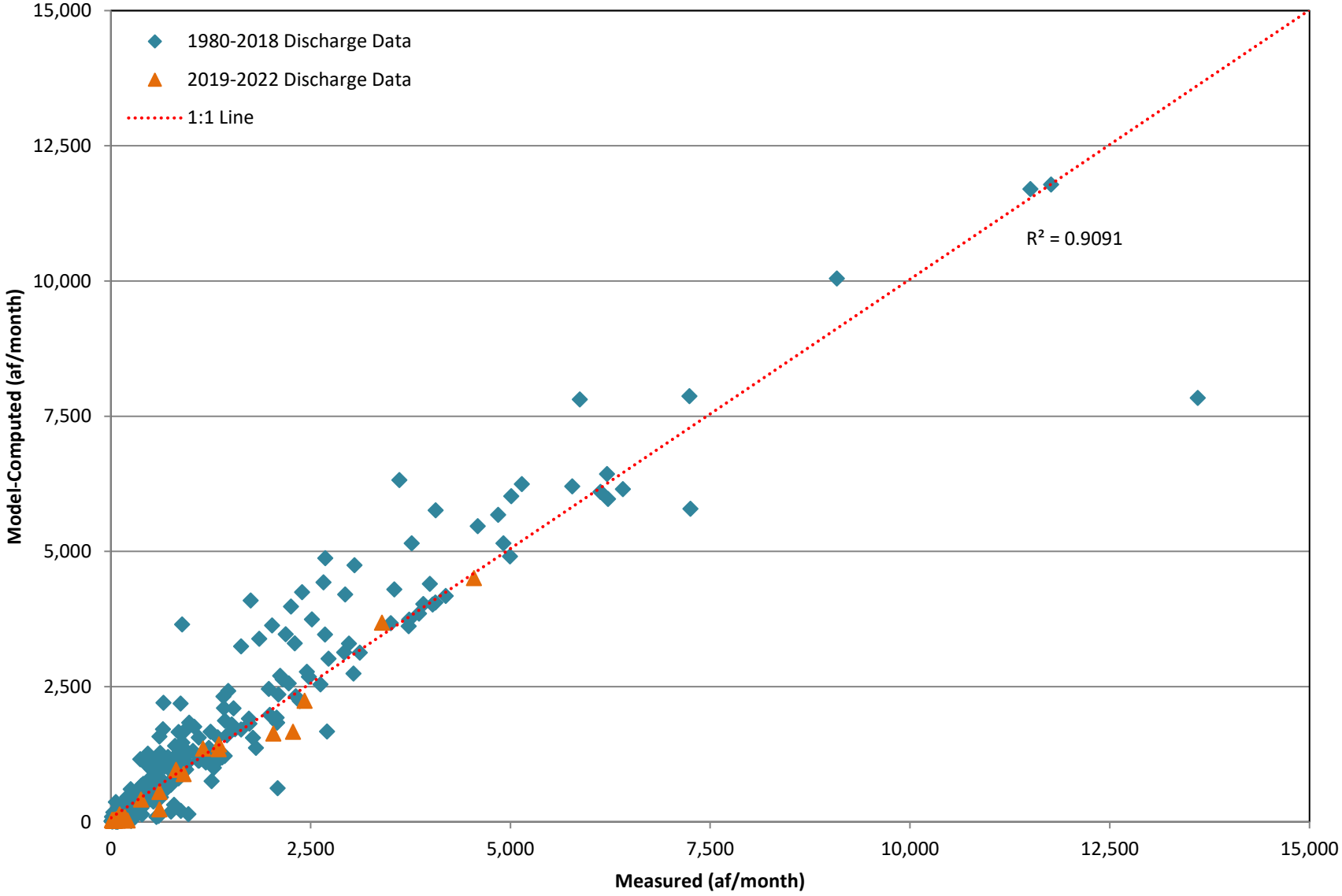


**Figure 4-3. Scatter Plot of R4-Estimated Monthly Discharge and USGS-Estimated Discharge for Cucamonga Creek near Mira Loma**

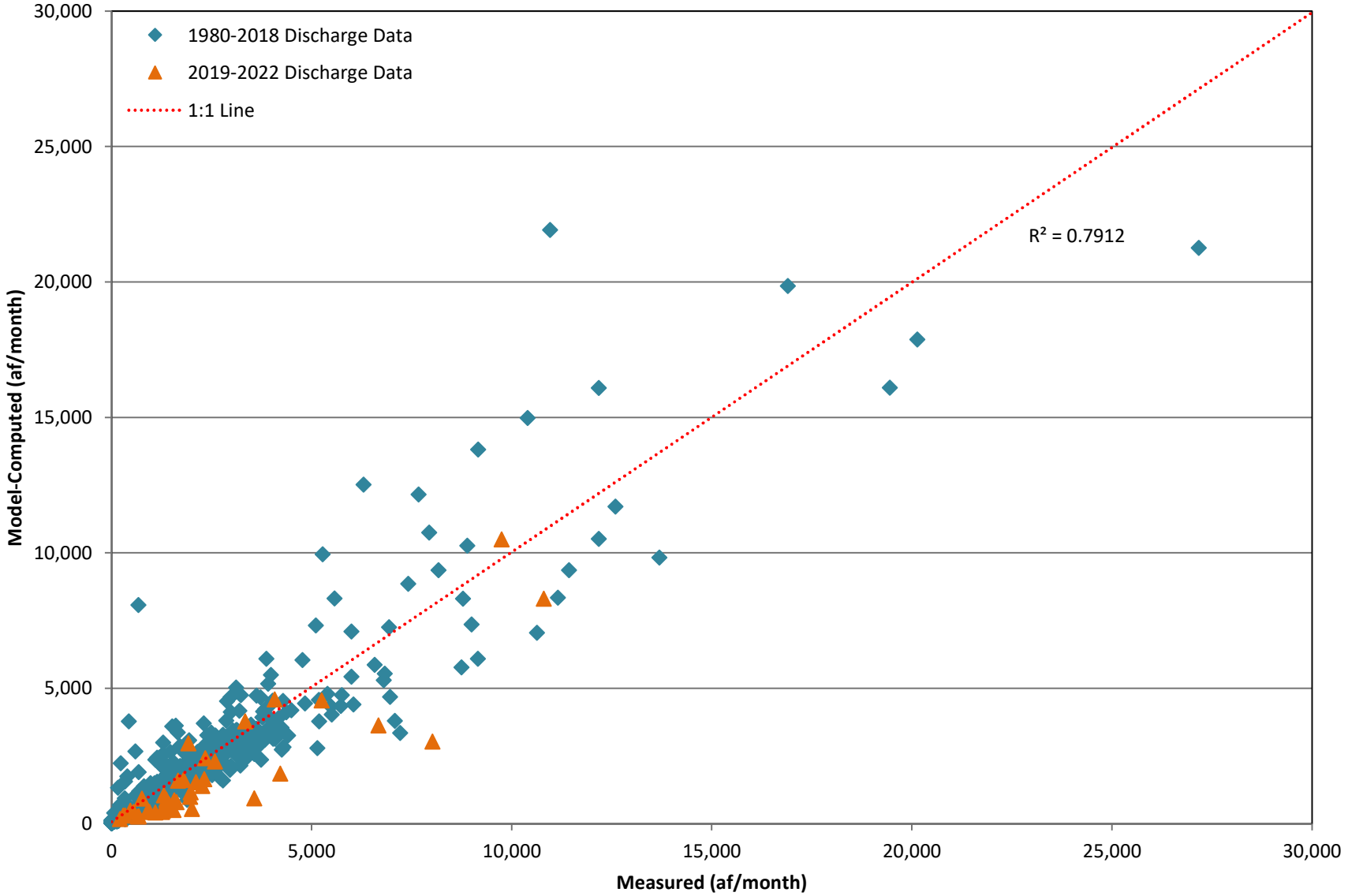


**Table 4-2. R4 Model Calibration Statistics for Urban Outdoor Water Use in the 2020 CVM and 2025 CVM**

| Sewershed | $R^2$ | | NSE | |
|---|---|---|---|---|
| | 2020 CVM[(a)] | 2025 CVM[(b)] | 2020 CVM | 2025 CVM |
| RP1/RP4 | 0.76 | 0.76 | 0.74 | 0.74 |
| CC/RP5 | 0.71 | 0.70 | 0.68 | 0.67 |

(a) The 2020 CVM was calibrated to monthly UOWU over the period of FY 1981 through FY 2018.
(b) The 2025 CVM was validated to monthly UOWU over the period of FY 1981 through FY 2022.

For the RP1/RP4 sewershed, the R4 calibration of urban irrigation demand achieved an $R^2$ of 0.76 and an NSE index of 0.74 in the 2020 CVM. When additional years of data were incorporated into the 2025 CVM, the $R^2$ and NSE remained at 0.76 and 0.74, respectively.

For the RP2/CC/RP5 sewershed, the R4 calibration of urban irrigation demand achieved an $R^2$ of 0.71 and an NSE index of 0.68 in the 2020 CVM. When additional years of data were incorporated into the 2025 CVM, the $R^2$ decreased to 0.70, while the NSE index slightly decreased to 0.67. The NSE indices indicate a good fit after adding the additional years of data.

Figures 4-4 and 4-5 are time-series charts that show the IEUA estimated total monthly water supply to the RP1/RP4 and RP2/CC/RP5 sewersheds, respectively, versus the R4-estimated urban irrigation supply. These charts illustrate the ability of R4 to replicate urban irrigation demand and its historical seasonality. Figures 4-6 and 4-7 are scatter plots that illustrate the IEUA estimated total monthly water supply versus the R4-estimated water supply for these sewersheds. Review of these figures and the $R^2$ and NSE statistics indicate the successful validation of the R4 model in the 2025 CVM.

#### *4.1.2.3 Stormwater Recharge in Basins*

The R4 model is calibrated to match estimates of stormwater recharge in flood control and conservation basins within the Chino Basin, using diversion estimates provided by IEUA as the comparison against observed data. Starting around FY 2006, IEUA began estimating stormwater diverted into the basins it operates using methods such as water-level sensors and assumed basin infiltration rates, with results reported as monthly totals.

For the 2020 CVM, the R4 model calibration targeted the IEUA diversion estimates and incorporated facility-specific information, including diversion rating curves, elevation-area-storage curves, outlet ratings, and depth-dependent infiltration rates. Calibration performance was assessed using $R^2$, which ranged from 0.14 to 0.88 across individual basins. Due to the limited number of monthly data points, NSE indices were not calculated. The quality of stormwater recharge calibration varied across facilities, with results ranging from unsatisfactory to very good. It is important to note that R4 model recharge calculations (which include evaporation, infiltration, and overflow) differ from IEUA's diversion estimates, which rely on measurements and assumptions that may not account for all these processes. As a result, the two sets of estimates are not directly comparable.

**Figure 4-4. Total Water Supply to the RP1/RP4 Sewershed and the Efficacy of the Supply**

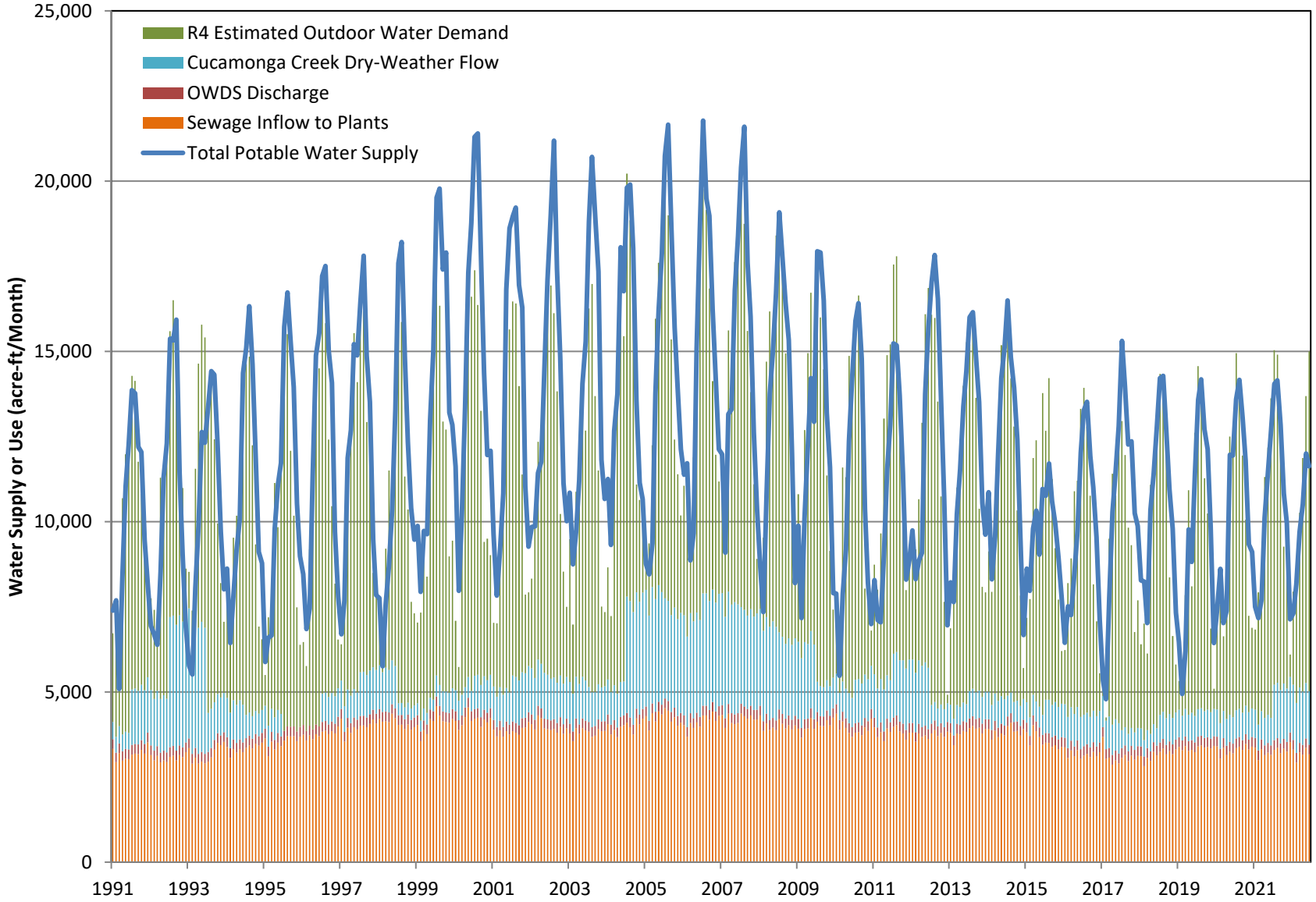


**Figure 4-5. Total Water Supply to the RP2/CC/RP5 Sewershed and the Efficacy of the Supply**

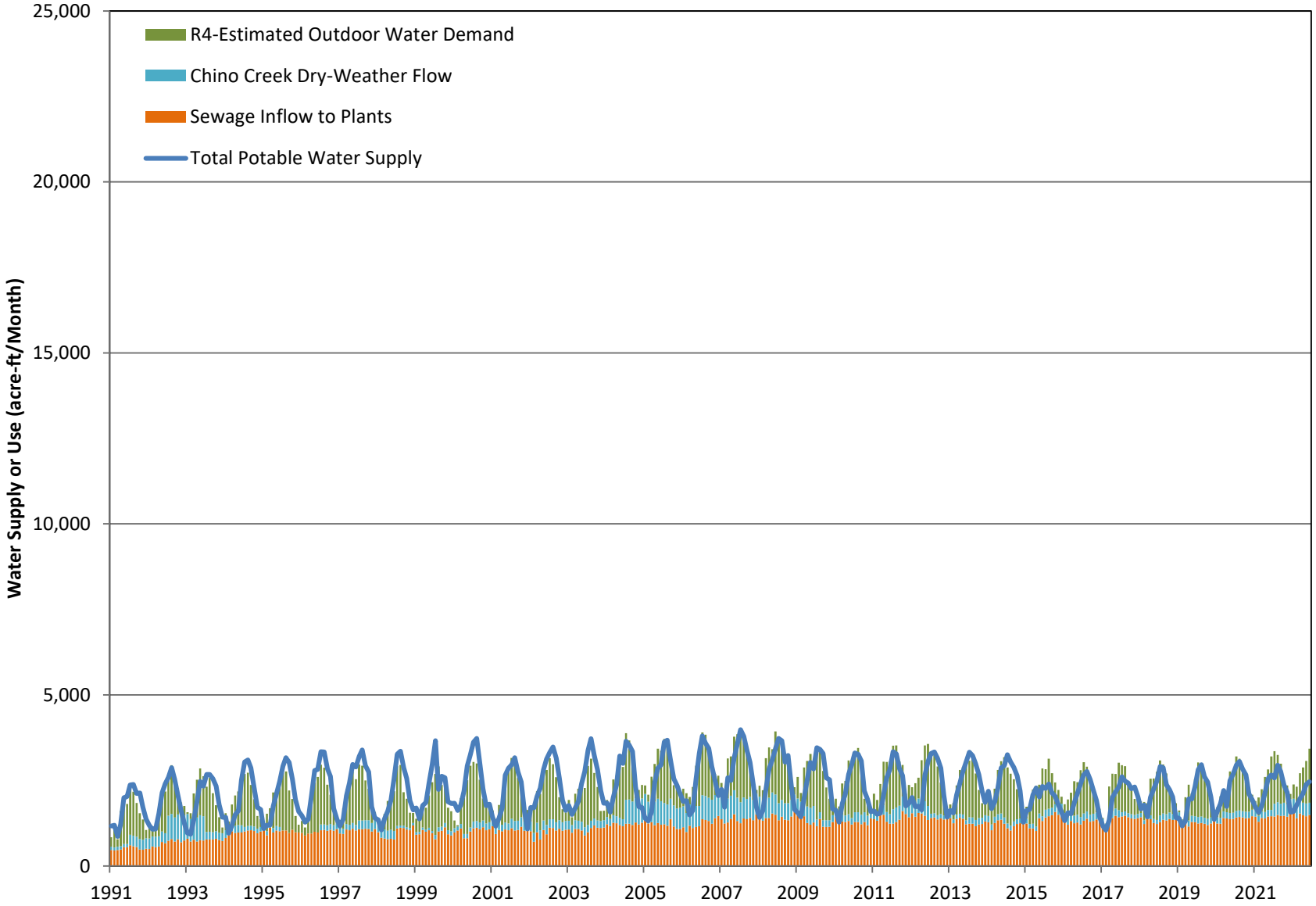


**Figure 4-6. Scatter Plot of IEUA-Estimated Water Supply and the R4 Estimated Water Supply for the RP1/RP4 Sewershed**

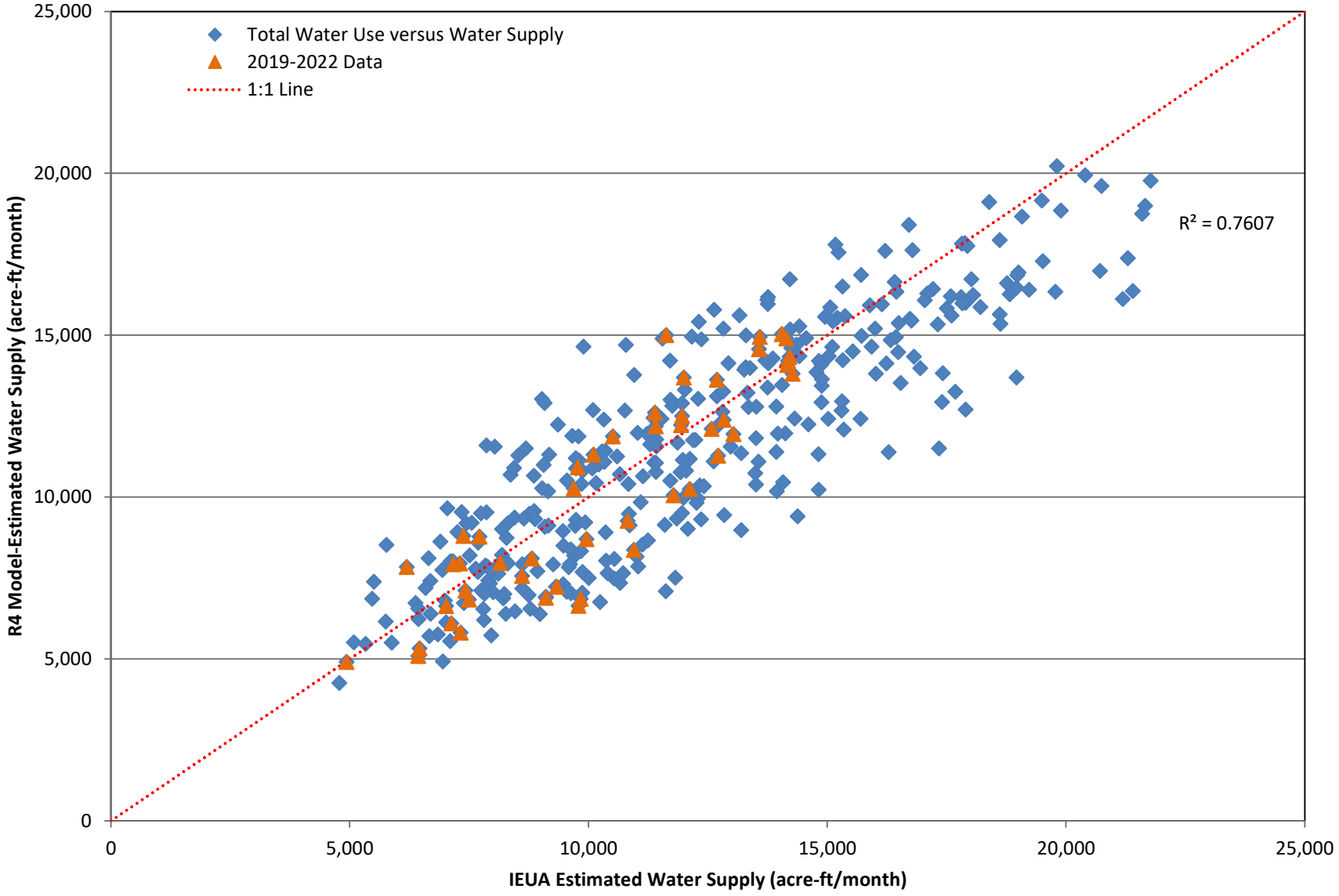


**Figure 4-7. Scatter Plot of IEUA-Estimated Water Supply and the R-4 Estimated Water Supply for the RP2/CC/RP5 Sewershed**

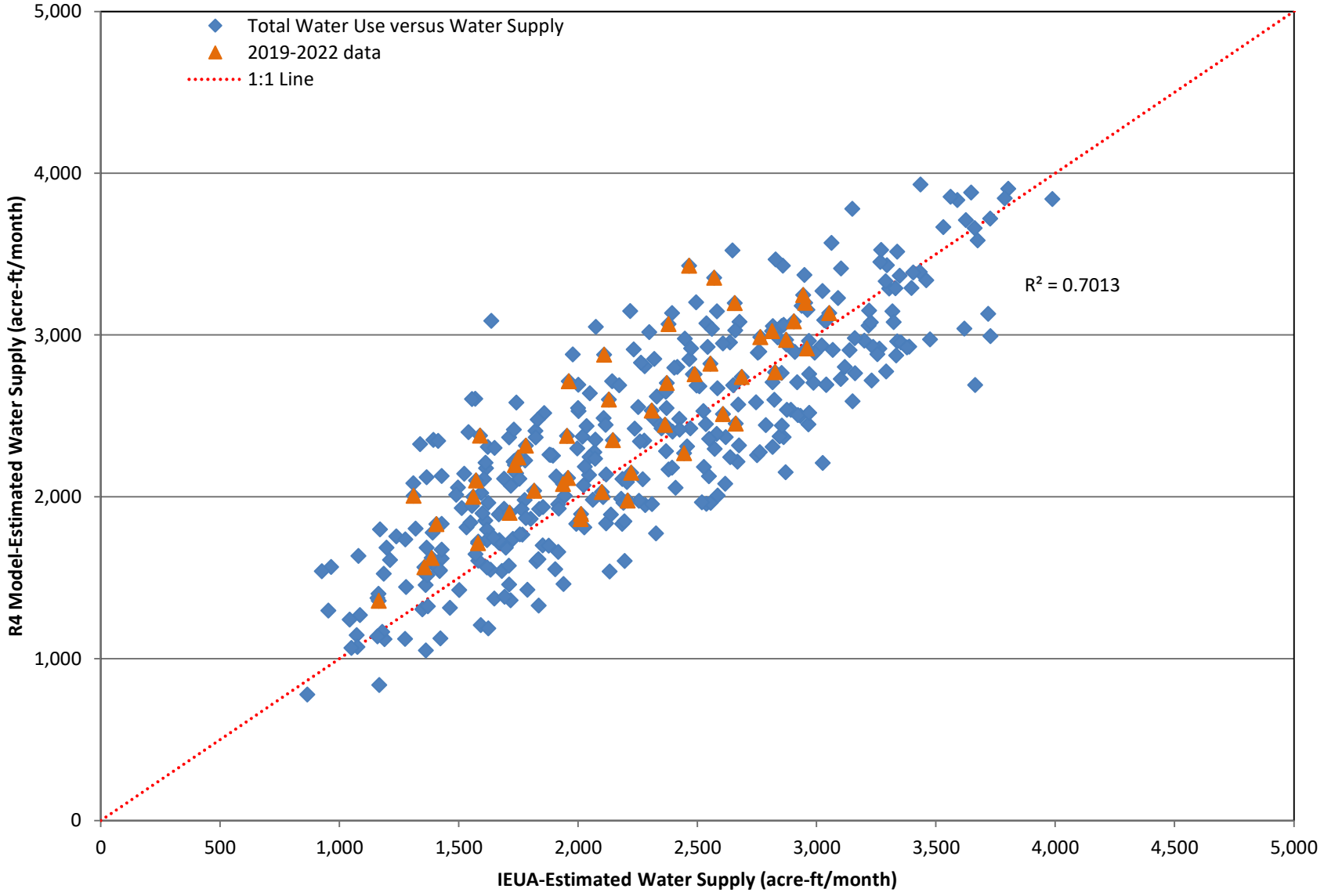


Table 4-3 compares the $R^2$ values based on monthly R4-simulated recharge and IEUA-estimated diversion volumes for the recharge basins, with corresponding scatter plots provided in Appendix B-1. Table 4-3 shows that the $R^2$ values were generally consistent after adding four additional years of data (FY 2018 through 2022). Specifically, four basins (Declez, RP3, Turner, and Upland) showed an increase in $R^2$ of more than 0.04, while three basins (Etiwanda Debris, Grove, and San Sevaine) showed a decrease of more than 0.04. The remaining seven basins exhibited minimal change in $R^2$, indicating stable model performance over the extended period.

**Table 4-3. Calibration and Validation of R4 Model - Recharge Basins**

| Recharge Basin | $R^2$ (R4-Simulated Recharge versus IEUA-Estimated Diversions) | |
|---|---|---|
| | 2020 CVM (2006-2018) | 2025 CVM (2006-2022) |
| 7th/8th Street Basins | 0.68 | 0.68 |
| Banana/Hickory Basins | 0.27 | 0.29 |
| Brooks Basin | 0.84 | 0.80 |
| Declez Basin | 0.35 | 0.41 |
| Etiwanda Debris Basin | 0.67 | 0.49 |
| Ely Basins | 0.56 | 0.57 |
| Grove Basin | 0.34 | 0.19 |
| Lower Day Basin | 0.86 | 0.83 |
| Montclair Basins | 0.88 | 0.90 |
| RP3 Basins | 0.14 | 0.46 |
| San Sevaine Basins | 0.83 | 0.77 |
| Turner Basins | 0.64 | 0.78 |
| Upland Basin | 0.79 | 0.90 |
| Victoria Basin | 0.81 | 0.83 |

## 4.2 RECALIBRATION AND UNCERTAINTY ANALYSIS

This subsection describes the methods and results of conducting Steps 1 and 2 of the 2022 Safe Yield Reset Methodology (2022 SYRM):

1. Re-calibrate the Watermaster's groundwater-flow model
2. Conduct an uncertainty analysis of the re-calibrated groundwater-flow model to identify a plausible range of calibrated models

### 4.2.1 Methods

A calibrated realization in the context of hydrologic models refers to a specific set of model parameters that have been adjusted to provide a close match between simulated and observed conditions. Multiple calibrated realizations exist because there are often many different sets of model parameters that can

produce a good fit between the model outputs and the observed data. This phenomenon is known as "non-uniqueness" in model calibration. The 2022 SYRM TM outlined a method for updating the 2025 CVM and generating calibrated realizations. The method includes the elements listed below. The following sections describe the work conducted to execute these elements.

1. Update the HSPF and R4 surface-water models for the calibration period to generate input data to the MODFLOW model.
2. Update the MODFLOW model for the calibration period based on observation data and the results of HSPF and R4.
3. Select adjustable model parameters (e.g., horizontal hydraulic conductivity) and prepare input files to incorporate the spatial relationships and variability of those parameters into PESTPP-IES. This involves defining how the parameters are distributed and varied across the model domain using techniques such as pilot points, variograms, and covariance matrices.
4. Prepare observation data as calibration targets, such as time series of groundwater elevations at wells and stream discharge.
5. Use PESTPP-IES[3] to generate calibrated realizations.
6. Rank and select calibrated realizations for projection scenarios. Review the outcome of the model with calibration realizations and determine which calibrated realizations should be selected for projection scenarios, and whether more calibrated realizations should be added. Conduct peer review process to share calibration results. Repeat the PESTPP-IES process and review outputs until enough calibrated realizations are developed.

Elements 1 and 2 of this method were completed and documented in Section 3.

### 4.2.2 Update of Calibration Period

The calibration period of the 2020 CVM was July 1, 1977 through June 30, 2018. During the August 30, 2023 workshop, West Yost proposed a calibration period for the 2025 CVM of July 1, 1991 to June 30, 2022. This calibration period was selected because most groundwater-level data in the Chino Valley were collected after 1992.[4]

The calibration period contains both wet and dry periods as demonstrated through a time-series analysis of precipitation data across the Chino Valley from the Parameter-elevation Relationships on Independent Slopes Model (PRISM)5 dataset. Figure 4-8 below shows the time history of annual precipitation, long-term average annual precipitation, and a curve of cumulative departure from mean precipitation (CDFM) based on the analysis. The latter is a graphical representation used to analyze precipitation trends over time. Positive slopes of the CDFM curve indicate periods of above-average precipitation (i.e., wet years), while negative slopes indicate periods of below-average precipitation (i.e., dry years). As shown

[3] Approaches to Highly Parameterized Inversion: PEST++ Version 5, a Software Suite for Parameter Estimation, Uncertainty Analysis, Management Optimization and Sensitivity Analysis

[4] At 152 wells in Chino Valley, there are 5,414 groundwater-elevation data points from fiscal year 1978 to 1991, and 752,473 data points from 1992 to 2022.

[5] PRISM Climate Group, Oregon State University, https://prism.oregonstate.edu

on Figure 4-8, the selected calibration period for the 2025 CVM includes a wet period from 1992 to 1999 and a dry period from 1999 to 2022 with some intermittent wet years.

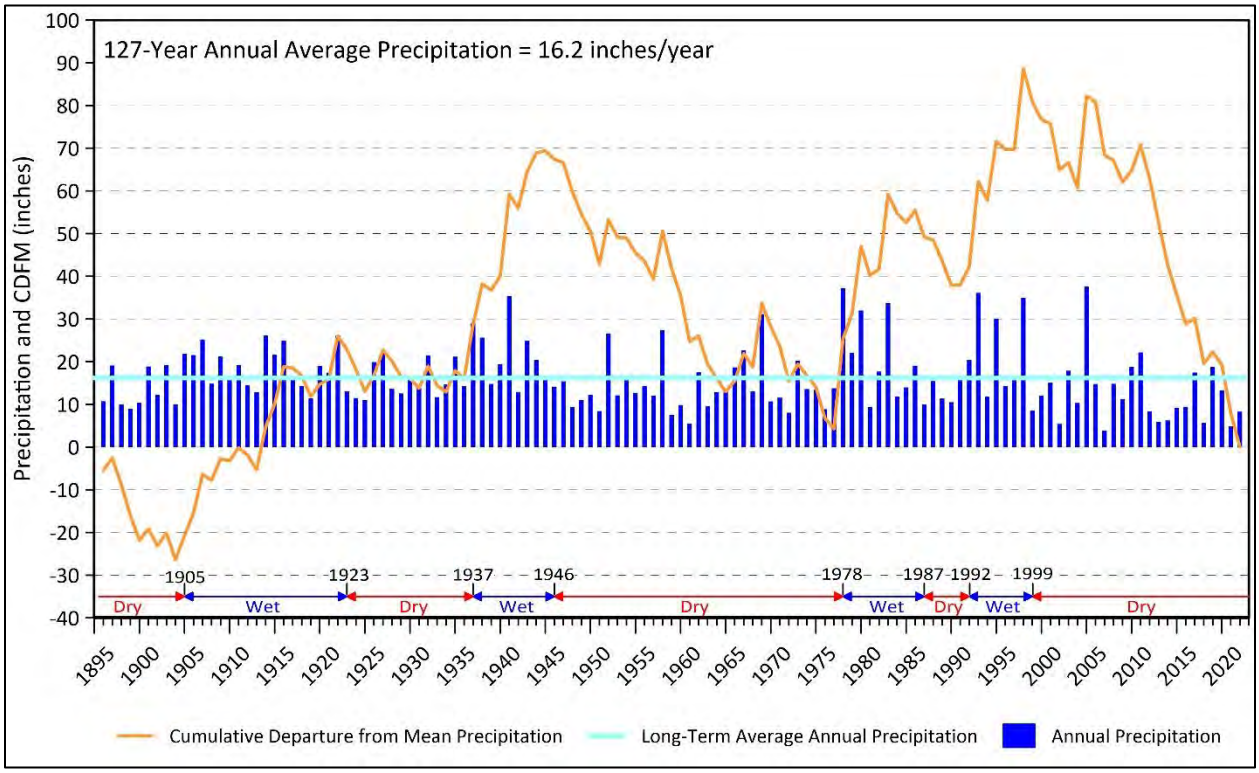



**Figure 4-8. Precipitation Time Series in the Chino Basin, FY 1896-2022.**

## 4.2.3 Select Adjustable Model Parameters and Prepare Input Files for PESTPP-IES

Many model input parameters are not well known and need to be adjusted through model calibration. For that purpose, the 2025 CVM uses the open-source computer code PESTPP-IES (Welter, et al., 2015; White, 2018; White, et al., 2020). PESTPP-IES is based on the Iterative Ensemble Smoother (iES) algorithm introduced by Chen and Oliver (2012; 2013). Using the iES algorithm, the required number of model runs for a calibration process depends on the desired number of calibrated realizations and does not depend on the number of adjustable parameters. The number of adjustable model parameters, however, still affects the required computing resources and computing time, as the information associated with each of the parameters needs to be stored and processed during the calibration process. Therefore, careful selection of a limited number of adjustable model parameters is still required. The rationale for the selected adjustable model parameters is given below.

### *4.2.3.1 DIPAW*

Initial conditions for DIPAW are based on the outputs from the R4 rootzone module adjusted for lag time through the vadose zone (see Section 3). The DIPAW input was first applied without spatial multipliers (i.e., a uniform scaling factor across the model domain), consistent with the assumption that the R4-derived recharge estimates (after lag adjustment) were physically representative. However, in response to peer review comments, the parameterization was refined to allow for spatial variability using pilot points.

In the updated approach, arrays of annual average DIPAW values were scaled using spatially distributed multipliers defined at 240 pilot points and interpolated across the model domain. These multipliers were treated as adjustable model parameters within the calibration process. After each iteration, updated multiplier values were estimated, applied to the DIPAW fields, and used as input to the subsequent groundwater flow simulation.

The initial values of the DIPAW multipliers were defined using a normal distribution with a mean of 1.0 and a standard deviation of 0.125, such that approximately 95 percent of values fall between 0.75 and 1.25. A multiplier greater than one indicates simulated DIPAW exceeding the R4-based estimate (after lag adjustment), while a multiplier less than one indicates lower simulated DIPAW relative to that estimate.

Although the R4 model is well-calibrated and the DIPAW estimates are considered physically defensible, inclusion of these multipliers allowed the calibration process to account for minor local or temporal variability that may not be explicitly represented in the R4 model. This approach does not alter the overall mass balance or conceptual consistency of the recharge estimates; rather, it provides limited flexibility for PESTPP-IES to reconcile small differences between the R4-estimated recharge and observed groundwater responses, ensuring numerical stability and improved spatial consistency in the calibrated realizations.

#### *4.2.3.2 Evapotranspiration*

Each array of monthly maximum ET rate was assigned a scalar multiplier as an adjustable model parameter. After each iteration of the calibration process, new values of the scalar multipliers were estimated, the associated maximum ET rates were scaled with the scalar multipliers, and then the scaled maximum ET rates were used as input to the groundwater flow simulation of the subsequent calibration iteration. Initially, the range of scalar multipliers for the maximum ET rate were allowed to vary within a range characterized by a normal distribution with a mean of 1.0 and a standard deviation of 0.1, which means that 95 percent of the multipliers would fall between 0.8 and 1.2.

#### *4.2.3.3 Subsurface Inflow*

The subsurface inflow boundary is divided into 45 segments as shown in Figure 3-13. Each segment was assigned a scalar multiplier as an adjustable model parameter to scale its inflow time series. The scalar multipliers for the inflow time series were defined using a normal distribution on a log scale with a mean of 1.0 and a standard deviation of 0.5 orders of magnitude, meaning that 95 percent of the values fell between 0.1 and 10. After each iteration of the calibration process, new values of the scalar multipliers were estimated, the associated initial inflow values were scaled with the scalar multipliers, and the scaled inflow values were then used as input to the groundwater flow simulation of the subsequent calibration iteration.

#### *4.2.3.4 Specified Head Boundary*

Two specified head boundaries were simulated with the FHB of the MODFLOW model. Figure 3-14 shows the segments of the specified head boundaries – one near Rialto and the other on the southern tip of the Spadra Basin. The specified head values at those boundaries were estimated based on nearby head measurements. Each specified head boundary was added as an adjustable model parameter. A positive addend increases the specified head, increasing the net flux into the active model domain for the stress period, and vice versa for a negative addend. After each iteration of the calibration process, the addends were updated and then added to the initial specified head values of the respective boundary. The addends were allowed to vary between +/- 35 feet for the Bloomington Divide and between +/-10 feet at the western edge of the Spadra Basin, based

on the range of historically observed variation. The Bloomington Divide was segmented into seven sections to allow for more flexibility in the heads at this boundary.

#### 4.2.3.5 Santa Ana River and Its Tributaries

The Santa Ana River and its tributaries are divided into 24 segments as shown in Figure 3-10. The streambed hydraulic conductivity for each segment was treated as an adjustable model parameter. This property governs the rate of water exchange between the stream and the underlying aquifer, thereby influencing stream–aquifer interactions. It was initially set to 1 ft/day, and during model calibration, it was allowed to vary within a range of 0.1 to 100 ft/day. After each iteration of the calibration process, the streambed hydraulic conductivity values were updated, and used in the groundwater flow simulation of the subsequent calibration iteration.

#### 4.2.3.6 Faults

The horizontal-flow barriers that represent faults are divided into segments as shown in Figure 3-12. The hydraulic conductivity of the flow barrier in each segment is an adjustable model parameter. These conductivity values determine how easily groundwater can move across the faults, thus influencing flow connectivity between adjacent hydrogeologic units. In the model, the conductivity factors were varied across several orders of magnitude, depending on the characteristics of each barrier. After each iteration of the calibration process, the hydraulic conductivity values of the segments were updated and then used in the groundwater flow simulation of the subsequent calibration iteration.

#### 4.2.3.7 Aquifer Properties and Pilot Points

Hydrogeological properties of the model include the horizontal hydraulic conductivity (HK), vertical hydraulic conductivity (VK), specific storage (SS), and specific yield (SY) of model layers. To represent the spatial variability of these properties, each layer was assigned several pilot points, each with an initial estimated value.

Pilot points serve as adjustable control locations within the model domain for the calibration process. Each pilot point's value for a specific hydrogeological property was treated as an independent parameter that PESTPP-IES modified during calibration. After each iteration[6], PESTPP-IES estimates updated values at these pilot point locations based on the differences between simulated and observed data.

These updated pilot point values were then spatially interpolated to assign values to all individual model cells within the corresponding layer. The Kriging method, a robust geostatistical interpolation technique, was employed for this spatial distribution. Kriging leverages the spatial correlation structure of the hydrogeological property (often defined through a variogram) to provide optimal estimates at unsampled

[6] In the context of PESTPP-IES, an iteration represents one complete cycle of the calibration process. During each iteration, PESTPP-IES adjusts the model parameters (like the pilot point values) based on the calculated differences between simulated and observed data. The model is then run again with these adjusted parameters, producing a new set of simulated results. This process is repeated to progressively refine the parameter values and improve the model's fit to the observed data.

locations (the model cell centers) based on the values at the pilot points. This method ensured that the interpolated values honor the pilot point values and reflect the assumed spatial continuity of the property.

The strategic use of pilot points, even in limited numbers, allowed for the efficient representation of complex spatial heterogeneity in hydrogeological properties across the entire model domain. By adjusting the values at these key locations, PESTPP-IES indirectly influenced the property values in all model cells through the Kriging interpolation.

The density and number of pilot points directly influence the level of spatial variability that the model can simulate. A higher density of pilot points allows for the representation of more complex and localized variations in hydrogeological properties. Ideally, with a sufficiently large number of well-placed pilot points, the precise location of individual points becomes less critical, and the interpolation method's influence diminishes as the pilot points effectively sample the spatial variability.[7]

Calibration using pilot points is specifically designed to capture the inherent heterogeneity required to adequately reproduce the observed hydrologic behavior. The pilot point parameters act as 'receptacles' for the information contained within the history-matching dataset (the observed data). Therefore, the effective placement of pilot points is crucial; they should be located in areas where they can best receive and propagate information relevant to the calibration targets. To investigate the impact of the number of realizations and the density and number of pilot points on the model's estimated net recharge values, four distinct scenarios for pilot point placement were implemented within PESTPP-IES, as described in Section 4.2.5.2.

### 4.2.4 Prepare Observation Data as Calibration Targets

Two types of observation data were collected and used for model calibration. The first type is the groundwater elevation time series at selected wells. The second type is the stream discharge time series observed at gaging stations. For the purposes of model calibration, a subset of the measured groundwater elevations was selected based on the principle that the selected data should be both temporally and spatially evenly distributed to avoid biasing the calibration with measurements from specific times or areas with more concentrated data collection. The selected observation data were used as calibration targets and each of the selected data is assigned a weight value. The monthly average daily stream discharge data was created based on the observed daily stream discharge data.

During the model calibration process, the differences between the (observed) calibration targets and the model calculated counterparts (i.e., the residuals) were calculated and then multiplied by the corresponding weights. These weighted residuals were squared (to avoid mutual cancelation of positive and negative residuals) and summed. The sum of the squared weighted residuals is known as the objective function, Phi (Φ).

PESTPP-IES minimizes Phi by adjusting model parameters through an iterative process. For the 2025 CVM, head values were assigned a weight value ranging from 0.5 to 10 depending on the confidence and importance of the data. For example, the piezometer at the Pomona Extensometer has highly precise and accurate, depth-specific, head measurements, and the measured head values were assigned a weight

[7] https://help.pesthomepage.org/index.html?pilot-point-emplacement.html

value of 10. All stream discharge values were assigned a weight value of $2\times10^{-5}$, reflecting the fact that stream discharge measurements are typically several orders of magnitude larger than head measurements. These weight values were selected so that the sum of the weighted residuals of stream discharge (in units of $ft^3$/day) and the sum of the weighted residuals of hydraulic head (in units of ft) lie in the same order of magnitude. This arrangement enabled PESTPP-IES to pick up adequate information for model calibration from both head and stream discharge time series.

Including observation uncertainty in PESTPP-IES is important because groundwater-level measurements have error and are not exact representations of model-scale conditions. Representing uncertainty in observations helps prevent overfitting to individual observations, preserves ensemble variability during PESTPP-IES updates, reduces the risk of ensemble collapse, and allows calibrated parameter sets to remain consistent with the expected range of measurement and local-scale variability. Groundwater-level observation uncertainty was represented in PESTPP-IES by adding normally distributed observation noise to the calibration targets, with a mean of zero and a standard deviation of 2.0 feet.

#### *4.2.4.1 Groundwater Elevation Time Series*

A total of 102 wells in the Chino Basin, Spadra Basin, Cucamonga Basin, and the Six Basins area were selected for model calibration. The selection was based on two criteria – their screened intervals must be available, and they must have relatively long-term groundwater-elevation measurements within the calibration period. Figure 4-9 shows the locations of the selected calibration wells. Table 4-4 shows the number of wells in each of the model layers where the wells are screened (calibration wells can be screened across multiple model layers). These wells have a total of 572,938 groundwater-elevation measurements during the calibration period. Some of the wells were equipped with transducers that measure and record groundwater elevations at high frequency (e.g., sometimes as short as 15 minutes).

A total of 7,781 groundwater-elevation measurements were selected as calibration targets. This reduction was necessary to ensure computational efficiency, to avoid "over-weighting" the frequently measured wells (e.g., wells with transducers), and to preserve temporal representativeness across the model domain. Including all available measurements would have resulted in excessive clustering of calibration targets at certain locations, potentially biasing the parameter estimation process and overwhelming the influence of observations from sparsely monitored areas. To address this, a data thinning strategy was applied to retain a representative subset of observations that captures the key temporal trends and seasonal variability of groundwater elevations at each site, while reducing redundancy. This approach allowed the model to be calibrated against meaningful and distributed information without compromising performance or interpretability. Figure 4-10 shows an example of groundwater-elevation measurements and selected calibration targets.

For single-layer observation wells (i.e., those with screened intervals across a single model layer), the selected groundwater-elevation measurements and the corresponding simulated head values of the given layer are used for the calculation of the objective function.

For multi-layer observation wells (i.e., those with screened intervals across multiple model layers), the selected groundwater-elevation measurements and the corresponding layer-weighted simulated head values were used for the calculation of the objective function. The following equation was used to calculate the layer-weighted simulated head values:

$$h = \frac{\sum_{l=1}^{n} h_l \cdot w_l}{\sum_{l=1}^{n} w_l} \quad (1)$$

where n is the number of layers of the model; $l$ is the layer number; $h_l$ is the simulated head in layer $l$; and $w_l$ is the weight of layer $l$. For a particular well, the initial weight of a layer is calculated based on the product of the screen length in that layer and the HK value of the model cell where the well is located. After each calibration iteration, the layer weights are adjusted based on the updated HK values.

**Table 4-4. Number of Monitoring Wells by Screened Model Layer**

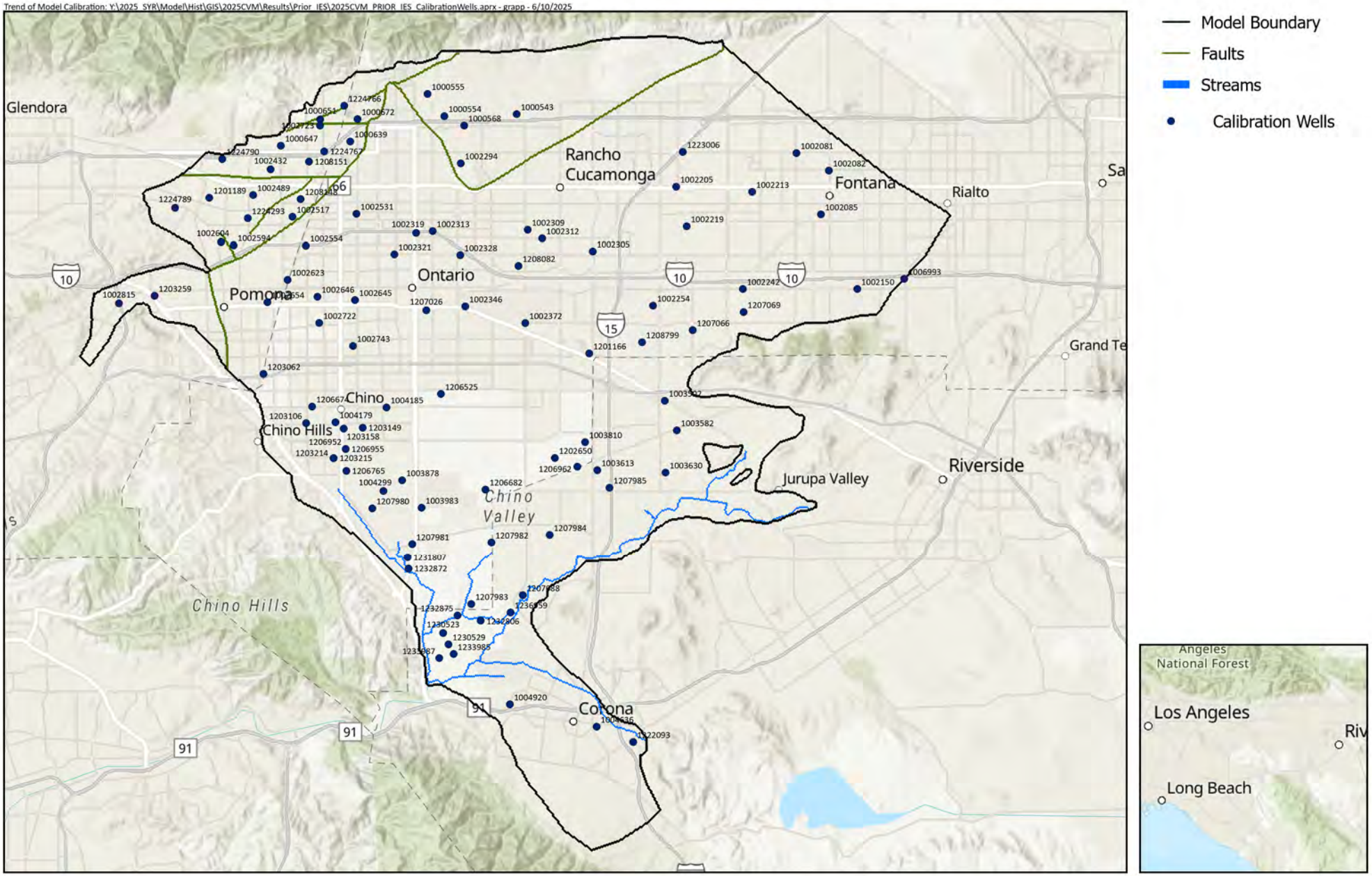
| Model Layer | Chino Basin | Spadra Basin | Cucamonga Basin | Six Basins |
|---|---|---|---|---|
| 1 | 42 | 2 | 5 | 18 |
| 2 | 17 | 0 | 0 | 0 |
| 3 | 32 | 0 | 0 | 0 |
| 4 | 10 | 0 | 0 | 0 |
| 5 | 24 | 0 | 0 | 0 |
| Any layer | 77 | 2 | 5 | 18 |

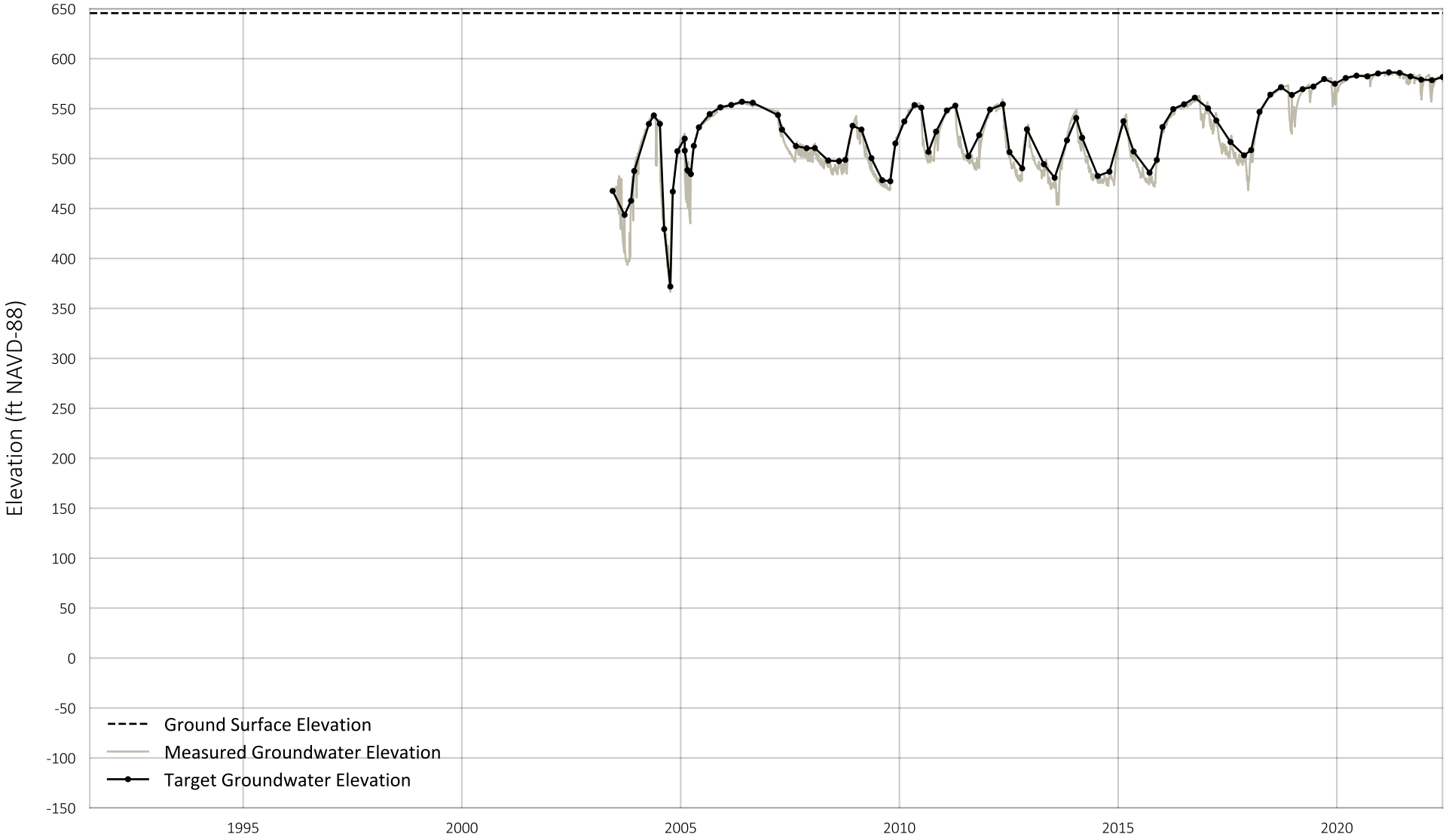
#### *4.2.4.2 Stream Discharge Time Series*

Daily streamflow data for streamflows at Prado Dam were obtained from the Santa Ana River Watermaster Annual Reports, and selected portions of the dataset were used as calibration targets. High stream discharge observations were excluded from the calibration because they are short-duration events dominated by surface runoff, not groundwater interaction. These peaks are difficult to measure accurately and are poorly represented in the groundwater-flow model focused on long-term groundwater/surface-water interactions. Including them could have distorted the parameter estimates and reduced model reliability under typical flow conditions.

### 4.2.5 Use PESTPP-IES to Generate Calibrated Realizations

Calibration of the 2025 CVM was conducted in two phases. In the first phase, a manual calibration was conducted with a few key model parameters. In the second phase, PESTPP-IES was used to generate calibrated realizations using all adjustable model parameters.

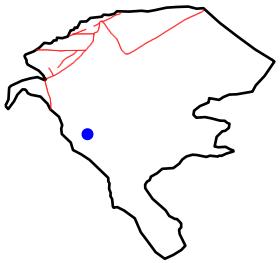

Trend of Model Calibration: Y:\2025_SYR\Model\Hist\GIS\2025CVM\Results\Prior_IES\2025CVM_PRIOR_IES_CalibrationWells.aprx - grapp - 6/10/2025
Model Boundary
Faults
Streams
Calibration Wells
Glendora
Rancho Cucamonga
Fontana
Rialto
Ontario
Pomona
Chino
Chino Hills
Jurupa Valley
Riverside
Corona
Grand Te
Chino Valley
Chino Hills
Angeles National Forest
Los Angeles
Long Beach
Riv
10
15
91
Prepared by:
WEST YOST
N
0 2 4 Miles
0 3 6 Km
Prepared for:
Chino Basin Watermaster
2025 Safe Yield Reevaluation
2025 CVM
Calibration Wells with HydroDaVE Well ID
Figure 4-9




Prepared by:

WEST YOST
Water. Engineered.

Well Location



Statistics

Target Groundwater Elevation (ft)
Mean = 526.27
Standard Deviation = 39.66

An Example of Groundwater Elevation Measurements and Selected Calibration Targets

Figure 4-10

### 4.2.5.1 Manual Calibration

In the first phase, a manual calibration was performed to adjust hydraulic conductivity values for faults and streambeds, as well as scalar multipliers for boundary inflow and DIPAW. The purpose of this manual calibration was twofold: to identify any potential problems or errors within the model setup and to "precondition" key model parameters, setting them to more reasonable starting values before the automated calibration phase using PESTPP-IES.

During this phase, the specific storage values of the 2020 CVM and the estimated maximum ET rates were used without any modification. The aquifer properties HK, VK, and SY of the 2020 CVM were assigned to pilot points that are placed in each model layer based on the density of groundwater elevation observation wells. The aquifer properties at pilot points were interpolated to model cells with the Kriging method. Guidance for the emplacement of pilot points outlined in the Parameter Estimation (PEST) homepage[8] was generally followed for the placement of pilot points.

Manual calibration of the model involved numerous iterative cycles. In each cycle, simulated head and stream discharge time series were compared against the calibration targets. The differences observed in this comparison then guided the adjustment of parameter values. After each parameter adjustment, the model was run again. This process was repeated until the sum of weighted squared residuals could not be meaningfully reduced by additional model runs.

The calibrated hydraulic conductivity of faults ranges between $1\times10^{-9}$ and 0.0017 ft/day. The calibrated streambed conductivity ranges between 0.23 and 10 ft/day. The calibrated multipliers for Subsurface Inflow range from 0.6 to 1.8. The calibrated multiplier for annual DIPAW values averaged approximately 0.94.

Appendix B-2 shows the maps of aquifer properties used in the manually calibrated model. Appendix B-3 contains the time series of simulated hydraulic heads versus the calibration targets of the manually calibrated model.

Figure 4-11 shows a scatter plot of the simulated hydraulic heads versus the calibration targets in the Chino Basin, Spadra Basin, Cucamonga Basin, and Six Basins. The root mean squared error (RMSE) is 18.88 ft for calibration targets in the Chino Basin, and 25.93 ft for all calibration targets. The linear regression equation is derived based on all calibration targets. All points are distributed closely around the regression line, which matches closely with the 1:1 line, indicating good inverse modeling performance and a robust calibration. The $R^2$ of 0.9989 suggests that 99.89 percent of the observed variance is explained by the model. Overall, these results indicate that the calibration is improved over the 2020 CVM.

Figure 4-12 is a map of average residuals at the calibration wells. The mean and median residuals for all calibration targets are 1.47 ft and 0.63 ft, respectively. These values are close to the expected value of zero, indicating that the prediction of groundwater elevations is not biased. Figure 4-13 shows a map of RMSE. Figure 4-14 shows a map of the trend of residuals between the average simulated hydraulic heads and calibration targets. Wells with overpredicted head values (i.e., average simulated heads greater than the average calibration targets) are colored blue, while wells with underpredicted head values (i.e., average simulated heads less than the average calibration targets) are colored yellow. A spatial bias in the simulated head can be identified if the overpredicted and/or underpredicted wells cluster in areas.

[8] https://help.pesthomepage.org/index.html?pilot-point-emplacement.html

The random distribution pattern of the overpredicted and/or underpredicted wells shown in Figure 4-14 indicates that the simulated heads are not spatially biased at the basin scale.

Figure 4-15 is a time-series chart that compares model-estimated stream discharge versus total Prado inflow estimated by the Santa Ana River Watermaster. Figure 4-16 is a scatter chart of model-estimated versus observed discharge values. The red dashed line represents the 1:1 line, while the blue dashed line is the regression line, which has a slope of 1.1765. This indicates that the model tends to overpredict discharge during rare, very high-flow events. During these events, it is expected that the discharge will be overpredicted due to the operations of Prado Dam, which would temporarily reduce discharge during high-flow events. The coefficient of determination ($R^2$) is 0.92, demonstrating a strong correlation between simulated and observed discharge.

### *4.2.5.2 Automated Calibration*

In the second phase, PESTPP-IES was used to adjust all adjustable model parameters to conduct the uncertainty analysis. PESTPP-IES does not seek a single set of parameters (i.e., a parameter realization) that is deemed to "calibrate" a model. Instead, it seeks a suite of parameter realizations which each result in an acceptably good match between observed and simulated conditions, and collectively express parameter uncertainty. Through a series of successive iterations, PESTPP-IES adjusts parameter realizations so that each meets the user-defined calibration criteria. Specifically, it modifies each realization within the ensemble such that, when the model is run with that parameter set, the simulated-to-measurement fit is sufficient for the model to be considered as "calibrated." The result is an ensemble of parameter realizations, which can be interpreted as samples from the posterior probability distribution of the parameters.

The effects of the number of desired calibrated realizations and the number and spatial distribution of pilot points on model-estimated net recharge were evaluated using five distinct pilot point scenarios:

- **Pilot Point Scenario 1:** Irregularly spaced pilot points were placed in each model layer based on the density of groundwater elevation monitoring wells. This scenario included a total of 2,701 adjustable parameters, of which 2,245 were pilot points. PESTPP-IES was configured to run for six iterations, with the number of desired calibrated realizations set to 100. During the calibration process, some realizations were excluded by PESTPP-IES—likely due to poorly performing parameter combinations—because their model run times exceeded twice the average runtime of successful realizations.
- **Pilot Point Scenario 2:** This scenario used the same pilot point layout and number of adjustable parameters as Scenario 1 (2,701 adjustable parameters, including 2,245 pilot points). The only change was an increase in the number of desired calibrated realizations from 100 to 400 to better explore parameter uncertainty and posterior variability.
- **Pilot Point Scenario 3:** In this scenario, regularly spaced pilot points were placed at 10-row by 10-column intervals across each model layer. This configuration significantly increased the number of adjustable parameters to 25,326, including 24,870 pilot points, enabling a more detailed exploration of spatial heterogeneity. The number of desired calibrated realizations was set to 400.
- **Pilot Point Scenario 4:** This high-resolution scenario involved 159,146 adjustable parameters, including 158,690 pilot points, and targeted 400 realizations. However, due to

the extreme computational demand, the PESTPP-IES run failed, exceeding available memory and runtime limitations.

- **Pilot Point Scenario 5:** This scenario was developed to implement several of the recommendations from the peer review, including:
  - Added spatially variable DIPAW multipliers
  - Reduced observation noise
  - Targeted 100 realizations to reduce runtime
  - Reduced head closure criteria
  - Increased weighting of streamflow observations

This scenario resulted in 32,800 adjustable parameters.

Pilot Point Scenario 5 was selected for use in projection simulations. It provided a balance between parameter complexity and computational feasibility, allowing the model to represent smaller-scale heterogeneities more effectively than the lower-resolution scenarios. The following section provides a detailed description of Pilot Point Scenario 5.

#### 4.2.5.2.1 Pilot Point Scenario 5

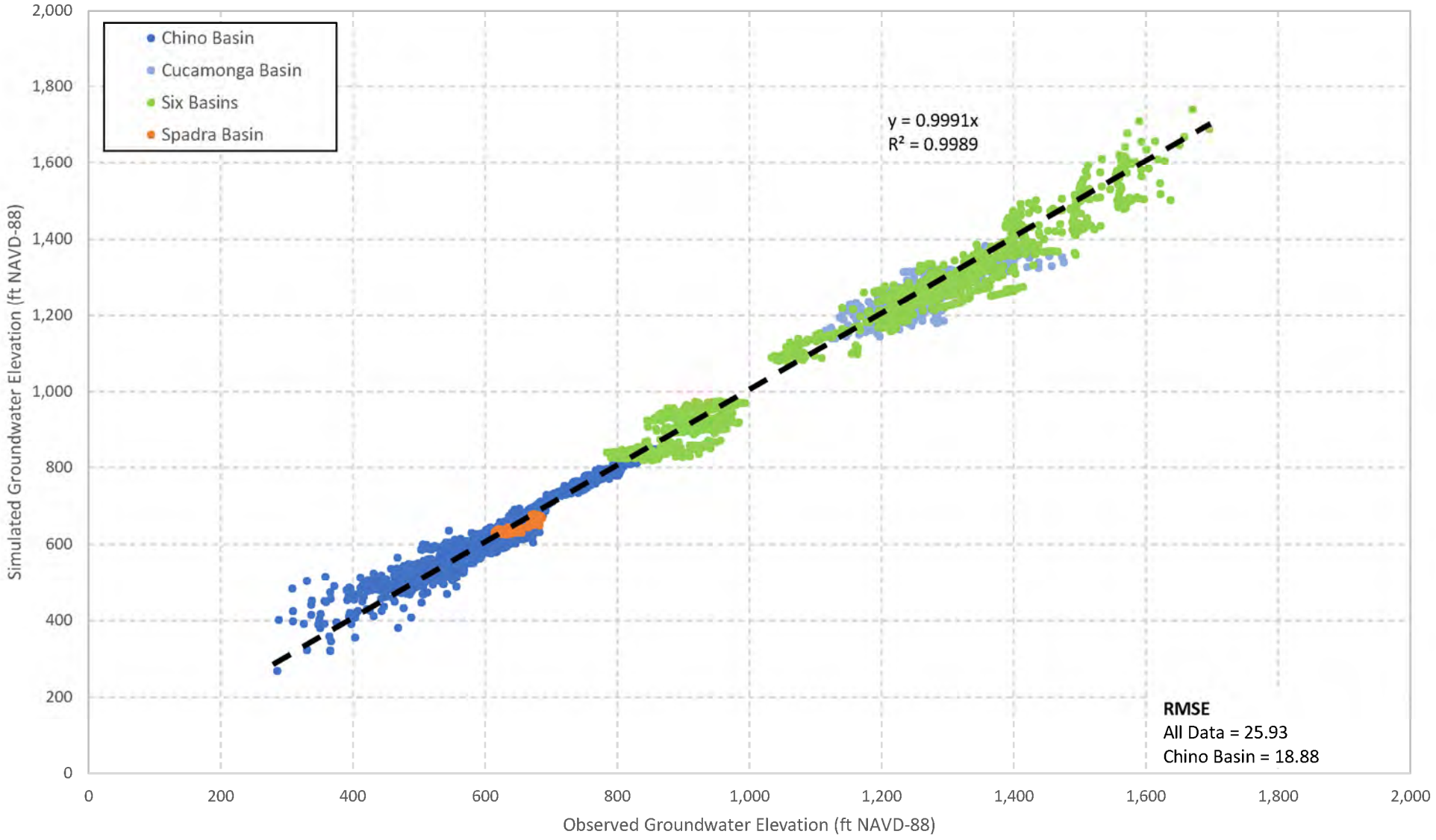
In this scenario, pilot points for aquifer properties were placed at a spacing of every ten model rows/columns in each model layer. This scenario incorporates a total of 32,800 adjustable parameters including 32,332 pilot points: 8,624 for HK, 8,067 for VK, 6,338 for SS, 2,061 for SY, and 7,440 for DIPAW multipliers.

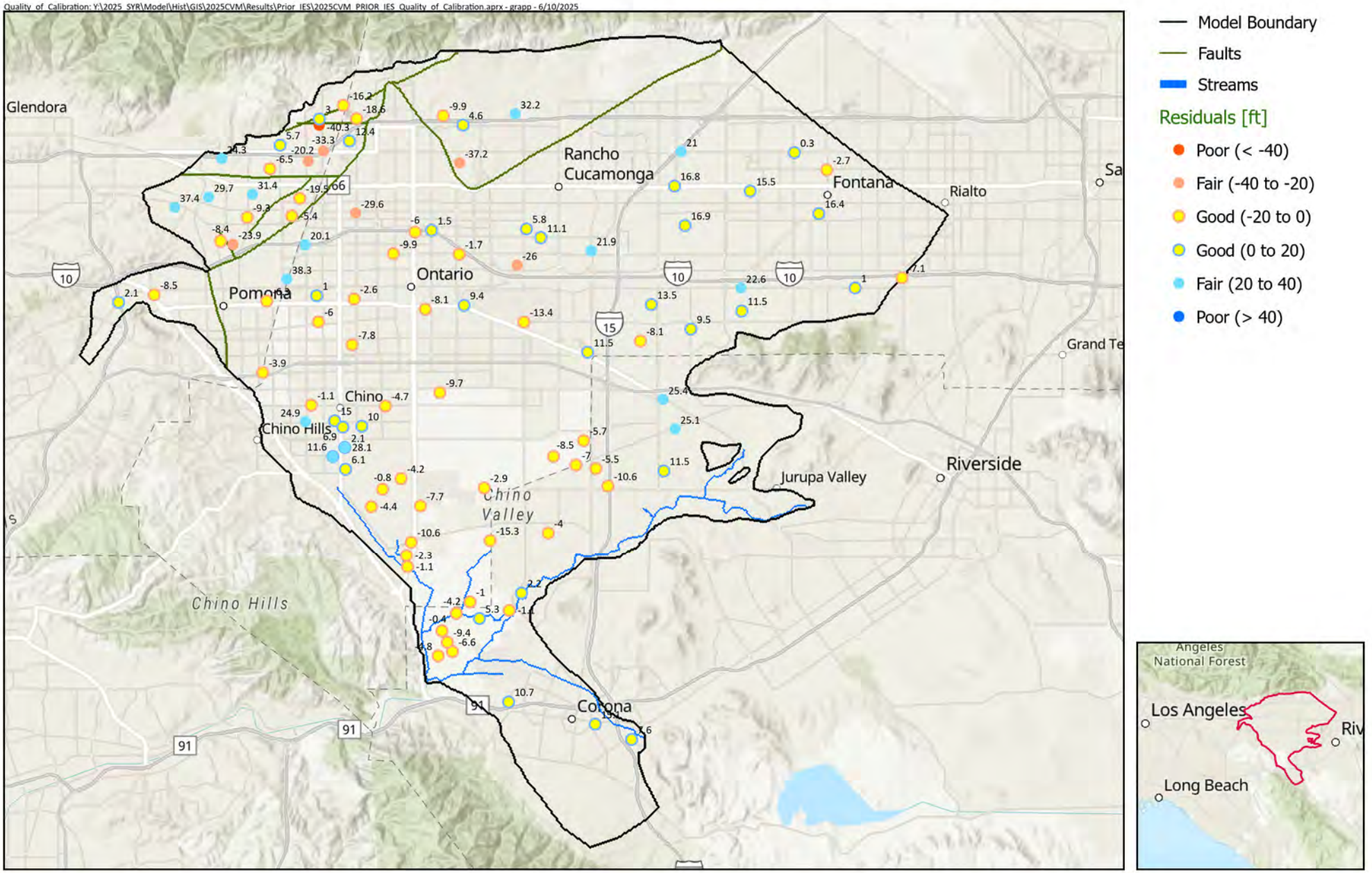
PESTPP-IES was configured to run for five iterations. The number of desired calibrated realizations was 100. Like previous scenarios, some realizations were dropped by PESTPP-IES during the calibration process. Figure 4-17 shows the range of the calculated net recharge for fiscal year 1992 to 2022 for the 97 realizations that remained active at the end of the third iteration. Runs with a larger number of adjustable parameters tended to be more complex, increasing both the calibration time and the likelihood of model instability or physically unrealistic behavior in some realizations. PESTPP-IES identified and removed such failing realizations, resulting in a smaller final ensemble.

Figure 4-18 shows a histogram of calculated mean net recharge for the 97 realizations that remained active at the end of the second iteration. The average net recharge of all active realizations for the calibration period was about 135,200 acre-feet/year (afy).

The realization with average net recharge closest to the ensemble mean at the end of the third PESTPP-IES iteration was selected to graphically illustrate the calibration results. Appendix B-4 presents maps of the calibrated aquifer properties for this realization. Appendix B-5 provides time series charts that compare simulated hydraulic heads versus the calibration targets.

Figure 4-11
Comparison of Simulated and Measured Groundwater Levels in Wells of the 2025 CVM Manual Calibration






Prepared by:

WEST YOST

N

0 2 4 Miles

0 3 6 Km

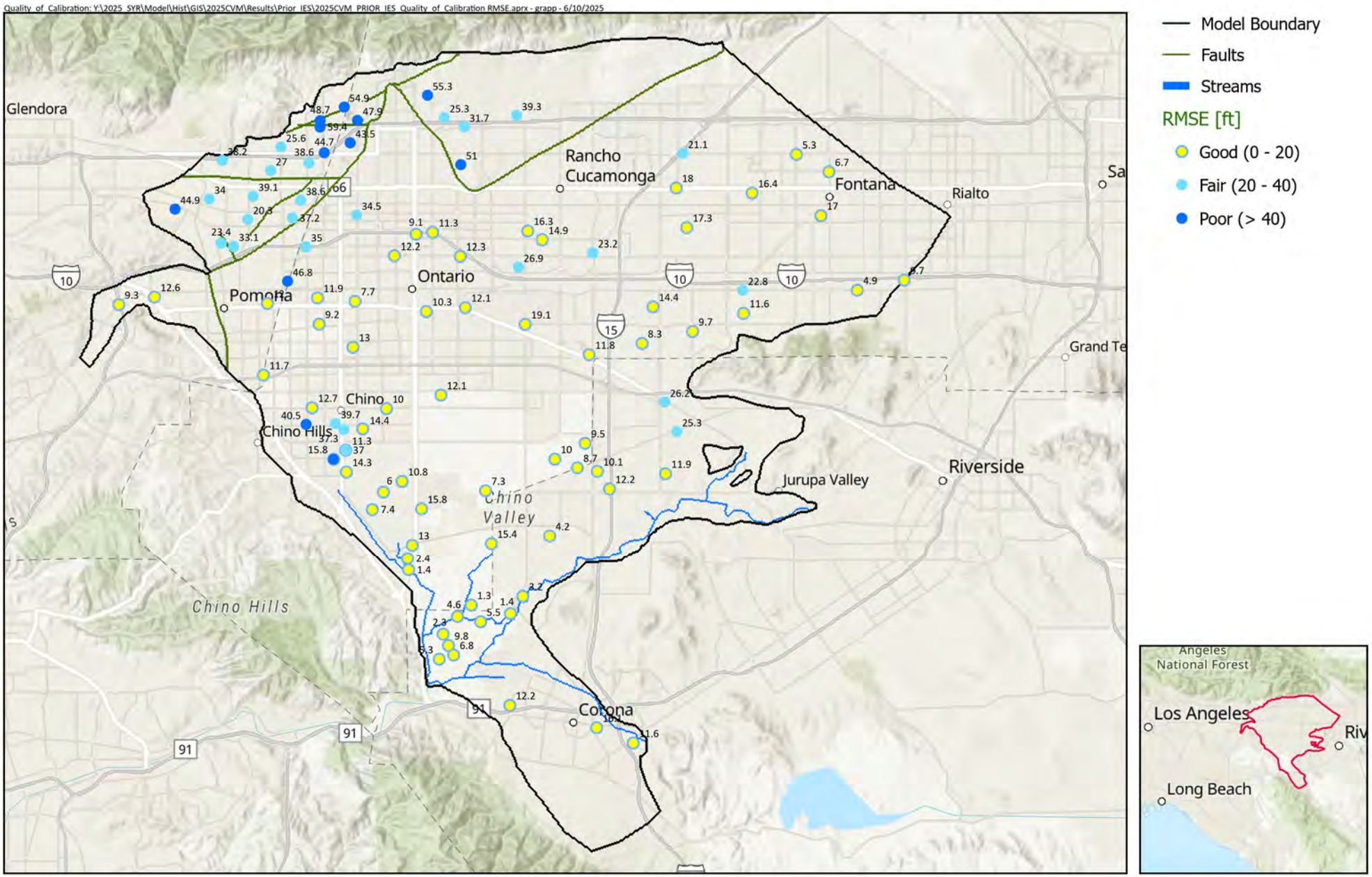
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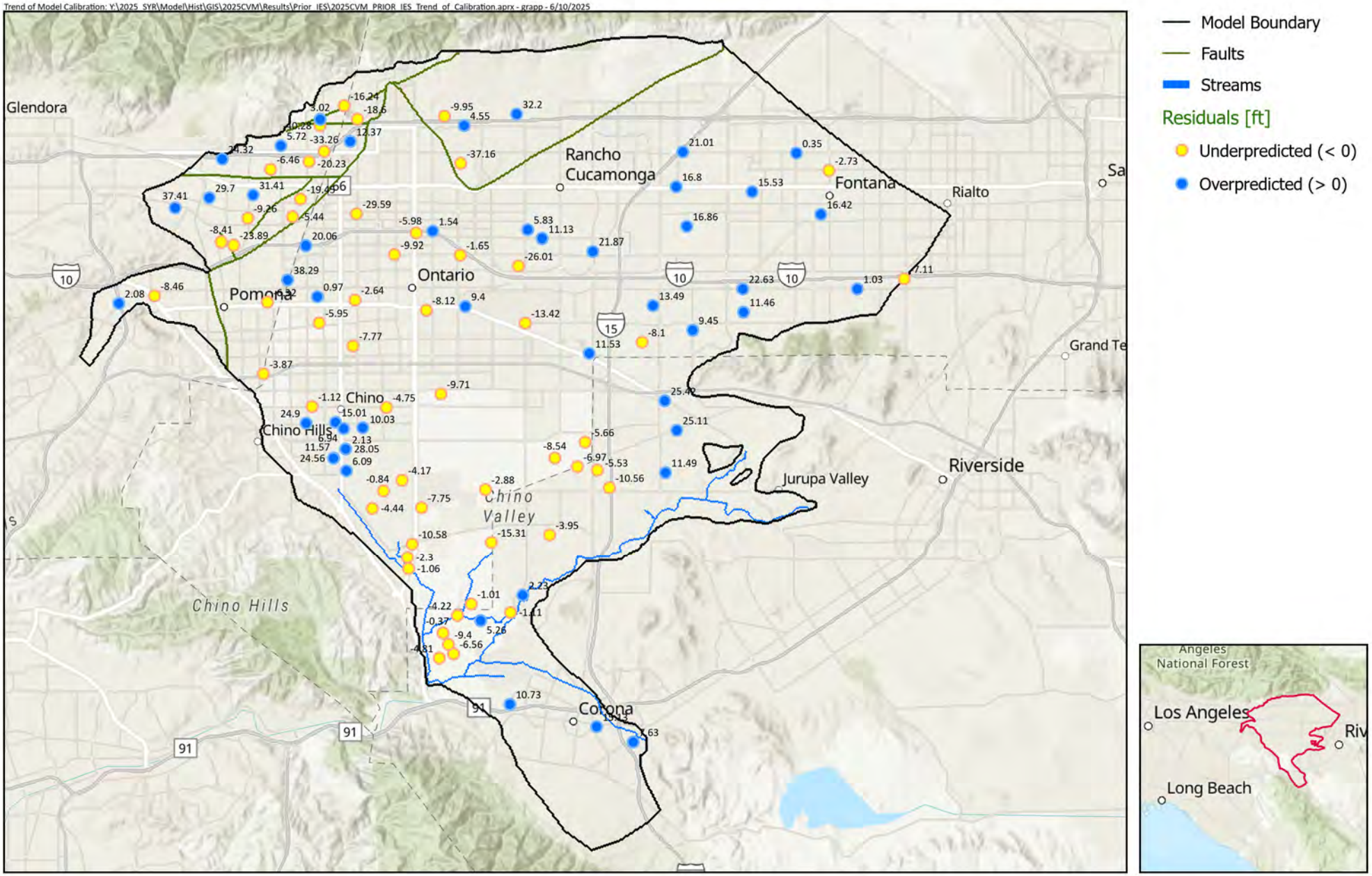
**Chino Basin Watermaster**

*2025 Safe Yield Reevaluation*

**2025 CVM: Manual Calibration Residuals of Groundwater Elevation**

**Figure 4-12**


Quality_of_Calibration: Y:\2025_SYR\Model\Hist\GIS\2025CVM\Results\Prior_IES\2025CVM_PRIOR_IES_Quality_of_Calibration RMSE.aprx - grapp - 6/10/2025
Model Boundary
Faults
Streams
RMSE [ft]
Good (0 - 20)
Fair (20 - 40)
Poor (> 40)
Glendora
Rancho Cucamonga
Fontana
Rialto
Ontario
Pomona
Chino
Chino Hills
Chino Valley
Jurupa Valley
Riverside
Corona
Grand Te
Sa
Angeles National Forest
Los Angeles
Riv
Long Beach
10
15
91
66
Prepared by:
WEST YOST
N
0 2 4 Miles
0 3 6 Km
Prepared for:
Chino Basin Watermaster
2025 Safe Yield Reevaluation
2025 CVM: Manual Calibration
RMSE of
Groundwater Elevation
Figure 4-13




Prepared by:

WEST YOST

Prepared for:

**Chino Basin Watermaster**
*2025 Safe Yield Reevaluation*

**2025 CVM: Manual Calibration**
**Trend of Groundwater Elevation Residuals**

**Figure 4-14**

Figure 4-15
Comparison of MODFLOW Estimated Streamflow and Santa Ana River Watermaster Estimated Streamflow to Prado Dam

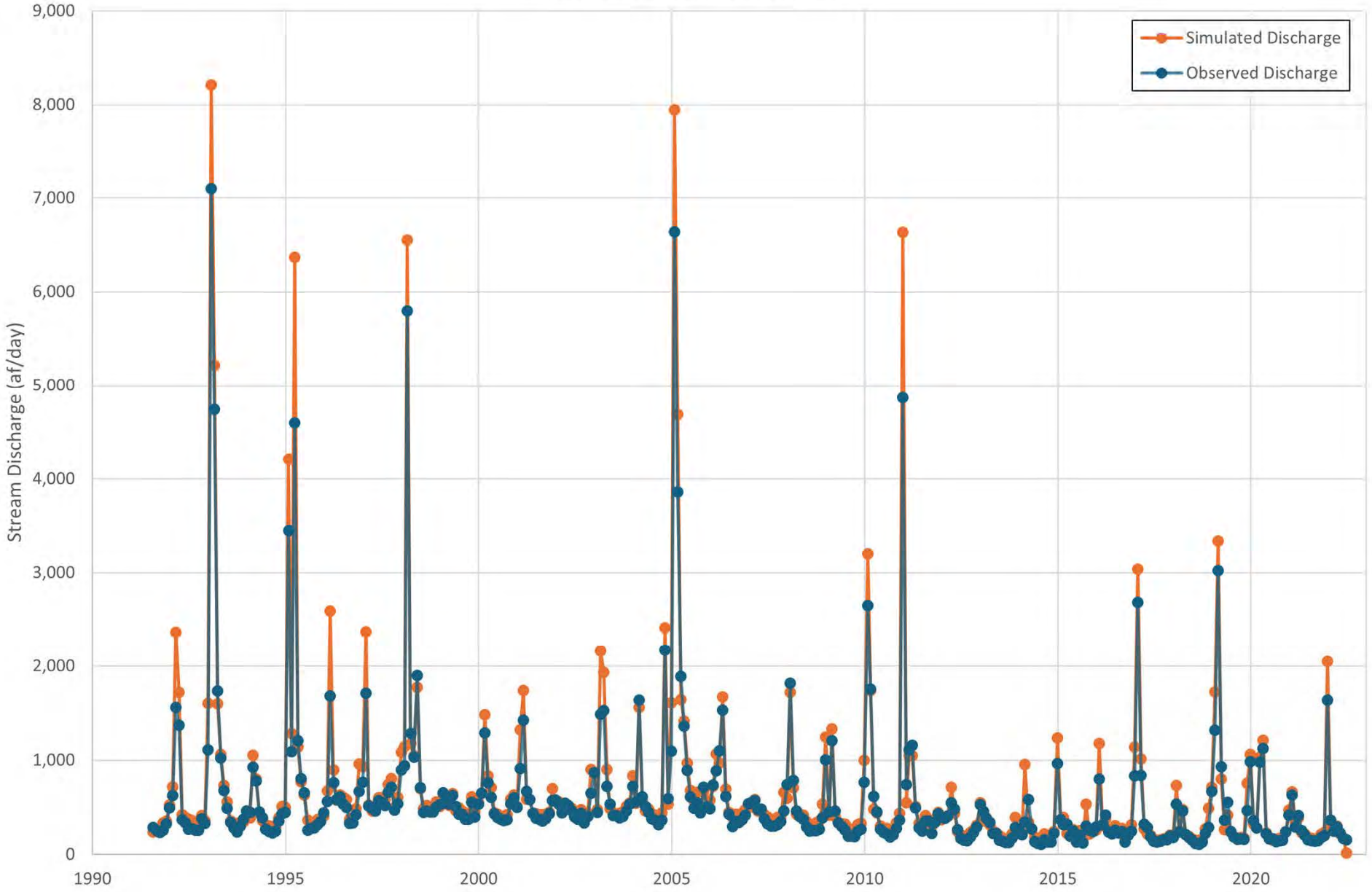


Figure 4-16
Comparison of MODFLOW Estimated Streamflow to Santa Ana River Water Master Estimated Streamflow to Prado Dam

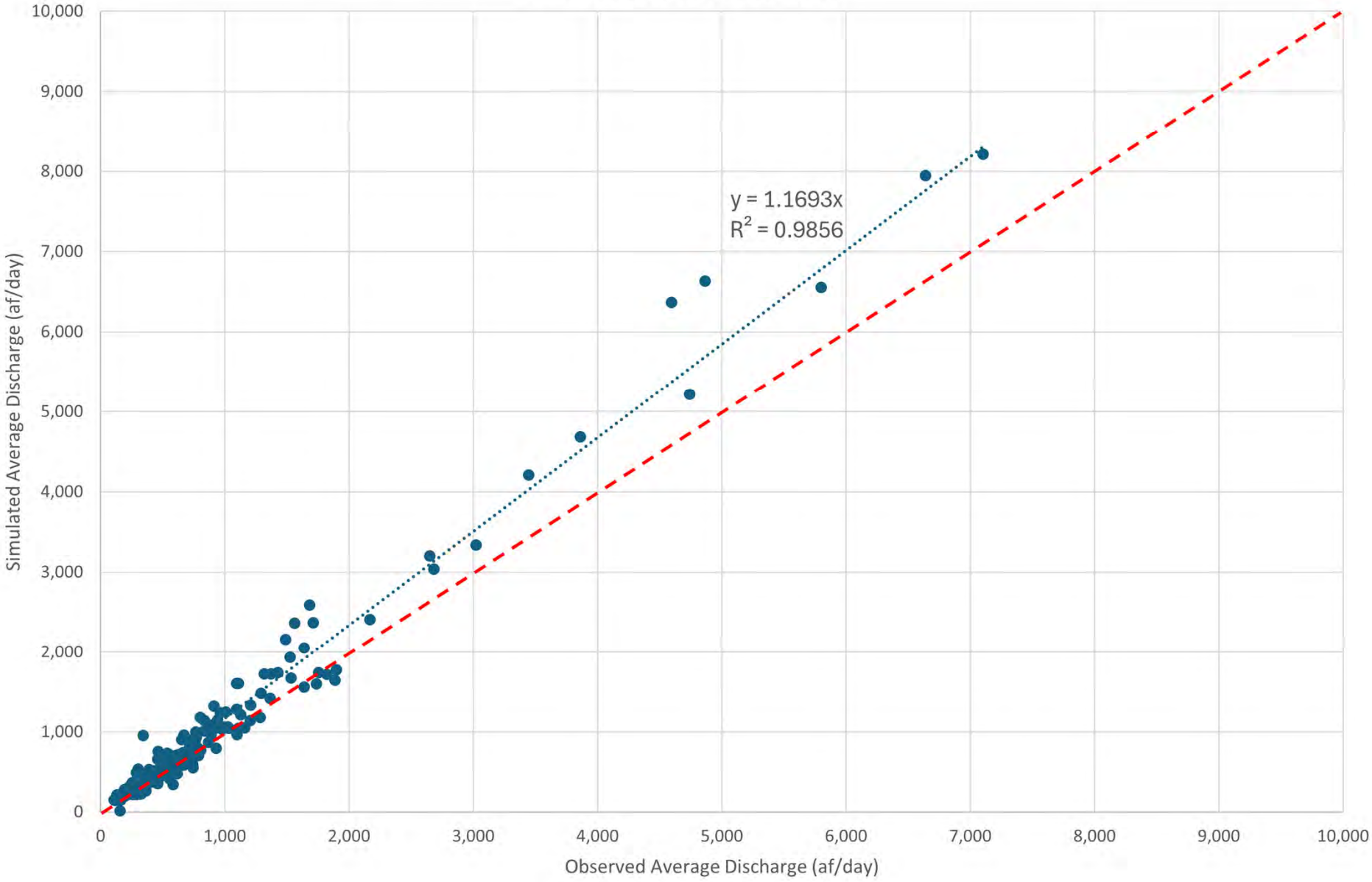


Figure 4-17
Simulated Net Recharge for the Chino Basin
Pilot Point Scenario 5 (97 Realizations)

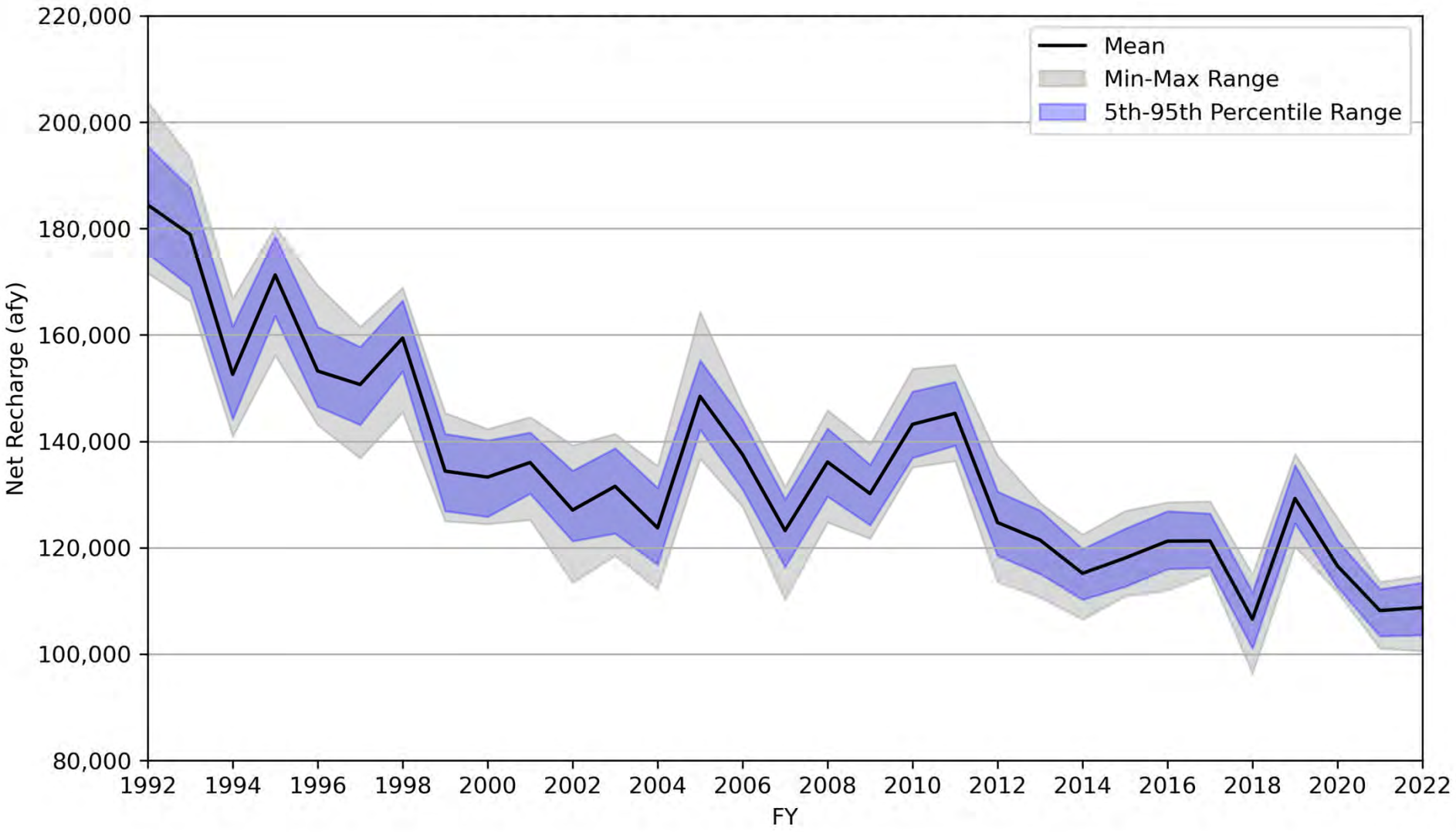


Figure 4-18
Mean Net Recharge in the Chino Basin, FY 1992-2022
Pilot Point Scenario 5 (97 Realizations)

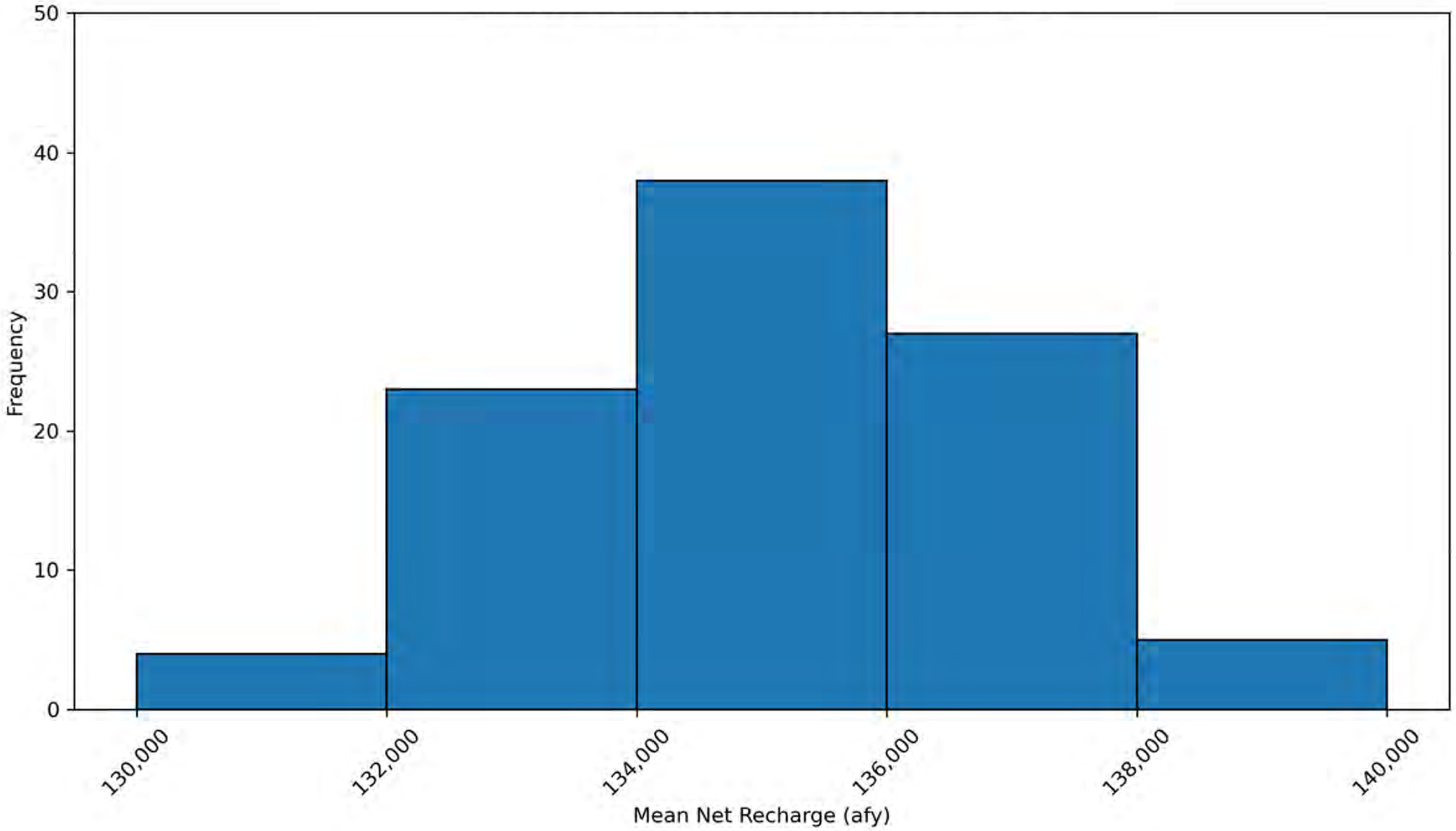


Figure 4-19 is a scatter plot of the simulated hydraulic heads versus the calibration targets at wells in the Chino Basin, Spadra Basin, Cucamonga Basin, and Six Basins. The RMSE is 21.4 ft for calibration targets in the Chino Basin, and 32.8 ft for all calibration targets. The linear regression line is derived based on all calibration targets. All points are distributed closely around the regression line, which matches closely with the 1:1 line, indicating good inverse modeling performance and a robust calibration. The coefficient of determination ($R^2$) of 0.998 suggests that 99.8 percent of the observed variance is explained by the model. Overall, this chart indicates that the calibration (for this calibrated realization) is improved over the manual calibration. Figure 4-20 is a map of residuals between the average simulated hydraulic heads and average calibration targets at the calibration wells. The mean and median residuals for all calibration targets are -36.2 ft and -0.6 ft, respectively. Figure 4-21 is a map of RMSE between the average simulated hydraulic heads and average calibration targets. Figure 4-22 is a map of the trend of residuals between average simulated hydraulic heads and calibration targets.

**Table 4-5. Summary of Adjustable Parameters for Scenario 5**

| Adjustable Parameter Type | Number of Adjustable Parameters |
|---|---|
| DIPAW multiplier | 7,440 |
| Boundary Inflow multiplier | 45 |
| Addend to specified head values | 8 |
| Maximum ET Rate multiplier | 372 |
| Streambed conductivity | 24 |
| Hydraulic conductivity of faults | 21 |
| HK values at pilot points in model layers 1 to 5 | 8,424 |
| VK values at pilot points in model layers 1 to 5 | 8,067 |
| SY values at pilot points in model layer 1 | 2,061 |
| SS values at pilot points in model layers 2 to 5 | 6,338 |
| **Total** | **32,800** |

### 4.2.6 Rank and Select Calibrated Realizations for Projection Scenarios

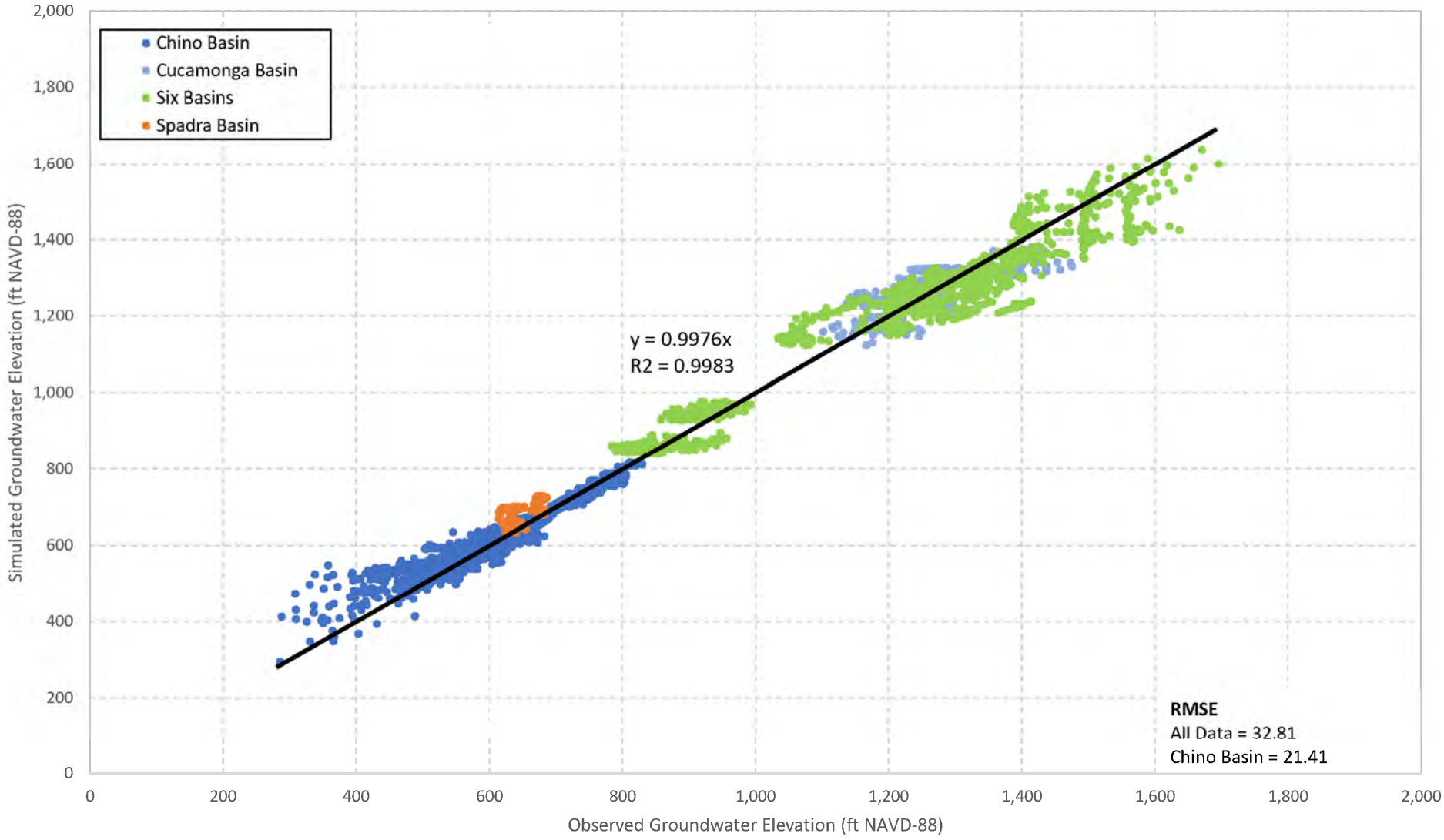
From the simulated scenarios, five calibrated realizations were chosen from the Pilot Point Scenario 5 for projection simulations. These five realizations include: one with the mean historical net recharge closest to the ensemble mean net recharge, and four realizations with net recharge values closest to one and two standard deviations above and below the ensemble mean, respectively.[9] For simplicity, the chosen realizations are labeled Realizations A through E based on their ranked net recharge over the historical period, as shown in Table 4-6.

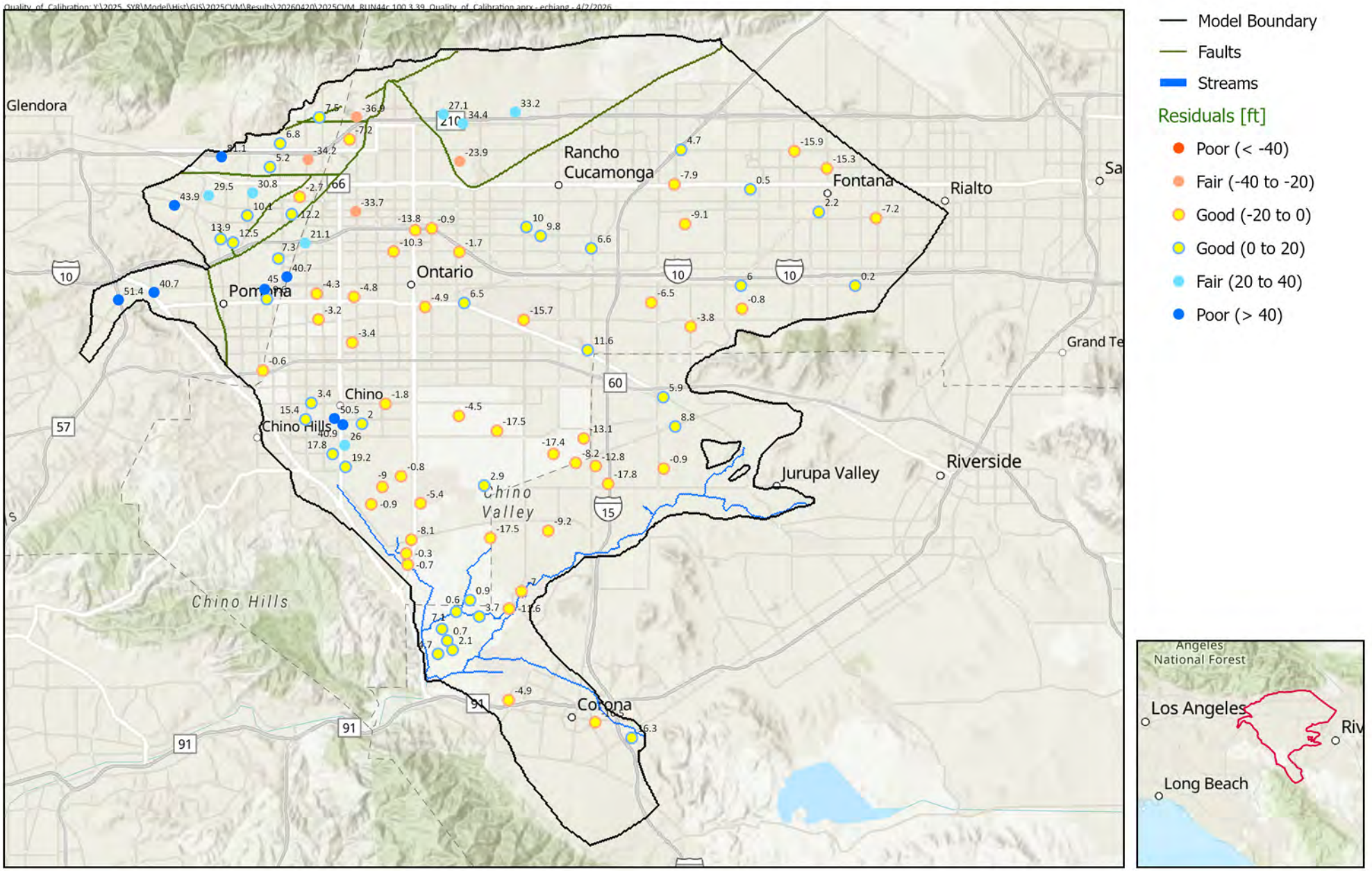
[9] The calibrated realization with the average net recharge closest to one standard deviation below the mean net recharge was excluded due to unreasonable groundwater levels in MZ-1. The next-closest calibrated realization was chosen to use as Realization B.

**Table 4-6. Summary of Net Recharge Statistics and Chosen Realizations, Pilot Point Scenario 5**

| Net Recharge Statistic (FY 1992-2022) | Volume, afy |
|---|---|
| Average, All Realizations | 135,210 |
| Standard Deviation, All Realizations | 1,750 |
| Maximum, All Realizations | 139,190 |
| Minimum, All Realizations | 131,180 |
| Average, Realization A | 131,840 |
| Average, Realization B | 133,210 |
| Average, Realization C | 135,190 |
| Average, Realization D | 136,940 |
| Average, Realization E | 138,890 |

Figure 4-19
Comparison of Simulated and Measured Groundwater Levels in Wells of the 2025 CVM
Pilot Point Scenario 5, Realization 3.39






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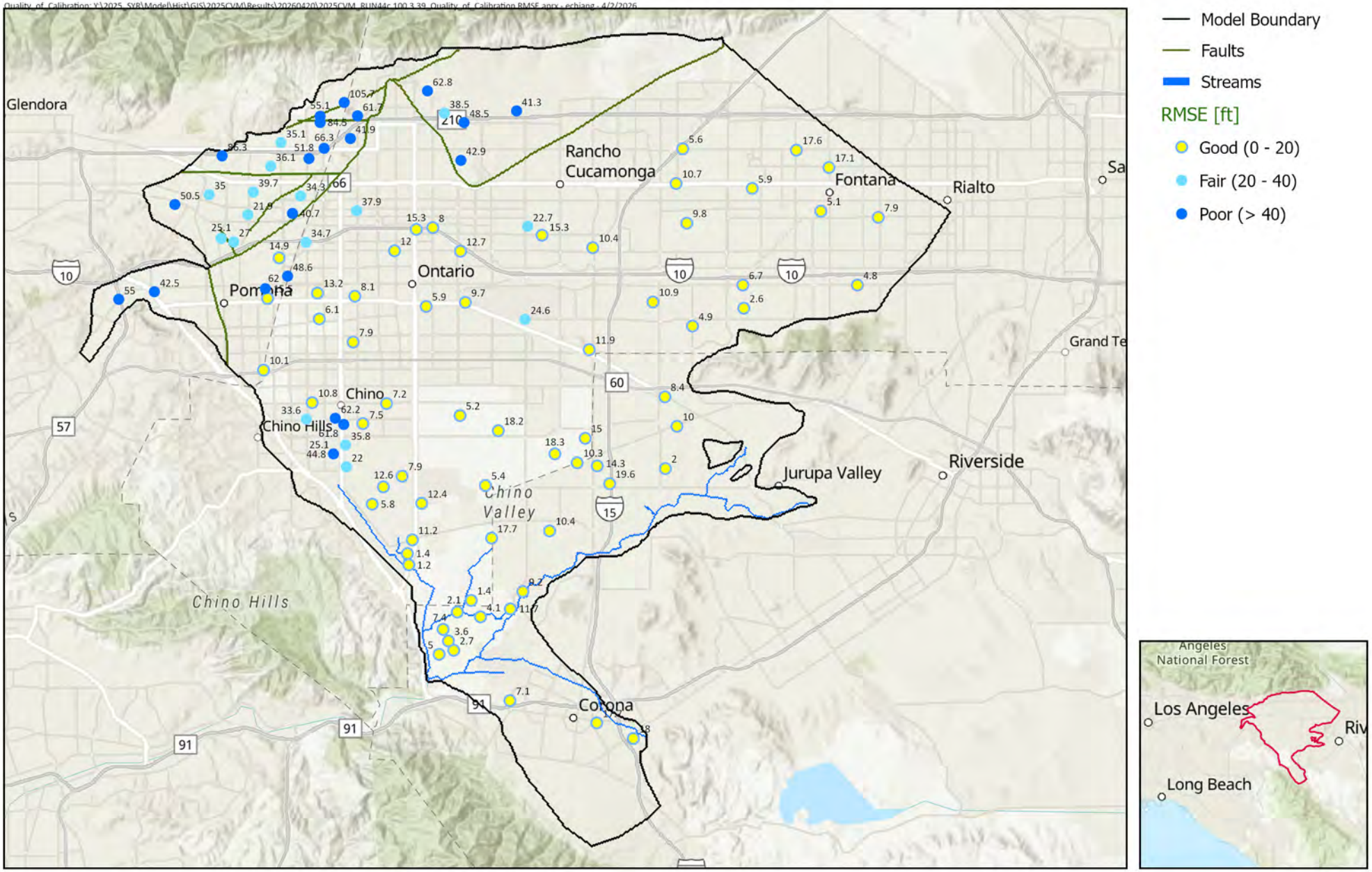
WEST YOST

Prepared for:

Chino Basin Watermaster
*2025 Safe Yield Reevaluation*

**2025 CVM: Run_44c.3.39**
**Residuals of**
**Groundwater Elevation**

**Figure 4-20**




Prepared by:

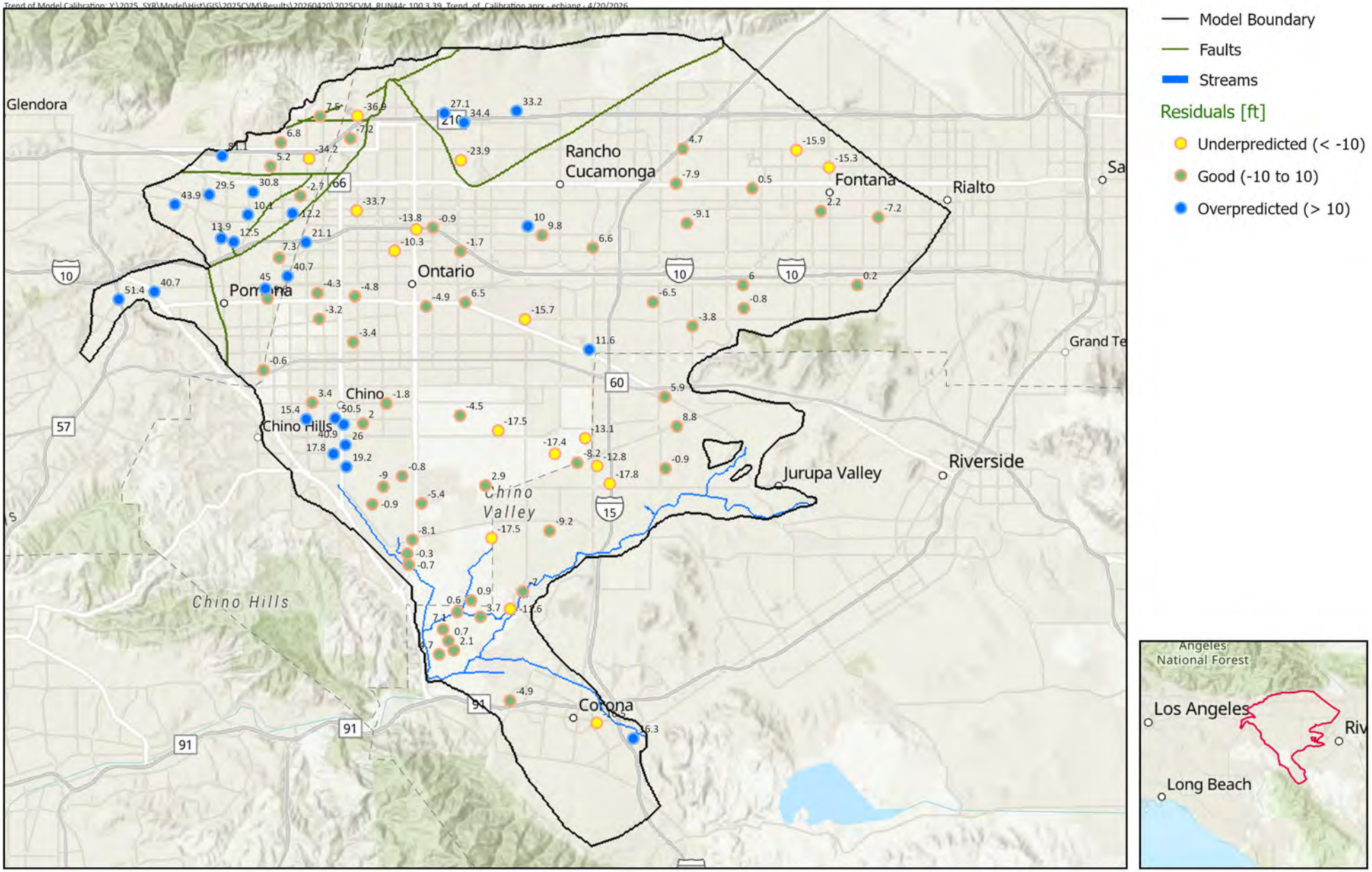
WEST YOST

Prepared for:

Chino Basin Watermaster
*2025 Safe Yield Reevaluation*

**2025 CVM: Run_44c.3.39**
**RMSE of**
**Groundwater Elevation**

**Figure 4-21**




Prepared by:

WEST YOST

Prepared for:

**Chino Basin Watermaster**
*2025 Safe Yield Reevaluation*

**2025 CVM: Run_44c.3.39**
**Trend of Groundwater Elevation Residuals**

**Figure 4-22**

Figure 4-23 illustrates the selected calibrated realizations along with the histogram based on the calculated mean net recharge for the 97 realizations. Figure 4-24 compares the net recharge time series of the selected realizations to the range of all realizations. Figure 4-24 suggests that the range of the simulated net recharge is well represented by these scenarios.

## 4.3 WATER BUDGET AND COMPARISON TO THE 2020 CVM

This section describes the major water budget components in the Chino Basin based on the selected realizations of the 2025 CVM and compares them to those from the 2020 CVM for the overlapping historical simulation period (FY 1992 through 2018).

### 4.3.1 Water Budget for Selected Realization

Table 4-7 displays the annual time series of recharge, discharge, change in storage, and net recharge from July 1, 1991 through June 30, 2022 for Realization C. Recharge and discharge components labeled with a column heading of "I" represent inputs directly provided to the 2025 CVM, with some variability introduced through PESTPP-IES as previously described. Components labeled with "R" are computational results generated by the CVM.

Water budget results for the other realizations are provided in Appendix B-6. The major water budget components for all five selected realizations, and their comparison to corresponding components in the 2020 CVM, are discussed below.

## Table 4-7 Water Budget for the Chino Basin for the Calibration Period - Realization C (af)

| Fiscal Year | Recharge | | | | | | | | | | | | Discharge | | | | | Change in Storage | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | R* | I* | R* | R* | R* | R* | I* | R* | I | I | I | | I | I | R* | R* | | | | |
| | Subsurface Inflow | | | | | | Deep Infiltration of Precipitation and Applied Water | Streambed Infiltration | Managed Aquifer Recharge | | | Total Recharge | Groundwater Pumping | | Riparian Veg ET | Rising Groundwater | Total Discharge | Annual | Cumulative | Net Recharge |
| | Bloomington Divide | Chino/Puente Hills, Jurupa Hills, and Rialto Basin | Net Temescal Basin | Six Basins | Cucamonga Basin | Spadra Basin | | | Stormwater | Recycled Water | Imported Water | | Overlying Non-Ag and Appropriative Pools | Overlying Agricultural Pool | | | | | | |
| 1992 | 14,344 | 5,585 | 4,931 | 3,613 | 34,022 | 2 | 109,846 | 48,766 | 3,598 | 0 | 5,568 | 230,274 | 102,664 | 77,336 | 15,032 | 21,895 | 216,927 | 13,347 | 13,347 | 187,779 |
| 1993 | 11,400 | 6,329 | 1,224 | 3,871 | 22,592 | 7 | 116,845 | 62,942 | 6,619 | 0 | 14,224 | 246,053 | 88,040 | 83,284 | 16,345 | 33,059 | 220,728 | 25,325 | 38,672 | 182,425 |
| 1994 | 11,108 | 6,269 | 2,568 | 3,588 | 20,226 | 16 | 113,515 | 38,878 | 1,486 | 0 | 16,448 | 214,104 | 93,564 | 72,115 | 15,567 | 29,577 | 210,823 | 3,280 | 41,952 | 152,511 |
| 1995 | 10,517 | 6,742 | 979 | 3,272 | 18,960 | 27 | 124,095 | 58,217 | 4,662 | 0 | 10,375 | 237,846 | 98,173 | 62,171 | 16,354 | 32,260 | 208,958 | 28,887 | 70,840 | 178,857 |
| 1996 | 10,677 | 6,844 | 2,185 | 3,334 | 18,401 | 47 | 113,798 | 42,352 | 2,425 | 0 | 82 | 200,146 | 109,609 | 71,220 | 17,260 | 31,625 | 229,715 | -29,568 | 41,271 | 151,179 |
| 1997 | 10,892 | 6,791 | 2,083 | 3,025 | 18,003 | 77 | 111,261 | 45,906 | 3,305 | 0 | 16 | 201,360 | 112,998 | 68,968 | 16,664 | 30,950 | 229,580 | -28,220 | 13,051 | 153,729 |
| 1998 | 10,635 | 6,716 | 296 | 3,040 | 17,746 | 103 | 108,263 | 57,609 | 5,780 | 0 | 8,352 | 218,540 | 104,141 | 45,302 | 17,361 | 34,956 | 201,760 | 16,780 | 29,831 | 157,871 |
| 1999 | 11,184 | 6,402 | 1,224 | 3,045 | 17,552 | 104 | 106,820 | 39,774 | 1,007 | 984 | 5,839 | 193,936 | 118,738 | 46,730 | 17,915 | 33,495 | 216,878 | -22,943 | 6,888 | 135,703 |
| 2000 | 11,749 | 6,051 | 686 | 2,854 | 17,358 | 109 | 102,989 | 41,748 | 1,985 | 3,630 | 997 | 190,156 | 133,609 | 46,538 | 18,635 | 31,437 | 230,220 | -40,064 | -33,176 | 135,457 |
| 2001 | 11,835 | 6,161 | 1,130 | 2,696 | 17,201 | 114 | 108,385 | 41,886 | 3,162 | 6,221 | 6,538 | 205,328 | 129,866 | 41,429 | 18,031 | 33,794 | 223,120 | -17,792 | -50,967 | 140,744 |
| 2002 | 12,442 | 5,532 | 1,862 | 2,636 | 16,975 | 119 | 96,541 | 37,081 | 1,148 | 7,444 | 6,493 | 188,273 | 139,934 | 38,650 | 17,267 | 33,376 | 229,227 | -40,954 | -91,921 | 123,693 |
| 2003 | 12,538 | 5,060 | 445 | 2,633 | 16,860 | 114 | 104,168 | 47,500 | 6,284 | 7,112 | 6,548 | 209,263 | 133,793 | 36,507 | 17,669 | 35,713 | 223,681 | -14,418 | -106,340 | 142,220 |
| 2004 | 12,886 | 5,158 | -11 | 2,571 | 16,777 | 112 | 90,494 | 40,399 | 3,357 | 8,942 | 7,607 | 188,293 | 139,028 | 36,809 | 17,054 | 35,532 | 228,423 | -40,130 | -146,470 | 119,157 |
| 2005 | 12,090 | 6,416 | -2,262 | 2,788 | 16,527 | 126 | 101,357 | 56,121 | 17,648 | 9,377 | 12,259 | 232,446 | 123,538 | 34,503 | 17,711 | 42,322 | 218,075 | 14,371 | -132,099 | 150,777 |
| 2006 | 12,412 | 6,104 | 1,945 | 3,065 | 16,314 | 109 | 93,910 | 46,940 | 12,940 | 1,303 | 34,567 | 229,610 | 133,372 | 30,812 | 17,267 | 38,185 | 219,636 | 9,975 | -122,124 | 138,288 |
| 2007 | 12,614 | 5,745 | 1,925 | 2,595 | 16,130 | 101 | 95,850 | 37,511 | 4,745 | 2,993 | 32,960 | 213,168 | 152,223 | 29,919 | 16,671 | 32,461 | 231,274 | -18,106 | -140,231 | 128,083 |
| 2008 | 12,955 | 5,712 | 1,243 | 2,490 | 16,101 | 100 | 87,021 | 42,368 | 10,205 | 2,340 | 0 | 180,534 | 157,812 | 26,280 | 15,525 | 29,901 | 229,518 | -48,984 | -189,214 | 132,768 |
| 2009 | 12,936 | 5,850 | 548 | 2,464 | 16,080 | 102 | 87,114 | 42,567 | 7,512 | 2,684 | 0 | 177,857 | 165,801 | 23,386 | 14,591 | 28,175 | 231,952 | -54,095 | -243,309 | 132,408 |
| 2010 | 13,016 | 5,221 | -224 | 2,469 | 16,024 | 96 | 84,874 | 49,258 | 14,273 | 7,210 | 5,000 | 197,216 | 137,948 | 22,038 | 14,685 | 28,360 | 203,030 | -5,813 | -249,123 | 141,962 |
| 2011 | 13,157 | 5,414 | -1,044 | 2,494 | 15,904 | 99 | 90,611 | 54,210 | 17,052 | 8,065 | 9,465 | 215,427 | 123,354 | 18,042 | 15,260 | 31,779 | 188,436 | 26,992 | -222,131 | 150,858 |
| 2012 | 13,074 | 5,156 | 520 | 2,545 | 15,671 | 100 | 82,795 | 38,777 | 9,271 | 8,634 | 22,560 | 199,102 | 136,731 | 22,412 | 14,179 | 27,781 | 201,102 | -2,000 | -224,131 | 125,948 |
| 2013 | 12,674 | 5,124 | 599 | 2,424 | 15,591 | 110 | 78,155 | 37,018 | 5,271 | 10,479 | 0 | 167,444 | 139,128 | 24,074 | 13,861 | 23,355 | 200,418 | -32,974 | -257,106 | 119,748 |
| 2014 | 12,761 | 4,976 | 358 | 2,512 | 15,501 | 112 | 70,190 | 38,336 | 4,299 | 13,593 | 795 | 163,433 | 148,475 | 22,131 | 13,040 | 22,083 | 205,729 | -42,295 | -299,401 | 113,923 |
| 2015 | 12,929 | 4,463 | -17 | 2,253 | 15,282 | 96 | 67,966 | 39,760 | 8,001 | 10,840 | 0 | 161,574 | 134,339 | 17,552 | 12,693 | 22,189 | 186,773 | -25,198 | -324,599 | 115,853 |
| 2016 | 12,639 | 3,804 | -182 | 2,307 | 15,106 | 92 | 71,756 | 42,284 | 9,236 | 13,222 | 0 | 170,264 | 129,492 | 16,908 | 12,541 | 22,196 | 181,136 | -10,872 | -335,471 | 122,306 |
| 2017 | 13,091 | 4,432 | -104 | 2,222 | 14,968 | 100 | 59,607 | 48,012 | 11,575 | 13,934 | 13,150 | 180,989 | 127,244 | 16,191 | 12,829 | 24,272 | 180,535 | 453 | -335,018 | 116,804 |
| 2018 | 12,830 | 3,833 | 1,330 | 2,122 | 14,553 | 100 | 62,531 | 34,772 | 4,494 | 13,212 | 33,763 | 183,538 | 123,992 | 16,776 | 12,318 | 21,489 | 174,574 | 8,964 | -326,054 | 102,757 |
| 2019 | 12,711 | 5,110 | -440 | 2,201 | 14,352 | 97 | 66,005 | 52,509 | 12,861 | 11,145 | 6,510 | 183,060 | 116,396 | 15,478 | 13,215 | 24,472 | 169,561 | 13,499 | -312,555 | 127,719 |
| 2020 | 13,013 | 4,853 | 614 | 2,153 | 14,155 | 112 | 67,024 | 44,348 | 9,967 | 12,953 | 18,103 | 187,294 | 132,618 | 15,722 | 12,913 | 25,250 | 186,503 | 792 | -311,763 | 118,076 |
| 2021 | 12,825 | 4,996 | 1,299 | 2,254 | 14,194 | 121 | 66,692 | 35,576 | 4,911 | 15,728 | 2,229 | 160,822 | 146,973 | 14,929 | 11,912 | 22,623 | 196,437 | -35,616 | -347,379 | 108,331 |
| 2022 | 12,735 | 4,626 | 140 | 2,258 | 14,053 | 119 | 62,103 | 35,340 | 8,108 | 15,042 | 1,742 | 156,265 | 148,608 | 14,077 | 10,965 | 20,873 | 194,523 | -38,258 | -385,637 | 107,643 |
| **Statistics for the Calibration Period 1992 through 2022** | | | | | | | | | | | | | | | | | | | | |
| Total | 382,671 | 171,477 | 25,849 | 83,793 | 529,179 | 2,842 | 2,802,580 | 1,378,762 | 217,187 | 207,086 | 282,191 | 6,083,616 | 3,982,201 | 1,108,289 | 473,327 | 905,436 | 6,469,254 | -385,637 | | 4,215,577 |
| Percent | 6.3% | 2.8% | 0.4% | 1.4% | 8.7% | 0.0% | 46.1% | 22.7% | 3.6% | 3.4% | 4.6% | 100.0% | 61.6% | 17.1% | 7.3% | 14.0% | 100.0% | | | |
| Average | 12,344 | 5,532 | 834 | 2,703 | 17,070 | 92 | 90,406 | 44,476 | 7,006 | 6,680 | 9,103 | 196,246 | 128,458 | 35,751 | 15,269 | 29,208 | 208,686 | -12,440 | | 135,986 |
| Median | 12,674 | 5,532 | 614 | 2,571 | 16,130 | 101 | 90,611 | 42,352 | 5,780 | 7,210 | 6,510 | 193,936 | 132,618 | 29,919 | 15,525 | 29,901 | 210,823 | -14,418 | | 132,768 |
| Maximum | 14,344 | 6,844 | 4,931 | 3,871 | 34,022 | 126 | 124,095 | 62,942 | 17,648 | 15,728 | 34,567 | 246,053 | 165,801 | 83,284 | 18,635 | 42,322 | 231,952 | 28,887 | 70,840 | 187,779 |
| Minimum | 10,517 | 3,804 | -2,262 | 2,122 | 14,053 | 2 | 59,607 | 34,772 | 1,007 | 0 | 0 | 156,265 | 88,040 | 14,077 | 10,965 | 20,873 | 169,561 | -54,095 | -385,637 | 102,757 |

Note: column heading R means model results and column heading I means model input. Asterisks indicate components that had volumes or related parameters that were allowed to vary during the uncertainty analysis.

Figure 4-23
Mean Net Recharge in the Chino Basin, FY 1992-2022
Chosen Realizations of 2025 CVM

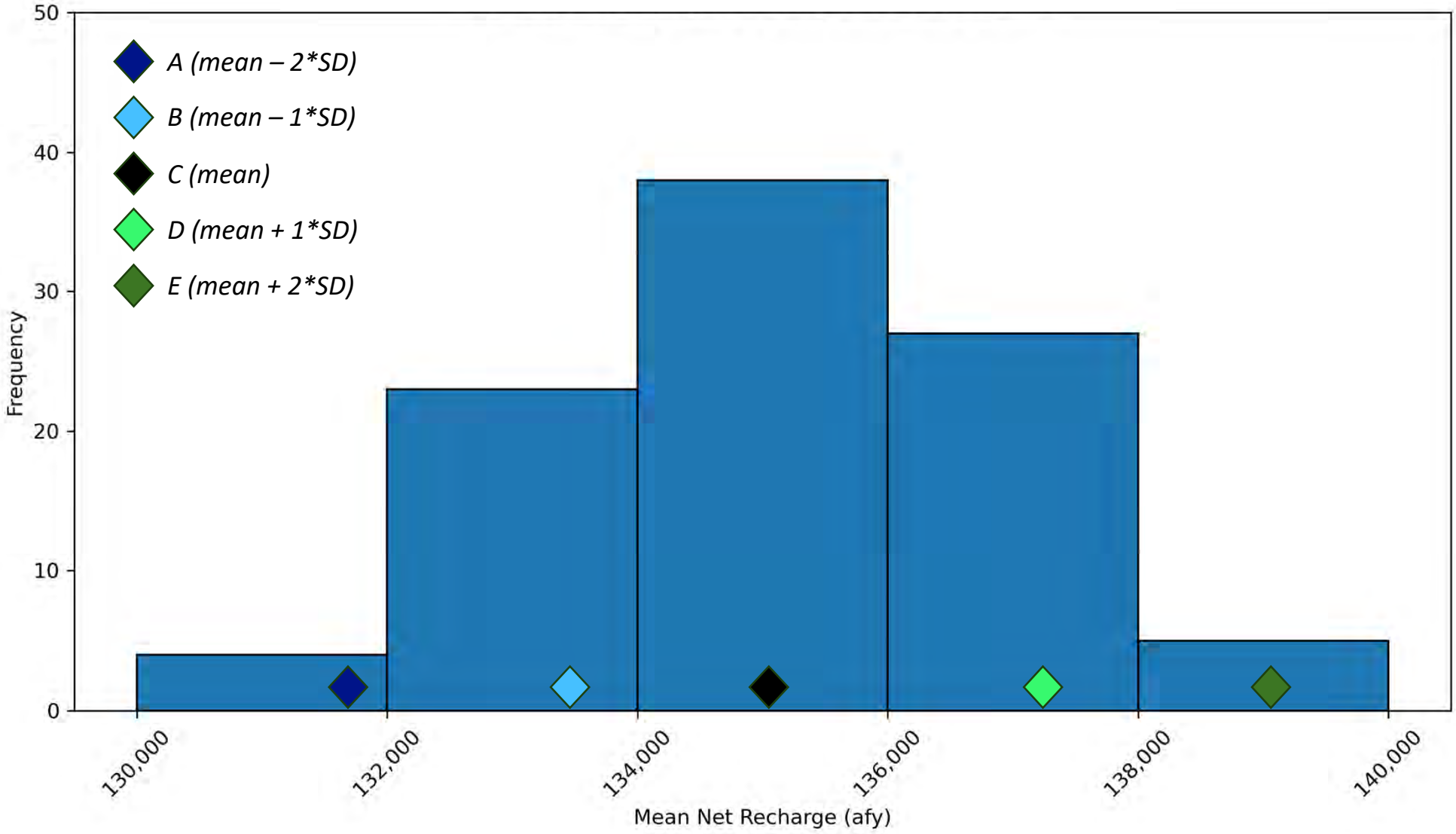
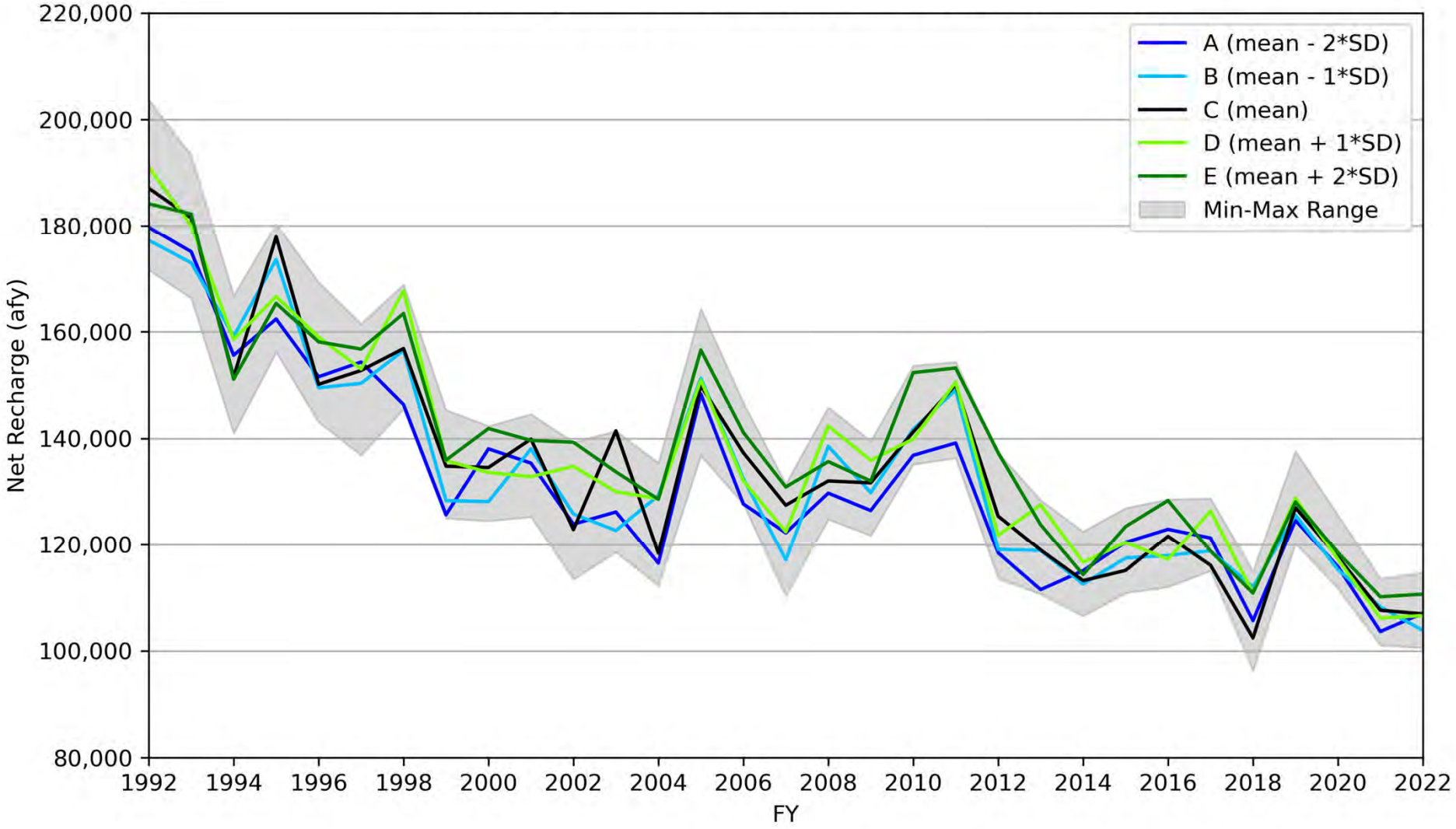


Figure 4-24
Simulated Net Recharge for Chosen Realizations of the 2025 CVM



### 4.3.2 Comparison of 2025 CVM Realizations to 2020 CVM

Table 4-8 compares the average annual water budget components for the FY 1992–2018 period for the 2025 CVM and the 2020 CVM. Measured components (such as managed aquifer recharge and groundwater pumping) that were not allowed to vary, are nearly identical in both models, and are therefore not included in Table 4-8. Figures 4-25 through 4-27 present time series of each of the components listed in Table 4-8, illustrating the range and mean of the volumes in the 2025 CVM compared to the corresponding time series from the 2020 CVM.

Differences between the 2020 CVM and the 2025 CVM water budgets are expected, given the recalibration and uncertainty analysis described above. Cumulative changes in the model structure, parameterization, calibration period, and the use of the PESTPP-IES tool have all contributed to the range of model outcomes. These differences are not attributable to any single factor but reflect refinements in the model processes that more accurately represent the range of possible conditions in the 2025 CVM.

**Table 4-8. Comparison of Water Budget Components - 2020 and 2025 CVM**

| Component[a] | Figure | Mean Annual Volume, FY 1992-2018 (afy) | | |
|---|---|---|---|---|
| | | 2020 CVM | 2025 CVM[a] | 2025 CVM minus 2020 CVM |
| Net Inflow from Six Basins | 4-25 | 4,960 | 4,160 | -800 |
| Net Inflow from Cucamonga Basin | 4-25 | 9,920 | 16,900 | 6,980 |
| Net Inflow from Temescal Basin | 4-25 | 2,120 | 2,580 | 460 |
| Net Inflow from Spadra Basin | 4-25 | 460 | 60 | -400 |
| Inflow from Bloomington Divide | 4-25 | 14,760 | 10,530 | -4,230 |
| Other Subsurface Inflows | 4-25 | 7,330 | 5,270 | -2,060 |
| Groundwater Pumping[b] | - | 166,140 | 160,700 | -5,440 |
| Managed Aquifer Recharge | - | 21,820 | 21,750 | -70 |
| DIPAW to Saturated Zone | 4-26 | 98,030 | 94,140 | -3,890 |
| SAR Infiltration | 4-26 | 31,920 | 45,420 | 13,500 |
| ET | 4-26 | 18,170 | 15,900 | -2,270 |
| Rising Groundwater | 4-26 | 19,670 | 30,860 | 11,190 |
| Total Recharge | 4-27 | 190,990 | 214,430 | 23,440 |
| Total Discharge | 4-27 | 203,970 | 221,820 | 17,850 |
| Net Recharge | 4-27 | 139,600 | 138,300 | -1,300 |
| Change in Storage | 4-27 | -12,980 | -7,400 | 5,580 |

(a) Volumes reflect the mean of all five calibrated realizations.
(b) Differences in groundwater pumping reflect the adjustment of the basin boundaries and refinements of the unmetered pumping in the 2025 CVM.

The following subsections describe each of the three figures comparing the 2020 CVM and the 2025 CVM.

### 4.3.2.1 Subsurface Inflows (Figure 4-25)

Figure 4-25 compares the subsurface inflow components of the Chino Basin, including net inflows from the Six Basins, Cucamonga Basin, Temescal Basin, Spadra Basin, the Bloomington Divide, and other subsurface inflows. The "other subsurface inflows" category includes contributions from the Chino/Puente Hills, Jurupa Hills, and Rialto Basin. Overall, the magnitude of these components is similar between the 2020 CVM and the 2025 CVM; however, relatively larger differences are observed for inflow from the Cucamonga Basin and across the Bloomington Divide. These differences reflect updated conceptualization, parameterization, or calibration of boundary conditions in the 2025 CVM, and highlight areas where subsurface flow remains more uncertain.

### 4.3.2.2 Other Variable Water Budget Components (Figure 4-26)

Figure 4-26 shows the variable water budget components beyond the Subsurface Inflows, including DIPAW to the saturated zone, infiltration from the SAR and its tributaries, ET, and rising groundwater outflows.

The estimated DIPAW in the 2025 CVM is approximately 3,900 afy lower than in the 2020 CVM. This difference reflects the impact of the spatial DIPAW multipliers introduced in the uncertainty analysis and the adjustment of the Chino Basin boundaries (see Section 3), which resulted in an approximately one percent reduction in area of the Chino Basin.

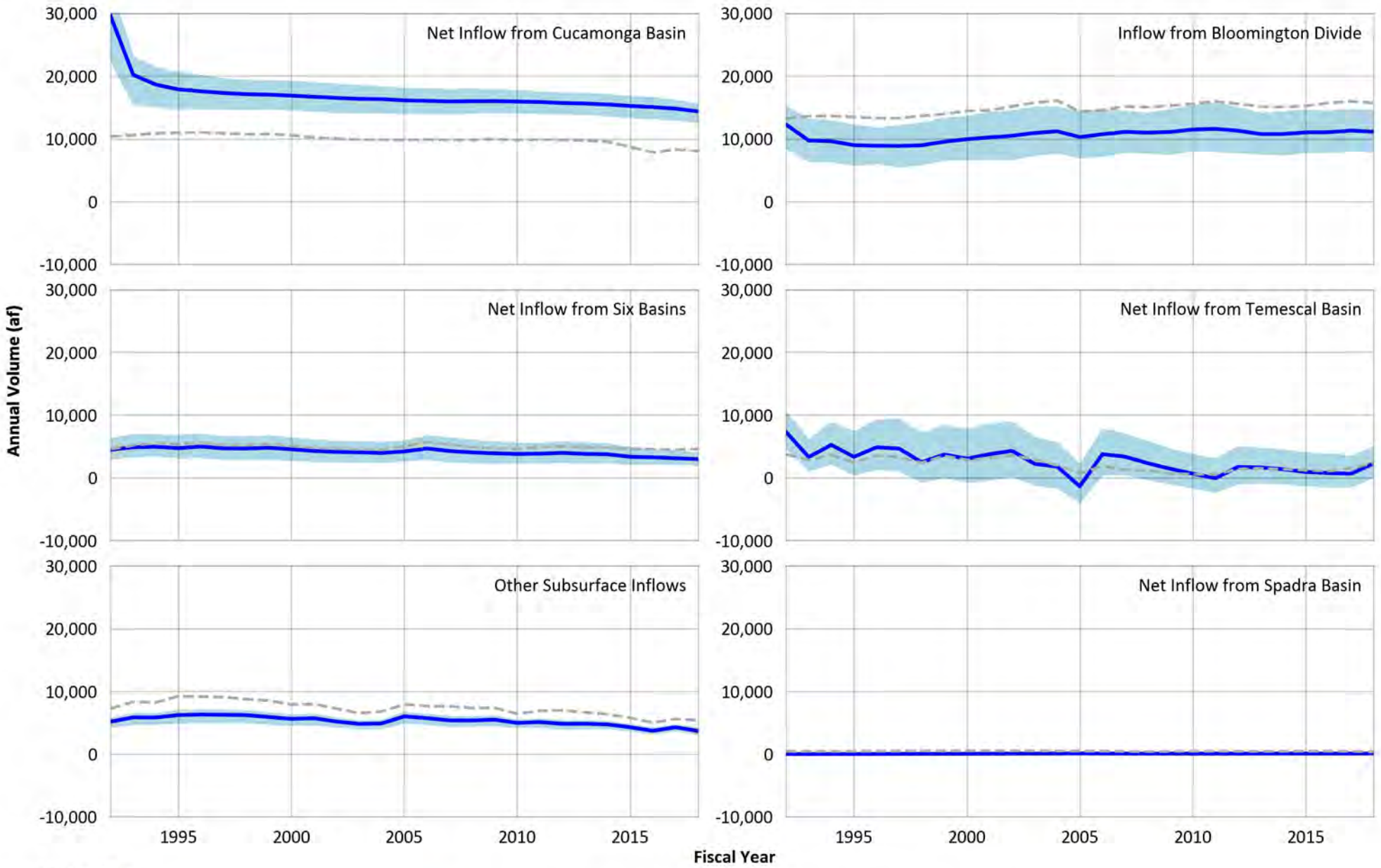
Both infiltration from the SAR and rising groundwater outflow are higher in the 2025 CVM by 13,500 afy and 11,200 afy, respectively, reflecting the overall increase in streambed hydraulic conductivity in the 2025 CVM. These differences suggest that groundwater/surface-water interactions are more extensive than previously represented. ET outflows from the basin are about 2,300 afy lower in the 2025 CVM compared to the 2020 CVM.

### 4.3.2.3 Summary of Water Budget (Figure 4-27)

Figure 4-27 compares total recharge, total discharge, net recharge, and the cumulative change in storage between the 2020 CVM and the 2025 CVM.

Net recharge represents the exploitable inflow to a groundwater basin over a given period (whether under historical conditions or future projections) and reflects the combined effects of hydrology, cultural conditions, and water management practices during that time. Net recharge is the sum of the natural recharge components (i.e., excluding supplemental water recharge) minus the sum of the natural discharge components (such as ET and rising groundwater). The methodology for computing net recharge is described in Section 1 of the 2020 SYR Report.

The average net recharge across the five selected realizations in the 2025 CVM is 138,300 afy for the 1992 through 2018 period, approximately 1,300 afy lower than that estimated in the 2020 CVM.

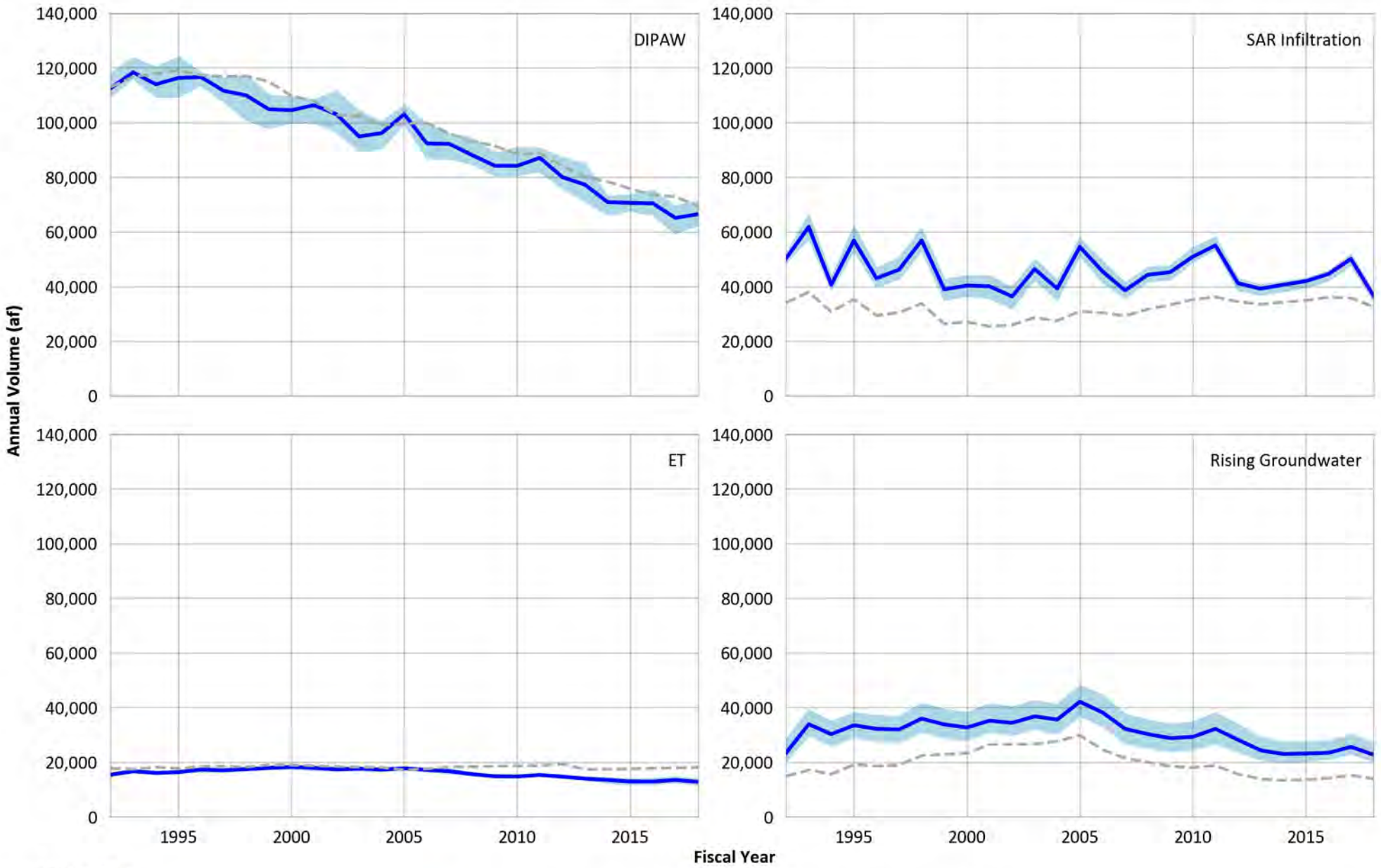



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Water. Engineered.

Comparison of Subsurface Inflows - 2020 and 2025 CVM

Figure 4-25

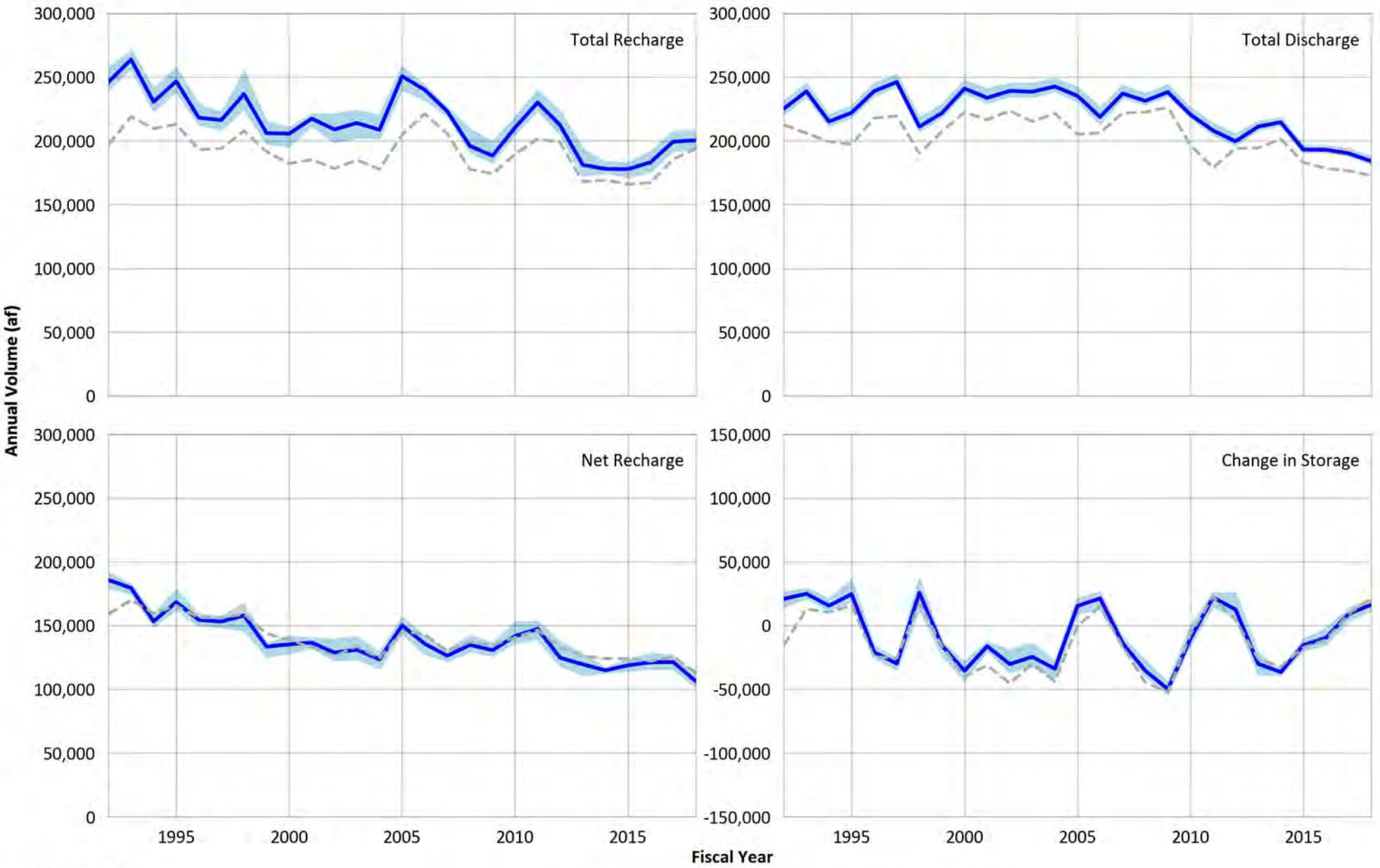



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Comparison of Other Variable Water Budget Components - 2020 and 2025 CVM

Figure 4-26




Prepared by:

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Comparison of Net Recharge and Discharge - 2020 and 2025 CVM

Figure 4-27

## 4.4 REFERENCES

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# SECTION 5
# Projection Ensemble

The Projection Ensemble is a series of planning scenarios that describe a reasonable range of future climate and cultural conditions in the Chino Basin through the planning horizon (2024-2080). The Projection Ensemble is used as input data for the 2025 CVM to simulate the potential range in future hydrologic conditions in the Chino Basin, including the water budget and changes in groundwater levels.

This section describes the objectives, methods, and results of the development of the Projection Ensemble, including the likelihoods associated with each Projection Scenario.

## 5.1 OBJECTIVES OF THE PROJECTION ENSEMBLE

The Projection Ensemble is designed to represent a reasonable range of uncertainty in future climate and cultural conditions, including the water demands and supply plans (Water Plans) of the water purveyors in the Chino Basin, pursuant to Steps 3 through 5 of the 2022 SYRM:[1]

- *Describe current and projected future cultural conditions, including but not limited to land use and water-management practices, such as: pumping, managed recharge, managed groundwater storage, impervious land cover, water recycling, and water conservation practices. Identify a possible range of projected future cultural conditions.*
- *Using the most current research on future climate and hydrology, identify a possible range of projected future climatic conditions in the Santa Ana River watershed.*
- *Using the results of [3.] and [4.] above, prepare an ensemble of multiple Projection Scenarios of combinations of future climate/hydrology and cultural conditions (herein called the "Projection Ensemble"). Assign likelihoods to each scenario in the Projection Ensemble.*

Recognizing that it is not feasible to include every possible permutation of future climate and cultural conditions in the Projection Ensemble, the objectives of the Projection Ensemble are to: (i) bracket a reasonable range in future climate and cultural conditions and (ii) result in the maximum potential range in the future hydrologic responses of the Chino Basin (i.e., high and low groundwater levels; high and low net recharge). This approach is based on Robust Decision Making (RDM)[2] principles, which inform strategies that perform well across a wide range of plausible futures.

This strategy informs parties about both the central tendency and potential extremes (high and low groundwater levels; high and low net recharge) of the Chino Basin's future hydrologic response. Understanding these extremes and their drivers can inform groundwater management strategies to avoid undesirable results and MPI and optimize basin management.

[1] See Attachment C of the 2022 Update of the Chino Basin Safe Yield Reset Methodology

[2] Robust Decision Making | RAND

## 5.2 STAKEHOLDER ENGAGEMENT AND TIMELINE

The development of the Projection Ensemble involved a collaborative process with multiple stakeholder workshops and technical documents to ensure that the scenarios were representative of the possible range in future conditions. This process involved:

- **Workshops**: Watermaster hosted four workshops with parties and other stakeholders to gather input during the development of the Projection Ensemble, to review accompanying Scenario Design TMs, and discuss stakeholder feedback:
  - **Workshop #1** (October 24, 2023). The objective of Workshop #1 was to identify key drivers for the Water Plans of the Chino Basin water purveyors. These drivers included economics, demographics, technology, policy, and climate. Stakeholders provided feedback on the methods and assumptions for quantifying the potential impacts of water conservation regulations, variation in precipitation, and temperature fluctuations.
  - **Workshop #2** (March 7, 2024). The objectives of Workshop #2 were to present a proposed *qualitative* Projection Ensemble, gather feedback on the Projection Ensemble, and gather input on proposed methods to *quantify* the Projection Scenarios.
  - **Workshop #3** (June 25, 2024). The objectives of Workshop #3 were to summarize feedback and responses from the Scenario Design TM #2 and Workshop #2 and to describe the proposed *quantitative* Projection Ensemble. Stakeholders provided feedback on the Water Plan Scenarios and the proposed methods for simulating future climate conditions.
  - **Workshop #4** (August 27, 2024). The objectives of Workshop #4 were to summarize feedback and responses from the draft Scenario Design TM #3 and Workshop #3 and to describe updates made to the proposed *quantitative* Projection Ensemble. Stakeholders provided feedback on the Water Plan Scenarios and the proposed Climate Scenarios.
- **Targeted Outreach to the Appropriative Pool Parties**: During the scenario design process, West Yost reached out to the Appropriative Pool (AP) parties to solicit input on the scenario development. Many AP parties[3] provided input and reviewed draft Water Plan Scenarios that were developed for each party.
- **Technical Memoranda**: Three TMs were prepared to document the development of the Projection Ensemble:
  - **Scenario Design TM #1** outlined the approach for developing Water Plan projections and presented questions for the first workshop.
  - **Scenario Design TM #2** documented feedback from the first workshop, described the proposed Water Plan projections, presented recommended climate datasets, and outlined the Projection Ensemble.

[3] All AP retailers were contacted to provide input on the scenario design process. The AP parties that provided input included the Cities of Chino, Chino Hills, Ontario, Pomona, Upland, Cucamonga Valley Water District, Jurupa Community Services District, the Chino Desalter Authority, Monte Vista Water District, and Fontana Water Company.

— **Scenario Design TM #3** documented feedback from previous TMs and workshops and quantitatively described the proposed Projection Ensemble.

Parties provided feedback on the TMs, the proposed Projection Ensemble, and the data used to prepare the Projection Ensemble. All written input was responded to in the Scenario Design TMs. General themes of the verbal feedback from the workshops were addressed in subsequent Scenario Design TMs and workshops.

- **Website**: Throughout the Scenario Design process, Watermaster maintained a webpage[4] on its website with links to the timeline, draft and final TMs, and workshop materials.
- **Updates at Watermaster Meetings**: Updates on the 2025 SYR process, including the development of the Projection Ensemble, were provided at monthly Pool Committee, Advisory Committee, and Board meetings. Updates included announcing distribution of TMs, future workshop dates, summaries of workshops, and other status updates.

### 5.2.1 Timeline for Development of the Projection Ensemble

The timeline for the development of the Projection Ensemble was:

- **October 20, 2023:** Scenario Design TM #1 was distributed to the parties.
- **October 24, 2023**: Scenario Design Workshop #1.
- **December 1, 2023**: Stakeholders provided written comments on Scenario Design TM #1.
- **March 5, 2024:** Scenario Design TM #2 was distributed to the parties.
- **March 7, 2024**: Scenario Design Workshop #2.
- **April 12, 2024**: Stakeholders provided written comments on Scenario Design TM #2.
- **Spring 2024**: West Yost requested information from five AP retailers to inform the development of Water Plan projections. This included the estimated response to the urban water-use objectives being developed to comply with Assembly Bill 1668 and Senate Bill 606 in 2018 ("Making Conservation a California Way of Life").
- **June 25, 2024**: A draft of Scenario TM #3 was distributed, and Scenario Design Workshop #3 was held.
- **July 19, 2024**: Stakeholders provided written comments on draft Scenario Design TM #3.
- **August 27, 2024**: A revised draft of Scenario TM #3 was distributed, and Scenario Design Workshop #4 was held.
- **September 27, 2024**: Stakeholders provided written comments on draft Scenario Design TM #3.
- **Fall 2024:** West Yost submitted draft Water Plan Scenarios to nine AP parties for their input. West Yost held meetings with five of the nine parties to discuss the Water Plan Scenarios and gather feedback.

[4] Chino Basin Watermaster - 2017 Safe Yield Court Order Implementation

- **February 12, 2025**: The final Scenario Design TM #3 was published, including responses to all written stakeholder comments on Scenario Design TM #2 and prior drafts of Scenario Design TM #3.

## 5.3 CHARACTERIZING UNCERTAINTY IN FUTURE CLIMATE

Future climate will directly and indirectly impact the hydrology of the Chino Basin by influencing water use, the availability of water supplies, and recharge. For instance, hotter and drier weather can lead to increased water demands, reduced natural recharge, and reduced water supplies (including surface waters used for artificial recharge). Future climate is also inherently uncertain due to natural variability in short-term weather conditions, incomplete knowledge of future climate trends, and the limitations of models used to forecast climate.

To incorporate the uncertainty of future climate into the 2025 SYR, as required in Step 4 of the 2022 SYRM, three "Climate Scenarios" were developed to represent the "possible range of projected future climatic conditions": *Average, Hot/Dry,* and *Cool/Wet*. Each Climate Scenario includes a time series for projected precipitation and reference evapotranspiration ($ET_o$) from FY 2024 through 2080. Each time series was derived from historical observations that were adjusted to incorporate the uncertainty in short-term weather patterns and long-term climatic trends.

The development of Climate Scenarios for the 2025 SYR involved two main steps. The first step was to prepare a 57-year time series of precipitation and $ET_o$ for the period 2024-2080 based on historical data. The second step was to modify the time series to produce the three Climate Scenarios (i.e., a possible range in future climate conditions). The following subsections describe the development of the Climate Scenarios.

### 5.3.1 Use of Historical Precipitation and $ET_o$ Data

The historical record of precipitation and $ET_o$ data[5] from FY 1950-2022[6] was used to develop a reasonable range of potential future climate conditions in the Chino Basin (i.e., *Average, Hot/Dry,* and *Cool/Wet*) for the projection period of FY 2024-2080. Each Climate Scenario is based on a continuous 7-year historical period to represent FY 2024-2030 and a continuous 50-year historical period to represent FY 2031-2080. Details for each period are outlined below:

1. **FY 2024-2030**: This 7-year period represents the final years over which the current Safe Yield was calculated. Precipitation and $ET_o$ during this period will have the greatest influence on net recharge and the evaluation of Safe Yield for the period 2021-2030. Hence, the historical data was analyzed and used to prepare a potential range for future precipitation and $ET_o$ for the period FY 2024-2030:
   - The **Average Climate Scenario** used historical precipitation and $ET_o$ data from FY 1968-1974, the 7-year period that most closely matches the annual average precipitation over the period FY 1950-2022.
   - The **Hot/Dry Climate Scenario** used historical precipitation and $ET_o$ data from FY 2012-2018, the driest 7-year period over the period FY 1950-2022.
   - The **Cool/Wet Climate Scenario** uses historical precipitation and $ET_o$ data from FY 1977-1983, the wettest 7-year period over the period FY 1950-2022.
2. **FY 2031-2080**: All three Climate Scenarios used the same continuous 50-year historical period from FY 1959-2008. This 50-year period was selected because its annual average precipitation (15.2 in) is similar to the long-term annual average precipitation from 1915-2011 (15.4 in), includes a mix of wet and dry periods, and falls within the period for which the Department of Water Resources (DWR) developed climate change factors (FY 1915-2011).

### 5.3.2 Incorporating DWR Climate Change Factors

To incorporate future climate trends, we initially explored the use of climate data from the sixth iteration of the Coupled Model Intercomparison Project (CMIP6). As documented in Scenario Design TM #2, CMIP6 models offer improvements in representing atmospheric processes, have denser grids, and better simulate historical conditions compared to CMIP5 models. We processed the precipitation and

[5] Estimates of daily precipitation over the Chino Basin were developed from precipitation stations and gridded precipitation data products produced by the PRISM Climate Group and the National Oceanic and Atmospheric Administration. Estimates of daily $ET_o$ over the Chino Basin were developed from the Pomona and Riverside California Irrigation Management Information System stations using a spatial-temperature interpolation algorithm, supplemented by evaporation data from Puddingstone Reservoir. Details can be found in Sections 3 of the 2020 SYR Report.

[6] 1950-2022 was chosen to derive the data for the climate scenarios because (1) it is consistent with the historical time series of climate data processed for the R4 model in the 2020 SYR; (2) includes multiple dry and wet periods; (3) overlaps the period for which the DWR developed change factors (through 2011); and (4) the average annual precipitation over the 2025 CVM domain and watershed area are approximately equal to their respective long-term precipitation averages. See Figure 3-13 from the 2020 SYR Report and Figure 4-8 from this report.

temperature datasets that Cal-Adapt[7] generated from the downscaled[8] CMIP6 scenarios. The data processing and review identified discrepancies between the CMIP6 datasets and the historical precipitation datasets for the overlapping historical period in the Chino Basin. We reviewed these discrepancies with the Cal-Adapt team and were unable to resolve the discrepancies in time to use the CMIP6 models in the 2025 SYR.

Instead, we followed the DWR recommended approach for incorporating climate change into groundwater sustainability planning (e.g., DWR, 2018).[9] The DWR-recommended approach employs Change Factors (CFs) derived from spatially downscaled climate data from CMIP5.[10] CFs are used to adjust historical climate datasets to reflect projected future conditions, which preserves historical variability while incorporating future climate change trends. The DWR provides CFs for the following four climatic conditions:

1. 2030 Central Tendency (2030 CT)
2. 2070 Central Tendency (2070 CT)
3. 2070 Wet with Moderate Warming (2070 WMW)
4. 2070 Dry with Extreme Warming (2070 DEW)

To incorporate climate change in the Climate Scenarios, we applied distinct climatic conditions to each scenario. All Climate Scenarios used the 2030 Central Tendency CF but differ in their 2070 CF as follows: the Average Climate Scenario used the 2070 Central Tendency CF, the Hot/Dry Climate Scenario used the 2070 Dry with Extreme Warming CF, and the Cool/Wet Climate Scenario uses the 2070 Wet with Moderate Warming CF.

Since the DWR CFs represent snapshots of climate conditions at specific future points (e.g., the 2030 CF represents 2030 conditions and the 2070 CFs represent 2070 conditions), a continuous time series of CFs for each year between 2024–2080 was developed for each Climate Scenario.

- 2024–2030: The CF was equal to the 2030 CF.
- 2031–2070: Unique CFs were calculated for each year using linear interpolation between the 2030 and 2070 CFs.
- 2071–2080: The CF was equal to the 2070 CF.

These CF time series were then applied to the precipitation and $ET_o$ datasets presented in Section 5.3.1 to generate the time series of precipitation and $ET_o$ for each Climate Scenario.

[7] https://analytics.cal-adapt.org/

[8] Memo on Evaluating Global Climate Models for Studying Regional Climate Change in California

[9] California Department of Water Resources. 2018. Guidance for Climate Change Data Use During Groundwater Sustainability Plan Development. Accessed on 15 Aug 2024 at https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/Sustainable-Groundwater-Management/Best-Management-Practices-and-Guidance-Documents/Files/Climate-Change-Guidance_Final_ay_19.pdf

[10] Memo on Evaluating Global Climate Models for Studying Regional Climate Change in California

### 5.3.3 Summary of Climate Scenarios

Table 5-1 summarizes the three Climate Scenarios used in the 2025 SYR:

**Table 5-1: Datasets Used for Climate Scenarios**

| Climate Scenario | Precipitation and ET | |
|---|---|---|
| | FY 2024 through 2030 | FY 2031 through 2080 |
| Average | Historical period with average precipitation[(a)] (FY 1968-1974) and $ET_o$ modified with 2030 CT | Historical period (FY 1959-2008) modified using 2030 CT and 2070 CT |
| Hot/Dry | Historical period with lowest precipitation (FY 2012-2018)[(b)] and $ET_o$ | Historical period (FY 1959-2008) modified using 2030 CT and 2070 DEW |
| Cool/Wet | Historical period with highest precipitation (FY 1977-1983) and $ET_o$ modified with 2030 CT | Historical period (FY 1959-2008) modified using 2030 CT and 2070 WMW |

(a) Calculated based on continuous seven-year periods taken from the historical (PRISM) data for FY 1950 through 2022.
(b) CFs are only available through 2011; therefore, precipitation and $ET_o$ were not adjusted for this period.

Figure 5-1 shows the time series for annual precipitation averaged across the Chino Basin over the historical period (1950-2023) and for each Climate Scenario over the projection period (2024-2080). For the 2024-2030 period, note the wide range in annual precipitation between Climate Scenarios that is designed to simulate the potential range in shorter-term weather variability. During the early part of the 2031-2080 period, there are smaller differences in precipitation between scenarios because of the strong influence of 2030 CT which is identical for each scenario. The mean precipitation over the historical period was 14.3 inches. The mean precipitation for the *Average*, *Hot/Dry*, and *Cool/Wet* Climate Scenarios are 15.3 inches, 13.8 inches, and 18.3 inches, respectively.

Figure 5-2 shows the CDFM for the three Climate Scenarios for FY 2024 through 2080. CDFMs are calculations of the accumulated differences between the annual precipitation relative to the long-term mean. To characterize the differences in precipitation between scenarios through the projection period, the CDFM for each scenario is calculated relative to the mean of the Average Climate Scenario (15.3 inches). This results in the CDFM for the Average Climate Scenario equaling zero at the end of the projection period, whereas the Hot/Dry and Cool/Wet scenarios are less than and greater than zero, respectively, at the end of the projection period. Generally, an upward trending CDFM curve indicates wetter-than-average period, while a downward trending CDFM curve indicates a drier than average period. Figure 5-2 illustrates that, over the projection period, the Hot/Dry Climate Scenario is projected to receive approximately 86 inches less precipitation than the Average Climate Scenario, while the Cool/Wet Climate Scenario is projected to receive about 171 inches more.

Figure 5-3 shows the time series for annual $ET_o$ in the Chino Basin over the historical period (1950-2023) and for each Climate Scenario over the projection period (2024-2080). These $ET_o$ estimates represent the annual $ET_o$ averaged across the Chino Basin. The mean $ET_o$ over the historical period was 53.3 inches. The mean $ET_o$ for the *Average*, *Hot/Dry*, and *Cool/Wet* Climate Scenarios are 56.7 inches, 58.4 inches, and 55.4 inches, respectively.

**Figure 5-1. Historical and Projected Annual Precipitation by Climate Scenario**

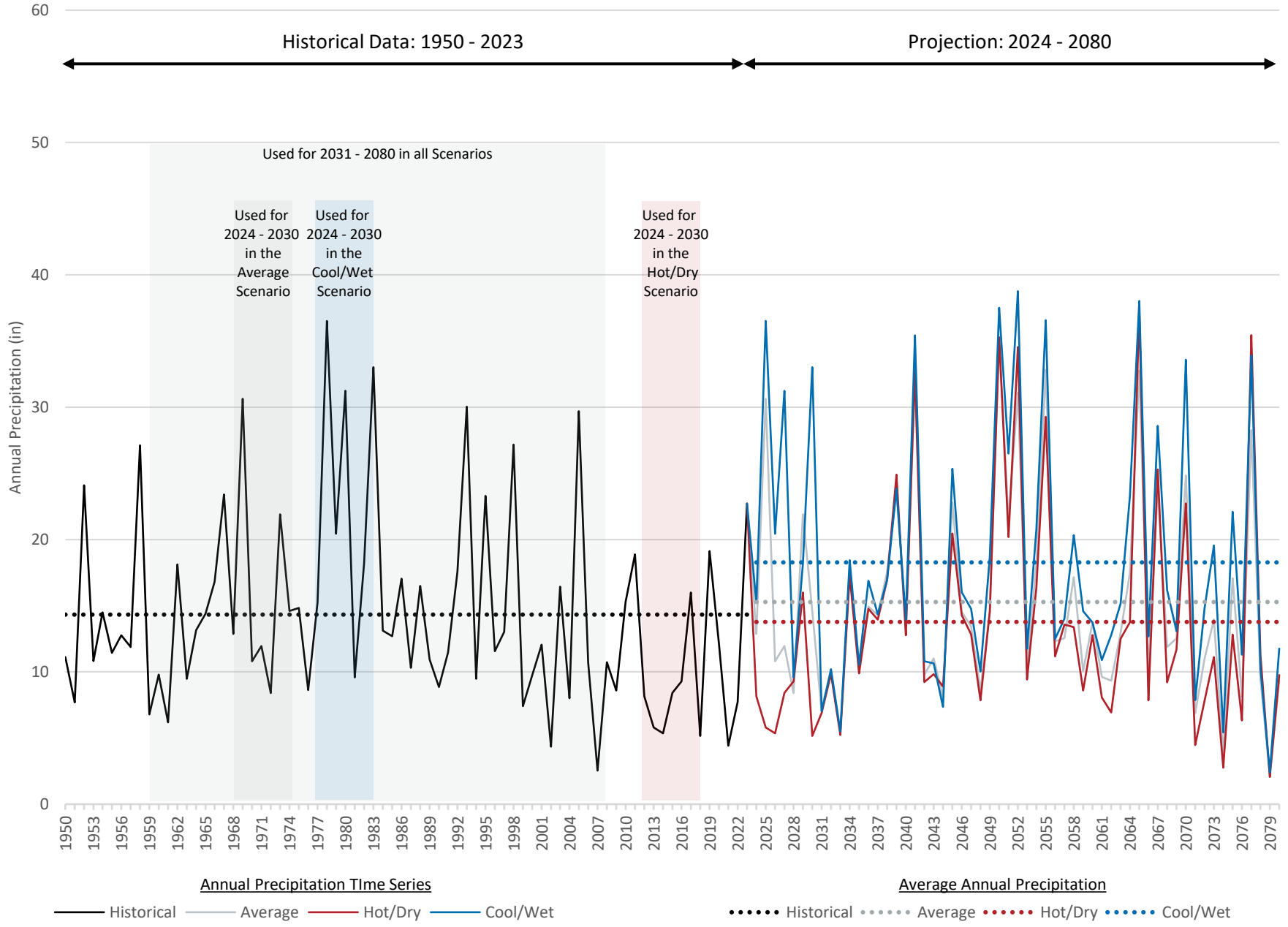


**Figure 5-2. Cumulative Departure from Mean Precipitation by Climate Scenario**

*Calculated Relative to Mean of Average Climate Scenario (15.3 inches/year)*

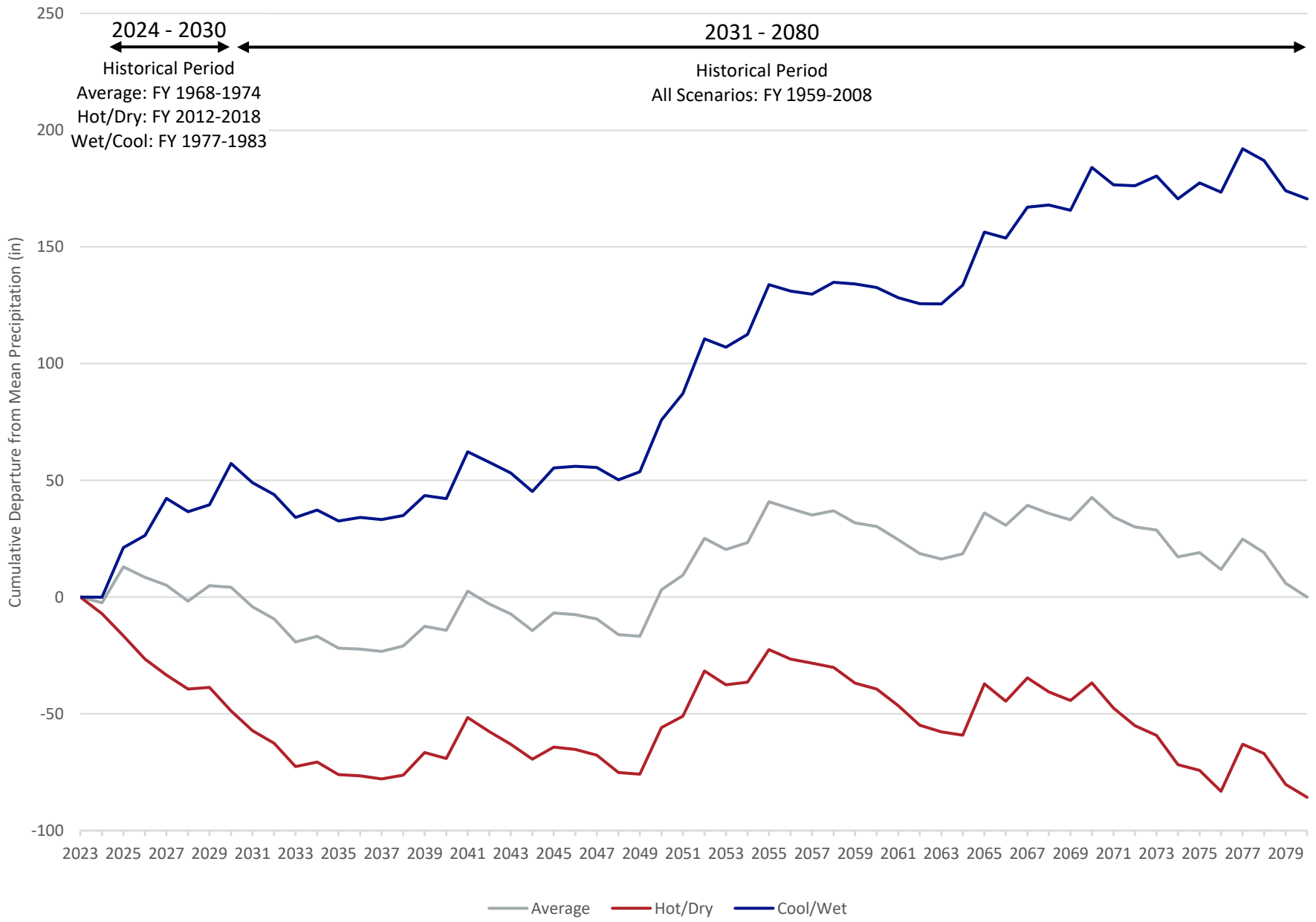
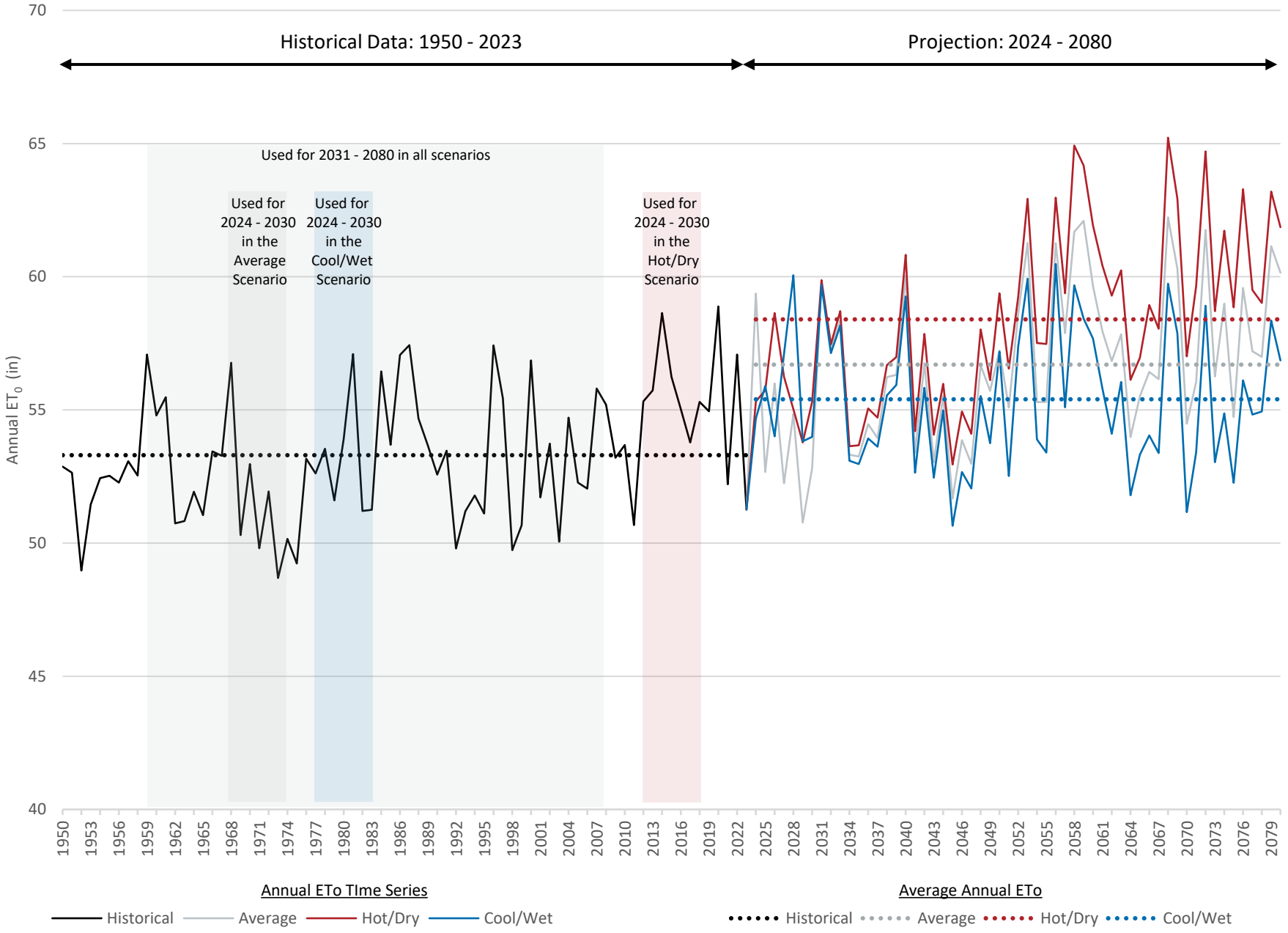


**Figure 5-3. Historical and Projected Annual $ET_o$ by Climate Scenario**



## 5.4 CHARACTERIZING UNCERTAINTY IN FUTURE CULTURAL CONDITIONS

Cultural conditions—including but not limited to land use, groundwater pumping, managed aquifer recharge, groundwater storage, and water conservation efforts—play a critical role in shaping the behavior of the groundwater basin. However, projecting future cultural conditions is inherently uncertain due to the complex interplay of various drivers that influence water and land management practices over time. These uncertainties arise from several sources, including:

- Changes in economic conditions influence population growth, land-use changes, and water demands.
- Innovations in water management, conservation technologies, and data monitoring tools may emerge and enable new water management (e.g., conservation) strategies or alter the feasibility of existing strategies.
- Future changes in laws, policies, or regulations governing land-use and water management are difficult to predict, yet they can significantly alter water-use practices and priorities.
- The ongoing and unpredictable effects of climate change—including changes in precipitation, temperature, evapotranspiration, and extreme weather events—can substantially affect recharge rates, outdoor water demands, water availability, and water management strategies.

Simulating multiple future Water Plans (i.e., water demand and supply projections) provides a framework for evaluating how the groundwater basin might respond under a range of plausible future conditions.

In alignment with Step 3 of the 2022 SYRM, three Water Plan Scenarios—Expected Demand, High Demand, and Low Demand—were developed to characterize the potential range of future cultural conditions. The development of these scenarios began with the creation of Reference Water Plans, which represent each party's best estimate of future water use in the absence of the recently adopted Conservation Regulation. Building upon these Reference Water Plans, Watermaster worked with the parties to identify and quantify the primary sources of uncertainty - demand, groundwater utilization, and imported water utilization. These elements were then systematically varied to construct the Water Plan Scenarios, each of which reflects distinct assumptions about future conditions and behaviors. The following subsections describe the formulation of the Reference Water Plans (Section 5.4.1), the primary elements of uncertainty considered in scenario development (Section 5.4.2), and the methodology used to develop the three Water Plan Scenarios (Section 5.4.3).

### 5.4.1 Reference Water Plans

Before developing the Water Plan Scenarios, Reference Water Plans were prepared for each party. The Reference Water Plans represent the best estimate of future cultural conditions in the absence of the conservation regulations adopted by the State Board on July 3, 2024 (Conservation Regulation).[11] The Conservation Regulation was not included in the Reference Water Plans because it had not been finalized at the time of their development. Instead, anticipated responses to the regulation are incorporated, to

[11] Final text of Conservation Regulation

varying degrees, into the Water Plan Scenarios. These Reference Water Plans were used as the foundation for the development of the three Water Plan Scenarios.

#### *5.4.1.1 Overlying (Agricultural) Pool*

The Reference Water Plans for the parties in the Overlying (Agricultural) Pool (Agricultural Pool) were developed based on the estimated "buildout"[12] of urban land uses by 2040. Watermaster estimated Agricultural Pool production at buildout using historical data and projections for wells expected to operate in the future. In addition to these wells, several agricultural areas are irrigated with recycled water, some of which are anticipated to remain in use. Figure 5-4 shows the Agricultural Pool wells that are expected to produce in the future beyond buildout of the Basin and the projected pumping at these wells. The total projected water use by the Agricultural Pool is approximately 11,100 afy in 2025, decreasing to 4,000 afy in 2040, when most of the basin is assumed to reach buildout, and remaining stable thereafter.

#### *5.4.1.2 Overlying (Non-Agricultural) Pool*

The Reference Water Plans for the parties in the Overlying (Non-Agricultural) Pool (ONAP) [excluding those also in the AP, such as Ontario and Monte Vista Water District (MVWD)] were developed based on historical trends or the party's response to Watermaster's annual data request. Excluding pumping from General Electric Company, which injects approximately the same volume of water that it pumps, the total projected pumping by the ONAP is about 1,430 afy in 2025 and remains constant over time.

#### *5.4.1.3 Appropriative Pool*

To develop the Reference Water Plans for the retailer members in the AP, we began by reviewing the Water Plans obtained as part of the Watermaster's annual data collection and evaluation process. The AP retailers included:

- City of Chino (Chino)
- City of Chino Hills (Chino Hills)
- City of Norco (Norco)
- City of Ontario (Ontario)
- City of Pomona (Pomona)
- City of Upland (Upland)
- Cucamonga Valley Water District (CVWD)
- Fontana Water Company (FWC)
- Golden State Water Company (GSWC)
- Jurupa Community Services District (JCSD)
- Marygold Mutual Water Company (MMWC)

[12] Buildout refers to the point at which all available land within a designated area has been fully developed to its planned capacity, based on zoning regulations, infrastructure constraints, and land-use policies. At buildout, population growth within the area is typically limited to changes in household density (e.g., converting single-family homes to multi-family units) rather than new land development.

- Monte Vista Water District (MVWD)
- Santa Ana River Water Company (SARWC)
- San Antonio Water Company (SAWCo)
- West Valley Water District (WVWD)

The "major" AP retailers, indicated in italics above, collectively produce the majority of Chino Basin groundwater (historically 56-65 percent, excluding the Chino Desalter Authority), serve most of the Basin area, and are subject to the Conservation Regulation.

We then worked closely with major AP retailers to refine these plans to consider historical overestimates in demands[13], define water supply priorities when projected supplies exceed demands, and develop monthly projections from the annual estimates. Our consultations with the major AP retailers were crucial for understanding the assumptions behind their initial demands projections and ensuring the Reference Water Plans accurately reflected actual demands aligned with this modeling effort's goals. Based on their input, we adjusted the projected demands and corresponding supplies, primarily resulting in reduced demands. The Reference Water Plans for the major AP retailers can be found in Appendix C.

For AP parties other than the major AP retailers and non-retail parties (e.g., BlueTriton Brands, Inc.), Reference Water Plans were developed based on historical averages, similar to the method used to develop Reference Water Plans for the Overlying Non-Agricultural Pool.

The Reference Water Plans indicate that projected pumping for all AP parties is about 134,400 afy in 2025, 161,800 afy in 2040, and 166,500 af in 2045.

[13] Scenario Design TM #1 documented the projected demands from prior groundwater studies compared to actual demands, concluding that historical projections are consistently greater than actual demands.

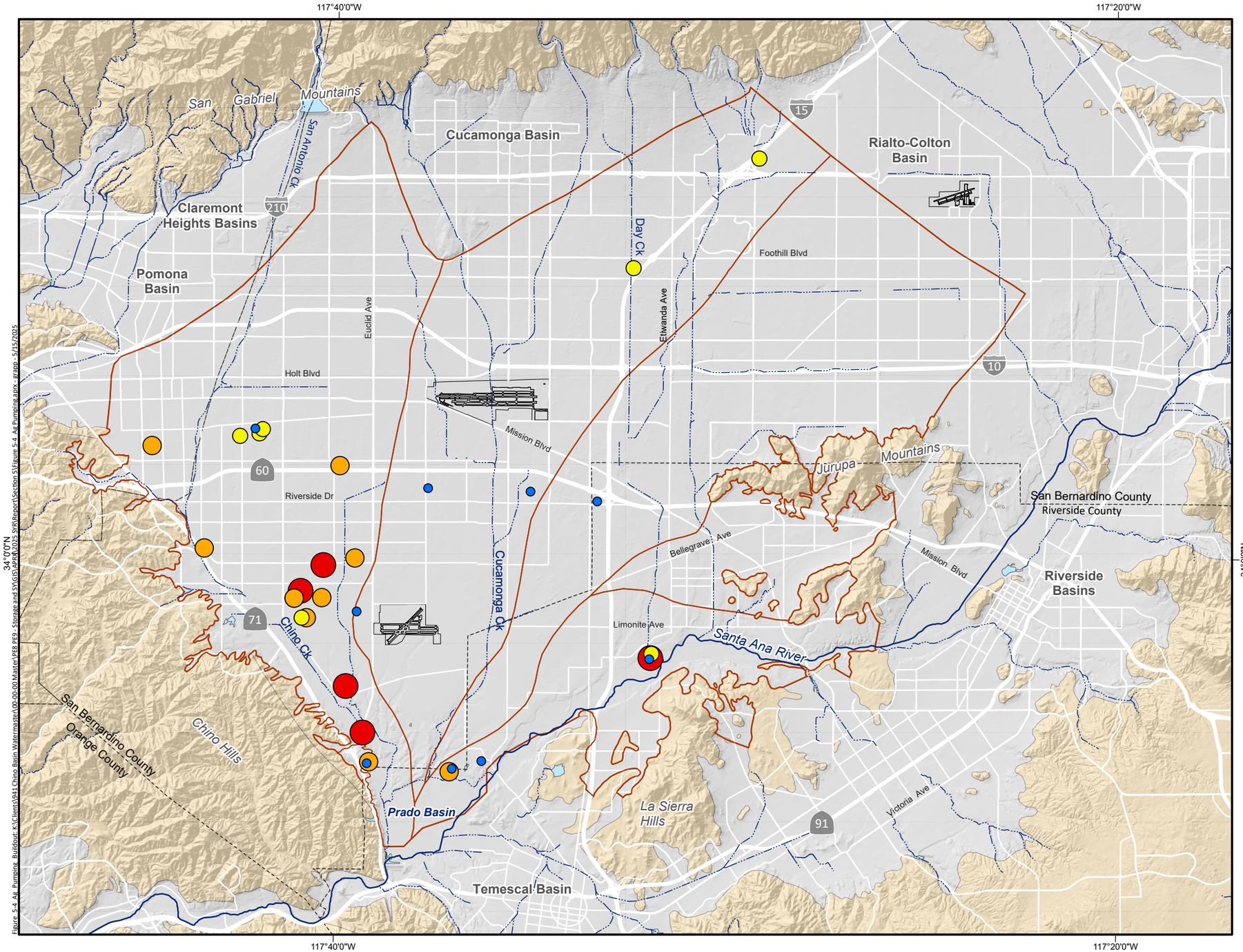



Figure_5-4_Ag_Pumping_Buildout_K:\Clients\941 Chino Basin Watermaster\00-00 Master\PE8 PE9 - Storage and SY\GIS\APRX\2025 SYAReport\Section 5\Figure 5-4_Ag Pumping.aprx - dlapp - 5/15/2025

## Projected Active Agricultural Wells at Buildout

Projected Annual Pumping (afy)

- 0 - 5
- 6 - 10
- 11 - 50
- 51 - 250
- > 250

## Geology

Water-Bearing Sediments

- Quaternary Alluvium

Consolidated Bedrock

- Undifferentiated Pre-Tertiary to Early Pleistocene Igneous, Metamorphic, and Sedimentary Rocks

## Hydrology

- Streams & Flood Control Channels
- Flood Control & Conservation Basins
- OBMP Management Zones




Prepared by:

WEST YOST
Water. Engineered.

Author: AK

Date: 5/15/2025

N

0 3 6 Miles

0 4 8 Km

Prepared for:

**Chino Basin Watermaster**
2025 Safe Yield Reevaluation

**Projected Active Agricultural Wells at Buildout**

**Figure 5-4**

### 5.4.1.4 Summary of Reference Water Plans

The Aggregate Reference Water Plans for the Watermaster Parties is shown in Table 5-2. As stated above, the Reference Water Plans assume no response to the Conservation Regulation.

**Table 5-2. Aggregate Reference Water Plan for the Watermaster Parties**

| Water Supply | 2020[(a)] | 2025 | 2030 | 2035 | 2040 | 2045 |
|---|---|---|---|---|---|---|
| Volume, afy | | | | | | |
| Chino Basin Groundwater | 151,365 | 146,897 | 155,317 | 159,266 | 168,447 | 171,961 |
| Non-Chino Basin Groundwater | 48,308 | 52,682 | 53,077 | 53,371 | 53,762 | 53,954 |
| Local Surface Water | 26,620 | 13,154 | 13,154 | 13,154 | 13,118 | 13,154 |
| Imported Water | 59,637 | 71,398 | 74,901 | 81,651 | 87,287 | 87,799 |
| Recycled Water for Direct Use | 20,857 | 25,091 | 27,088 | 28,385 | 29,982 | 30,482 |
| **Total** | **306,787** | **309,222** | **323,537** | **335,826** | **352,596** | **357,350** |
| Percent of Total Supply | | | | | | |
| Chino Basin Groundwater | 49 | 48 | 48 | 47 | 48 | 48 |
| Non-Chino Basin Groundwater | 16 | 17 | 16 | 16 | 15 | 15 |
| Local Surface Water | 9 | 4 | 4 | 4 | 4 | 4 |
| Imported Water | 19 | 23 | 23 | 24 | 25 | 25 |
| Recycled Water for Direct Use | 7 | 8 | 8 | 8 | 9 | 9 |
| **Total** | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** |

(a) Historical data compiled for Water Year 2020 for the Chino Basin SGMA Annual Report.

## 5.4.2 Primary Elements of Uncertainty in Cultural Conditions

In the initial stages of the scenario design process, Watermaster presented an overview of cultural conditions and their impact on the hydrology of the Chino Basin. Following this presentation, input was gathered from the parties to achieve the following two objectives (1) ensure that the list of cultural conditions considered all major impacts to groundwater conditions and (2) identify the most significant sources of uncertainty related to cultural conditions and the parties' Water Plans. Based on the feedback from Scenario Design TM #1 and the October 24, 2023 workshop, three primary elements were identified for addressing uncertainty: (1) demands; (2) groundwater utilization; and (3) imported water utilization.

### 5.4.2.1 Historical Variation in Water Demands and Use of Water Supplies

To understand the year-to-year variability in historical Water Plans, we compiled the historical water demand and supply data from the Chino Basin parties. Figure 5-5 shows the historical data on water supplies used to meet demands data compiled from Water Year (WY) 2015 through 2023. Over this period, total water demand ranged between 271,000 af (WY 2023) to 307,000 af (WY 2020). There was no discernible upward or downward trend in total water demand over the period. However, the historical use of water supplies varied depending on hydrologic conditions. The nine-year period included three wetter-than-average years (WYs 2017, 2019, and 2023), while the other six years experienced below-average precipitation. Total groundwater use declined from 67 percent of total supplies in dry years

to 63 percent in wet years. Conversely, total imported and local surface water use increased from 25 percent of total supplies in dry years to 31 percent of total supplies in wet years.

### *5.4.2.2 Uncertainty in Demands*

Demands refers to the total quantity of potable and non-potable water required to meet the needs of the parties. During the first scenario design workshop, the parties emphasized that uncertainty in the following factors will have the largest influence on demand projections:

- Growth (e.g., population, economic, buildout, infrastructure improvements)
- Water conservation efforts
- Climate

#### 5.4.2.2.1 Growth

Growth plays a significant role in projecting demand; however, it is inherently uncertain due to factors such as changes in migration patterns, economic conditions, and policy and governance. For example, the recent urban densification legislation[14] in California, aimed at increasing housing supply, has the potential to impact the pace and type of land use changes associated with growth.

Feedback from the parties emphasized that growth primarily affects demand projections through the timing of buildout. If buildout occurs faster than expected, demand is likely to rise more quickly than projected. Conversely, if buildout occurs slower than expected, demand is likely to rise more gradually than projected.

#### 5.4.2.2.2 Conservation Regulation

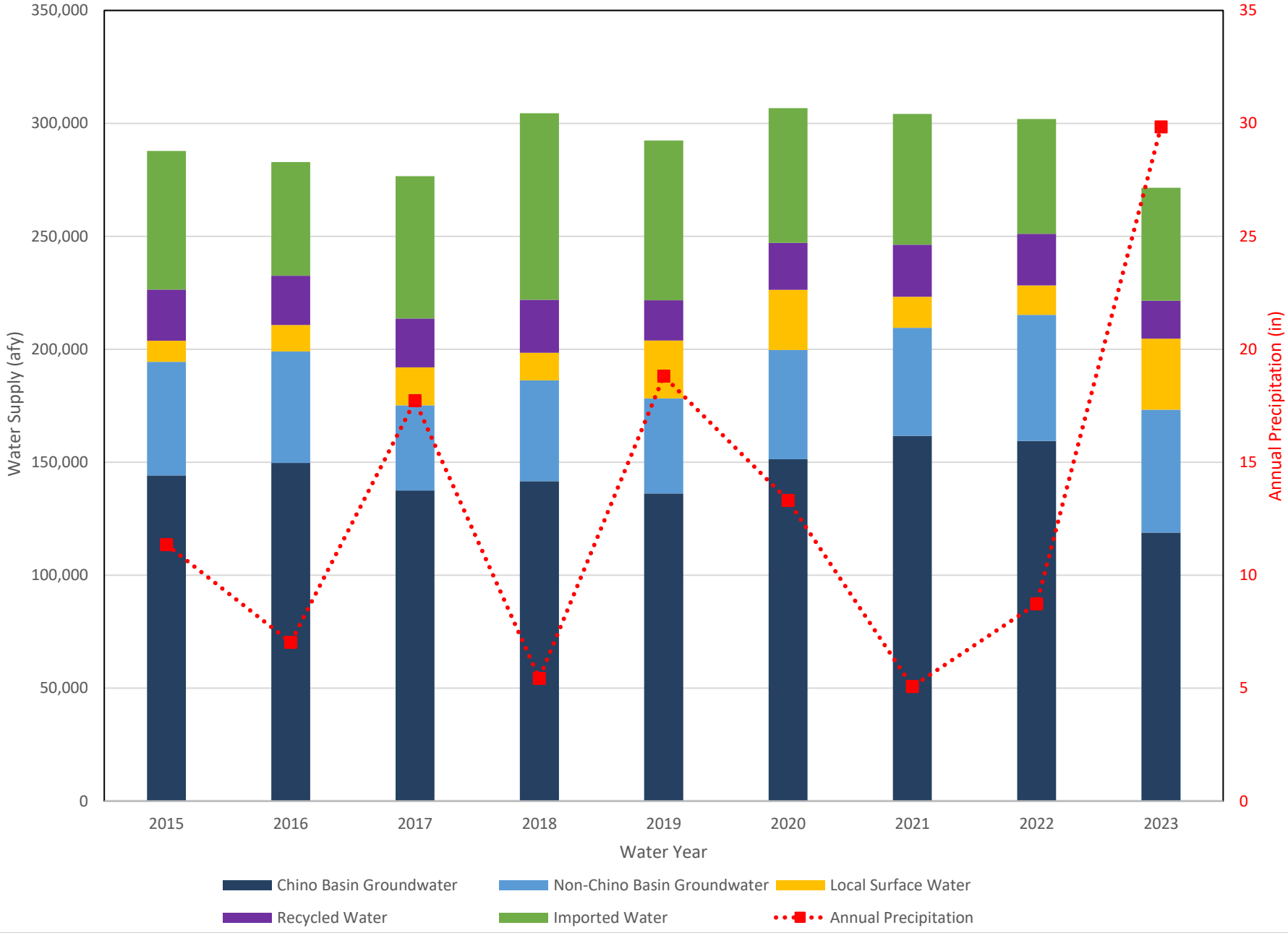
Since 2018, the State Water Resources Control Board (State Board) and the DWR have been developing new water use efficiency standards for urban retail water suppliers to implement the 2018 Urban Water Use Objectives legislation (Assembly Bill 1668 and Senate Bill 606) and the related "Making Conservation a California Way of Life" regulation.[15] The State Board adopted the Conservation Regulation on July 3, 2024. The Conservation Regulation took effect in January 2025, with compliance expected to be assessed beginning in 2027.

The Conservation Regulation requires water agencies to calculate their total urban water use annually and compare it to an agency-specific overall water use objective. This objective is the sum of four components: (1) residential water use, including indoor, outdoor, and residential agricultural use; (2) water losses; (3) outdoor irrigation for commercial, industrial, and institutional properties with dedicated irrigation meters [Commercial, Industrial, and Institutional (CII) with Dedicated Irrigation Meter (DIMs)]; and (4) bonus credits for recycled water use. Each component is determined using statewide efficiency standards and local service area factors such as population, climate, and landscape area. These efficiency standards become stricter over time, meaning that even if local conditions remain unchanged, the overall water use objective is required to gradually decrease.

[14] e.g., Assembly Bill 2011 (2022) and Assembly Bill 2243 (2024)

[15] Making Conservation a California Way of Life Fact Sheet

**Figure 5-5. Historical Water Supplies of the Chino Basin Parties, Water Year 2015 through 2023**



Based on feedback from the parties, there is significant uncertainty regarding how customers will respond to the Conservation Regulation and how this will ultimately impact demand. Since compliance with the regulation is not required until 2027, no historical data exists to evaluate customer behavior or the State's actions in cases of non-compliance. Several Parties facing significant required reductions have indicated that, even with additional funding, achieving full compliance would remain challenging.

This introduces substantial uncertainty in forecasting the anticipated scale of response to the Conservation Regulation. Should the actual response exceed projections, water demand will likely be lower than estimated. Conversely, if the response falls short of projections, water demand will likely exceed anticipated levels.

#### 5.4.2.2.3 Climate Change

Climate trends influence water demand projections. Typically, water use increases during hot and dry periods and decreases during cooler, wetter conditions (e.g., WY 2023 in Figure 5-5). However, the projected demands in the Reference Water Plans assume an "average hydrologic year"[16] and do not account for interannual variability. Extended droughts or unusually wet periods impact water demands; the effects can be complex in urbanized areas such as the Chino Basin where statewide policies[17] can influence the response to extreme conditions. Moreover, uncertainty surrounding future climate conditions, including the potential for more frequent and extreme weather events due to climate change, further complicates efforts to accurately forecast long-term water demand.

#### 5.4.2.2.4 Impacts of Demand Deviations on Groundwater Levels and Net Recharge

Water demand is subject to considerable uncertainty due to factors such as growth, regulatory responses, and climate variability. Factors that could lead to higher-than-expected demand include:

- Greater-than-expected growth due to economic or other conditions
- The scale of the response to the Conservation Regulation is less than anticipated (e.g., less stringent enforcement, weaker consumer response)
- Extended periods of below-average precipitation compared to current assumptions for future climate

An increase in demand would likely result in greater utilization of one or more water-supply sources. If this additional demand is met through increased groundwater pumping, it could lead to declining groundwater levels. In turn, lower groundwater levels may increase net recharge through mechanisms such as enhanced recharge along the SAR due to increased hydraulic gradients and reduced discharge of rising groundwater in the Prado Basin. Additionally, if outdoor irrigation demand remains elevated due to limited response to the Conservation Regulation, associated DIPAW would also remain elevated, potentially affecting groundwater levels.

[16] An average hydrologic year is a representative year in which precipitation, temperature, and other hydrologic conditions reflect the long-term historical average for Chino Basin.

[17] E.g., the 2015 Statewide mandatory water reductions

Conversely, factors that could lead to lower-than-expected demand include:

- Slower-than-expected growth due to economic or other conditions
- The scale of the response to the Conservation Regulation is greater than anticipated (e.g., more stringent enforcement, stronger consumer response)
- Extended periods of above-average precipitation compared to current assumptions for future climate

A reduction in demand would likely decrease the utilization of one or more water supply sources. If this results in reduced groundwater pumping, it could lead to higher groundwater levels. The higher groundwater levels could lower net recharge by decreasing infiltration along the SAR and increasing discharge of rising groundwater in Prado Basin. Additionally, if outdoor irrigation demand declines in response to the Conservation Regulation, associated DIPAW would also decrease, which could further reduce net recharge and affect groundwater levels.

### *5.4.2.3 Groundwater Utilization*

Groundwater utilization (GWU) represents the amount of Chino Basin groundwater that the parties use to satisfy their water demands. When projecting future groundwater utilization, parties consider both current conditions and anticipated trends. Key factors influencing these projections include:

- Regional hydrologic conditions
- Pumping capacity
- Groundwater quality and treatment infrastructure
- Policy
- Conveyance infrastructure
- The cost of groundwater compared to other water supplies

Factors that could lead to higher-than-expected groundwater utilization include:

- Unanticipated improvements to infrastructure for treatment, pumping, and conveyance that would increase accessibility to groundwater
- The timing and scale of new groundwater regulations (e.g., quality) and the responses to these regulations that result in fewer disruptions to projected pumping activities than expected
- Greater-than-expected recharge (either natural or managed) that would increase groundwater availability locally or basin-wide through a combination of greater pumping rights and greater pumping capacity because of higher groundwater levels

The probable effect of higher-than-expected groundwater utilization would be decreased utilization of supplemental water supplies, potentially resulting in lower groundwater levels and higher net recharge.

Factors that could lead to lower-than-expected groundwater utilization include:

- Unexpected groundwater-quality, regulatory, or infrastructure challenges that prevent or increase costs of pumping in the near-term or long-term
- Less-than-expected recharge (either natural or managed) that would decrease groundwater availability locally or basin-wide through a combination of reduced pumping rights and reduced pumping capacity because of lower groundwater levels

The probable effect of lower-than-expected groundwater utilization would be increased utilization of supplemental water supplies, potentially resulting in higher groundwater levels and lower net recharge.

### *5.4.2.4 Imported Water Utilization*

Imported water utilization (IWU) represents the amount of imported water that the parties use to satisfy their water demands. When projecting their expected IWU, parties evaluate both current conditions and anticipated trends. Key factors influencing these projections include:

- Cost and availability of imported water
- Imported water reliability estimates documented by the Metropolitan Water District of Southern California (MWD)
- Regional hydrologic conditions
- Water-quality challenges with their other water supplies
- Infrastructure
- Policy

IWU also depends on the volume of wet-water recharge used to satisfy replenishment obligations. Pursuant to the Judgment, Watermaster levies and collects assessments each year in amounts sufficient to purchase replenishment water to replace pumping by a Pool during the preceding year in excess of that Pool's allocated share of Safe Yield (Overlying Agricultural and ONAPs) or Operating Safe Yield (Appropriative Pool). Each party's obligation is determined after accounting for any transfers or recovery of stored water.

With Watermaster approval, parties in the Overlying Non-Agricultural and Appropriative Pools may transfer stored water and/or unused Safe Yield rights among themselves to reduce their replenishment obligations. After the end of each fiscal year, Watermaster compiles pumping and transfer data from all parties to determine the final replenishment obligations for that year.

Projected future replenishment obligations are influenced by several factors, including current and projected Safe Yield, augmentation of production rights (e.g., Reoperation credits from pumping at Chino Desalter Authority wells), and transfer activity among parties.

Factors that could lead to an increase in expected IWU include:

- MWD's successful planning and implementation of infrastructure and operations to improve imported water supply reliability greater and/or faster than expected

- Relatively wetter and cooler conditions across the western U.S. (i.e., California and the Colorado River watershed)
- The percentage of replenishment obligations met via wet-water recharge is greater than anticipated

The probable effect of higher-than-expected IWU would be to reduce groundwater pumping and increase the use of supplemental water for recharge, potentially leading to higher groundwater levels and lower net recharge.

Factors that could lead to a decrease in the expected IWU include:

- MWD's planning and implementation of infrastructure and operations necessary to improve imported water supply reliability is less and/or slower than expected
- Relatively drier and warmer conditions across the region (i.e., California and the Colorado River watershed)
- The percentage of replenishment obligations met via wet-water recharge is less than anticipated

It is important to note that MWD's planning efforts and regional hydrologic conditions are not necessarily correlated; MWD's successful planning and implementation of imported water infrastructure may still result in higher imported water availability even under drier Climate Scenarios.

The probable effect of lower-than-expected IWU would be to increase groundwater pumping and reduce the use of supplemental water for recharge, potentially leading to lower groundwater levels and higher net recharge.

### 5.4.3 Water Plan Scenarios

Building on the preceding analysis, three Water Plan Scenarios were formulated to bracket the plausible range of future cultural conditions (i.e., water demands, groundwater utilization, and imported water use) and to evaluate their resulting effects on net recharge and groundwater levels in the Chino Basin:

- **Expected Demand Scenario:** Represents the most likely estimate of the future water demands and the mix of water supplies required to meet them.
- **High Demand Scenario:** Assumes higher-than-expected demands, higher-than-expected groundwater utilization, and lower-than-expected IWU. This scenario results in the highest total demand and groundwater pumping, which would likely lead to lower groundwater levels and higher net recharge compared to the Expected Demand Scenario.
- **Low Demand Scenario:** Assumes lower-than-expected demands, lower-than-expected groundwater utilization, and higher-than-expected IWU. This scenario results in the lowest total demand and groundwater pumping, which would likely lead to higher groundwater levels and lower net recharge compared to the Expected Demand Scenario.

Figure 5-6 presents a flowchart illustrating the process that was used to develop the three Water Plan Scenarios and Table 5-3 summarizes the differences between the scenarios. This section describes the development of the Water Plan Scenarios.

**Table 5-3. Water Plan Scenario Descriptions**

| Water Plan Scenario | Description | | | Approximate Buildout Year | Response to Conservation Regulation (Major AP Retailers) | | Utilization Adjustment for Major AP Retailers[b] | Change in CDA Pumping Relative to Reference Plans | Change in Pumping for Other Parties[c] Relative to Reference Plans | Water Supply Plan (Average, 2025-2045) | | | Minimum Percentage of Replenishment Obligations Met with Wet-Water (Imported Water) Recharge |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Demand | Groundwater Utilization (GWU) | Imported Water Utilization (IWU) | | Minimum Residential Conservation Reductions Met | Minimum CII w/ DIMs Conservation Reductions Met | | | | Total Demand (afy) | Percentage of Demands met with Chino Basin Groundwater | Percentage of Demands met with Imported Water | |
| 1 | Expected | Expected | Expected | 2040 | 60% | 70% | 0% | 0% | 0% | 319,000 | 49% | 22% | 7% |
| 2 | High | High | Low | 2037 | 35% | 50% | +8% | 0% | +5% | 332,000 | 51% | 21% | 0% |
| 3 | Low | Low | High | 2045 | 80% | 90% | -8% | 0% | -5% | 310,000 | 46% | 25% | 20% |

(a) Percentages are relative to the nominal reductions calculated for each party.
(b) Utilization adjustment is the percentage of the Chino Basin groundwater pumping (based on the party's Reference Water Plan) that is added to the pumping for each of the major AP retailers; the same volume is subtracted from imported water use.
(c) Other parties include all parties in the Overlying Ag Pool (active wells only), Overlying Non-Ag Pool, and AP parties not included in the major AP retailers.

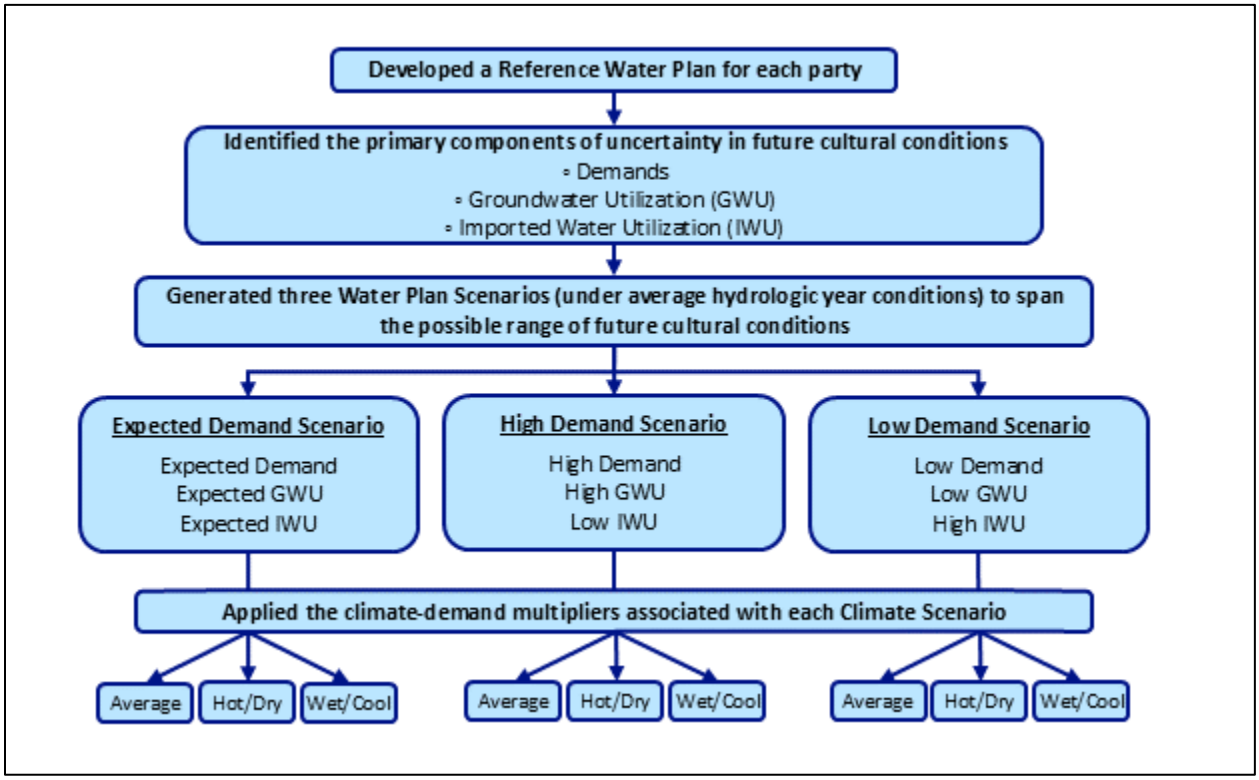



**Figure 5-6. Process to Develop the Water Plan Scenarios**

### *5.4.3.1 Response to the Conservation Regulation*

To construct the three Water Plan Scenarios, we first estimated the required reductions in water demand for the major AP retailers, relative to their respective Reference Water Plans, to reflect varying levels of compliance with the Conservation Regulation. The methodology for projecting responses and calculating associated demand reductions is detailed in Appendix C and summarized below.

For each major AP retailer, nominal water use objectives were calculated for residential uses (including indoor, outdoor, and residential agriculture) and for outdoor irrigation at CII properties with DIMs. The reductions required to meet these objectives were then determined for each retailer. The total projected demand reductions needed to achieve the nominal objectives across all major AP parties are presented in Table 5-4.

**Table 5-4. Reductions in Demand Required to Meet the Water Use Objectives**

| Water Use Objective | Reductions, afy | | | | |
|---|---|---|---|---|---|
| | 2025 | 2030 | 2035 | 2040 | 2045 |
| Residential Uses | 3,400 | 8,800 | 20,500 | 26,500 | 27,100 |
| CII with Dims | 0 | 5,600 | 12,400 | 18,100 | 18,100 |
| **Total** | **3,400** | **14,400** | **32,900** | **44,600** | **45,200** |

To address the uncertainty surrounding the impact of the Conservation Regulation on future water demands, we worked closely with the parties to develop three potential response scenarios, summarized in Table 5-5, that represent a range of possible outcomes. The Expected Demand Scenario represents the parties' anticipated level of compliance with the Conservation Regulation. The High Demand Scenario assumes a limited response, leading to higher-than-expected demand. The Low Demand Scenario assumes a robust response, resulting in lower-than-expected demand. Based on input from the parties, all demand reductions are assumed to result in an equivalent decrease in the use of imported water, with two exceptions: the City of Chino and the City of Upland, which indicated that all demand reductions will instead be met through decreased groundwater pumping.

**Table 5-5. Summary of Conservation Regulation Responses in Water Plan Scenarios**

| Water Plan Scenario | Minimum percentage of the reductions required to meet nominal objectives in residential water uses | Minimum percentage of the reductions required to meet nominal objectives in CII w/DIMs | Reduction in Demand, afy | | | | |
|---|---|---|---|---|---|---|---|
| | | | 2025 | 2030 | 2035 | 2040 | 2045 |
| Expected Demand | 60 | 70 | 2,000 | 9,200 | 20,900 | 28,600 | 28,900 |
| High Demand | 35 | 50 | 1,200 | 5,900 | 13,300 | 18,300 | 18,500 |
| Low Demand | 80 | 90 | 2,700 | 12,000 | 27,500 | 37,500 | 38,000 |

### *5.4.3.2 Groundwater and Imported Water Utilization*

Next, we adjusted GWU and IWU for the major AP retailers. For each major AP retailer, 8 percent of their Chino Basin groundwater pumping, as outlined in their Reference Water Plans, was calculated. In the High Demand Scenario (High GWU/Low IWU), this volume was shifted from imported water use to groundwater pumping. Conversely, in the Low Demand Scenario (Low GWU/High IWU), the same volume was shifted from groundwater pumping to imported water use. No changes were made to the Expected Demand Scenario.

### *5.4.3.3 Pumping Adjustments for Other Parties*

This category encompasses all parties within the Agricultural Pool (with active wells), the ONAP, and AP parties not classified as major AP retailers. In the Expected Demand Scenario, pumping levels remained consistent with those outlined in the Reference Water Plans. For the High Demand Scenario, pumping in the Reference Water Plans was increased by 5 percent. For the Low Demand Scenario, pumping in the Reference Water Plans decreased by 5 percent.

### 5.4.3.4 Buildout

To address the uncertainty of the effect of the growth on demands, we adjusted the rate that demands will increase over time by varying the assumed buildout year across scenarios. The Expected Demand Scenario assumes demand increases at the same rate as in the Reference Water Plans with buildout at approximately 2040. The High Demand Scenario assumes a faster-than-expected buildout (approximately 2037). The Low Demand Scenario assumes a slower-than-expected buildout (approximately 2045).

### 5.4.3.5 Replenishment Obligation

Finally, varying assumptions were developed for how parties would satisfy their replenishment obligations using managed storage and imported water recharge. Managed storage is calculated based on water rights (including Safe Yield, Reoperation, supplemental water recharge, and other credits), groundwater production, and the expected behavior of the parties to satisfy replenishment obligations. A replenishment obligation arises when a party's groundwater production exceeds its production rights. Parties can satisfy this obligation either by drawing from their managed storage accounts (if available) or by paying Watermaster to procure imported water for wet-water recharge. Historical data gathered from Watermaster's Assessment Packages indicates that the parties have used managed storage to meet about 80 percent of replenishment obligations.[18]

During the scenario design process, Watermaster requested projections from the AP parties on the anticipated method to satisfy replenishment obligations. The average response of the AP parties, weighted by managed storage volume, indicated that the parties expect to satisfy about 93 percent of their replenishment obligations via use of managed storage and 7 percent via wet-water recharge. These findings were used to develop the following assumptions:

- The Expected Demand Scenario (Expected Demand/Expected GWU/Expected IWU) assumes parties will satisfy 7 percent of their obligations via wet-water recharge and 93 percent through managed storage.
- The High Demand Scenario (High Demand/High GWU/Low IWU) assumes parties will satisfy 100 percent of their obligations via managed storage.
- The Low Demand Scenario (Low Demand/Low GWU/High IWU) assumes parties will satisfy 20 percent of their obligations via wet-water recharge and 80 percent through managed storage.

If managed storage accounts are insufficient to satisfy the projected replenishment obligation, the balance will be accounted for with wet-water recharge. Projected managed storage is an iterative calculation. Initial estimates for the scenarios are refined and updated based on groundwater-flow model results, as these are necessary to project net recharge and Safe Yield. Additional details on managed storage for the Projection Scenarios are provided in Section 6.

[18] See Section 7.3.1.2 of the 2020 SYR Report

### *5.4.3.6 Variability of Demands due to Climate Scenarios*

The projected demands in the three Water Plans described above are based on average hydrologic year conditions. When each Water Plan Scenario is combined with a Climate Scenario to form a Projection Scenario, the associated demands are further adjusted to account for the specific precipitation and $ET_o$ patterns of that Climate Scenario. The effects of precipitation and temperature on demand are assumed to be independent. Additionally, the demand for individual supplies (e.g., Chino Basin groundwater) is expected to adjust proportionally to changes in other supplies.

#### 5.4.3.6.1 Variability of Demands due to Precipitation

Water demands tend to vary with annual precipitation, largely due to the impact of weather on outdoor irrigation. Historical data (Figure 5-5) show that total demands can be up to 7 percent lower than average in wet years and up to 5 percent higher in dry years. In its 2020 Urban Water Management Plan (UWMP), IEUA estimated that extended dry periods (lasting three or more years) could result in demand increases of approximately 9 percent by 2040[19]. These projections are consistent with findings from other regional studies[20] and many of the 2020 UWMPs developed by the parties in Chino Basin.

Recent data and experience suggest that conservation measures, such as local or statewide mandates[21], can mitigate the typical increase in water demand during dry years. However, the demand adjustment methodology used in this analysis does not directly incorporate these potential reductions, leading to a broader plausible range in future demands. The uncertainty regarding the impact of future conservation measures is addressed by the three Water Plan Scenarios, which reflect varying levels of response to the Conservation Regulation. The potential for low-demand/dry-year scenarios is thus captured within the broader range of future conditions evaluated in the proposed Projection Scenarios.

To reflect how demand responds to changes in precipitation, the methodology applies adjustment factors, referred to as "precipitation-demand multipliers", to the projected demands under average hydrologic year conditions. These multipliers are determined based on the classification of years as Dry, Wet, or Normal, using the projected precipitation time series. Year types are defined using thresholds derived from historical annual precipitation data:

- **Dry years:** precipitation falls below the 33rd percentile.
- **Wet years**: precipitation exceeds the 66th percentile.
- **Normal years**: precipitation falls between the 33rd and 66th percentiles.

Precipitation-demand multipliers are applied based on the number of consecutive dry or wet years, as follows:

- The precipitation-demand multipliers for a single dry or wet year are 1.03 and 0.97, respectively, representing a ±3 percent change in demand.

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[19] Section 2.6 of IEUA's 2020 UWMP

[20] Miro, Michelle E., David G. Groves, David Catt, and Benjamin M. Miller, Estimating Future Water Demand for San Bernardino Valley Municipal Water District. Santa Monica, CA: RAND Corporation, 2018. https://www.rand.org/pubs/working_papers/WR1288.html

[21] E.g., Executive Order N-7-22

- The precipitation-demand multipliers for a second consecutive dry or wet year are 1.06 and 0.94, respectively, representing a ±6 percent change in demand.
- The precipitation-demand multipliers for a third (or more) consecutive dry or wet year are 1.09 and 0.91, respectively, representing a ±9 percent change in demand.

Figure 5-7 demonstrates this approach applied to projected water demands in the Chino Basin under the Average Climate Scenario. The highest adjustment occurs in 2033, where demand is projected to increase by approximately 28,500 acre-feet, or 9 percent above the projected demand for an average hydrologic year. The lowest adjustment occurs in 2039 and 2050, where demand is projected to decrease by about 19,600 acre-feet, or 6 percent below the projected demand for an average hydrologic year.

#### 5.4.3.6.2 Variability of Demands due to Temperature

Temperature drives water demands, primarily by influencing $ET_o$ demands for irrigated landscapes and crops. IEUA estimates that a 3.6 °F increase in temperature may result in a 4.3 percent increase in demand (about 1.2 percent per °F).[22]

The parties that have developed 2020 UWMPs incorporate assumptions regarding the effects of future climate change on demand, as required by the California Water Code.[23] Accordingly, it is assumed that the Reference Water Plans already account for temperature-related impacts on demand under the Average Climate Scenario. Therefore, demands in the Water Plan Scenarios that are paired with the Average Climate Scenario were not adjusted for temperature.

For the Water Plan Scenarios paired with the Hot/Dry and Cool/Wet Climate Scenarios, the following steps were performed to account for the effect of temperature on demand:

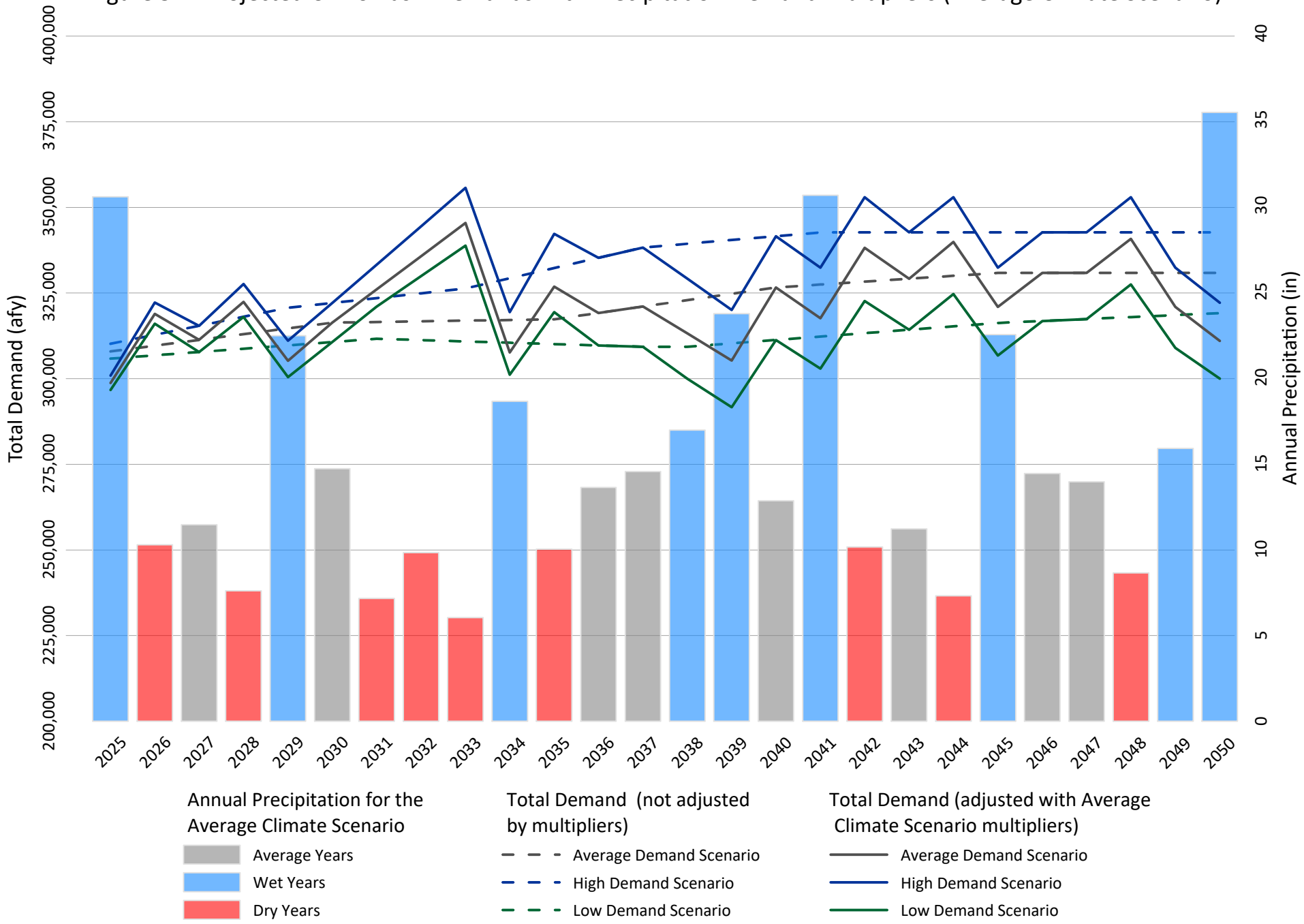
1. Conducted a regression analysis to quantify the relationship between temperature and reference $ET_o$. This was necessary because the R4 model uses $ET_o$ as the sole temperature-related climate variable.
2. Estimated the average annual temperature for each year between 2024 and 2080 for each Climate Scenario based on the regression results.
3. Calculated the annual difference in temperature between the Average Climate Scenario and the Hot/Dry and Cool/Wet Climate Scenarios, respectively.
4. Adjusted demand in the Water Plan Scenarios:
    a. For the Hot/Dry Climate Scenario, demand was increased by 1.2 percent per °F difference relative to the Average Climate Scenario.
    b. For the Cool/Wet Climate Scenario, demand was decreased by 1.2 percent per °F difference relative to the Average Climate Scenario.

For the Water Plan Scenarios paired with the Hot/Dry and Cool/Wet Climate Scenarios, demands are projected to change by approximately ±1.5 percent by 2050, and up to ±2.8 percent by 2080.

[22] Table 2-3 of IEUA's 2015 IRP

[23] Appendix I. Considering Climate Change Impacts (ca.gov)

Figure 5-7. Projected Chino Basin Demands with Precipitation-Demand Multipliers (Average Climate Scenario)



### *5.4.3.7 Comparison of Water Plan Scenarios*

Tables 5-6a, 5-6b, and 5-6c show the aggregate Water Plans for the three Water Plan Scenarios under average hydrologic year conditions (i.e., without applying multipliers for interannual variability in precipitation or ET). Individual Water Plans Scenarios for each of the nine major AP retailers are included in Appendix C. The key differences between the Scenarios are summarized below.

#### 5.4.3.7.1 Demand

Figure 5-8 shows the projected total demand for the three Water Plan Scenarios under average hydrologic year conditions, compared to the 2020 SYR projections and the Reference Water Plans. The projected demand ranges for each scenario are as follows:

- Expected Demand Scenario: 308,000 af to 331,000 af
- High Demand Scenario: 310,000 af to 343,000 af
- Low Demand Scenario: 306,00 af to 316,000 af

#### 5.4.3.7.2 Groundwater Utilization

Figure 5-9 shows the total projected Chino Basin groundwater pumping for the three Water Plan Scenarios under average hydrologic year conditions, alongside the 2020 SYR projections and the Reference Water Plans. Table 5-7 shows the historical and projected future pumping by party and scenario, also based on average hydrologic year conditions.

The projected range of Chino Basin GWU and the corresponding percentages of total demand met by groundwater for each scenario are as follows:

- Expected Demand Scenario (expected GWU):
  147,000 af (48 percent) to 163,000 af (49 percent)
- High Demand Scenario (greater-than-expected GWU):
  154,000 af (50 percent) to 177,000 af (52 percent)
- Low Demand Scenario (less-than-expected GWU):
  139,000 af (46 percent) to 148,000 af (47 percent)

#### 5.4.3.7.3 Imported Water Utilization

Figure 5-10 shows the projected IWU for the three Water Plan Scenarios under average hydrologic year conditions, alongside the 2020 SYR projections and the Reference Water Plans. The projected range of IWU and the corresponding percentages total demand met by imported water for each scenario are as follows:

- Expected Demand Scenario (expected IWU):
  71,000 af (23 percent) to 73,000 af (22 percent)
- High Demand Scenario (less-than-expected IWU):
  65,000 af (21 percent) to 70,000 af (21 percent)
- Low Demand Scenario (greater-than-expected IWU):
  76,000 af (24 percent) to 78,000 af (25 percent)

**Table 5-6a. Aggregate Water Plans for the Expected Demand Scenario (Expected Demands, Expected Groundwater Utilization, Expected Imported Water Utilization)**

| Category | 2025 | 2030 | 2035 | 2040 | 2045 |
|---|---|---|---|---|---|
| Volume (afy) | | | | | |
| Chino Basin Groundwater | 146,986 | 153,496 | 153,822 | 160,673 | 163,434 |
| Non-Chino Basin Groundwater | 51,317 | 51,032 | 50,586 | 50,652 | 50,878 |
| Local Surface Water | 13,154 | 13,154 | 13,154 | 13,118 | 13,154 |
| Imported Water | 71,398 | 71,583 | 71,376 | 72,198 | 72,925 |
| Recycled Water for Direct Use | 25,091 | 27,088 | 28,385 | 29,982 | 30,482 |
| Total | 307,946 | 316,353 | 317,323 | 326,624 | 330,873 |
| Percentage | | | | | |
| Chino Basin Groundwater | 48% | 49% | 48% | 49% | 49% |
| Non-Chino Basin Groundwater | 17% | 16% | 16% | 16% | 15% |
| Local Surface Water | 4% | 4% | 4% | 4% | 4% |
| Imported Water | 23% | 23% | 22% | 22% | 22% |
| Recycled Water for Direct Use | 8% | 9% | 9% | 9% | 9% |
| Total | 100% | 100% | 100% | 100% | 100% |

**Table 5-6b. Aggregate Water Plans for the High Demand Scenario (High Demands, High Groundwater Utilization, Low Imported Water Utilization)**

| Category | 2025 | 2030 | 2035 | 2040 | 2045 |
|---|---|---|---|---|---|
| Volume (afy) | | | | | |
| Chino Basin Groundwater | 154,306 | 162,948 | 169,251 | 175,976 | 176,797 |
| Non-Chino Basin Groundwater | 52,262 | 51,959 | 51,720 | 51,919 | 51,972 |
| Local Surface Water | 13,154 | 13,154 | 13,136 | 13,145 | 13,154 |
| Imported Water | 65,366 | 66,631 | 69,015 | 70,192 | 70,288 |
| Recycled Water for Direct Use | 25,091 | 27,412 | 29,184 | 30,357 | 30,482 |
| Total | 310,179 | 322,105 | 332,306 | 341,589 | 342,693 |
| Percentage | | | | | |
| Chino Basin Groundwater | 50% | 51% | 51% | 52% | 52% |
| Non-Chino Basin Groundwater | 17% | 16% | 16% | 15% | 15% |
| Local Surface Water | 4% | 4% | 4% | 4% | 4% |
| Imported Water | 21% | 21% | 21% | 21% | 21% |
| Recycled Water for Direct Use | 8% | 9% | 9% | 9% | 9% |
| Total | 100% | 100% | 100% | 100% | 100% |

**Table 5-6c. Aggregate Water Plans for the Low Demand Scenario (Low Demands, Low Groundwater Utilization, High Imported Water Utilization)**

| Category | 2025 | 2030 | 2035 | 2040 | 2045 |
|---|---|---|---|---|---|
| Volume (afy) | | | | | |
| Chino Basin Groundwater | 139,427 | 142,583 | 142,887 | 144,146 | 147,907 |
| Non-Chino Basin Groundwater | 50,447 | 50,598 | 50,054 | 49,644 | 49,694 |
| Local Surface Water | 13,154 | 13,154 | 13,154 | 13,144 | 13,118 |
| Imported Water | 77,724 | 77,591 | 76,389 | 75,523 | 75,562 |
| Recycled Water for Direct Use | 25,091 | 26,755 | 27,829 | 28,841 | 29,982 |
| Total | 305,843 | 310,681 | 310,314 | 311,298 | 316,263 |
| Percentage | | | | | |
| Chino Basin Groundwater | 46% | 46% | 46% | 46% | 47% |
| Non-Chino Basin Groundwater | 16% | 16% | 16% | 16% | 16% |
| Local Surface Water | 4% | 4% | 4% | 4% | 4% |
| Imported Water | 25% | 25% | 25% | 24% | 24% |
| Recycled Water for Direct Use | 8% | 9% | 9% | 9% | 9% |
| Total | 100% | 100% | 100% | 100% | 100% |

**Table 5-7 Historical and Projected Pumping for the Chino Basin Parties**
*(afy)*

| Party | Historical Pumping | | | | | | | | | | | | | Projected Pumping - Expected Demand, Expected GWU, Expected IWU[a] | | | | | Projected Pumping - Low Demand, Low GWU, High IWU | | | | | | Projected Pumping - High Demand, High GWU, Low IWU | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | Statistics (2019-2023) | | | | | | | | | | | | | | | | | | |
| | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | Min | Max | Mean | 2025 | 2030 | 2035 | 2040 | 2045 | 2025 | 2030 | 2035 | 2040 | 2045 | 2051 | 2025 | 2030 | 2035 | 2040 | 2045 |
| Agricultural Pool | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Aggregate Agricultural Pool Pumping | 22,063 | 17,361 | 16,904 | 17,786 | 18,827 | 15,652 | 15,793 | 15,022 | 14,159 | 11,343 | 11,343 | 15,793 | 14,394 | 11,081 | 8,607 | 6,744 | 5,249 | 4,000 | 10,527 | 8,568 | 7,165 | 6,001 | 4,987 | 3,800 | 11,635 | 8,548 | 6,296 | 4,528 | 4,200 |
| Overlying Non-Agricultural Pool | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 9W Halo Western OpCo L.P. | 37 | 26 | 28 | 20 | 21 | 23 | 26 | 29 | 27 | 26 | 23 | 29 | 26 | 26 | 26 | 26 | 26 | 26 | 25 | 25 | 25 | 25 | 25 | 25 | 27 | 27 | 27 | 27 | 27 |
| California Speedway Corporation | 436 | 454 | 300 | 410 | 438 | 389 | 427 | 388 | 403 | 274 | 274 | 427 | 376 | 274 | 274 | 274 | 274 | 274 | 260 | 260 | 260 | 260 | 260 | 260 | 288 | 288 | 288 | 288 | 288 |
| California Steel Industries, Inc. | 1,417 | 1,279 | 1,187 | 1,298 | 1,266 | 1,419 | 1,065 | 1,302 | 671 | 1,058 | 671 | 1,419 | 1,103 | 1,103 | 1,103 | 1,103 | 1,103 | 1,103 | 1,048 | 1,048 | 1,048 | 1,048 | 1,048 | 1,048 | 1,158 | 1,158 | 1,158 | 1,158 | 1,158 |
| General Electric Company | 1,626 | 1,355 | 917 | 1,667 | 957 | 1,320 | 784 | 1,018 | 647 | 809 | 647 | 1,320 | 916 | 916 | 916 | 916 | 916 | 916 | 870 | 870 | 870 | 870 | 870 | 870 | 961 | 961 | 961 | 961 | 961 |
| GenOn California South, LP | 290 | 221 | 204 | 211 | 212 | 18 | 2 | 0 | 0 | 0 | 0 | 18 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Riboli Family and San Antonio Winery, Inc. | 10 | 7 | 4 | 5 | 6 | 26 | 26 | 43 | 16 | 2 | 2 | 43 | 22 | 22 | 22 | 22 | 22 | 22 | 21 | 21 | 21 | 21 | 21 | 21 | 24 | 24 | 24 | 24 | 24 |
| TAMCO | 18 | 29 | 30 | 25 | 18 | 10 | 20 | 15 | 2 | 0 | 0 | 20 | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Subtotal Overlying Non-Agricultural Pool Pumping* | *3,834* | *3,371* | *2,670* | *3,636* | *2,919* | *3,204* | *2,350* | *2,795* | *1,767* | *2,168* | *1,618* | *3,277* | *2,457* | *2,341* | *2,341* | *2,341* | *2,341* | *2,341* | *2,224* | *2,224* | *2,224* | *2,224* | *2,224* | | *2,458* | *2,458* | *2,458* | *2,458* | *2,458* |
| Appropriative Pool | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| BlueTriton Brands, Inc. | 379 | 426 | 356 | 367 | 308 | 285 | 279 | 271 | 252 | 277 | 252 | 285 | 273 | 273 | 273 | 273 | 273 | 273 | 259 | 259 | 259 | 259 | 259 | 259 | 286 | 286 | 286 | 286 | 286 |
| Chino, City Of | 6,725 | 6,546 | 5,010 | 4,972 | 5,162 | 4,315 | 5,173 | 6,133 | 6,193 | 5,569 | 4,315 | 6,193 | 5,477 | 7,348 | 10,008 | 10,381 | 10,946 | 12,935 | 6,760 | 8,605 | 8,966 | 9,048 | 9,268 | 10,775 | 7,642 | 10,834 | 11,811 | 14,035 | 14,641 |
| Chino Hills, City Of | 7,522 | 3,745 | 1,633 | 2,246 | 2,839 | 1,608 | 1,472 | 2,529 | 2,694 | 2,218 | 1,472 | 2,694 | 2,104 | 2,315 | 2,315 | 2,315 | 2,315 | 2,315 | 2,130 | 2,130 | 2,130 | 2,130 | 2,130 | 2,130 | 2,500 | 2,500 | 2,500 | 2,500 | 2,500 |
| Norco, City Of | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Ontario, City Of | 21,980 | 17,676 | 22,849 | 24,840 | 26,280 | 20,722 | 18,395 | 21,751 | 19,670 | 16,933 | 16,933 | 21,751 | 19,494 | 26,358 | 29,612 | 30,222 | 37,187 | 37,187 | 24,249 | 26,508 | 27,066 | 28,913 | 33,333 | 33,333 | 28,467 | 32,544 | 37,234 | 41,116 | 41,116 |
| Pomona, City Of | 12,909 | 12,520 | 9,964 | 8,067 | 9,286 | 10,840 | 10,551 | 9,192 | 10,184 | 10,197 | 9,192 | 10,840 | 10,193 | 10,858 | 11,685 | 12,543 | 13,376 | 14,238 | 9,989 | 10,623 | 11,201 | 11,759 | 12,306 | 13,099 | 11,727 | 12,851 | 13,996 | 15,144 | 15,377 |
| Upland, City Of | 2,822 | 3,416 | 2,601 | 1,260 | 1,764 | 2,381 | 2,449 | 2,177 | 1,473 | 808 | 808 | 2,449 | 1,858 | 3,133 | 2,808 | 2,232 | 1,979 | 2,005 | 2,799 | 2,444 | 1,938 | 1,516 | 1,277 | 1,312 | 3,519 | 3,219 | 2,876 | 2,808 | 2,812 |
| Cucamonga Valley Water District | 16,122 | 14,640 | 20,537 | 16,562 | 6,838 | 9,624 | 23,318 | 26,226 | 27,281 | 13,515 | 9,624 | 27,281 | 19,993 | 13,900 | 13,400 | 12,400 | 10,400 | 10,400 | 13,333 | 12,853 | 12,201 | 11,237 | 9,868 | 9,868 | 14,467 | 13,786 | 11,974 | 10,932 | 10,932 |
| Fontana Water Company | 15,378 | 13,344 | 15,317 | 13,250 | 11,392 | 9,961 | 10,427 | 13,565 | 16,387 | 8,721 | 8,721 | 16,387 | 11,812 | 9,278 | 9,983 | 11,128 | 12,293 | 13,183 | 8,536 | 9,076 | 9,786 | 10,544 | 11,310 | 12,128 | 10,020 | 11,091 | 12,647 | 13,997 | 14,238 |
| Jurupa Community Services District | 18,407 | 12,805 | 9,284 | 11,498 | 15,286 | 13,894 | 12,760 | 11,161 | 12,094 | 7,522 | 7,522 | 13,894 | 11,486 | 10,131 | 12,414 | 13,011 | 14,002 | 14,002 | 9,408 | 10,016 | 10,568 | 11,041 | 11,417 | 10,723 | 10,858 | 13,967 | 16,118 | 16,880 | 16,880 |
| Marygold Mutual Water Company | 1,315 | 1,250 | 753 | 619 | 944 | 950 | 860 | 841 | 944 | 560 | 560 | 950 | 831 | 1,322 | 1,403 | 1,484 | 1,565 | 1,727 | 1,256 | 1,320 | 1,377 | 1,432 | 1,487 | 1,641 | 1,388 | 1,494 | 1,601 | 1,771 | 1,813 |
| Monte Vista Irrigation Company | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Monte Vista Water District[b] | 7,163 | 7,402 | 8,371 | 7,086 | 6,483 | 6,631 | 6,710 | 7,674 | 7,185 | 5,293 | 5,293 | 7,674 | 6,699 | 6,500 | 6,500 | 6,500 | 6,500 | 6,500 | 5,980 | 5,980 | 5,980 | 5,980 | 5,980 | 5,980 | 7,020 | 7,020 | 7,020 | 7,020 | 7,020 |
| Niagara Bottling, LLC | 1,343 | 1,860 | 1,775 | 1,532 | 1,571 | 1,683 | 1,760 | 1,752 | 1,684 | 1,401 | 1,401 | 1,760 | 1,656 | 1,656 | 1,656 | 1,656 | 1,656 | 1,656 | 1,573 | 1,573 | 1,573 | 1,573 | 1,573 | 1,573 | 1,739 | 1,739 | 1,739 | 1,739 | 1,739 |
| San Antonio Water Company | 1,159 | 1,479 | 1,031 | 538 | 428 | 376 | 614 | 677 | 402 | 459 | 376 | 677 | 506 | 592 | 592 | 592 | 592 | 592 | 562 | 562 | 562 | 562 | 562 | 562 | 622 | 622 | 622 | 622 | 622 |
| San Bernardino, County of (Shooting Park) | 16 | 11 | 9 | 13 | 11 | 11 | 8 | 17 | 20 | 18 | 8 | 20 | 15 | 15 | 15 | 15 | 15 | 15 | 14 | 14 | 14 | 14 | 14 | 14 | 16 | 16 | 16 | 16 | 16 |
| Santa Ana River Water Company | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Golden State Water Company | 736 | 720 | 807 | 850 | 148 | 0 | 640 | 1,074 | 1,066 | 922 | 0 | 1,074 | 740 | 800 | 800 | 900 | 900 | 980 | 696 | 696 | 746 | 783 | 783 | 853 | 904 | 932 | 1,017 | 1,085 | 1,107 |
| West End Consolidated Water Company | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| West Valley Water District | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Subtotal Appropriative Pool Pumping* | *113,976* | *97,842* | *100,297* | *93,699* | *88,740* | *83,280* | *95,418* | *105,040* | *107,529* | *74,412* | *74,412* | *107,529* | *93,136* | *94,479* | *103,464* | *105,652* | *113,999* | *118,008* | *87,546* | *92,661* | *94,368* | *96,791* | *101,566* | *104,250* | *101,174* | *112,903* | *121,458* | *129,952* | *131,100* |
| Chino Desalter Authority | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Total Desalter Pumping[c] | 29,282 | 30,022 | 28,191 | 28,284 | 30,088 | 31,233 | 35,630 | 40,156 | 40,566 | 39,815 | 31,233 | 40,566 | 37,480 | 40,000 | 40,000 | 40,000 | 40,000 | 40,000 | 40,000 | 40,000 | 40,000 | 40,000 | 40,000 | 40,000 | 40,000 | 40,000 | 40,000 | 40,000 | 40,000 |
| Total Pumping | 169,155 | 148,596 | 148,061 | 143,405 | 140,574 | 133,368 | 149,190 | 163,013 | 164,021 | 127,737 | 118,605 | 167,165 | 147,466 | 147,902 | 154,412 | 154,738 | 161,589 | 164,349 | 140,297 | 143,453 | 143,757 | 145,016 | 148,777 | 148,050 | 155,267 | 163,910 | 170,213 | 176,938 | 177,758 |
| Less GE Injection | -1,626 | -1,355 | -917 | -1,667 | -957 | -1,320 | -784 | -1,018 | -647 | -809 | -1,320 | -647 | -916 | -916 | -916 | -916 | -916 | -916 | -870 | -870 | -870 | -870 | -870 | -870 | -961 | -961 | -961 | -961 | -961 |
| Projected Net Total Basin Pumping | | | | | | | | | | | | | | 146,986 | 153,496 | 153,822 | 160,673 | 163,434 | 139,427 | 142,583 | 142,887 | 144,146 | 147,907 | 147,180 | 154,306 | 162,948 | 169,251 | 175,976 | 176,797 |
| 2020 SYR Projected Net Total Basin Pumping | | | | | | | | | | | | | | 144,596 | 151,808 | 164,600 | 173,805 | 173,805 | 144,596 | 151,808 | 164,600 | 173,805 | 173,805 | 173,806 | 144,596 | 151,808 | 164,600 | 173,805 | 173,805 |
| Change in Projected Net Total Basin Pumping from the 2020 SYR | | | | | | | | | | | | | | 2,390 | 1,688 | -10,778 | -13,132 | -10,371 | -5,169 | -9,225 | -21,713 | -29,659 | -25,898 | -26,626 | 9,710 | 11,140 | 4,651 | 2,171 | 2,992 |

[a] GWU = Groundwater utilization; IWU = Imported water utilization

[b] Projected pumping includes projected wholesale deliveries to Chino Hills originating from MVWD wells and assumes that MVWD does not pump any of Chino Hills' pumping rights via MVWD wells.

[c] Includes pumping from San Bernardino County wells that will come online in FY 2026 to remediate the Chino Airport plume and supplement Desalter Pumping.

**Figure 5-8. Total Demands for Water Plan Scenarios**

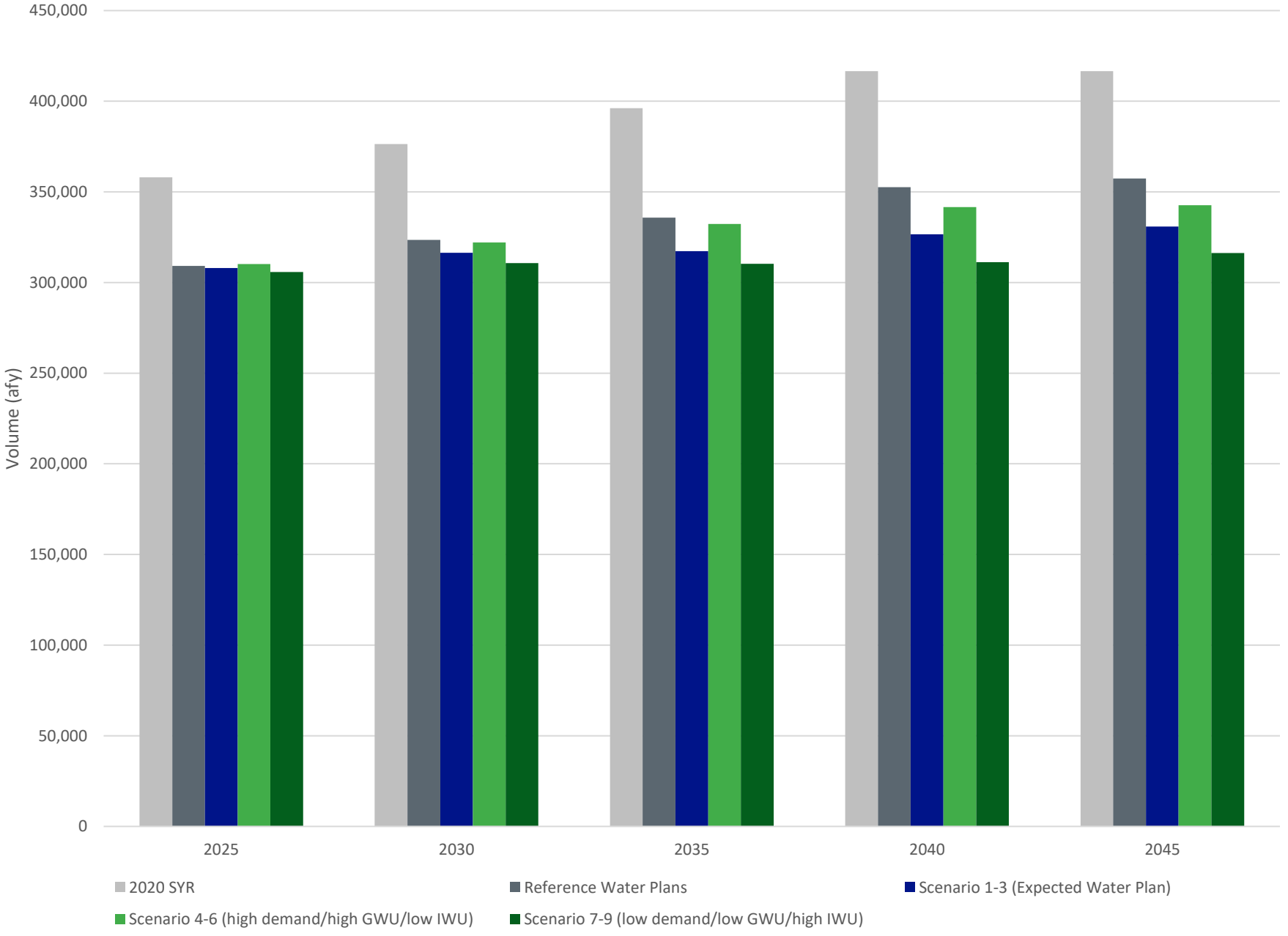


**Figure 5-9. Total Chino Basin Groundwater Pumping Demands for Water Plan Scenarios**

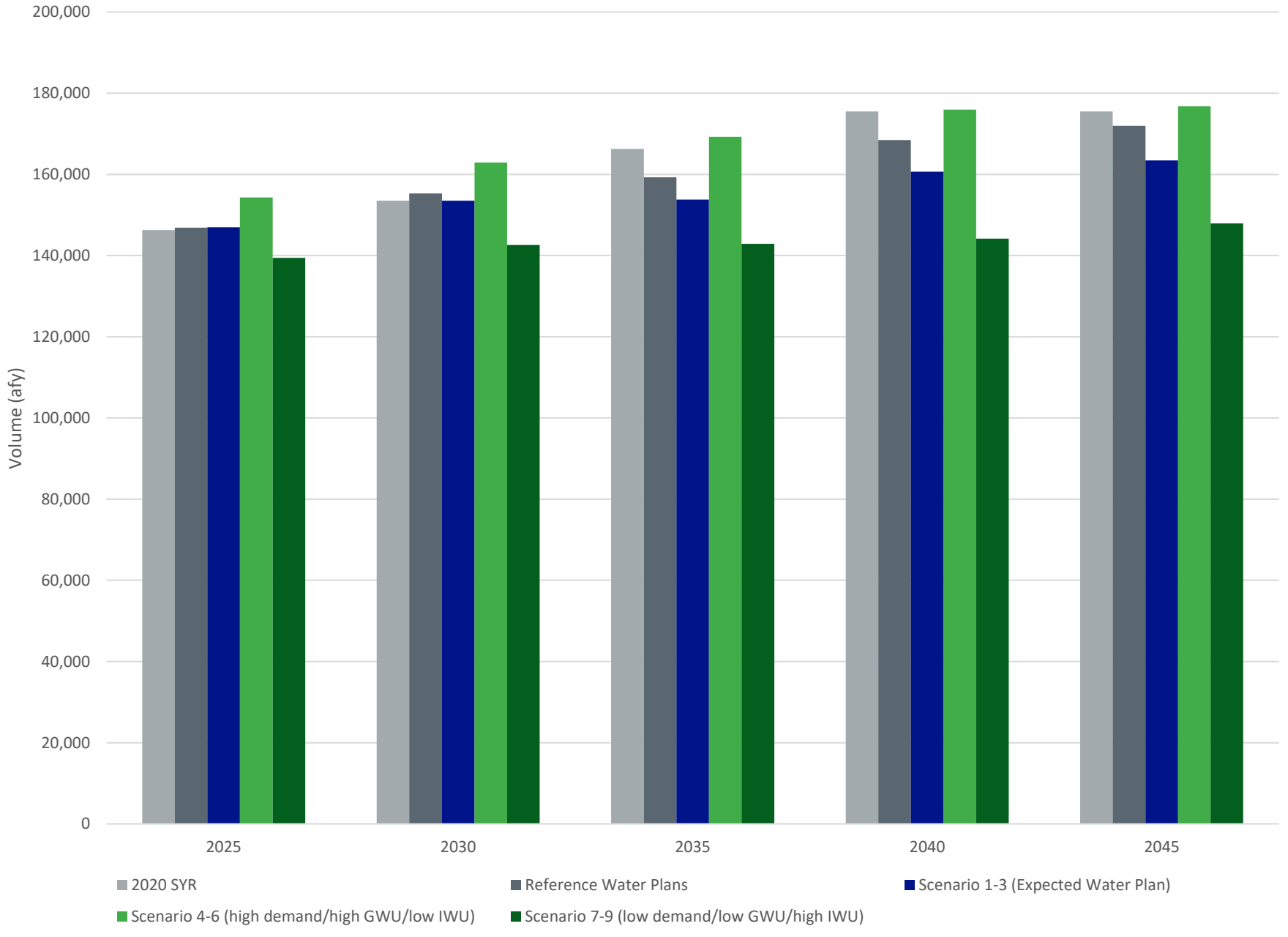
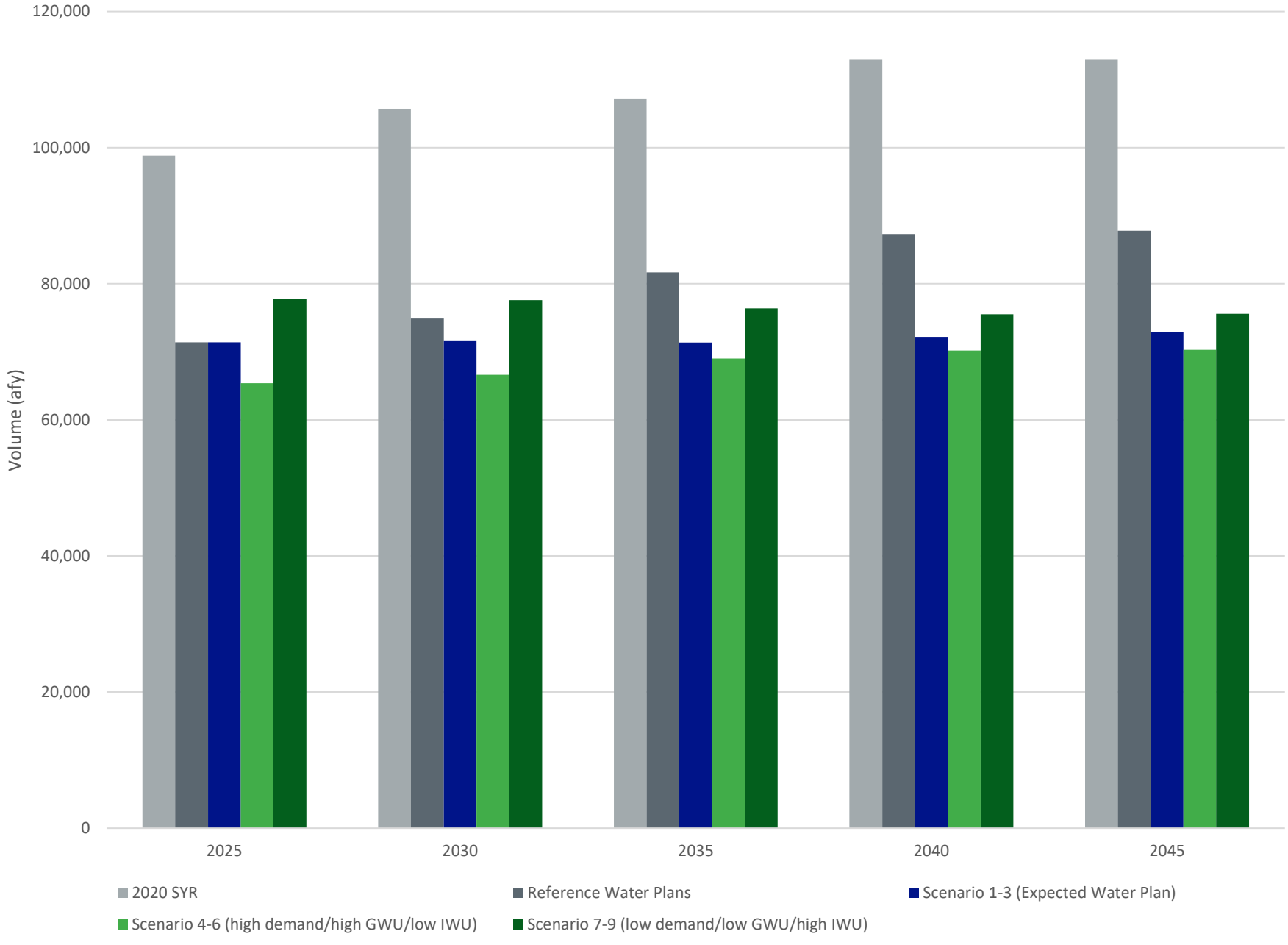


**Figure 5-10. Total Imported Water Demands for Water Plan Scenarios**



## 5.5 SUMMARY OF PROJECTION ENSEMBLE

Table 5-8 summarizes the nine Projection Scenarios, each representing a unique combination of three Climate Scenarios and three Water Plan Scenarios. These scenarios are designed to capture a broad range of plausible future conditions related to demand, groundwater utilization, and IWU.

**Table 5-8. Projection Ensemble**

| Projection Scenario | Rationale | Water Plan Scenario[a] | | | Climate Scenario |
|---|---|---|---|---|---|
| | | Demand | Groundwater Utilization | Imported Water Utilization | |
| 1 | Expected/Baseline | Expected | Expected | Expected | Average |
| 2 | Hot/Dry Climate | Expected | Expected | Expected | Hot/dry |
| 3 | Cool/Wet Climate | Expected | Expected | Expected | Cool/wet |
| 4 | Impact Of High Demands | High | High | Low | Average |
| 5 | Low Groundwater Levels | High | High | Low | Hot/dry |
| 6 | High Net Recharge | High | High | Low | Cool/wet |
| 7 | Impact Of Low Demands | Low | Low | High | Average |
| 8 | Low Net Recharge | Low | Low | High | Hot/dry |
| 9 | High Groundwater Levels | Low | Low | High | Cool/wet |

(a) Each Water Plan Scenario is adjusted to reflect the unique precipitation and evapotranspiration ($ET_o$) patterns of the corresponding Climate Scenario as described in Section 5.4.3.2.

**Scenario 1** serves as the "baseline" scenario and reflects expected conditions for both Water Plans and average future climate/hydrology.

**Scenarios 2 and 3** modify the baseline to isolate the impacts of climate variability. Scenario 2 evaluates the effects of a hotter/drier climate, while Scenario 3 simulates a cooler and wetter future. Together, these scenarios characterize the influence of climatic uncertainty on net recharge and groundwater levels.

**Scenarios 4 and 7** focus on the effects of future uncertainty in Water Plans, specifically how changes in demand and supply portfolios influence groundwater pumping, net recharge, and groundwater levels. Scenario 4 assumes high demands and high groundwater utilization with low IWU. Scenario 7 assumes low demands and low groundwater utilization with high IWU. Both scenarios use the average climate conditions.

**Scenarios 5 and 9** explore the potential range of future groundwater levels. Scenario 5 represents a worst-case combination of high demand, high groundwater utilization, low IWU, and a hot/dry climate, likely resulting in the lowest groundwater levels. Conversely, Scenario 9 combines low demand, low groundwater utilization, high IWU, and a cool/wet climate, which is expected to result in the highest groundwater levels.

**Scenarios 6 and 8** examine the plausible range in net recharge. Scenario 6, with high demands, high groundwater utilization, low IWU, and a Cool/wet climate, is likely to yield the highest net recharge of any Projection Scenario. Scenario 8 represents the opposite, with low demands, low groundwater utilization, high IWU, and a hot/dry climate, likely producing the lowest net recharge of any Projection Scenario.

Other combinations of Water Plan and Climate Scenarios are not expected to result in conditions (e.g., net recharge or groundwater levels) beyond the range captured by these nine scenarios.

## 5.6 LIKELIHOODS

Step 5 of the 2022 Safe Yield Reset Methodology directs Watermaster to "[a]ssign likelihoods to each scenario in the Projection Ensemble." This step acknowledges that not all Projection Scenarios have the same probability of occurrence, and that the simulated Basin responses should be evaluated within this probabilistic context. For example, if a single Projection Scenario with a low likelihood of occurrence is projected to result in MPI, it may warrant less concern than a higher-likelihood scenario with a similar impact.

To incorporate scenario likelihoods into the analysis, scalar weighting factors are applied independently to the Water Plan Scenario and Climate Scenario components of each Projection Scenario. If all scenarios are considered equally likely, each component is assigned a weight of 1. If a component is believed to be twice as likely as another, it is assigned a weight of 2. The total likelihood weight for each Projection Scenario is calculated as the product of the Water Plan Scenario weight and the Climate Scenario weight.

The Expected Demand Water Plan Scenario (which includes expected demand, expected groundwater utilization and expected IWU) is considered more likely than either the High Demand or Low Demand Water Plan Scenarios. Therefore, a scalar weight of 2 is applied to the Expected Demand Water Plan Scenario (Projection Scenarios 1, 2, and 3), while a weight of 1 is applied to the High and Low Demand Water Plan Scenarios (Projection Scenarios 4 through 9). This implies that the Expected Demand Water Plan Scenario is twice as likely to occur as either the High or Low Demand Water Plan Scenarios occurring.

Similarly, the Average Climate Scenario is considered more likely than the Hot/Dry or Cool/Wet Climate alternatives. A scalar weight of 2 is assigned to the Average Climate Scenario, and a weight of 1 is assigned to both the Hot/Dry and Cool/Wet Climate Scenarios.

Table 5-9 summarizes the Projection Ensemble with the assigned likelihood weights. The total likelihood weight for each Projection Scenario is the product of its assigned Water Plan Scenario weight and Climate Scenario weight. For example, Scenario 1, which includes the Expected Demand Water Plan Scenario and the Average Climate Scenario, is assigned a total weight of 4 (Water Plan weight of 2 times Climate Scenario weight of 2).

**Table 5-9. Projection Ensemble with Likelihood Weights**

| Projection Scenario | Water Plan Scenario | | | Climate Scenario | Likelihood Weights | | |
|---|---|---|---|---|---|---|---|
| | Demand | Groundwater Utilization | IWU | | Water Plan Scenario (a) | Climate Scenario (b) | Total (c) = (a) * (b) |
| 1 | Expected | Expected | Expected | Average | 2 | 2 | 4 |
| 2 | Expected | Expected | Expected | Hot/dry | 2 | 1 | 2 |
| 3 | Expected | Expected | Expected | Cool/wet | 2 | 1 | 2 |
| 4 | High | High | Low | Average | 1 | 2 | 2 |
| 5 | High | High | Low | Hot/dry | 1 | 1 | 1 |
| 6 | High | High | Low | Cool/wet | 1 | 1 | 1 |
| 7 | Low | Low | High | Average | 1 | 2 | 2 |
| 8 | Low | Low | High | Hot/dry | 1 | 1 | 1 |
| 9 | Low | Low | High | Cool/wet | 1 | 1 | 1 |

# SECTION 6
# 2025 Determination of Tentative Safe Yield

## 6.1 BACKGROUND AND METHODS

Sections 6 and 7 present the findings of the 2025 Safe Yield Reevaluation and document the execution of Steps 6 through 9 of the 2022 SYRM:

6. *Simulate the range for the potential future water budget and groundwater conditions in the Chino Basin over no less than a 50-year future period. This is accomplished by using:*
   i. *The range of calibrated models [i.e., the chosen calibrated realizations], and*
   ii. *The Projection Ensemble as model input data.*
7. *Using the results of [6.] above, characterize the range in the model results for:*
   i. *Groundwater conditions, including: groundwater elevations, groundwater in storage, and groundwater flow directions, and*
   ii. *The water budget, including: basin inflows, outflows, change in storage, and net recharge.*
8. *Using the set of net recharge results from [7.ii], determine a Tentative Safe Yield as the likelihood-weighted average net recharge over the 10-year prospective period for which the Safe Yield is being redetermined (Tentative Safe Yield).*
9. *Evaluate whether the groundwater production at the Tentative Safe Yield estimated in [8] above will cause or threaten to cause "undesirable results" or "Material Physical Injury." If groundwater production at Tentative Safe Yield will cause or threaten to cause "undesirable results" or "Material Physical Injury," then Watermaster will identify and implement prudent measures necessary to mitigate "undesirable results" or "Material Physical Injury," set the value of Safe Yield to ensure there is no "undesirable results" or "Material Physical Injury," or implement a combination of mitigation measures and a changed Safe Yield.*

Section 6 describes the methods to implement Steps 6 through 9 and the results of Steps 6 through 8. Section 7 describes the results and conclusions of the execution of Step 9, including the determination of the viability of groundwater production at the Tentative Safe Yield (TSY).

### 6.1.1 Methods

Figure 6-1 shows a flowchart of Steps 6 through 9 of the 2022 SYRM. Steps 6 through 8 include the simulation of the Initial and TSY Ensemble and the calculation of the TSY for the 10-year period (FY 2021-2030). The assumed Safe Yield of the Chino Basin is a factor that determines the projections for managed storage, and therefore the imported wet-water recharge that is used to satisfy replenishment obligations when groundwater production exceeds production rights. Imported water recharge, in turn, impacts the water budget and groundwater levels in the Chino Basin, impacting net recharge and Safe Yield calculations for future decades. This feedback loop of net recharge, Safe Yield, managed storage, and imported water recharge requires that the modeling process be iterative to result in a stable net recharge volume. The Initial Projection Ensemble is necessary to ensure the TSY converges to a stable value to use in the TSY Ensemble. The managed storage for all realizations of the Initial Projection Ensemble assumes that managed storage is identical to historical managed storage through FY 2024, when the total balance was about 709,000 af.

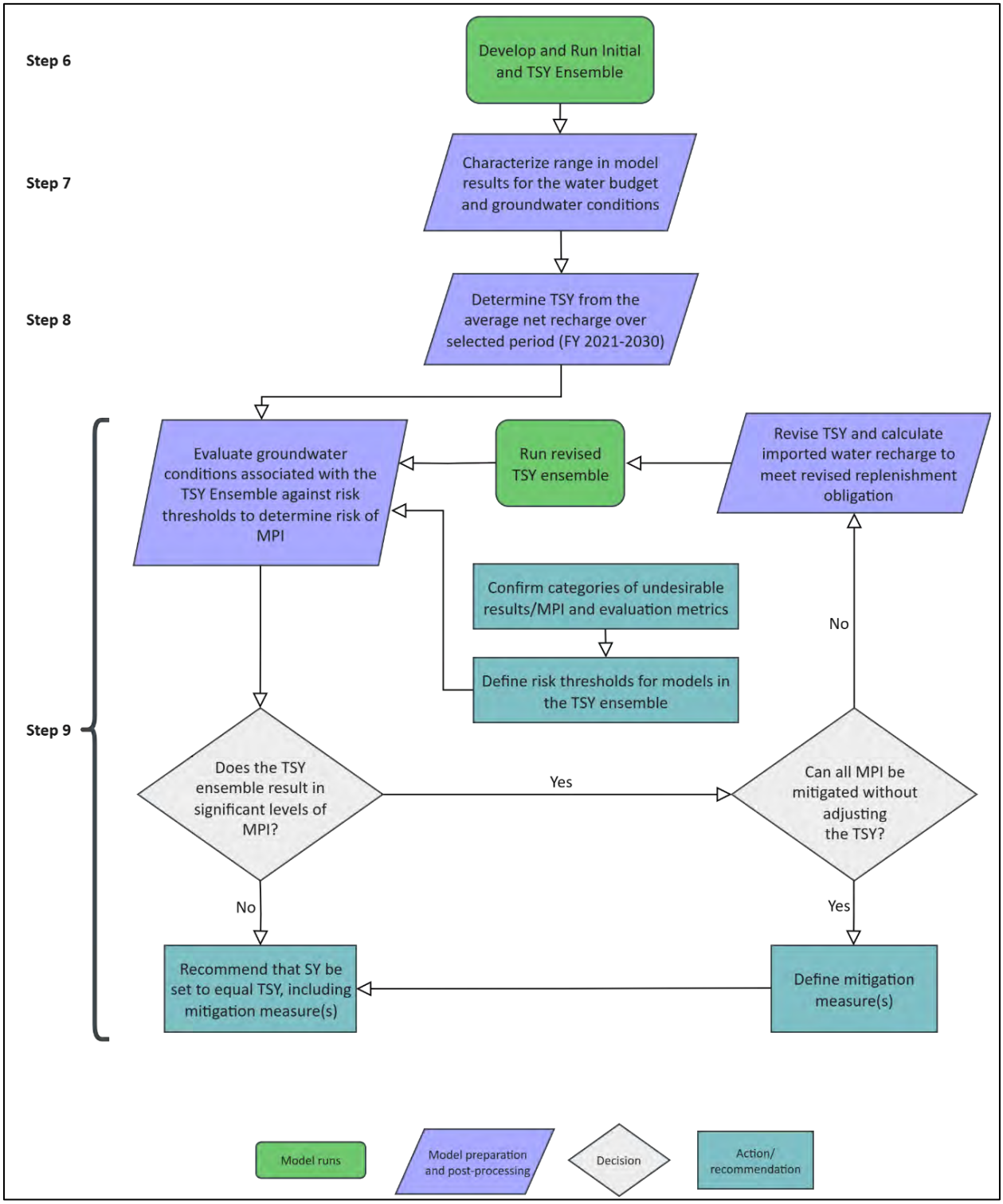



**Figure 6-1. Flowchart Characterizing Steps 6 through 9 of 2022 Safe Yield Reset Methodology**

## 6.1.2 Development of the TSY Ensemble

The TSY Ensemble is identical to the Initial Projection Ensemble except for revised calculations of managed storage and imported water recharge. Managed storage must be calculated using the TSY for FY 2021-2030 to calculate the imported water recharge to meet any replenishment obligations in FY 2021-2030.

### *6.1.2.1 Managed Storage*

Managed storage for the TSY Ensemble is calculated using the following assumptions:

- Managed storage for all Projection Realizations is identical to the historical managed storage through FY 2024, when the managed storage was about 709,000 af. This includes about 45,900 af in the balance of the DYYP.
- Pumping of water in the DYYP accounts is assumed to occur in FY 2026 through 2028, leaving a zero balance in the DYYP account at the end of FY 2028.
- For all Projection Realizations in the TSY Ensemble, the Safe Yield assumed for FY 2021-2030 is the TSY.
- For subsequent decades, the Safe Yield is assumed to be the average net recharge for that decade in that projection realization.
- Recycled water recharge is assumed to occur as projected by the IEUA as of 2023 (16,850 afy).
- Reoperation water is allocated to the replenishment of desalter production, as provided in the Peace II Agreement and by a 2017 agreement among members of the AP following Court approval of the Safe Yield in 2017. Reoperation water will be allocated to the replenishment of desalter production through 2030.
- Managed storage is calculated based on comparing aggregate pumping to aggregate pumping rights; that is, individual parties' rights and replenishment obligations are not calculated. If aggregate pumping is greater than aggregate pumping rights, the difference is the replenishment obligation. This is handled as follows:
    - If aggregate pumping rights are greater than the projected aggregate pumping, then the under-pumping is credited to storage accounts and there is no wet-water recharge for replenishment.
    - If projected aggregate pumping exceeds aggregate pumping rights, a replenishment obligation exists. 80 to 100 percent of this obligation is debited from managed storage accounts, with the remainder fulfilled by wet-water recharge. The percentage debited to managed storage accounts is determined by the scenario (see Section 5).
    - If the calculated debit to managed storage accounts for the replenishment obligation exceeds available managed storage, the shortfall is added to wet-water recharge. For instance, a 30,000 af debit with only 20,000 af of managed storage available means 10,000 af will be added to wet-water recharge, leaving zero managed storage.

Figure 6-2 shows the projected managed storage for the TSY Ensemble, depicting the range of projected managed storage due to the demand scenarios under the Expected Climate Scenario (i.e., Scenarios 1, 4, and 7), with the range between them shown in dark purple. The lighter purple shading encompasses the total range of projected managed storage for the entire TSY Ensemble.

At the end of FY 2030, total managed storage ranges from 490,000 af (Scenario 5) to 647,000 af (Scenario 9), with Scenario 1 resulting in about 574,000 af of managed storage. In Scenario 5 (High Demand, High GWU, Low IWU, Hot/Dry Climate), managed storage is projected to reach zero at around 2042. By 2050, total managed storage ranges from 0 (Scenarios 4 through 6) to 453,000 af (Scenario 9), with Scenario 1 resulting in about 152,000 af.

#### *6.1.2.2 Imported Water Recharge*

The only imported water recharge assumed in the TSY Ensemble in the Chino Basin is wet-water recharge due to replenishment obligations. For each year a replenishment obligation is accrued, the calculated volume of imported water recharge is assumed to occur in the following year. Imported water recharge is allocated to recharge basins for each month based on (1) the recommended pattern of supplemental recharge described in the 2023 Recharge Master Plan Update[1] (2023 RMPU) and (2) the assumed monthly availability of the recharge basins due to the competing uses of stormwater and recycled water recharge.

Section 6.4 of the 2023 RMPU included a recommendation for Watermaster to prioritize supplemental water recharge in the basins in OBMP Management Zone 1 (MZ-1) up to its recharge capacity, then to MZ-3, and finally to MZ-2. The distribution of recharge was calculated monthly until all imported water was allocated to recharge basins for the year.

Figures 6-3, 6-4, and 6-5 show the projected imported water recharge and managed storage for Scenarios 1, 5, and 9, respectively, showing the scenarios with the central tendency (Scenario 1), highest (Scenario 5), and lowest (Scenario 9) imported water recharge. The highest one-year imported water recharge occurs in Scenario 5 in FY 2073, where 50,500 af of imported water was recharged to satisfy the replenishment obligation that accrued in FY 2072.

## 6.2 RESULTS OF TSY ENSEMBLE

This subsection describes the range of projected groundwater conditions associated with the results of the TSY Ensemble. The naming convention to identify each member of the TSY Ensemble is the letter of the CVM realization (A through E) followed by the number of the Projection Scenario (1 through 9). Table 6-1 below lists the nine Projection Scenarios.

[1] 2023 Recharge Master Plan Update

Figure 6-2
Projected Managed Storage
2020 SYR and 2025 SYR

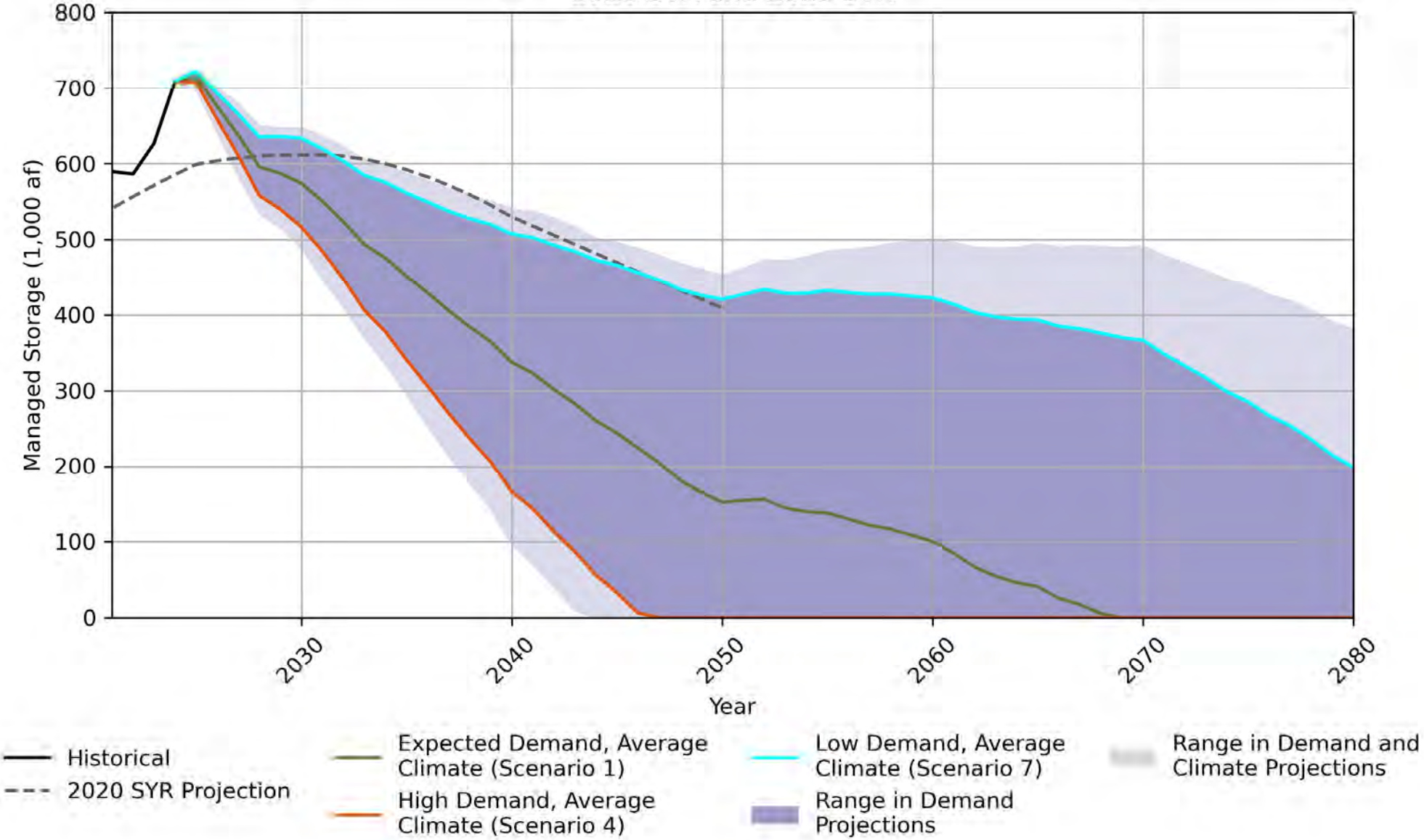


**Figure 6-3. Projected Imported Water Recharge, TSY Ensemble Scenario 1**

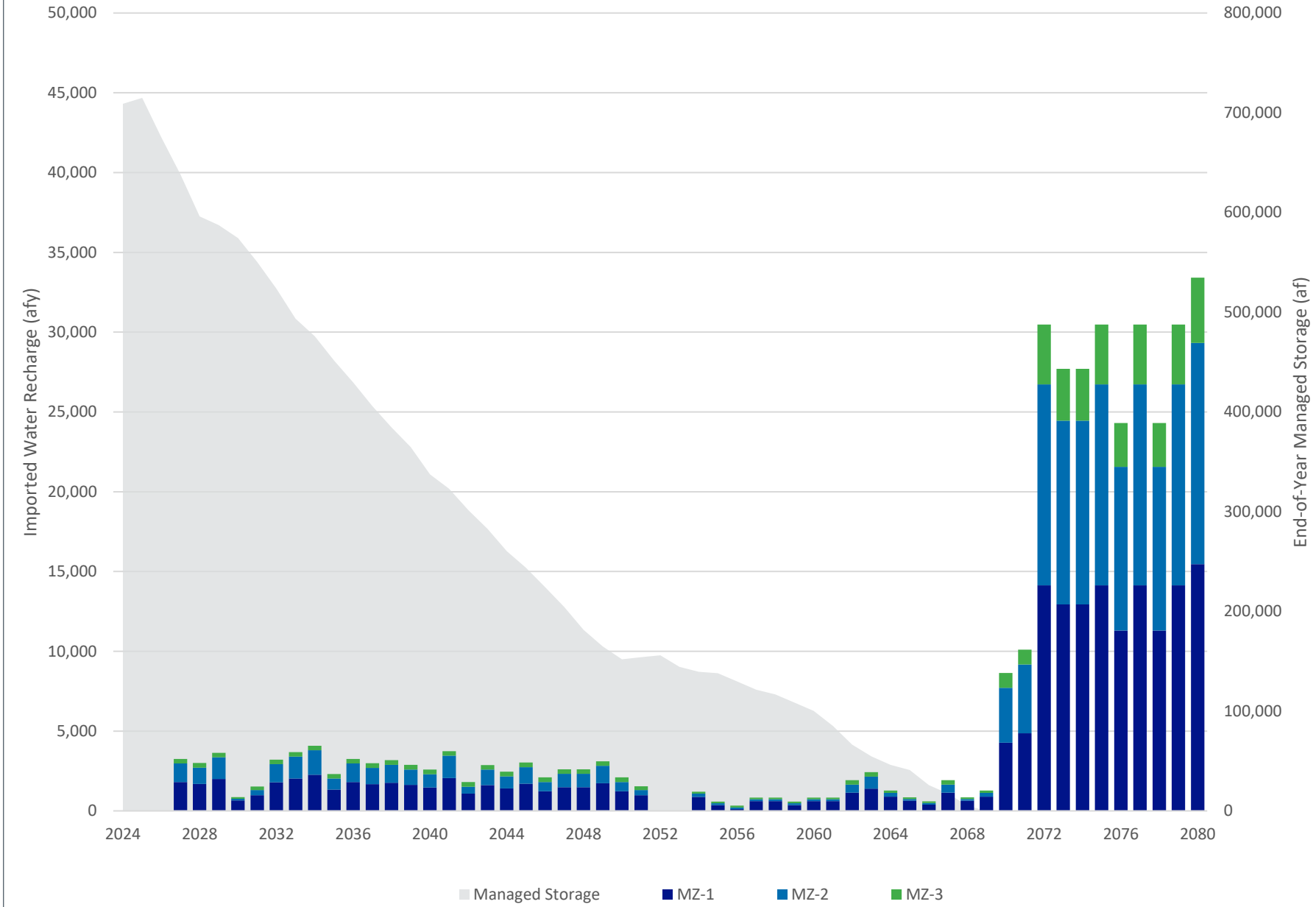


**Figure 6-4. Projected Imported Water Recharge, TSY Ensemble Scenario 5**

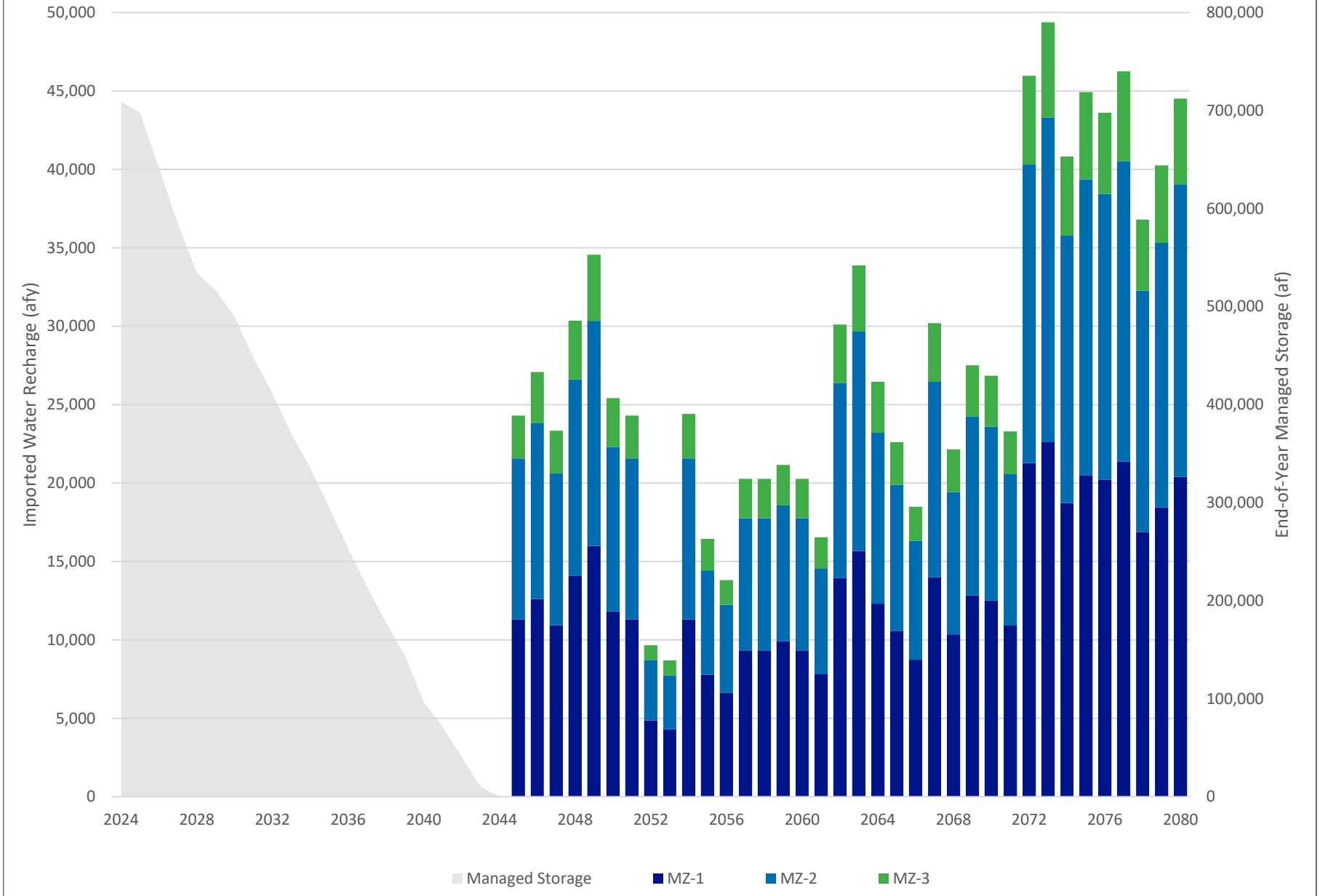


**Figure 6-5. Projected Imported Water Recharge, TSY Ensemble Scenario 9**

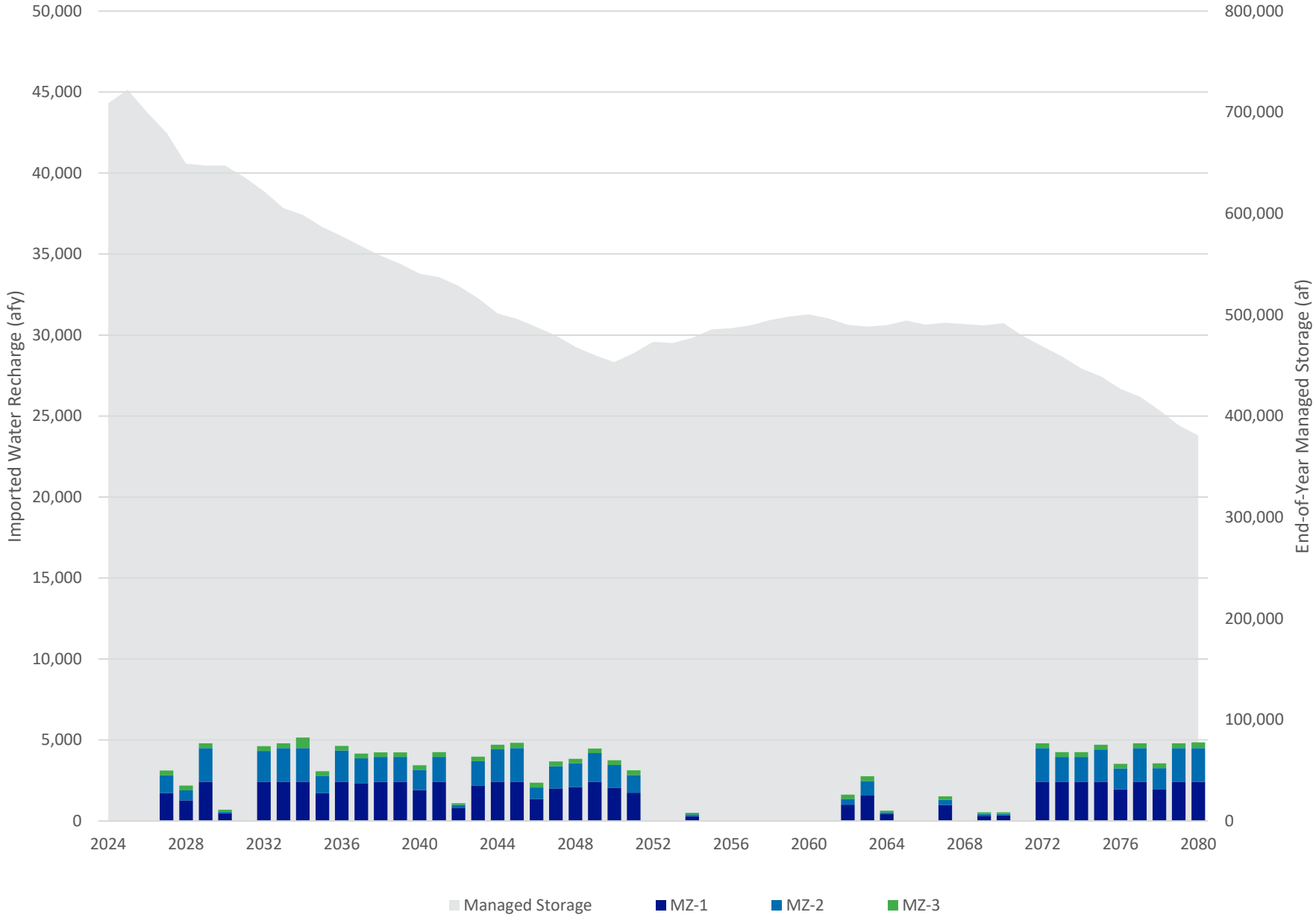


**Table 6-1. Projection Ensemble**

| Projection Scenario | Rationale | Water Plan Scenario[(a)] | | | Climate Scenario |
|---|---|---|---|---|---|
| | | Demand | Groundwater Utilization | Imported Water Utilization | |
| 1 | Expected/Baseline | Expected | Expected | Expected | Average |
| 2 | Hot/Dry Climate | Expected | Expected | Expected | Hot/dry |
| 3 | Cool/Wet Climate | Expected | Expected | Expected | Cool/wet |
| 4 | Impact Of High Demands | High | High | Low | Average |
| 5 | Low Groundwater Levels | High | High | Low | Hot/dry |
| 6 | High Net Recharge | High | High | Low | Cool/wet |
| 7 | Impact Of Low Demands | Low | Low | High | Average |
| 8 | Low Net Recharge | Low | Low | High | Hot/dry |
| 9 | High Groundwater Levels | Low | Low | High | Cool/wet |

(a) Each Water Plan Scenario is adjusted to reflect the unique precipitation and evapotranspiration ($ET_o$) patterns of the corresponding Climate Scenario as described in Section 5.4.3.2.

## 6.2.1 Water Budgets

Table 6-2 and Figure 6-6 show the water budget for Scenario D1 of the TSY Ensemble for FY 2021 through 2080. Water budgets for the other members of the TSY Ensemble can be found in Appendix D. The description of the recharge and discharge components and how each component was computed is described below or referenced in prior Sections. For each component where multipliers were applied to a time series during the uncertainty analysis (see Section 4), the average multiplier from the calibration period for that realization was used for the projection period. For example, if the average multiplier for a subsurface inflow time series from the calibration period was 1.2, the entire time series for future subsurface inflow was multiplied by 1.2 for all scenarios based on that calibrated realization.

The bullets below outline the water budget components shown in Figures 6-7 through 6-14, which depict for FY 1992 through 2080: the minimum and maximum range, 20$^{th}$ to 80$^{th}$ percentile range, and the likelihood-weighted average flows from the TSY Ensemble and the flows simulated in the 2020 SYR (1992-2050).

The projection period assumptions for FY 2023 through FY 2080, and the primary differences relative to the 2020 SYR, are summarized below:

- **Subsurface inflow (Figure 6-7):** Subsurface inflows were computed for the projection period using the same assumptions as the calibration period. The specified head boundary from the Riverside Basin through the Bloomington Divide was held equal to the monthly groundwater head values calculated along that boundary for FY 2022. Subsurface inflows remain relatively constant during the projection period. Differences from the 2020 SYR reflect the combined effects of updates to the model domain and boundary representation, recalibration, and the uncertainty analysis described in Sections 3 and 4.

- **DIPAW to the saturated zone (Figure 6-8):** DIPAW was calculated using the same general methods described for the calibration and uncertainty analysis in Section 4 and in greater detail in the 2020 SYR Report. This process includes using the R4 model to estimate the DIPAW to the vadose zone and applying lag time through the vadose zone to estimate the DIPAW to the saturated zone, which is an input to the MODFLOW model.

  DIPAW in the 2025 SYR is lower than in the 2020 SYR during FY 2021 through FY 2030 for several reasons: adjustment to the Chino Basin boundaries, recalibration and uncertainty analysis, addition of recent historical data, and revised projection assumptions. These drivers are summarized below and discussed in greater detail in Section 6.2.1.2.

  - *Adjustment to Chino Basin boundaries*. As discussed in Section 3, updates to the Chino Basin model boundary based on new hydrogeologic data reduced the modeled Basin area by about one percent, which reduced the area contributing to DIPAW.
  - *Recalibration and uncertainty analysis*. As discussed in Section 4, the recalibration and uncertainty analysis changed the CVM simulation of the magnitude and spatial distribution of DIPAW to the saturated zone relative to the 2020 SYR.
  - *Recent historical data (FY 2019 through 2023)*. Historical data added since the 2020 SYR reflect recent hydrologic and water-use conditions that were generally drier and included less urban outdoor water use than was assumed for FY 2019-23 in the 2020 SYR.
  - *Revised projections for FY 2024 through 2080*. As discussed in Section 5 and Appendix C, the 2025 SYR projections incorporate updated water supply plans, assumptions regarding urban irrigation practices and continued conservation-related reductions in outdoor water use, and variable hydrology. These assumptions resulted in less projected applied-water infiltration than was assumed in the 2020 SYR for the period FY 2024-30. From FY 2031-80, projected DIPAW varies with hydrology and water-plan assumptions and generally fluctuates around a lower range than was projected in the 2020 SYR.

- **Managed aquifer recharge (Figure 6-9):** Managed aquifer recharge comprises stormwater, recycled water, and imported water. The calculation of these components is described in Section 5, and for imported water recharge associated with replenishment obligations, in Section 6.1.2.2. The upper end of the projected range of managed aquifer recharge is higher than in the 2020 SYR after about FY 2040. This occurs primarily in the High Demand scenarios, where managed storage accounts are projected to approach or reach zero. Once managed storage is reduced or depleted, a greater portion of replenishment obligations is satisfied through wet-water recharge, increasing projected imported water recharge.
- **Streambed infiltration (Figure 6-10):** Differences in streambed infiltration between the 2020 SYR and 2025 SYR reflect recalibration of groundwater/surface-water interaction, updates to model parameters and boundary conditions, and the use of variable future hydrology in the 2025 SYR.
- **Groundwater ET (Figure 6-11):** Differences between the 2020 SYR and 2025 SYR reflect updates to the ET representation in the 2025 CVM, including the updated treatment of riparian vegetation extent and density, as well as the recalibration and uncertainty analysis described in Section 4.

- **Rising groundwater (Figure 6-12):** Differences between the 2020 SYR and 2025 SYR reflect recalibration of groundwater/surface-water interaction, updates to model parameters and boundary conditions, and the use of variable future hydrology in the 2025 SYR.
- **Net recharge (Figure 6-13):** See 6.2.1.1 below.
- **Annual change in storage (Figure 6-14):** The 2025 SYR shows greater year-to-year variability in change in storage than the 2020 SYR because the 2025 SYR uses variable hydrology and an ensemble of future climate and water-plan conditions, whereas the 2020 SYR relied on expected-value average hydrology for the projection period.
- **Cumulative change in storage from FY 1992-2080 (Figure 6-15):** Figure 6-15 shows six panels, one for each of the five calibrated realizations (showing all Projection Scenarios), and one for all Projection Realizations. The final panel shows the cumulative change in storage for three selected Projection Realizations: Scenarios D1, E9, and A5. These represent the median, maximum (smallest decline), and minimum (greatest decline) cumulative changes in storage over the period from FY 2021 to 2050, respectively.

  The cumulative change in storage over the modeled period (FY 1992 through 2080) ranges from -990,000 af (Scenario A2) to -14,000 af (Scenario E9). The likelihood-weighted average change in storage over this period is -595,000 af.

Projected storage declines occur primarily because projected groundwater production exceeds projected production rights in most scenarios and most years (see Figure 6-2 and Section 5). All Projection Scenarios assume that overproduction is satisfied primarily through debits to managed storage when managed storage is available. When overproduction is debited to managed storage rather than satisfied through wet-water recharge, the replenishment obligation is met, but no new water is added to the Basin. This results in a decline in physical groundwater storage until managed storage balances are reduced or depleted, at which point wet-water recharge increases to satisfy a larger portion of replenishment obligations (e.g., Scenario A5, where managed storage is depleted in the 2040s).

### *6.2.1.1 Net Recharge and TSY*

Table 6-3 summarizes the recharge and discharge components, change in storage, and net recharge over the FY 2021-2030 period for the TSY Ensemble and the 2020 SYR. The values for the TSY Ensemble represent the likelihood-weighted average.

## Table 6-2. Water Budget for the Chino Basin for the Period FY 2021 through 2080 - Scenario D1 (af)

| Fiscal Year | Recharge | | | | | | | | | | | | | | | | | Change in Storage | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | R* | I* | R* | R* | R* | R* | I* | R* | I | I | I | | I | I | R* | R* | | | | |
| | Subsurface Inflow | | | | | | | | Managed Aquifer Recharge | | | | Groundwater Pumping | | | | | | | |
| | Bloomington Divide | Chino/Puente Hills, Jurupa Hills, and Rialto Basin | Net Temescal Basin | Six Basins | Cucamonga Basin | Spadra Basin | Deep Infiltration of Precipitation and Applied Water | Streambed Infiltration | Stormwater | Recycled Water | Imported Water | Total Recharge | Overlying Non-Ag and Appropriative Pools | Overlying Agricultural Pool | Riparian Veg ET | Rising Groundwater | Total Discharge | Annual | Cumulative | Net Recharge |
| 2021 | 11,451 | 5,153 | 2,845 | 3,731 | 14,875 | 48 | 65,666 | 37,976 | 4,911 | 15,741 | 2,229 | 164,627 | 146,973 | 14,929 | 11,582 | 28,327 | 201,811 | -37,184 | -37,184 | 106,748 |
| 2022 | 11,612 | 4,757 | 721 | 3,467 | 14,804 | 48 | 62,536 | 40,331 | 8,108 | 15,080 | 1,742 | 163,206 | 148,608 | 14,077 | 10,678 | 26,824 | 200,187 | -36,981 | -74,166 | 108,882 |
| 2023 | 12,563 | 1,057 | 133 | 3,507 | 14,621 | 39 | 65,818 | 58,222 | 20,019 | 14,293 | 9,029 | 199,300 | 115,523 | 11,343 | 11,848 | 29,063 | 167,776 | 31,524 | -42,642 | 135,068 |
| 2024 | 12,584 | 4,579 | 2,254 | 3,504 | 14,268 | 44 | 65,281 | 39,902 | 12,929 | 13,369 | 43,198 | 211,912 | 125,746 | 11,212 | 11,795 | 27,908 | 176,661 | 35,251 | -7,391 | 115,642 |
| 2025 | 12,116 | 4,530 | -55 | 3,862 | 14,345 | 53 | 69,977 | 73,040 | 23,652 | 16,844 | 0 | 218,365 | 133,128 | 10,749 | 13,232 | 33,902 | 191,011 | 27,354 | 19,963 | 154,387 |
| 2026 | 11,743 | 1,981 | 2,986 | 4,162 | 14,484 | 48 | 68,440 | 36,621 | 9,513 | 16,844 | 0 | 166,821 | 154,302 | 10,904 | 13,273 | 31,568 | 210,046 | -43,225 | -23,262 | 105,137 |
| 2027 | 11,620 | 2,744 | 2,704 | 4,386 | 14,551 | 47 | 66,265 | 37,258 | 10,772 | 16,844 | 1,812 | 169,003 | 153,268 | 10,091 | 11,516 | 26,702 | 201,577 | -32,574 | -55,836 | 112,130 |
| 2028 | 11,749 | 5,634 | 2,445 | 4,542 | 14,556 | 62 | 64,545 | 36,729 | 6,151 | 16,869 | 1,683 | 164,966 | 158,003 | 9,884 | 10,875 | 25,038 | 203,801 | -38,835 | -94,671 | 110,500 |
| 2029 | 11,945 | 3,592 | 1,543 | 4,526 | 14,473 | 67 | 64,952 | 45,299 | 22,508 | 16,844 | 2,001 | 187,749 | 137,356 | 8,829 | 11,065 | 25,396 | 182,645 | 5,104 | -89,567 | 132,444 |
| 2030 | 12,033 | 8,596 | 1,919 | 4,689 | 14,434 | 87 | 64,852 | 40,761 | 13,095 | 16,844 | 657 | 177,967 | 142,145 | 8,607 | 11,050 | 25,441 | 187,243 | -9,276 | -98,843 | 123,976 |
| 2031 | 12,110 | 6,284 | 2,473 | 4,837 | 14,430 | 89 | 62,780 | 35,797 | 8,161 | 16,844 | 976 | 164,781 | 145,642 | 8,481 | 10,624 | 23,248 | 187,996 | -23,215 | -122,058 | 113,089 |
| 2032 | 12,257 | 6,603 | 2,205 | 4,884 | 14,418 | 86 | 61,288 | 37,562 | 10,062 | 16,869 | 1,790 | 168,024 | 149,165 | 8,334 | 10,281 | 22,250 | 190,030 | -22,006 | -144,064 | 116,834 |
| 2033 | 12,464 | 2,739 | 2,629 | 4,788 | 14,373 | 70 | 58,700 | 33,494 | 4,687 | 16,844 | 2,027 | 152,815 | 152,715 | 8,163 | 9,886 | 20,640 | 191,404 | -38,589 | -182,652 | 103,419 |
| 2034 | 12,619 | 4,440 | 1,337 | 4,522 | 14,270 | 61 | 59,672 | 43,773 | 17,859 | 16,844 | 2,263 | 177,659 | 140,798 | 6,903 | 10,042 | 21,921 | 179,664 | -2,005 | -184,657 | 126,589 |
| 2035 | 12,736 | 7,110 | 1,867 | 4,694 | 14,282 | 78 | 58,698 | 38,555 | 9,124 | 16,844 | 1,341 | 165,329 | 147,446 | 6,946 | 10,063 | 21,396 | 185,850 | -20,522 | -205,178 | 115,686 |
| 2036 | 12,824 | 1,452 | 1,240 | 4,814 | 14,249 | 64 | 58,995 | 43,368 | 13,299 | 16,869 | 1,809 | 168,983 | 146,003 | 6,445 | 10,202 | 22,735 | 185,385 | -16,403 | -221,581 | 117,368 |
| 2037 | 12,891 | 2,185 | 1,330 | 4,846 | 14,183 | 48 | 59,419 | 41,023 | 12,827 | 16,844 | 1,673 | 167,270 | 147,672 | 6,146 | 10,008 | 21,311 | 185,137 | -17,867 | -239,448 | 117,434 |
| 2038 | 12,947 | 1,393 | 453 | 4,917 | 14,137 | 41 | 60,101 | 48,757 | 16,038 | 16,844 | 1,769 | 177,397 | 146,080 | 5,672 | 10,283 | 24,171 | 186,205 | -8,809 | -248,257 | 124,330 |
| 2039 | 12,921 | 3,436 | 233 | 5,046 | 14,186 | 51 | 62,508 | 52,586 | 21,446 | 16,844 | 1,624 | 190,880 | 144,387 | 5,215 | 10,773 | 25,364 | 185,739 | 5,141 | -243,116 | 136,275 |
| 2040 | 12,921 | 1,773 | 797 | 5,231 | 14,261 | 51 | 62,508 | 41,324 | 12,852 | 16,869 | 1,474 | 170,061 | 152,680 | 5,249 | 10,548 | 23,093 | 191,571 | -21,510 | -264,626 | 118,077 |
| 2041 | 12,880 | 3,272 | -1,893 | 5,369 | 14,329 | 47 | 67,045 | 75,554 | 23,640 | 16,844 | 2,057 | 219,143 | 150,096 | 4,849 | 12,425 | 29,830 | 197,200 | 21,943 | -242,683 | 157,988 |
| 2042 | 12,920 | 3,148 | 1,211 | 5,504 | 14,435 | 50 | 65,734 | 37,896 | 9,409 | 16,844 | 1,083 | 168,232 | 157,694 | 4,892 | 12,255 | 27,612 | 202,454 | -34,222 | -276,905 | 110,438 |
| 2043 | 13,045 | 3,233 | 1,092 | 5,585 | 14,489 | 53 | 64,243 | 38,326 | 10,688 | 16,844 | 1,617 | 169,217 | 155,086 | 4,500 | 10,491 | 23,081 | 193,158 | -23,941 | -300,846 | 117,183 |
| 2044 | 13,252 | 4,095 | 978 | 5,636 | 14,531 | 59 | 62,724 | 37,811 | 6,043 | 16,869 | 1,407 | 163,407 | 159,346 | 4,377 | 9,881 | 21,354 | 194,958 | -31,551 | -332,397 | 113,896 |
| 2045 | 13,437 | 2,532 | 15 | 5,681 | 14,532 | 56 | 63,367 | 47,204 | 22,648 | 16,844 | 1,697 | 188,012 | 153,207 | 3,880 | 10,107 | 21,822 | 189,015 | -1,004 | -333,401 | 137,543 |
| 2046 | 13,545 | 5,869 | 446 | 5,759 | 14,585 | 64 | 63,301 | 42,133 | 12,820 | 16,844 | 1,232 | 176,599 | 156,690 | 4,000 | 10,050 | 21,876 | 192,615 | -16,016 | -349,416 | 126,598 |
| 2047 | 13,633 | 2,519 | 743 | 5,829 | 14,645 | 60 | 62,375 | 39,100 | 13,510 | 16,844 | 1,485 | 170,742 | 156,690 | 4,000 | 9,718 | 19,932 | 190,339 | -19,597 | -369,013 | 122,764 |
| 2048 | 13,770 | 2,138 | 718 | 5,881 | 14,682 | 48 | 61,078 | 38,227 | 8,137 | 16,869 | 1,485 | 163,032 | 160,172 | 4,120 | 9,408 | 18,603 | 192,302 | -29,270 | -398,283 | 116,668 |
| 2049 | 13,912 | 1,933 | -213 | 5,911 | 14,648 | 44 | 61,038 | 46,401 | 13,813 | 16,844 | 1,737 | 176,068 | 153,207 | 3,880 | 9,739 | 20,581 | 187,407 | -11,339 | -409,623 | 127,167 |
| 2050 | 13,933 | 4,817 | -1,697 | 5,976 | 14,658 | 59 | 67,540 | 71,707 | 30,610 | 16,844 | 1,232 | 225,680 | 149,725 | 3,760 | 11,638 | 26,641 | 191,764 | 33,916 | -375,707 | 169,324 |
| 2051 | 13,829 | 3,196 | -534 | 6,081 | 14,772 | 63 | 69,582 | 51,678 | 21,412 | 16,844 | 980 | 197,903 | 146,242 | 3,640 | 12,042 | 29,010 | 190,935 | 6,968 | -368,739 | 139,026 |
| 2052 | 13,611 | 2,783 | -2,258 | 6,192 | 14,876 | 59 | 74,274 | 76,201 | 23,099 | 16,869 | 0 | 225,705 | 146,242 | 3,640 | 13,028 | 31,768 | 194,679 | 31,026 | -337,713 | 164,039 |
| 2053 | 13,495 | 2,635 | 729 | 6,277 | 14,994 | 53 | 72,900 | 42,299 | 9,390 | 16,844 | 0 | 179,616 | 160,172 | 4,120 | 12,829 | 30,290 | 207,411 | -27,795 | -365,509 | 119,653 |
| 2054 | 13,448 | 3,801 | 242 | 6,308 | 15,033 | 59 | 71,949 | 53,009 | 18,899 | 16,844 | 871 | 200,461 | 153,207 | 3,880 | 11,766 | 27,056 | 195,909 | 4,552 | -360,956 | 143,925 |
| 2055 | 13,339 | 8,339 | -1,175 | 6,358 | 15,119 | 85 | 75,836 | 78,511 | 32,562 | 16,844 | 366 | 246,186 | 149,725 | 3,760 | 13,449 | 33,775 | 200,708 | 45,477 | -315,479 | 181,752 |
| 2056 | 13,159 | 6,385 | 876 | 6,429 | 15,264 | 92 | 73,523 | 51,010 | 13,998 | 16,869 | 114 | 197,719 | 156,690 | 4,000 | 13,763 | 33,019 | 207,471 | -9,752 | -325,231 | 133,954 |
| 2057 | 13,054 | 7,289 | 1,290 | 6,449 | 15,345 | 91 | 72,104 | 48,263 | 10,700 | 16,844 | 618 | 192,047 | 156,690 | 4,000 | 12,140 | 27,450 | 200,280 | -8,232 | -333,464 | 134,995 |
| 2058 | 13,082 | 3,016 | 783 | 6,443 | 15,419 | 75 | 71,925 | 56,177 | 16,695 | 16,844 | 618 | 201,077 | 153,207 | 3,880 | 12,135 | 28,093 | 197,315 | 3,762 | -329,702 | 143,387 |
| 2059 | 13,156 | 4,654 | 1,316 | 6,441 | 15,516 | 67 | 69,078 | 49,392 | 8,863 | 16,844 | 366 | 185,694 | 156,690 | 4,000 | 12,077 | 26,832 | 199,598 | -13,905 | -343,607 | 129,575 |
| 2060 | 13,240 | 7,211 | 878 | 6,438 | 15,592 | 87 | 67,855 | 50,720 | 12,009 | 16,869 | 618 | 191,518 | 156,690 | 4,000 | 11,662 | 26,235 | 198,587 | -7,069 | -350,675 | 136,134 |
| 2061 | 13,373 | 2,783 | 1,747 | 6,437 | 15,645 | 78 | 66,211 | 44,207 | 9,491 | 16,844 | 618 | 177,435 | 160,172 | 4,120 | 11,136 | 23,721 | 199,149 | -21,714 | -372,390 | 125,116 |
| 2062 | 13,583 | 3,214 | 1,267 | 6,424 | 15,641 | 59 | 64,113 | 47,260 | 8,143 | 16,844 | 1,145 | 177,692 | 163,654 | 4,240 | 10,792 | 22,873 | 201,559 | -23,867 | -396,257 | 126,038 |
| 2063 | 13,787 | 4,976 | 577 | 6,401 | 15,595 | 64 | 64,222 | 52,155 | 11,443 | 16,844 | 1,397 | 187,461 | 156,690 | 4,000 | 11,066 | 23,665 | 195,421 | -7,960 | -404,217 | 134,488 |
| 2064 | 13,893 | 3,172 | 481 | 6,401 | 15,617 | 64 | 65,213 | 52,513 | 17,247 | 16,869 | 893 | 192,362 | 153,207 | 3,880 | 11,173 | 24,571 | 192,831 | -470 | -404,686 | 138,856 |
| 2065 | 13,811 | 3,061 | -1,888 | 6,447 | 15,672 | 61 | 71,145 | 76,354 | 27,181 | 16,844 | 641 | 229,329 | 149,725 | 3,760 | 12,770 | 31,581 | 197,836 | 31,493 | -373,193 | 167,493 |
| 2066 | 13,699 | 2,758 | 1,186 | 6,514 | 15,798 | 57 | 69,619 | 43,774 | 9,170 | 16,844 | 389 | 179,808 | 160,172 | 4,120 | 12,493 | 28,214 | 204,998 | -25,191 | -398,384 | 121,869 |
| 2067 | 13,610 | 2,254 | -767 | 6,539 | 15,828 | 52 | 72,047 | 69,279 | 20,834 | 16,844 | 1,145 | 217,666 | 153,207 | 3,880 | 12,944 | 30,377 | 200,408 | 17,258 | -381,126 | 156,356 |
| 2068 | 13,573 | 3,557 | 712 | 6,575 | 15,882 | 50 | 70,661 | 49,562 | 11,199 | 16,869 | 641 | 189,281 | 156,690 | 4,000 | 13,090 | 29,639 | 203,419 | -14,138 | -395,264 | 129,042 |
| 2069 | 13,578 | 4,934 | 698 | 6,598 | 15,909 | 61 | 69,160 | 50,872 | 13,165 | 16,844 | 893 | 192,712 | 156,690 | 4,000 | 12,116 | 27,432 | 200,238 | -7,526 | -402,790 | 135,426 |
| 2070 | 13,547 | 7,288 | -1,385 | 6,604 | 15,962 | 77 | 71,355 | 74,333 | 24,685 | 16,844 | 7,356 | 236,666 | 153,207 | 3,880 | 13,002 | 31,698 | 201,787 | 34,878 | -367,912 | 167,766 |
| 2071 | 13,526 | 2,883 | 1,862 | 6,610 | 16,041 | 65 | 67,567 | 44,724 | 4,729 | 16,844 | 9,156 | 184,008 | 160,172 | 4,120 | 12,719 | 28,315 | 205,326 | -21,318 | -389,230 | 116,974 |
| 2072 | 13,530 | 5,205 | 1,347 | 6,545 | 16,004 | 63 | 66,227 | 49,931 | 9,779 | 16,869 | 30,860 | 216,361 | 156,690 | 4,000 | 11,763 | 25,552 | 198,004 | 18,357 | -370,873 | 131,318 |
| 2073 | 13,495 | 3,172 | 1,168 | 6,489 | 16,013 | 61 | 65,415 | 52,271 | 10,937 | 16,844 | 27,257 | 213,124 | 156,690 | 4,000 | 11,542 | 25,718 | 197,950 | 15,174 | -355,699 | 131,763 |

## Table 6-2. Water Budget for the Chino Basin for the Period FY 2021 through 2080 - Scenario D1 (af)

| Fiscal Year | Recharge | | | | | | | | | | | | Change in Storage | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | R* | I* | R* | R* | R* | R* | I* | R* | I | I | I | | I | I | R* | R* | | | | |
| | Subsurface Inflow | | | | | | | | Managed Aquifer Recharge | | | | Groundwater Pumping | | | | | | | |
| | Bloomington Divide | Chino/Puente Hills, Jurupa Hills, and Rialto Basin | Net Temescal Basin | Six Basins | Cucamonga Basin | Spadra Basin | Deep Infiltration of Precipitation and Applied Water | Streambed Infiltration | Stormwater | Recycled Water | Imported Water | Total Recharge | Overlying Non-Ag and Appropriative Pools | Overlying Agricultural Pool | Riparian Veg ET | Rising Groundwater | Total Discharge | Annual | Cumulative | Net Recharge |
| 2074 | 13,440 | 3,387 | 1,705 | 6,442 | 15,996 | 57 | 61,734 | 43,428 | 2,799 | 16,844 | 27,257 | 193,088 | 160,172 | 4,120 | 10,926 | 22,663 | 197,881 | -4,793 | -360,492 | 115,398 |
| 2075 | 13,379 | 6,524 | 304 | 6,382 | 15,889 | 68 | 62,443 | 57,526 | 16,592 | 16,844 | 30,860 | 226,810 | 153,207 | 3,880 | 11,154 | 24,775 | 193,016 | 33,794 | -326,697 | 143,178 |
| 2076 | 13,285 | 1,202 | 1,382 | 6,358 | 15,888 | 56 | 60,862 | 47,874 | 7,939 | 16,869 | 23,655 | 195,369 | 160,172 | 4,120 | 11,097 | 23,752 | 199,141 | -3,772 | -330,469 | 119,996 |
| 2077 | 13,098 | 3,469 | -1,642 | 6,351 | 15,796 | 52 | 65,140 | 81,398 | 23,468 | 16,844 | 30,860 | 254,833 | 153,207 | 3,880 | 12,746 | 32,259 | 202,092 | 52,741 | -277,728 | 162,124 |
| 2078 | 12,901 | 3,878 | 847 | 6,392 | 15,855 | 57 | 63,682 | 54,578 | 9,047 | 16,844 | 23,655 | 207,737 | 160,172 | 4,120 | 13,251 | 30,489 | 208,032 | -295 | -278,024 | 123,498 |
| 2079 | 12,814 | 1,080 | 1,786 | 6,375 | 15,823 | 46 | 60,790 | 41,775 | 726 | 16,844 | 30,860 | 188,918 | 163,654 | 4,240 | 11,532 | 24,490 | 203,916 | -14,998 | -293,021 | 105,193 |
| 2080 | 12,824 | 3,206 | 843 | 6,311 | 15,674 | 46 | 59,659 | 48,450 | 9,611 | 16,869 | 34,462 | 207,955 | 156,690 | 4,000 | 10,813 | 23,538 | 195,041 | 12,914 | -280,108 | 122,272 |
| **Statistics for the Period FY 2021 through 2080** | | | | | | | | | | | | | | | | | | | | |
| Total | 782,592 | 234,907 | 47,836 | 338,700 | 902,194 | 3,646 | 3,937,735 | 2,976,264 | 825,142 | 1,002,083 | 382,683 | 11,433,784 | 9,119,346 | 339,717 | 688,353 | 1,566,476 | 11,713,891 | -280,108 | | 7,794,189 |
| Percent | 6.8% | 2.1% | 0.4% | 3.0% | 7.9% | 0.0% | 34.4% | 26.0% | 7.2% | 8.8% | 3.3% | 100.0% | 77.9% | 2.9% | 5.9% | 13.4% | 100.0% | | | |
| Average | 13,043 | 3,915 | 797 | 5,645 | 15,037 | 61 | 65,629 | 49,604 | 13,752 | 16,701 | 6,378 | 190,563 | 151,989 | 5,662 | 11,473 | 26,108 | 195,232 | -4,668 | | 129,903 |
| Median | 13,157 | 3,330 | 862 | 6,029 | 14,840 | 59 | 65,176 | 47,232 | 12,415 | 16,844 | 1,485 | 187,880 | 153,207 | 4,120 | 11,524 | 25,635 | 196,554 | -8,520 | | 126,314 |
| Maximum | 13,933 | 8,596 | 2,986 | 6,610 | 16,041 | 92 | 75,836 | 81,398 | 32,562 | 16,869 | 43,198 | 254,833 | 163,654 | 14,929 | 13,763 | 33,902 | 210,046 | 52,741 | 19,963 | 181,752 |
| Minimum | 11,451 | 1,057 | -2,258 | 3,467 | 14,137 | 39 | 58,698 | 33,494 | 726 | 13,369 | 0 | 152,815 | 115,523 | 3,640 | 9,408 | 18,603 | 167,776 | -43,225 | -409,623 | 103,419 |

Note: column heading R means model results and column heading I means model input. Asterisks indicate components that had volumes or related parameters that were allowed to vary during the uncertainty analysis.

**Table 6-3. Water Budget Components for 2020 SYR and 2025 SYR TSY Ensemble, FY 2021-2030 (afy)[a]**

| Water Budget Component | 2020 SYR | 2025 SYR (Likelihood-Weighted Average) | 2025 SYR minus 2020 SYR |
|---|---|---|---|
| Recharge Components | | | |
| Subsurface Inflow* | 37,900 | 33,400 | -4,500 |
| DIPAW* | 75,800 | 65,200 | -10,600 |
| Streambed Infiltration* | 37,100 | 45,500 | 8,400 |
| MAR - Stormwater* | 13,500 | 13,800 | 300 |
| MAR - Recycled and Imported | 15,200 | 22,100 | 6,900 |
| **Total** | **179,600** | **180,000** | **400** |
| Discharge Components | | | |
| Groundwater Pumping | 148,500 | 151,900 | 3,400 |
| Riparian ET* | 18,700 | 12,600 | -6,100 |
| Rising Groundwater* | 15,200 | 24,000 | 8,800 |
| **Total** | **182,400** | **188,600** | **6,200** |
| Aggregate Components | | | |
| Change in Storage | -2,700 | -8,600 | -5,900 |
| Net Recharge[b] | 130,600 | 121,200 | -9,400 |

(a) For clarity, values are rounded to the nearest 100 afy and may not sum precisely.
(b) Net recharge is calculated from the net volume of only those recharge and discharge components designated with an asterisk.

**Figure 6-6. Water Budget for the Chino Basin - Scenario D1**

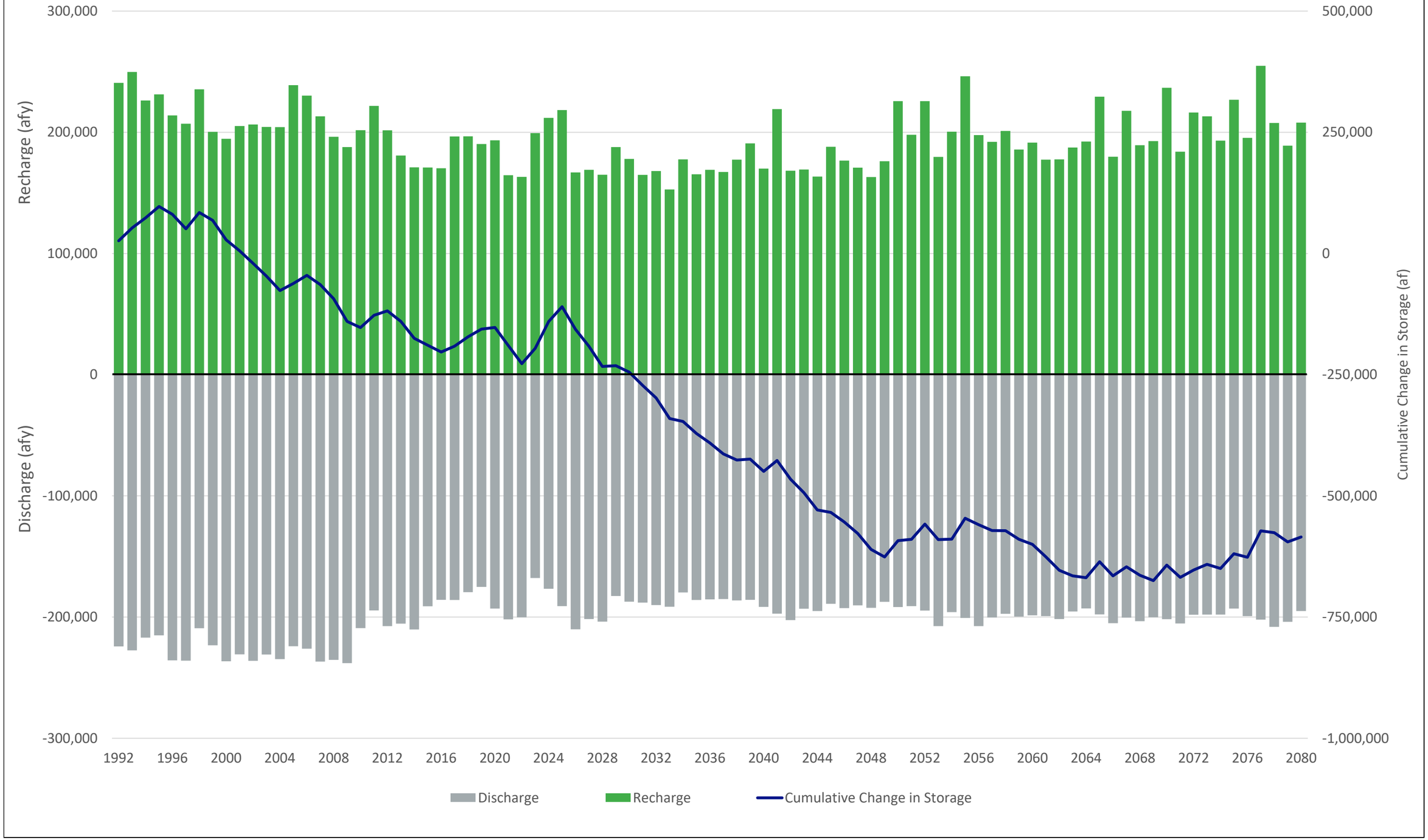


Figure 6-7
Comparison of Subsurface Inflows
2020 SYR and 2025 SYR

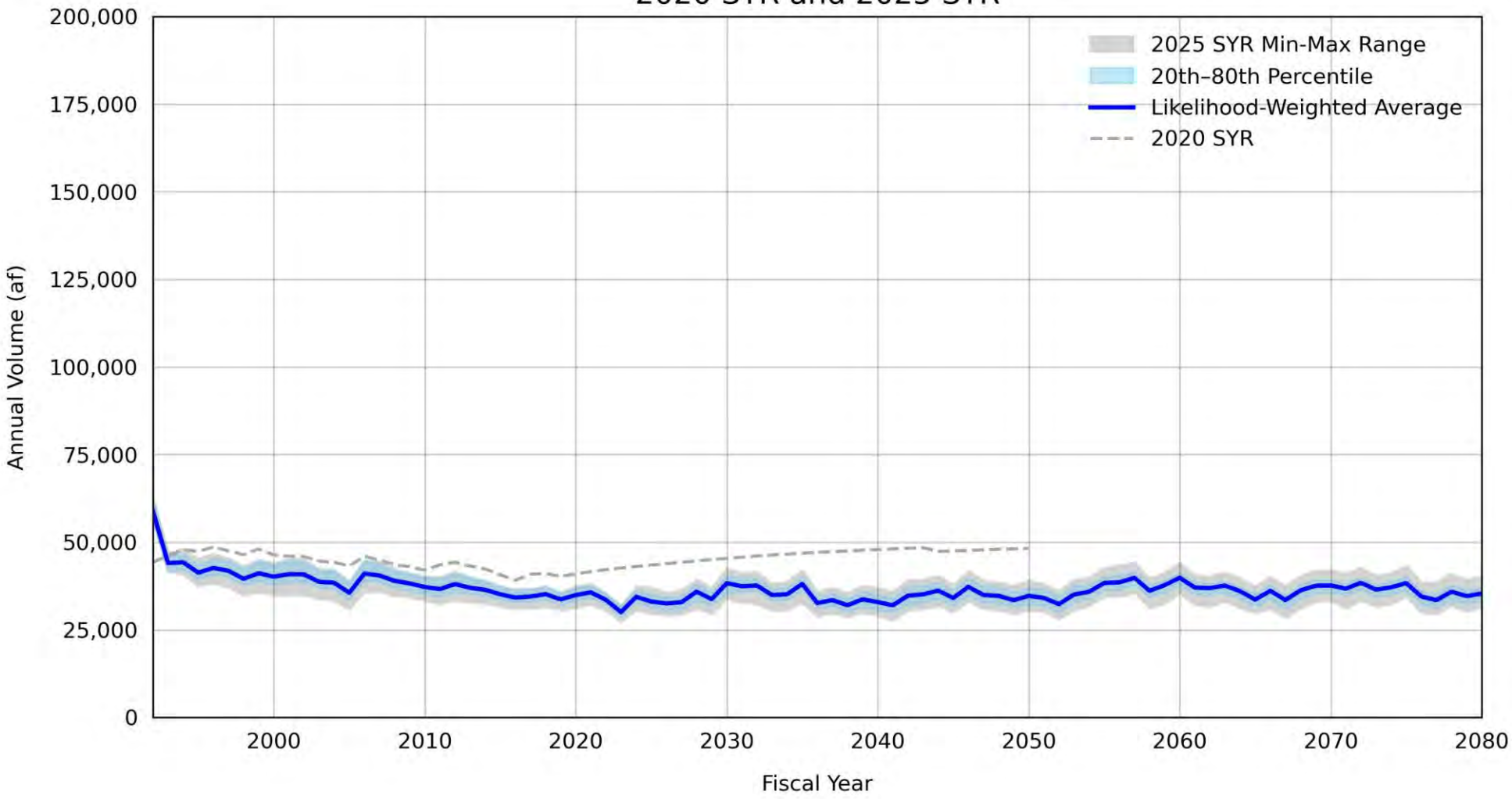


Figure 6-8
Comparison of DIPAW
2020 SYR and 2025 SYR

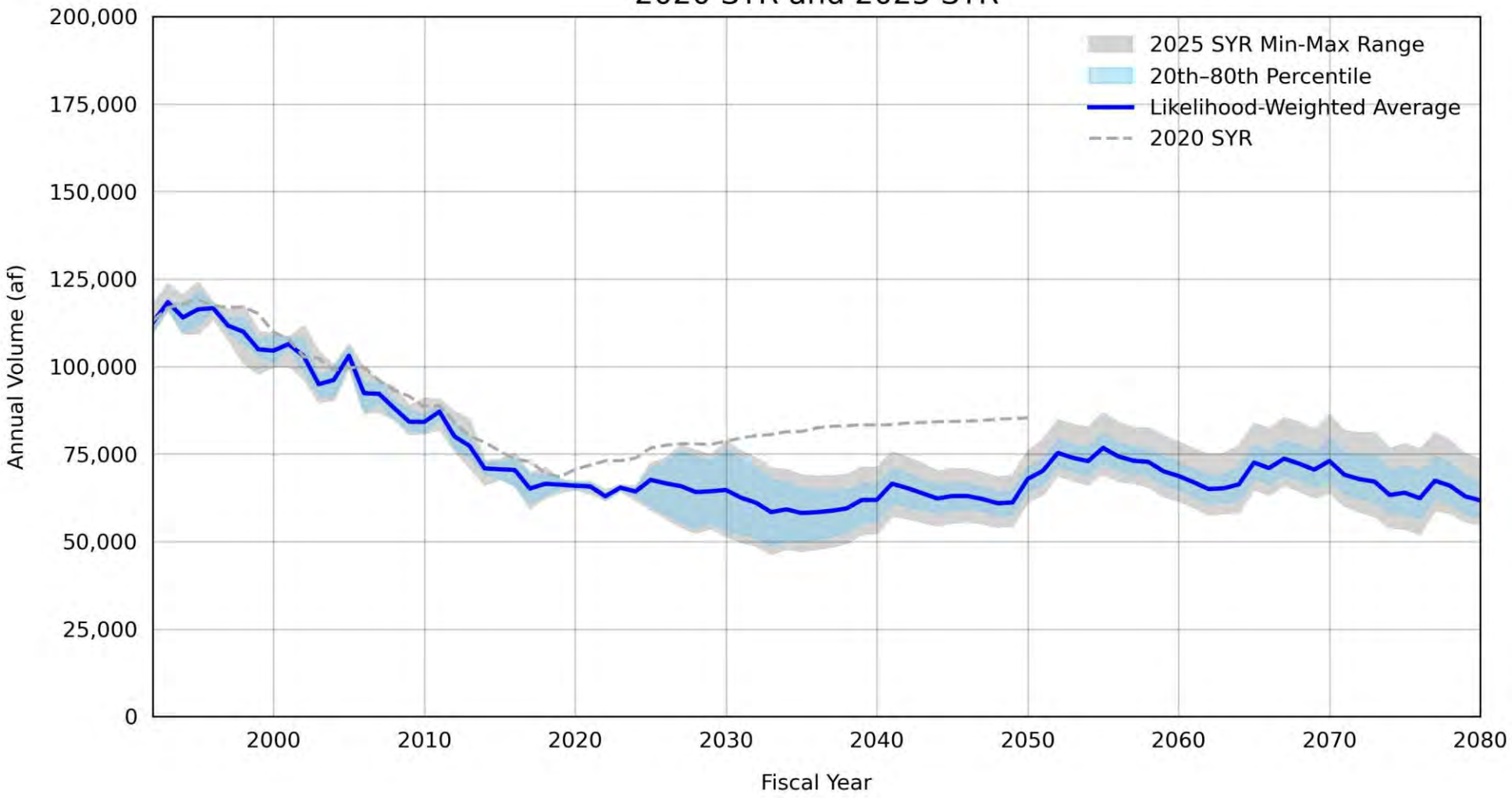


Figure 6-9
Comparison of Managed Aquifer Recharge
2020 SYR and 2025 SYR

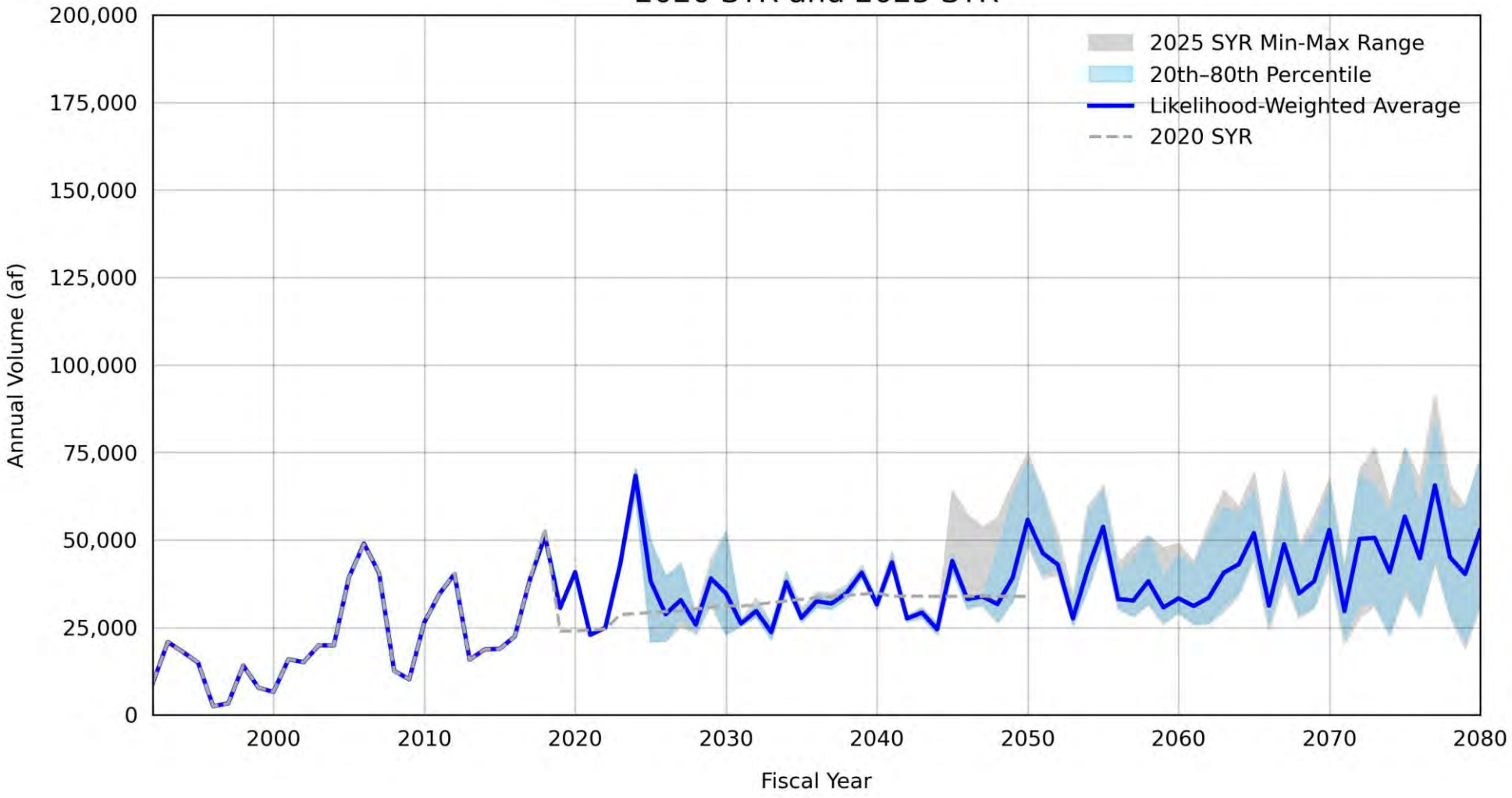


Figure 6-10
Comparison of SAR Infiltration
2020 SYR and 2025 SYR

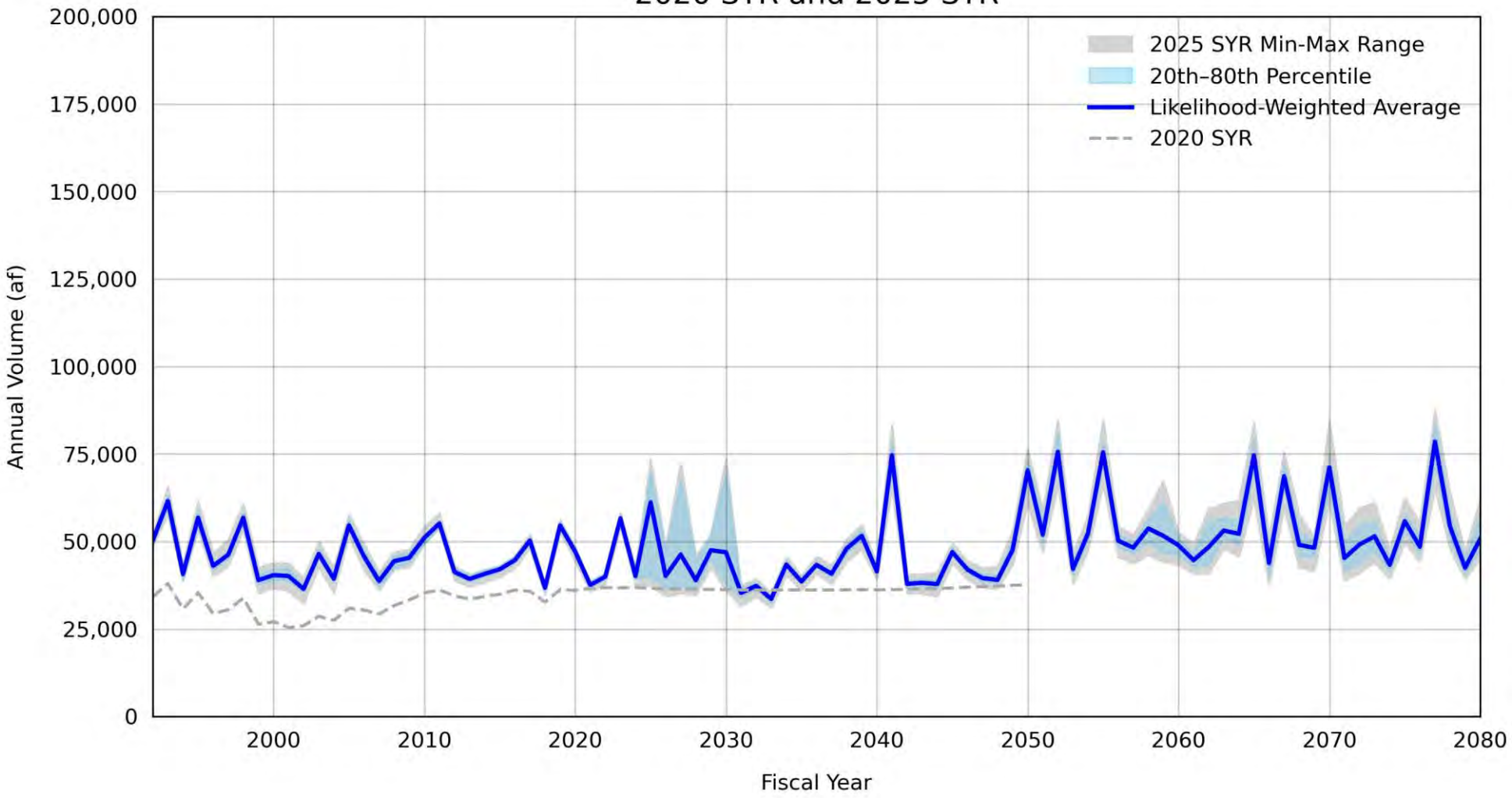


Figure 6-11
Comparison of ET
2020 SYR and 2025 SYR

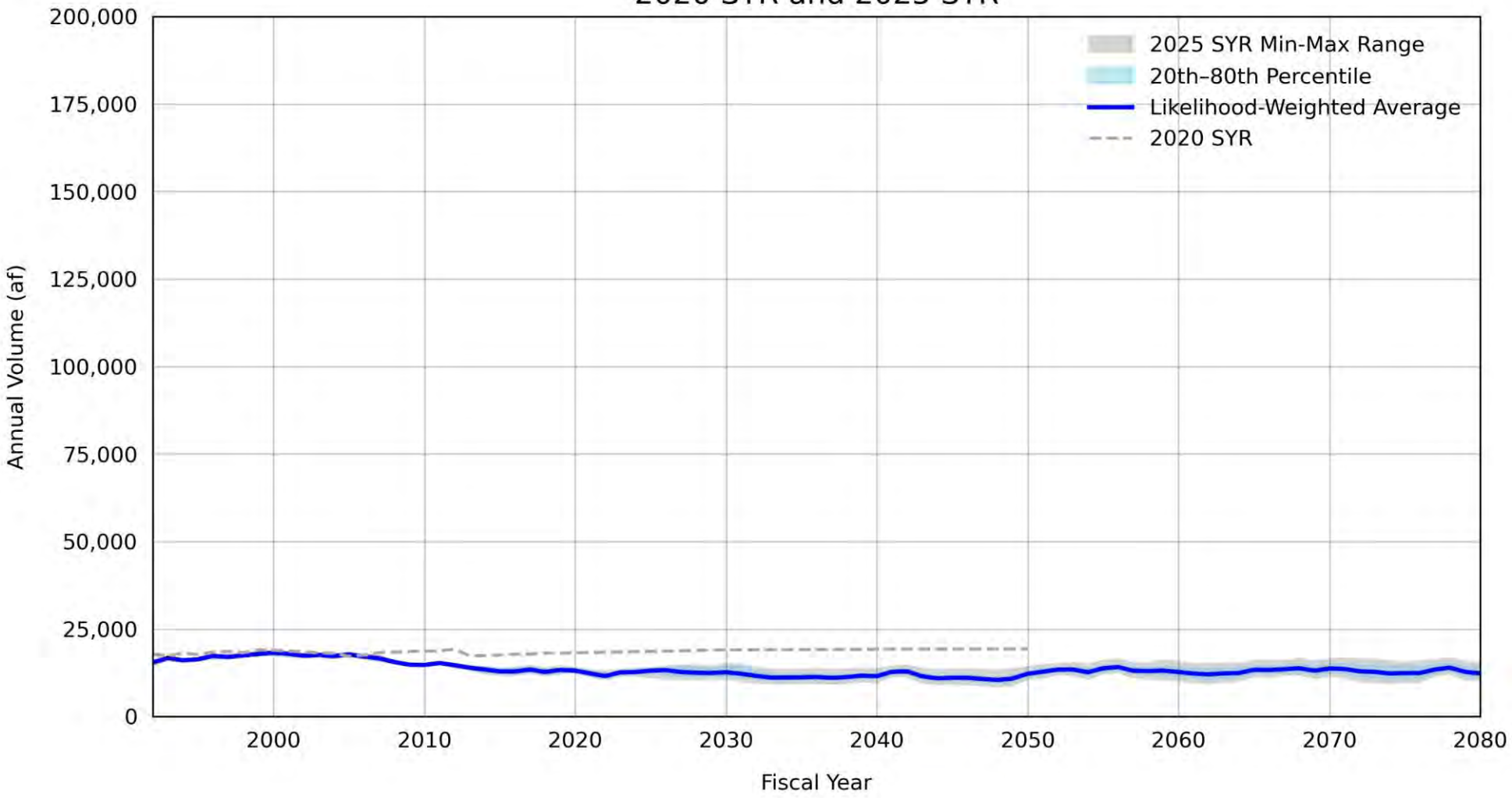


Figure 6-12
Comparison of Rising Groundwater
2020 SYR and 2025 SYR

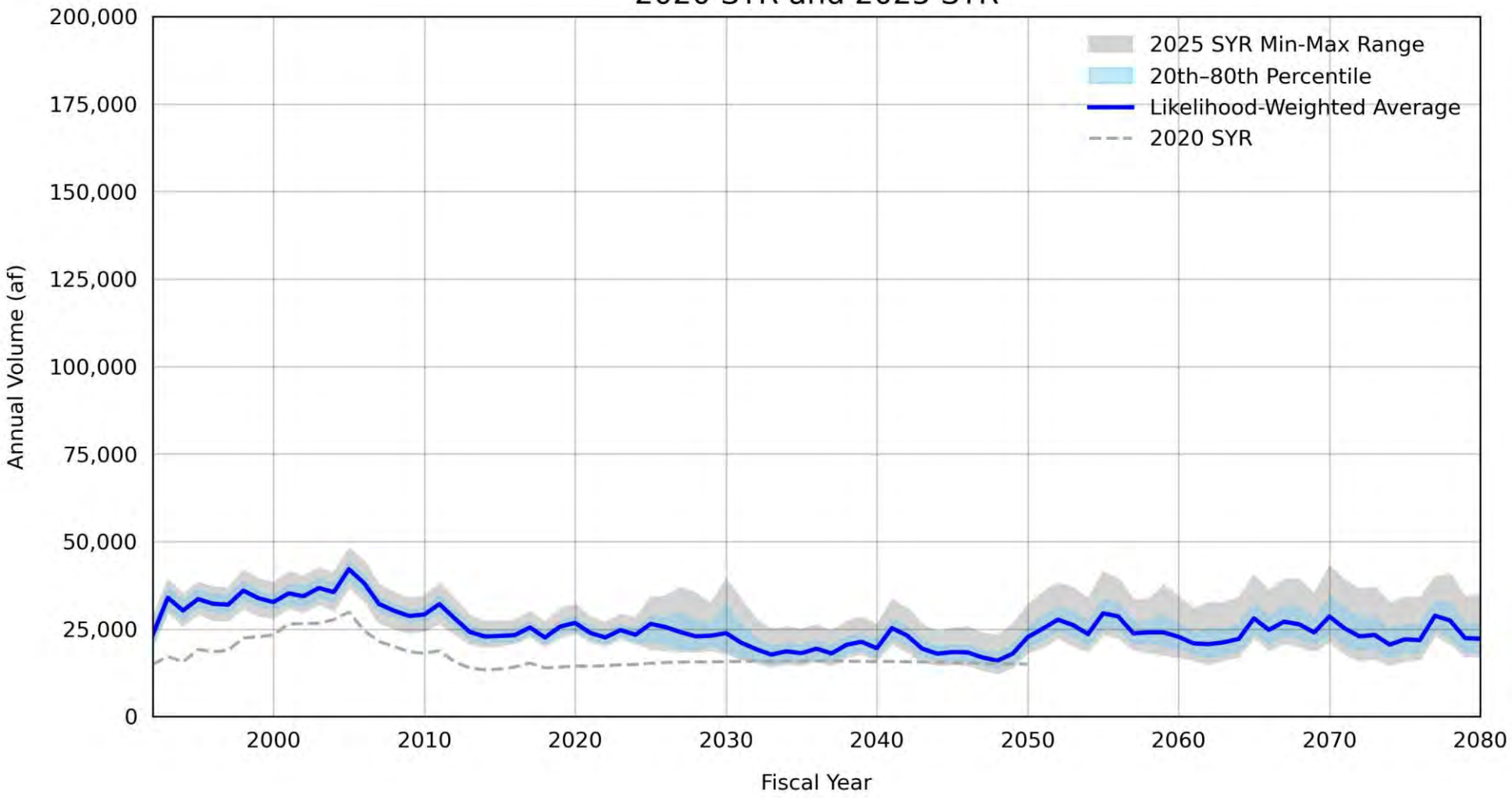


Figure 6-13
Comparison of Net Recharge
2020 SYR and 2025 SYR

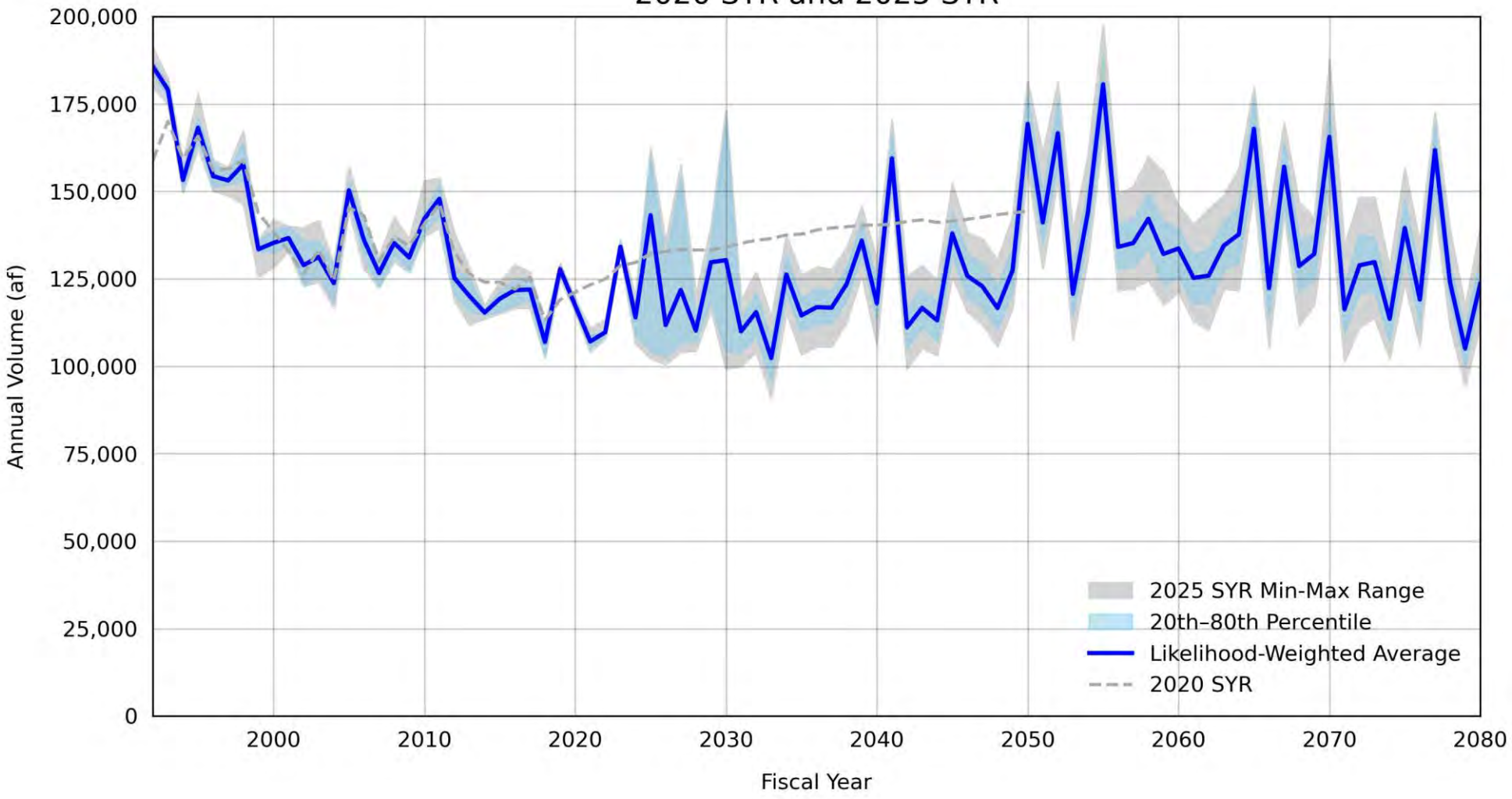


Figure 6-14
Comparison of Change in Storage
2020 SYR and 2025 SYR

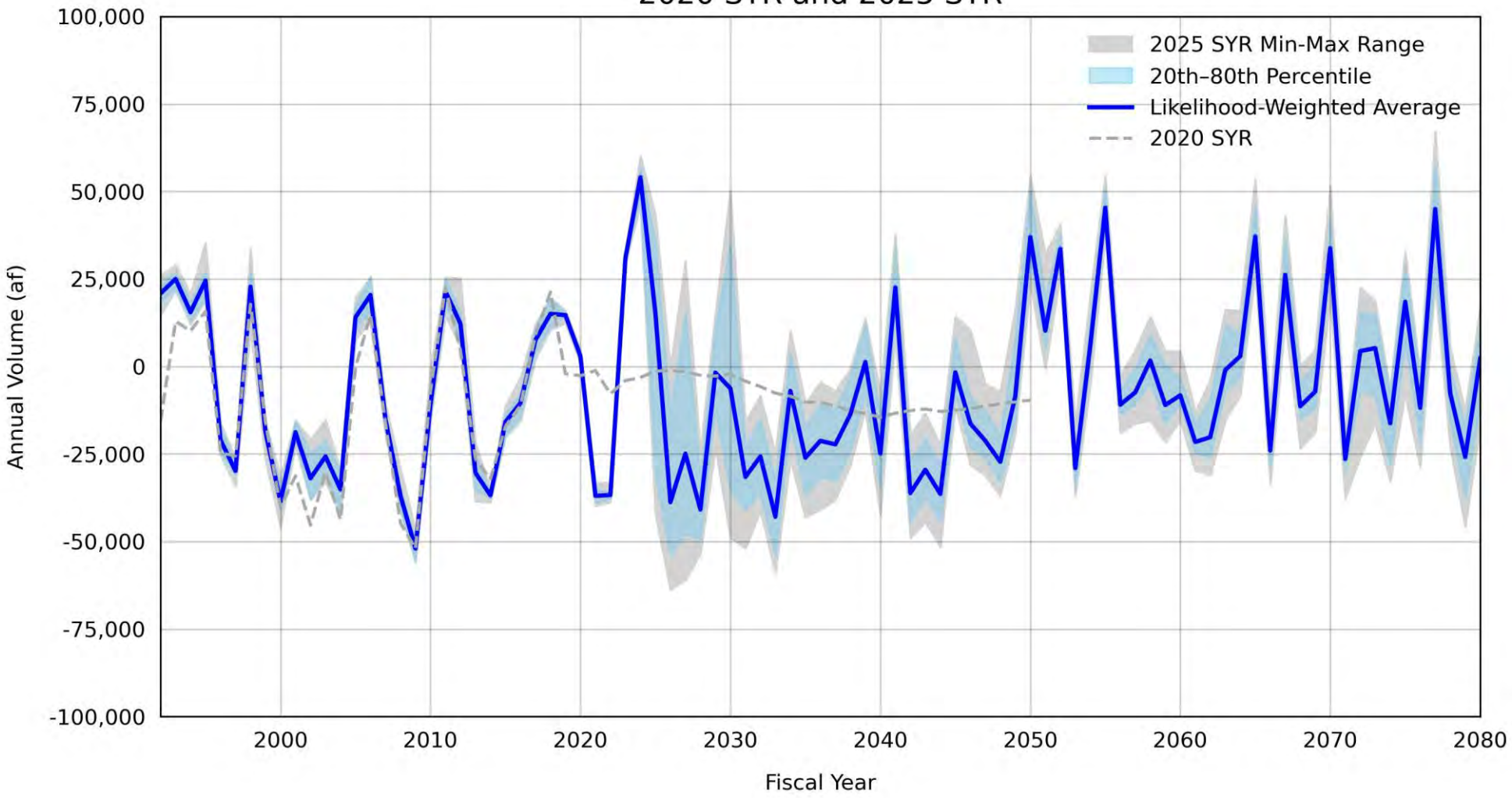
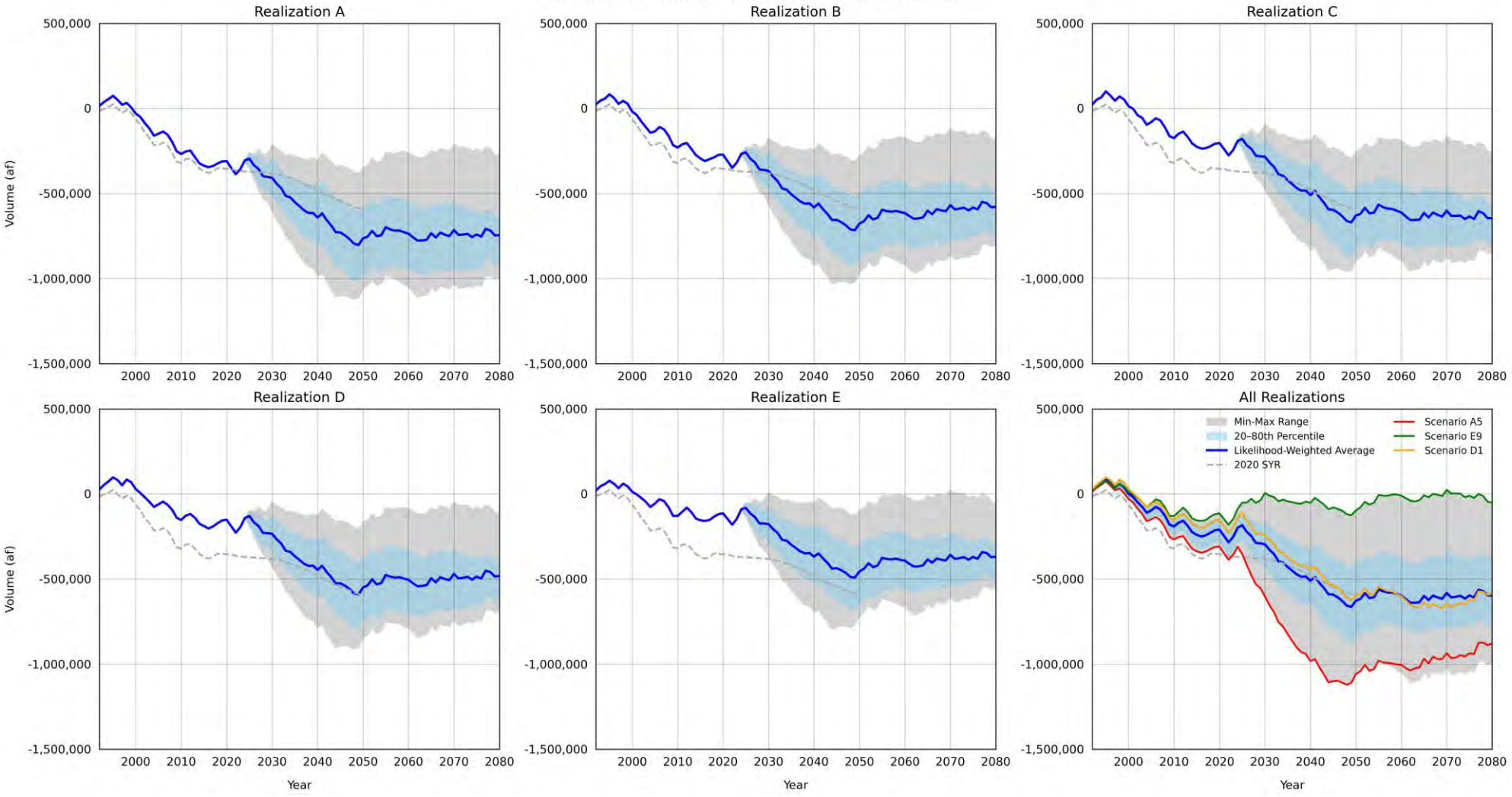


Figure 6-15
Cumulative Change in Storage - TSY Ensemble



The differences between the water budget components reflect a combination of the model recalibration and uncertainty analysis (see Section 4), the three years of historical pumping and recharge data (FY 2021-2023), and revised pumping and recharge assumptions. **The TSY for the 2025 Safe Yield Reevaluation is 121,200 afy, which is the likelihood-weighted average net recharge for the TSY Ensemble for the FY 2021-2030 period.**

Compared to the 2020 SYR, the 2025 SYR likelihood-weighted average net recharge is lower by 9,400 afy. This difference reflects the combined effects of all recharge and discharge components shown in Table 6-3; however, the largest individual reduction is the decrease in DIPAW. Because DIPAW is both the largest recharge component included in the net recharge calculation and the largest negative difference between the 2020 SYR and 2025 SYR, the primary drivers of the difference in DIPAW are discussed below.

#### *6.2.1.2 Drivers of the Difference in DIPAW Between the 2020 SYR and 2025 SYR*

A primary reason that the TSY is lower than the Safe Yield calculated in the 2020 SYR is the reduction in DIPAW. As shown in Table 6-3, the likelihood-weighted average DIPAW for the 2025 SYR is 65,200 afy for FY 2021 through FY 2030, which is 10,600 afy lower than the 75,800 afy simulated in the 2020 SYR for the same period. This reduction accounts for more than the total 9,400 afy reduction in net recharge because the lower DIPAW is partly offset by increases in other net recharge components, including streambed infiltration and stormwater recharge, and by lower riparian ET.

The four drivers described in Section 6.2.1 do not act independently and cannot be apportioned exactly from the TSY Ensemble results. The updated Basin boundary, recalibration, and uncertainty analysis affect the same DIPAW time series that are then combined with updated historical hydrology, updated water-use data, and revised projection assumptions. Therefore, the following attribution is intended as an approximate screening-level comparison rather than a strict causal decomposition.

Over the common historical comparison period of FY 1992 through FY 2018, the combined effects of the Basin boundary adjustment, recalibration, and uncertainty analysis reduced simulated DIPAW by about 3,900 afy relative to the 2020 SYR. This model-update effect is equivalent to about 37 percent of the 10,600 afy difference in DIPAW between the 2020 SYR and 2025 SYR for FY 2021 through FY 2030. The remaining difference, about 6,700 afy, or 63 percent, is attributable to updated historical and projected conditions, including the addition of recent historical hydrology and water-use data and the revised projection assumptions for hydrology, water demands, and urban outdoor water use.

This apportionment is approximate because DIPAW is affected by interacting model and scenario assumptions and because recharge to the saturated zone is delayed by travel time through the vadose zone. The reduction in DIPAW is the largest single factor contributing to the lower 2025 TSY, but it is not the only factor affecting net recharge. The TSY is determined from the full net recharge calculation for the TSY Ensemble, including changes in subsurface inflow, streambed infiltration, stormwater recharge, riparian ET, and rising groundwater.

#### *6.2.1.3 Average Net Recharge Across the TSY Ensemble*

The reduction in DIPAW is the largest single factor contributing to the lower 2025 TSY, but it is not the only factor affecting net recharge. The net recharge result also reflects changes in subsurface inflow, streambed infiltration, stormwater recharge, riparian ET, and rising groundwater.

Figure 6-16 shows a heatmap to demonstrate the range of average net recharge volumes for the TSY Ensemble for FY 2021-2030. Average net recharge ranges from 108,000 afy (Scenario A8) to 135,800 afy (Scenario E6). This chart reveals several patterns to guide the future analysis of the TSY Ensemble:

- Average net recharge is generally lowest in Calibrated Realization A, and highest in Calibrated Realization E, consistent with the patterns shown over the calibration period (see Section 4 and Figure 4-24).
- The Hot/Dry Climate Scenarios (2, 5, and 8) indicate lower net recharge compared to the Average and Cool/Wet Climate Scenarios. There is high variability of the net recharge between the Climate Scenarios compared to the Water Plan Scenarios. This is due to the high variability of precipitation simulated for this period compared to the smaller changes in Water Plans.

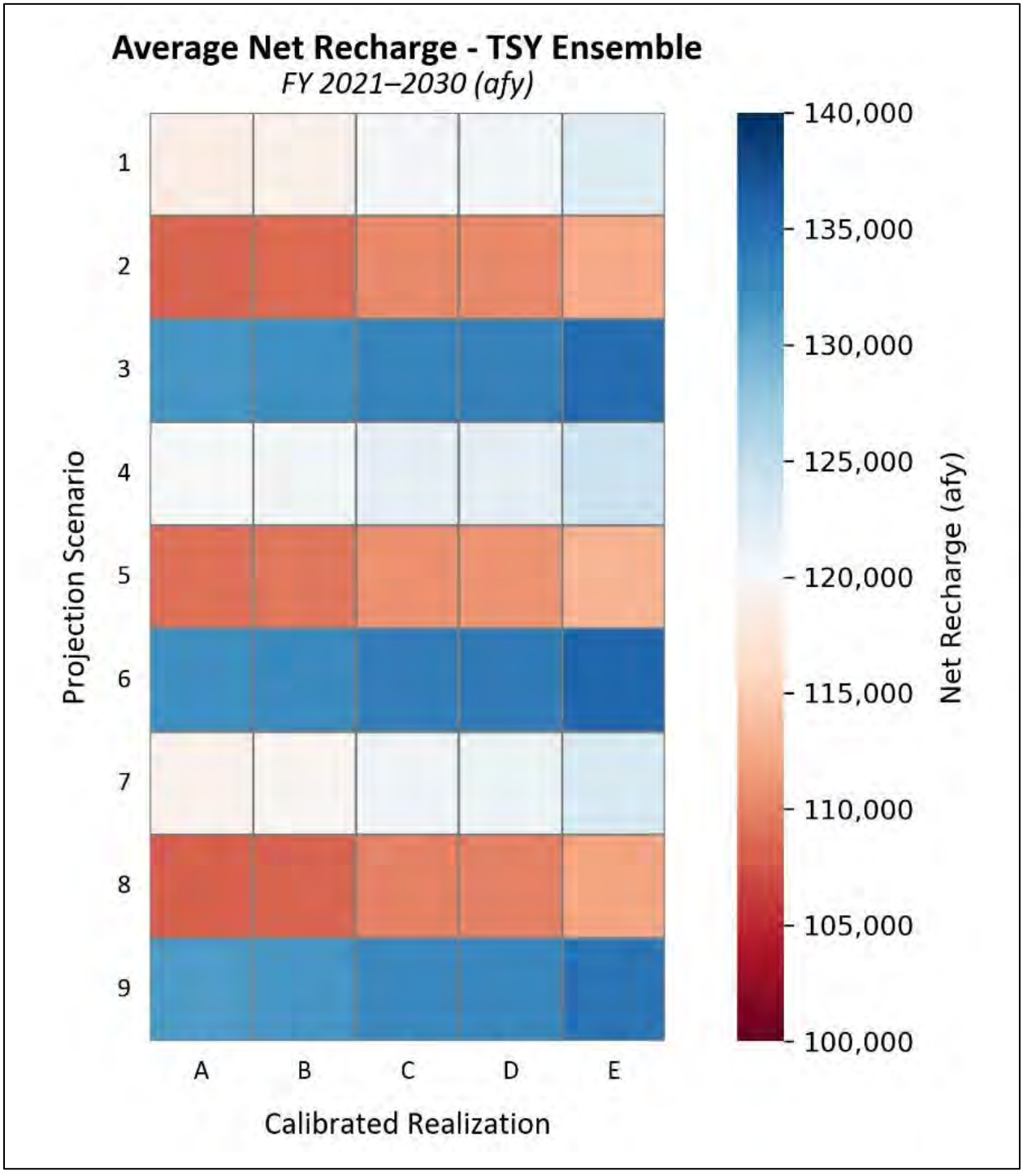



**Figure 6-16. Average Net Recharge for the TSY Ensemble, FY 2021-2030**

Figure 6-17 is a likelihood-weighted exceedance curve for the average net recharge of the TSY Ensemble over the period of FY 2021-2030. Figure 6-17 indicates the likelihood-weighted average net recharge (121,200 afy) and the current Safe Yield (131,000 afy). Thirty-three percent of the TSY Ensemble (15 Projection Realizations) have an average net recharge above the current Safe Yield.

Table 6-4 compares the likelihood-weighted average water budget components of the TSY Ensemble for FY 2021-2030, FY 2031-2040, and FY 2041-2050. The average net recharge for FY 2031-2040 (118,000 afy) is less than FY 2021-2030 due to the relatively dry period of precipitation assumed for this period (i.e., FY 1959-1968). Average net recharge for FY 2041-2050 is greater than FY 2021-2030 due to (1) the relatively greater assumed precipitation over this period and (2) lower groundwater levels and increased pumping resulting in greater streambed infiltration.

**Figure 6-17. Likelihood-Weighted Exceedance Curve**
**Average Net Recharge for TSY Ensemble, FY 2021-2030**

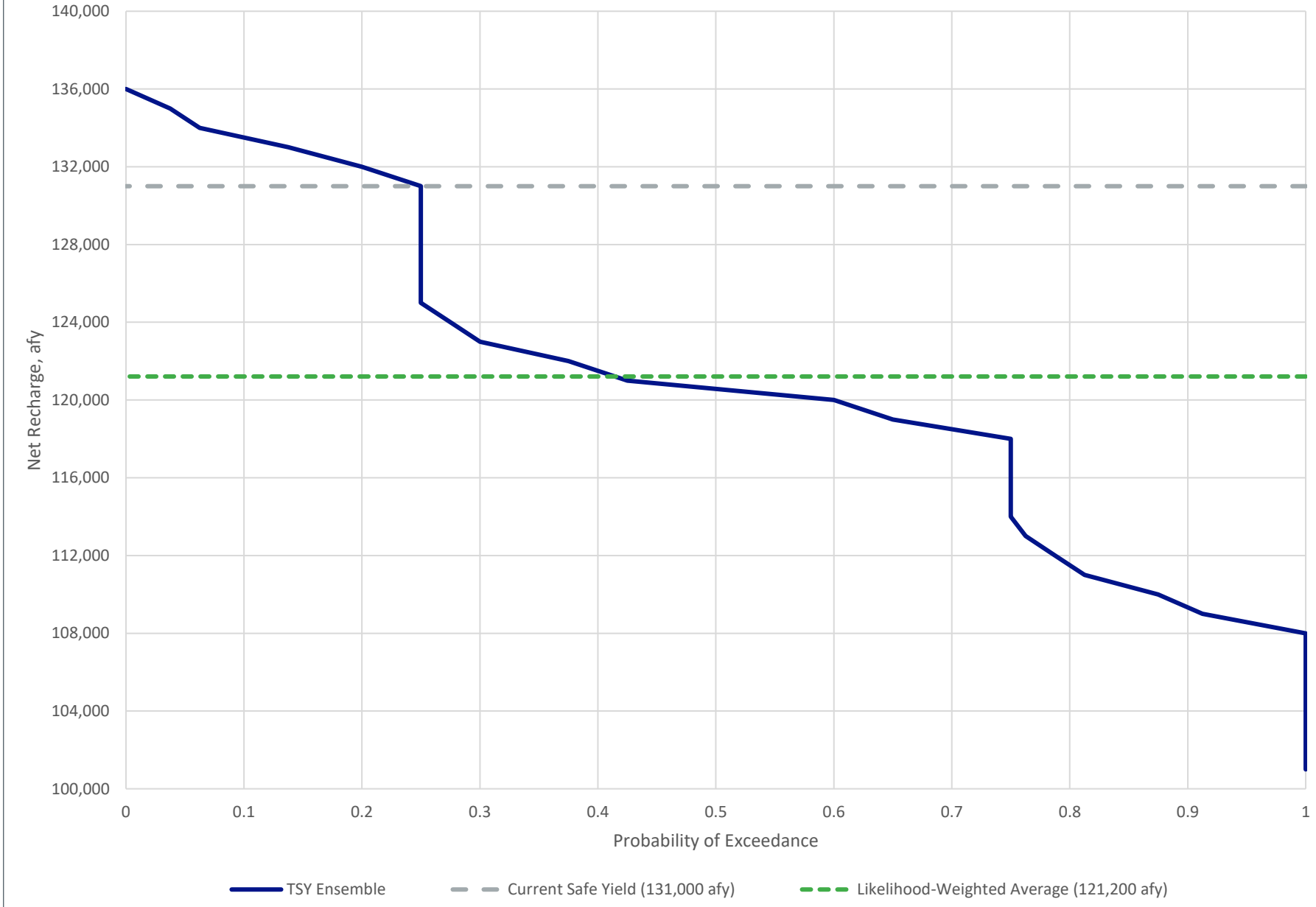


**Table 6-4. Decadal Average Water Budget Components for 2025 SYR TSY Ensemble (afy)[a]**

| Water Budget Component | FY 2021-2030 | FY 2031-2040 | FY 2041-2050 |
|---|---|---|---|
| Recharge Components | | | |
| Subsurface Inflow* | 33,400 | 34,200 | 34,100 |
| DIPAW* | 65,200 | 60,000 | 63,600 |
| Streambed Infiltration* | 45,500 | 41,300 | 47,400 |
| MAR - Stormwater* | 13,800 | 13,200 | 15,900 |
| MAR - Recycled and Imported | 22,100 | 18,400 | 20,300 |
| **Total** | **180,000** | **167,200** | **181,400** |
| Discharge Components | | | |
| Groundwater Pumping | 151,900 | 157,800 | 162,100 |
| Riparian ET* | 12,600 | 11,400 | 11,500 |
| Rising Groundwater* | 24,000 | 19,400 | 19,600 |
| **Total** | **188,600** | **188,600** | **193,100** |
| Aggregate Components | | | |
| Change in Storage | -8,600 | -21,400 | -11,700 |
| Net Recharge[b] | 121,200 | 118,000 | 130,000 |

(a) For clarity, values are rounded to the nearest 100 afy and may not sum precisely.
(b) Net recharge is calculated from the net volume of only those recharge and discharge components designated with an asterisk.

## 6.2.2 Groundwater Conditions

This subsection describes the range in potential future groundwater conditions for all members of the TSY Ensemble but only includes maps for the three Projection Realizations that span the range of results (Scenarios D1, E9, and A5), as indicated on Figure 6-15.

### *6.2.2.1 Groundwater Levels*

Figures 6-18 through 6-20 show the simulated groundwater levels at the beginning of the projection period (July 1, 2022) for Scenario D1 and Layers 1, 3, and 5, respectively. While there are differences between the groundwater levels for each of the calibrated realizations, the groundwater levels shown here are representative of the simulated conditions at the beginning of the projection period.

#### 6.2.2.1.1 Groundwater Level Changes, FY 2022 to 2030

Table 6-5 summarizes the changes in groundwater levels for each of the Projection Realizations, indicating the minimum, maximum, and average groundwater level elevations in July 1, 2030, and the average difference in groundwater levels between July 1, 2022 and July 1, 2030.

Hydraulic Head Contours (ft-amsl)

Appropriative Pool Pumping Wells

- City of Chino
- City of Chino Hills
- City of Ontario
- City of Pomona
- City of Upland
- Cucamonga Valley Water District
- Fontana Water Company
- Jurupa Community Services District
- Monte Vista Water District

Chino Desalter Well

Rivers and Streams

Flood Control and or Conservation Basins

OBMP Management Zones

*Faults*

- Location Certain
- Location Concealed
- Location Approximate
- Location Uncertain
- Approximate Location of Groundwater Barrier



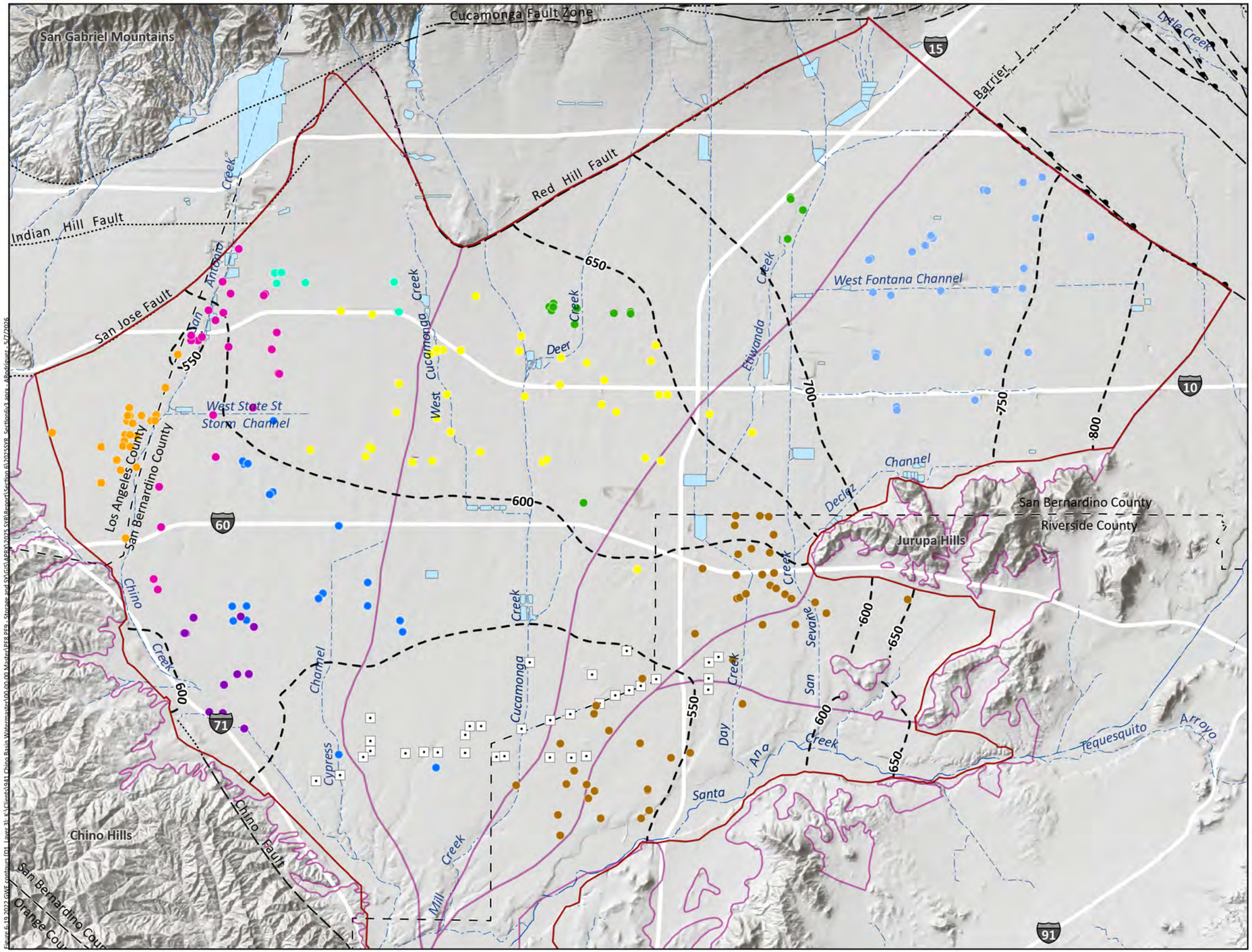

Prepared by: WEST YOST

0 2 4 Miles

0 3 6 Km

Prepared for:
Chino Basin Watermaster
2025 Safe Yield Reevaluation

**Hydraulic Head Contours -- Layer 1**
*Scenario D1 - July 2022*
**Figure 6-18**




Hydraulic Head Contours (ft-amsl)

Appropriative Pool Pumping Wells

- City of Chino
- City of Chino Hills
- City of Ontario
- City of Pomona
- City of Upland
- Cucamonga Valley Water District
- Fontana Water Company
- Jurupa Community Services District
- Monte Vista Water District

Chino Desalter Well

Rivers and Streams

Flood Control and or Conservation Basins




OBMP Management Zones

*Faults*

- Location Certain
- Location Approximate
- Location Concealed
- Location Uncertain
- Approximate Location of Groundwater Barrier




Prepared by: WEST YOST

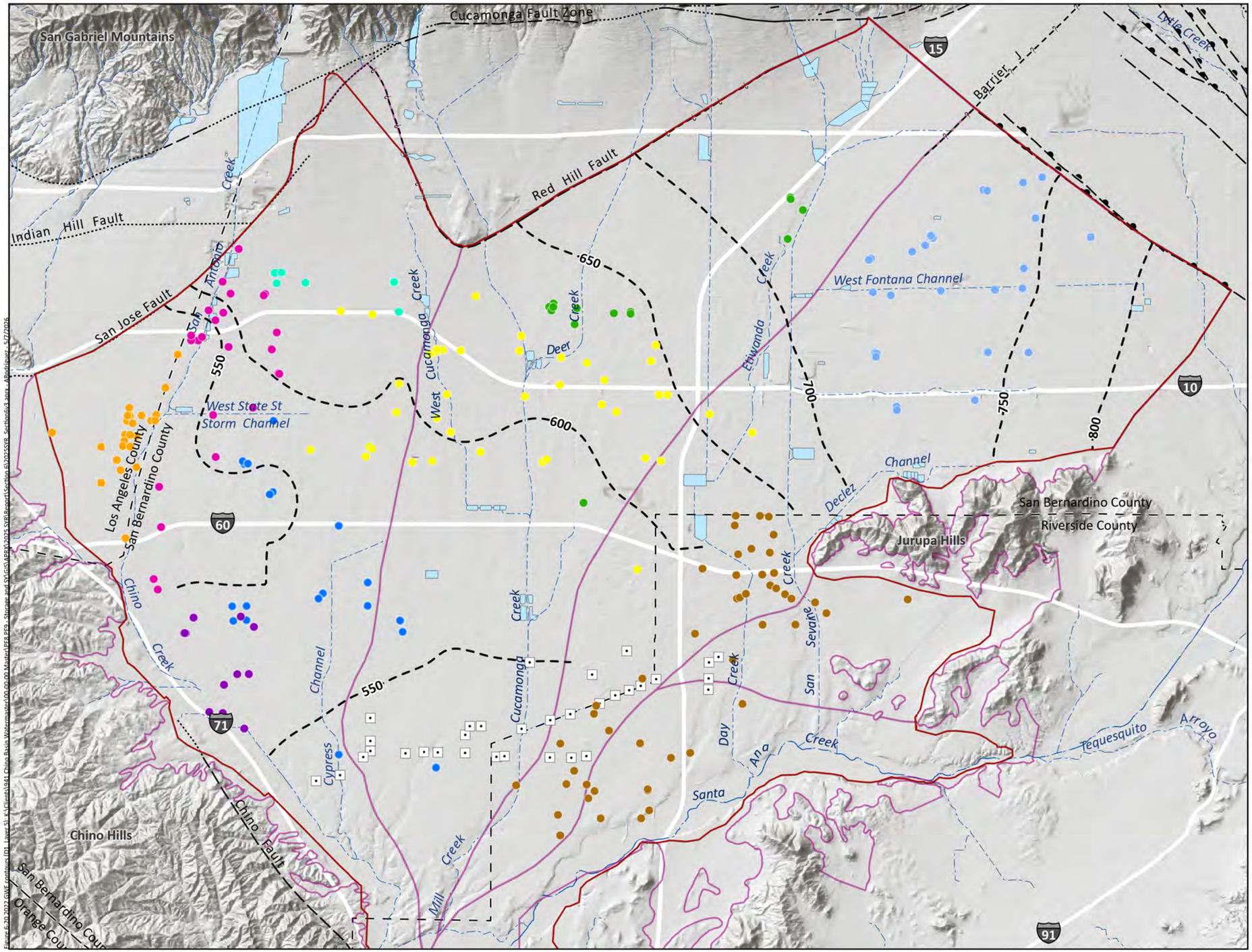
N

0 2 4 Miles

0 3 6 Km

Prepared for:
**Chino Basin Watermaster**
**2025 Safe Yield Reevaluation**

**Hydraulic Head Contours -- Layer 3**
*Scenario D1 - July 2022*
**Figure 6-19**




Hydraulic Head Contours (ft-amsl)

Appropriative Pool Pumping Wells

- City of Chino
- City of Chino Hills
- City of Ontario
- City of Pomona
- City of Upland
- Cucamonga Valley Water District
- Fontana Water Company
- Jurupa Community Services District
- Monte Vista Water District

Chino Desalter Well

Rivers and Streams

Flood Control and or Conservation Basins




OBMP Management Zones

*Faults*

- Location Certain
- Location Approximate
- Location Concealed
- Location Uncertain
- Approximate Location of Groundwater Barrier




Prepared by: WEST YOST

N

0 2 4 Miles

0 3 6 Km

Prepared for:
**Chino Basin Watermaster**
**2025 Safe Yield Reevaluation**

**Hydraulic Head Contours -- Layer 5**
*Scenario D1 - July 2022*
**Figure 6-20**

| Table 6-5. Summary of Groundwater Elevations<br>Selected Projection Realizations, July 2030 (ft-amsl) | | | |
|---|---|---|---|
| Statistic | Scenario D1 | Scenario E9 | Scenario A5 |
| Minimum Groundwater Elevation | 480 | 480 | 477 |
| Maximum Groundwater Elevation | 840 | 841 | 844 |
| Average Groundwater Elevation | 624 | 635 | 608 |
| Average Difference Compared to 2022 | -0.1 | 13 | -9 |

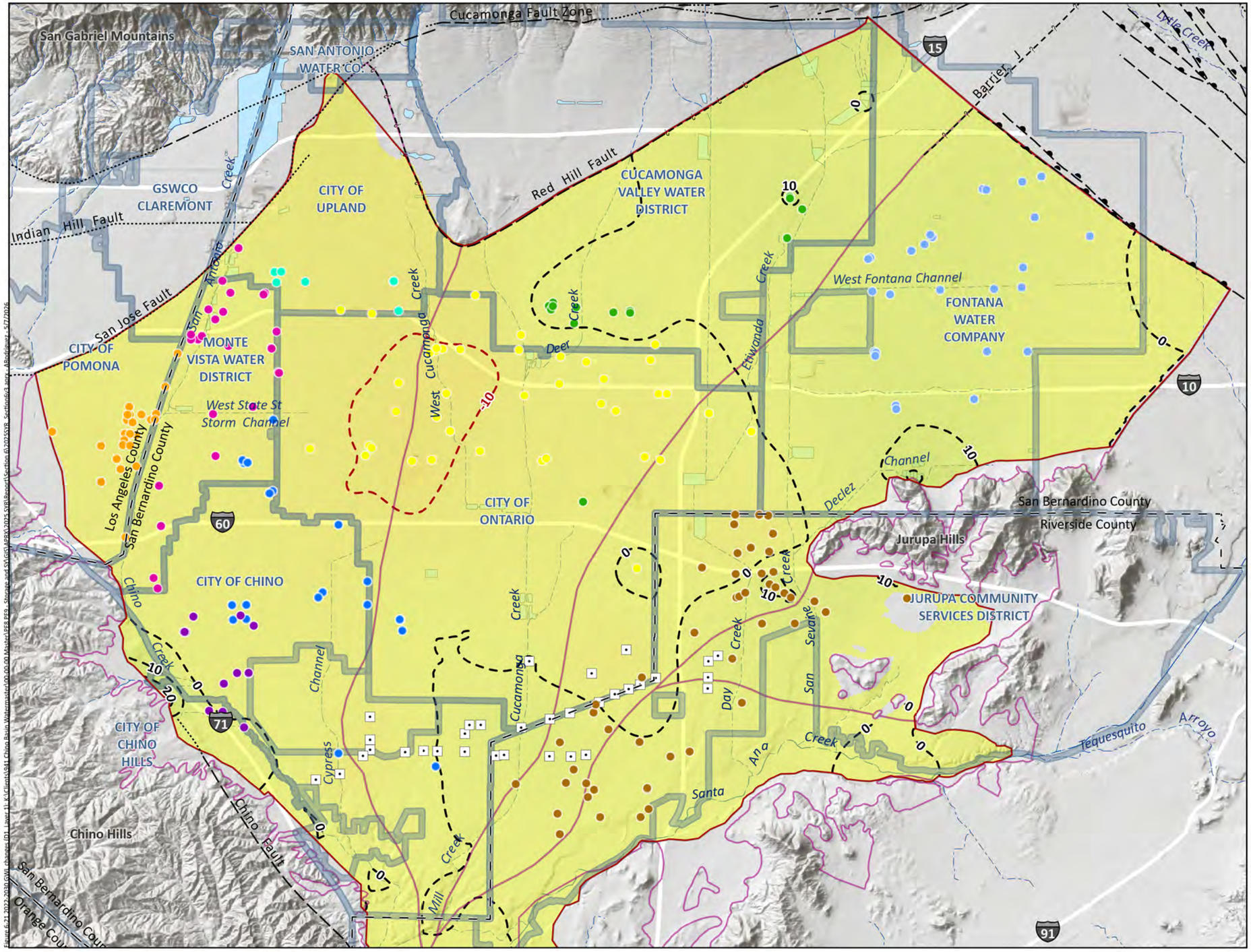
Figures 6-21 through 6-23 show the simulated changes in groundwater levels for the period of July 1, 2022 to July 1, 2030 for Layer 1 of Scenarios D1, E9, and A5, respectively.

- In Scenario D1 (Figure 6-21), groundwater levels average about the same as 2022. Groundwater levels generally remain within 10 feet of their levels in 2022.
- In Scenario E9 (Figure 6-22), groundwater levels average about 13 feet higher than 2022. Increases in groundwater levels are consistent across most of the Basin except for the western portion of the CDA wellfield near where the remediation wells near the Chino Airport are projected to begin pumping in FY 2027.
- In Scenario A5 (Figure 6-23), groundwater levels average about 9 feet lower than 2022. Groundwater level declines are focused in the western Chino Basin near the Ontario and Pomona wellfields, and near where the remediation wells near the Chino Airport are projected to begin pumping in FY 2027.

#### 6.2.2.1.2 Groundwater Level Changes, FY 2022 to 2050

Table 6-6 summarizes the changes in groundwater levels for each of the Projection Realizations, indicating the minimum, maximum, and average groundwater level elevations on July 1, 2050, and the average difference in groundwater levels between July 1, 2022 and July 1, 2050.

| Table 6-6. Summary of Groundwater Elevations<br>Selected Projection Realizations, July 2050 (ft-amsl) | | | |
|---|---|---|---|
| Statistic | Scenario D1 | Scenario E9 | Scenario A5 |
| Minimum Groundwater Elevation | 467 | 477 | 447 |
| Maximum Groundwater Elevation | 840 | 841 | 844 |
| Average Groundwater Elevation | 609 | 629 | 588 |
| Average Difference Compared to 2022 | -16 | 7 | -29 |




Hydraulic Head Change (ft-amsl) Positive Change
*July 2022 to July 2030*

Hydraulic Head Change (ft-amsl) Negative Change
*July 2022 to July 2030*

Hydraulic Head Change (ft) July 2022 to 2030

100 — Increase

-100 — Decrease

Appropriative Pool Pumping Wells

- City of Chino
- City of Chino Hills
- City of Ontario
- City of Pomona
- City of Upland
- Cucamonga Valley Water District
- Fontana Water Company
- Jurupa Community Services District
- Monte Vista Water District

Chino Desalter Well

Rivers and Streams

Flood Control and or Conservation Basins

Water Service Area




OBMP Management Zones

*Faults*

- Location Certain
- Location Approximate
- Location Concealed
- Location Uncertain
- Approximate Location of Groundwater Barrier




Prepared by:
WEST YOST

N

0 2 4 Miles

0 3 6 Km

Prepared for:
**Chino Basin Watermaster**
**2025 Safe Yield Reevaluation**

**Projected Hydraulic Head Change -- Layer 1**
*Scenario D1 - July 2030 minus July 2022*
**Figure 6-21**

Hydraulic Head Change (ft-amsl) Positive Change
*July 2022 to July 2030*

Hydraulic Head Change (ft-amsl) Negative Change
*July 2022 to July 2030*

Hydraulic Head Change (ft) July 2022 to 2030

100 — Increase

-100 — Decrease

Appropriative Pool Pumping Wells

- City of Chino
- City of Chino Hills
- City of Ontario
- City of Pomona
- City of Upland
- Cucamonga Valley Water District
- Fontana Water Company
- Jurupa Community Services District
- Monte Vista Water District

Chino Desalter Well

Rivers and Streams

Flood Control and or Conservation Basins

Water Service Area

OBMP Management Zones

*Faults*

- Location Certain
- Location Approximate
- Location Concealed
- Location Uncertain
- Approximate Location of Groundwater Barrier



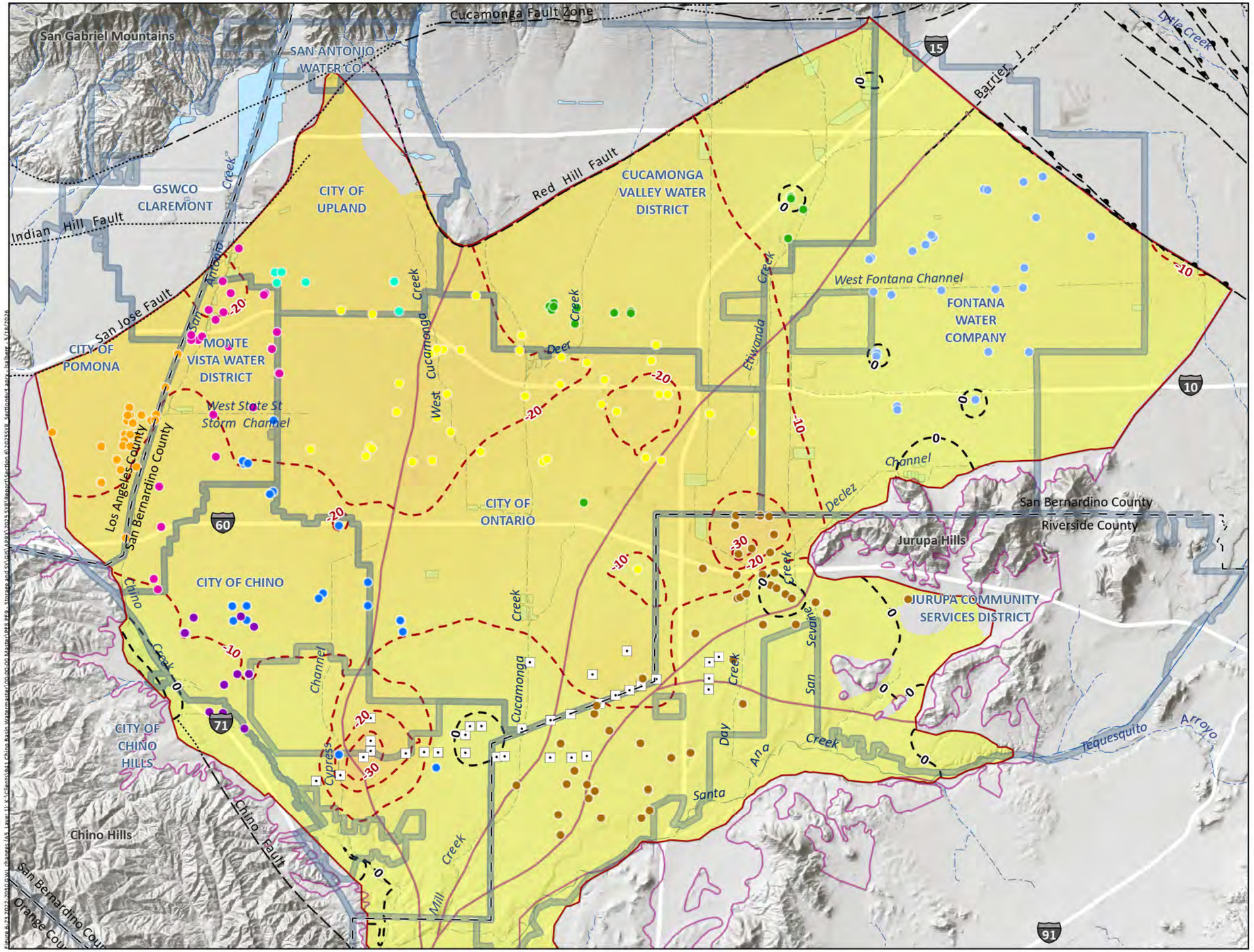

Prepared by: WEST YOST

0 2 4 Miles

0 3 6 Km

Prepared for:
**Chino Basin Watermaster**
**2025 Safe Yield Reevaluation**

**Projected Hydraulic Head Change -- Layer 1**
*Scenario E9 - July 2030 minus July 2022*
**Figure 6-22**




Hydraulic Head Change (ft-amsl) Positive Change
*July 2022 to July 2030*

Hydraulic Head Change (ft-amsl) Negative Change
*July 2022 to July 2030*

Hydraulic Head Change (ft) July 2022 to 2030

100 — Increase

-100 — Decrease

Appropriative Pool Pumping Wells

- City of Chino
- City of Chino Hills
- City of Ontario
- City of Pomona
- City of Upland
- Cucamonga Valley Water District
- Fontana Water Company
- Jurupa Community Services District
- Monte Vista Water District

Chino Desalter Well

Rivers and Streams

Flood Control and or Conservation Basins

Water Service Area




OBMP Management Zones

*Faults*

- Location Certain
- Location Approximate
- Location Concealed
- Location Uncertain
- Approximate Location of Groundwater Barrier




Prepared by: WEST YOST

N

0 2 4 Miles

0 3 6 Km

Prepared for:
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**2025 Safe Yield Reevaluation**

**Projected Hydraulic Head Change -- Layer 1**
*Scenario A5 - July 2030 minus July 2022*
**Figure 6-23**

Figures 6-24 through 6-26 show the simulated changes in groundwater levels for the period of July 1, 2022 to July 1, 2050 for Layer 1 of Scenarios D1, E9, and A5, respectively.

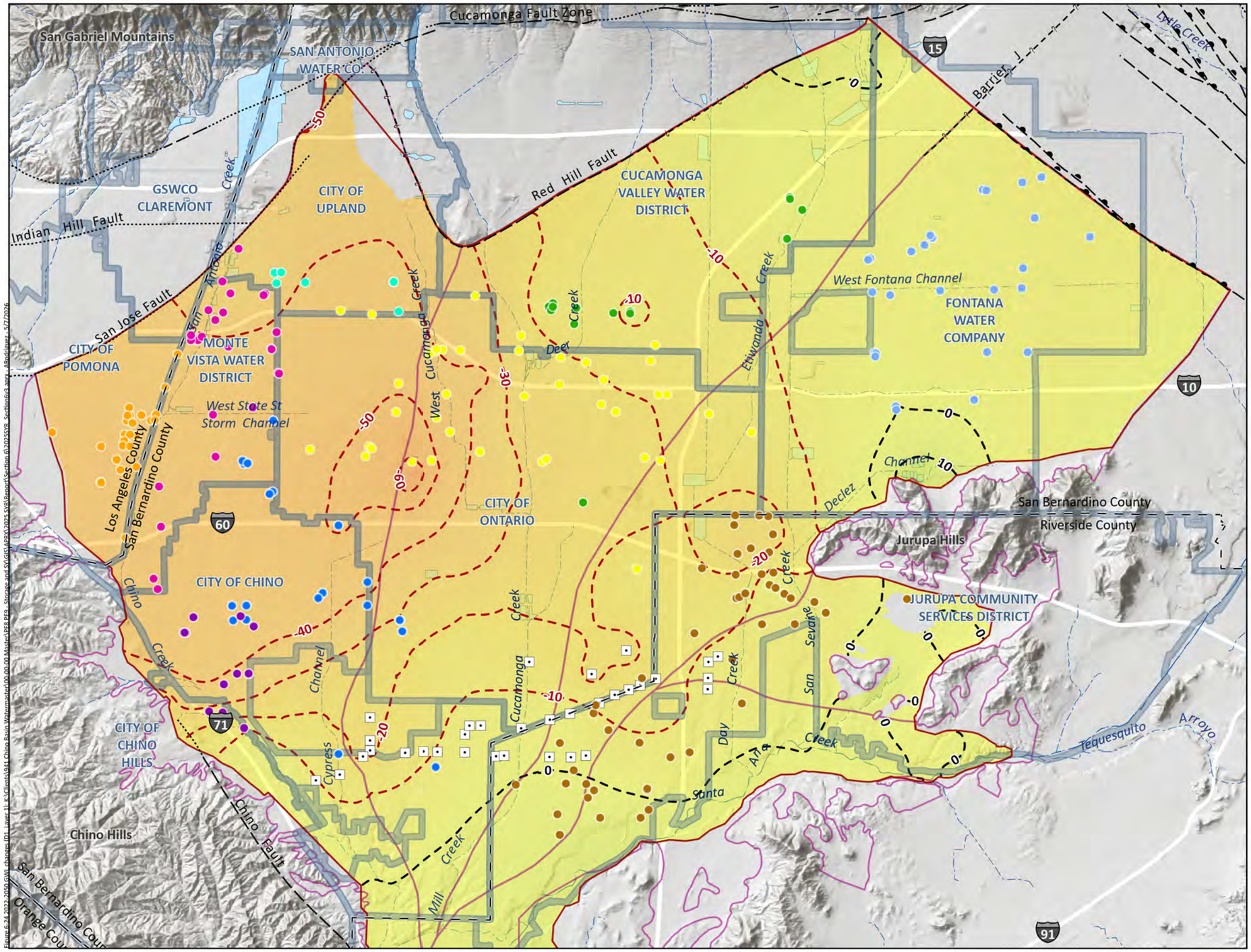
- In Scenario D1 (Figure 6-24), groundwater levels average about 16 feet lower than 2022. Groundwater levels generally remain within 10 feet of their levels in 2022 in MZ-3, while groundwater level declines of up to 60 feet occur across the boundary between MZ-1 and MZ-2.
- In Scenario E9 (Figure 6-25), groundwater levels average about 7 feet higher than 2022. Increases in groundwater levels are consistent across most of the Basin except for central MZ-1 and near the Chino Airport, where declines are up to about 30 feet.
- In Scenario A5 (Figure 6-26), groundwater levels average about 29 feet lower than 2022. Groundwater level declines occur across the entire Basin, exceeding 90 feet near the boundary between MZ-1 and MZ-2.

#### *6.2.2.2 Groundwater Flow Patterns*

Groundwater flow patterns vary over time for members of the TSY Ensemble. Figures 6-27 through 6-29 show the simulated groundwater velocity vectors on July 1, 2030 for Layer 1 of Scenarios D1, E9, and A5, respectively. Figures 6-30 through 6-32 show the simulated groundwater velocity vectors on July 1, 2050 for Layer 1 of Scenarios D1, E9, and A5, respectively.

Overall, groundwater flow patterns mimic surface drainage patterns, flowing from the areas of high elevation in the north and east flanking the San Gabriel and Jurupa Mountains towards pumping wells and areas of discharge near the Santa Ana River within Prado Basin. The CDA wellfield draws groundwater from the upgradient Chino Basin and the Santa Ana River, weakening the Chino Basin's hydraulic connection to the Santa Ana River.

By 2050 in Scenario D1, groundwater flows in Layer 1 tend to focus on local minima in groundwater levels near the Ontario wellfield (see Figure 6-30).




Hydraulic Head Change (ft-amsl) Positive Change
*July 2022 to July 2050*

Hydraulic Head Change (ft-amsl) Negative Change
*July 2022 to July 2050*

Hydraulic Head Change (ft) July 2022 to 2050

100 — Increase

-100 — Decrease

Appropriative Pool Pumping Wells

- City of Chino
- City of Chino Hills
- City of Ontario
- City of Pomona
- City of Upland
- Cucamonga Valley Water District
- Fontana Water Company
- Jurupa Community Services District
- Monte Vista Water District

Chino Desalter Well

Rivers and Streams

Flood Control and or Conservation Basins

Water Service Area




OBMP Management Zones

*Faults*

- Location Certain
- Location Approximate
- Location Concealed
- Location Uncertain
- Approximate Location of Groundwater Barrier




Prepared by: WEST YOST

N

0 2 4 Miles

0 3 6 Km

Prepared for:
**Chino Basin Watermaster**
**2025 Safe Yield Reevaluation**

**Projected Hydraulic Head Change -- Layer 1**
*Scenario D1 - July 2050 minus July 2022*
**Figure 6-24**

Hydraulic Head Change (ft-amsl) Positive Change
*July 2022 to July 2050*

Hydraulic Head Change (ft-amsl) Negative Change
*July 2022 to July 2050*

Hydraulic Head Change (ft) July 2022 to 2050

100 — Increase

-100 — Decrease

Appropriative Pool Pumping Wells

- City of Chino
- City of Chino Hills
- City of Ontario
- City of Pomona
- City of Upland
- Cucamonga Valley Water District
- Fontana Water Company
- Jurupa Community Services District
- Monte Vista Water District

Chino Desalter Well

Rivers and Streams

Flood Control and or Conservation Basins

Water Service Area

OBMP Management Zones

*Faults*

- Location Certain
- Location Approximate
- Location Concealed
- Location Uncertain
- Approximate Location of Groundwater Barrier




Prepared by: WEST YOST

0 2 4 Miles

0 3 6 Km

Prepared for:
**Chino Basin Watermaster**
**2025 Safe Yield Reevaluation**

**Projected Hydraulic Head Change -- Layer 1**
*Scenario E9 - July 2050 minus July 2022*
**Figure 6-25**

Hydraulic Head Change (ft-amsl) Positive Change
*July 2022 to July 2050*

Hydraulic Head Change (ft-amsl) Negative Change
*July 2022 to July 2050*

Hydraulic Head Change (ft) July 2022 to 2050

100 — Increase

-100 — Decrease

Appropriative Pool Pumping Wells

- City of Chino
- City of Chino Hills
- City of Ontario
- City of Pomona
- City of Upland
- Cucamonga Valley Water District
- Fontana Water Company
- Jurupa Community Services District
- Monte Vista Water District

Chino Desalter Well

Rivers and Streams

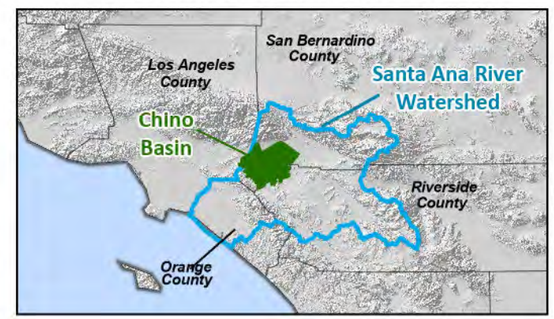
Flood Control and or Conservation Basins

Water Service Area

OBMP Management Zones

*Faults*

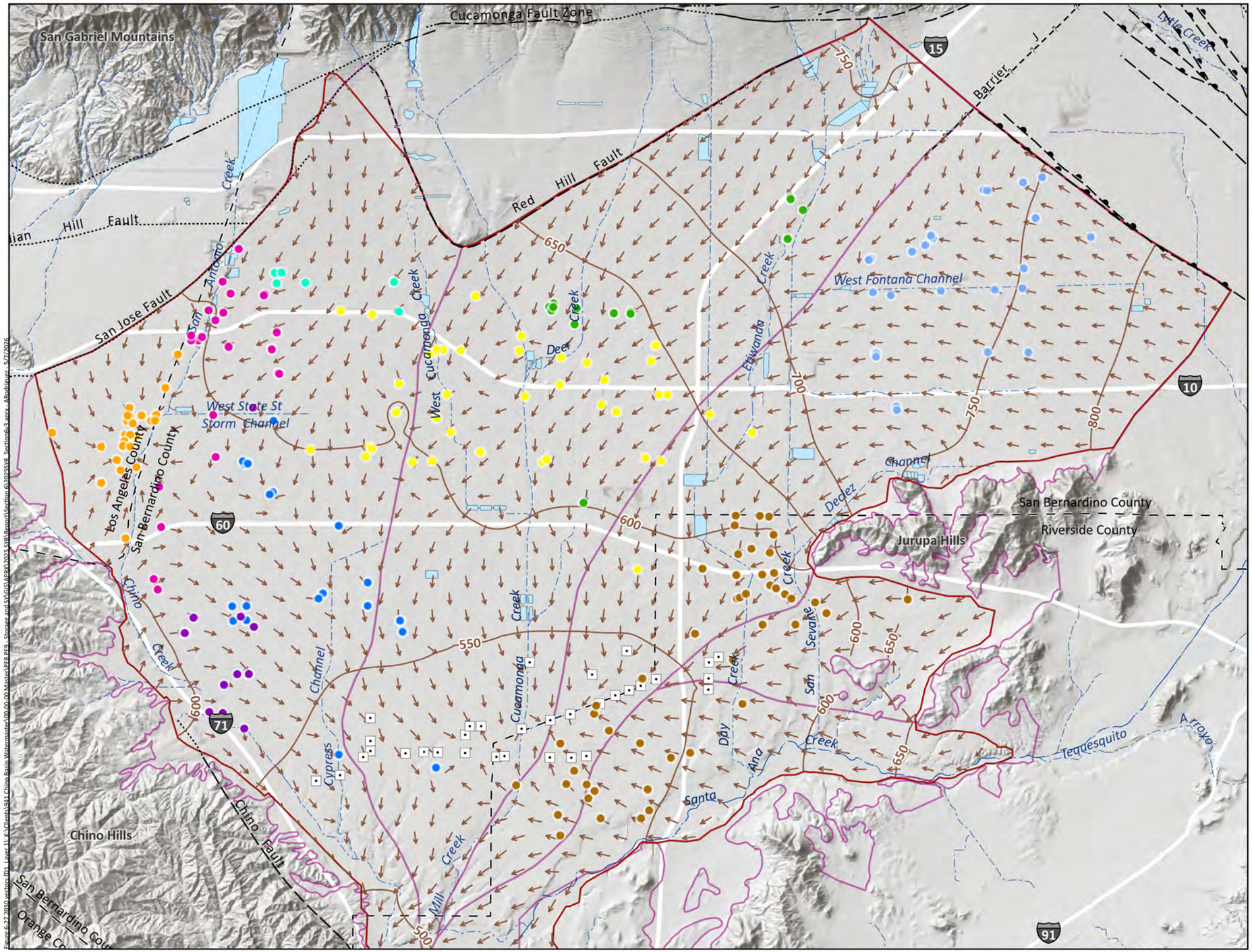
- Location Certain
- Location Approximate
- Location Concealed
- Location Uncertain
- Approximate Location of Groundwater Barrier




Prepared by: WEST YOST

Prepared for: Chino Basin Watermaster
2025 Safe Yield Reevaluation

**Projected Hydraulic Head Change -- Layer 1**
*Scenario A5 - July 2050 minus July 2022*
**Figure 6-26**




2030 Groundwater Flow Vector - Model Layer 1

800 2030 Groundwater Elevation Contours (ft-amsl) - Model Layer 1

Appropriative Pool Pumping Wells

- City of Chino
- City of Chino Hills
- City of Ontario
- City of Pomona
- City of Upland
- Cucamonga Valley Water District
- Fontana Water Company
- Jurupa Community Services District
- Monte Vista Water District

Chino Desalter Well

Rivers and Streams

Flood Control and or Conservation Basins




OBMP Management Zones

*Faults*

- Location Certain
- Location Approximate
- Approximate Location of Groundwater Barrier
- Location Concealed
- Location Uncertain




Prepared by: WEST YOST

0 2 4 Miles

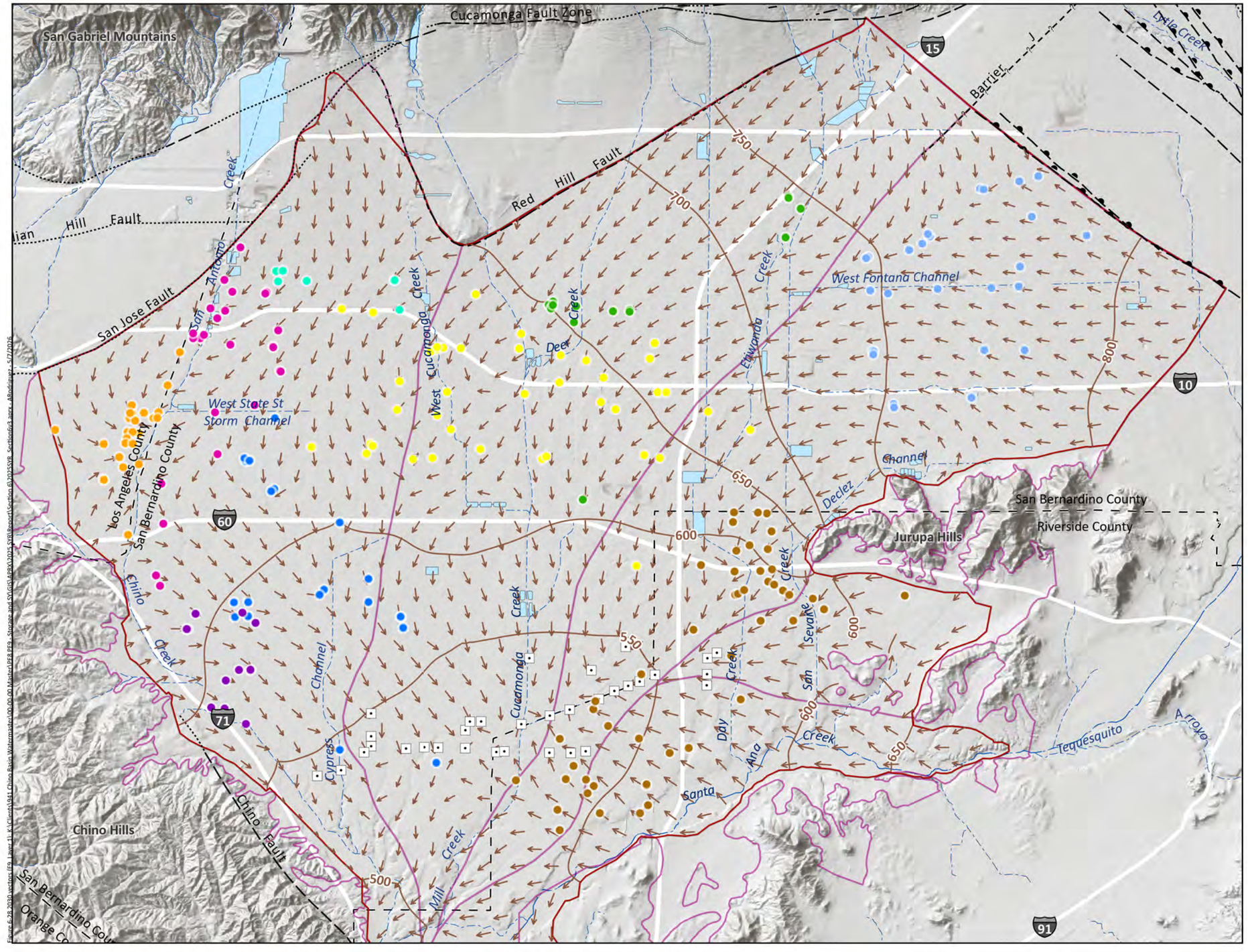
0 3 6 Km

Prepared for: Chino Basin Watermaster
2025 Safe Yield Reevaluation

**Projected Groundwater Level Elevations and Flow Vectors for July 2030**

*Scenario D1, Layer 1*

**Figure 6-27**




2030 Groundwater Flow Vector - Model Layer 1

2030 Groundwater Elevation Contours (ft-amsl) - Model Layer 1

Appropriative Pool Pumping Wells

- City of Chino
- City of Chino Hills
- City of Ontario
- City of Pomona
- City of Upland
- Cucamonga Valley Water District
- Fontana Water Company
- Jurupa Community Services District
- Monte Vista Water District

Chino Desalter Well

Rivers and Streams

Flood Control and or Conservation Basins




OBMP Management Zones

*Faults*

- Location Certain
- Location Approximate
- Location Concealed
- Location Uncertain
- Approximate Location of Groundwater Barrier




Prepared by: WEST YOST

0 2 4 Miles

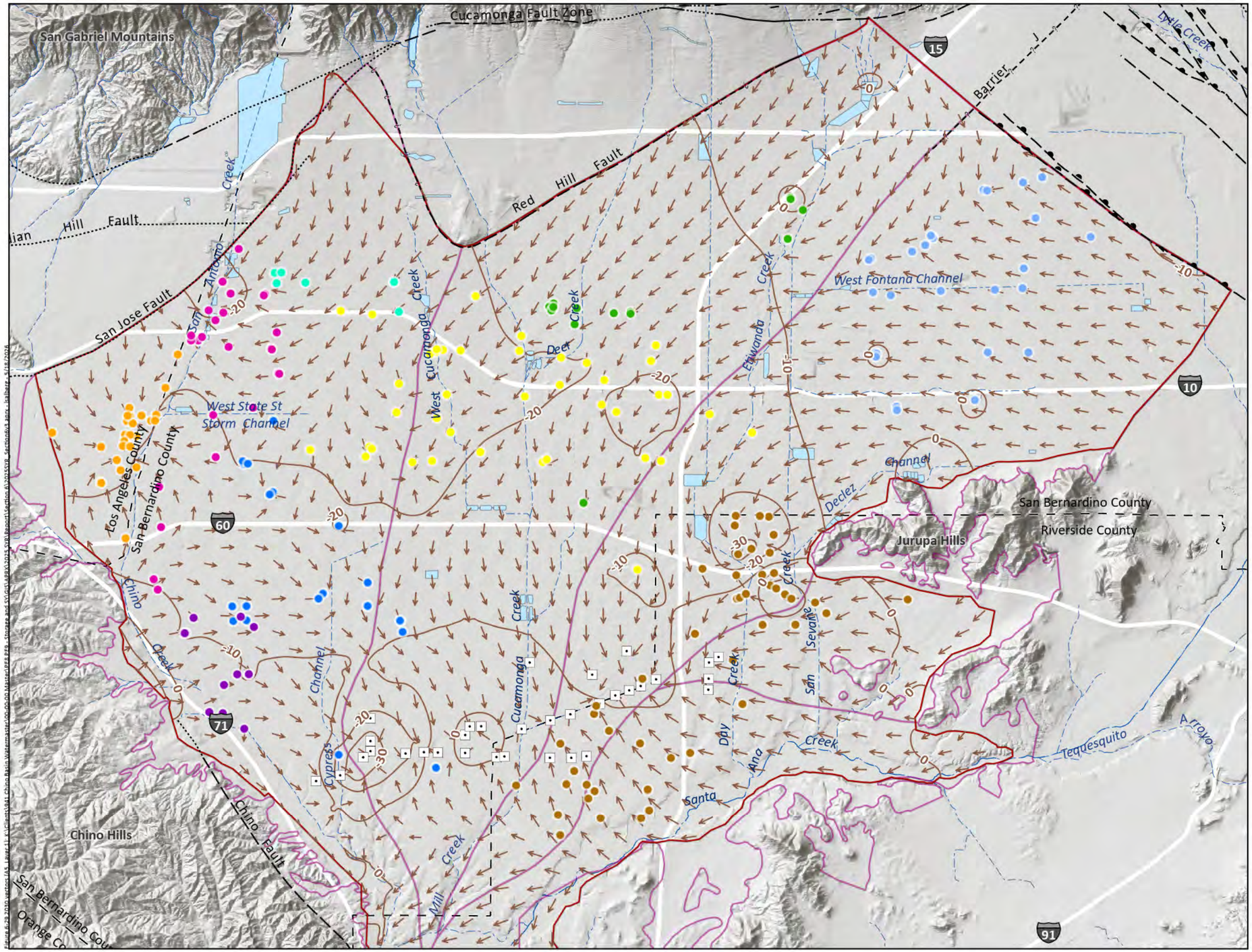
0 3 6 Km

Prepared for: Chino Basin Watermaster
2025 Safe Yield Reevaluation

**Projected Groundwater Level Elevations and Flow Vectors for July 2030**

*Scenario E9, Layer 1*

**Figure 6-28**




2030 Groundwater Flow Vector - Model Layer 1

800 2030 Groundwater Elevation Contours (ft-amsl) - Model Layer 1

Appropriative Pool Pumping Wells

- City of Chino
- City of Chino Hills
- City of Ontario
- City of Pomona
- City of Upland
- Cucamonga Valley Water District
- Fontana Water Company
- Jurupa Community Services District
- Monte Vista Water District

Chino Desalter Well

Rivers and Streams

Flood Control and or Conservation Basins




OBMP Management Zones

*Faults*

- Location Certain
- Location Approximate
- Location Concealed
- Location Uncertain
- Approximate Location of Groundwater Barrier



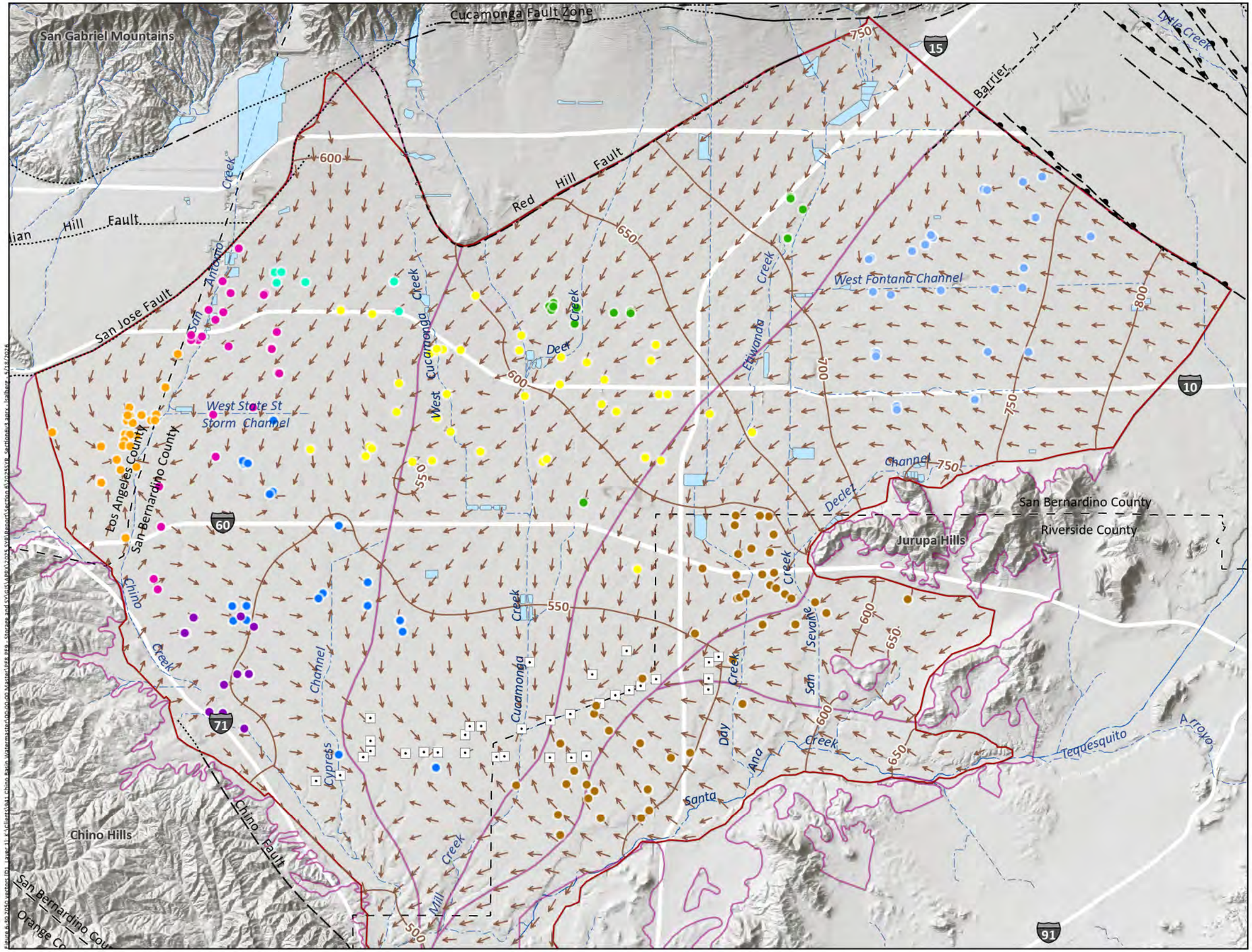

Prepared by: WEST YOST

0 2 4 Miles

0 3 6 Km

Prepared for:
**Chino Basin Watermaster**
**2025 Safe Yield Reevaluation**

**Projected Groundwater Level Elevations and Flow Vectors for July 2030**
*Scenario A5, Layer 1*
**Figure 6-29**




2050 Groundwater Flow Vector - Model Layer 1

2050 Groundwater Elevation Contours (ft-amsl) - Model Layer 1

Appropriative Pool Pumping Wells

- City of Chino
- City of Chino Hills
- City of Ontario
- City of Pomona
- City of Upland
- Cucamonga Valley Water District
- Fontana Water Company
- Jurupa Community Services District
- Monte Vista Water District

Chino Desalter Well

Rivers and Streams

Flood Control and or Conservation Basins




OBMP Management Zones

*Faults*

- Location Certain
- Location Approximate
- Approximate Location of Groundwater Barrier
- Location Concealed
- Location Uncertain




**Projected Groundwater Level Elevations and Flow Vectors for July 2050**

*Scenario D1, Layer 1*

**Figure 6-30**

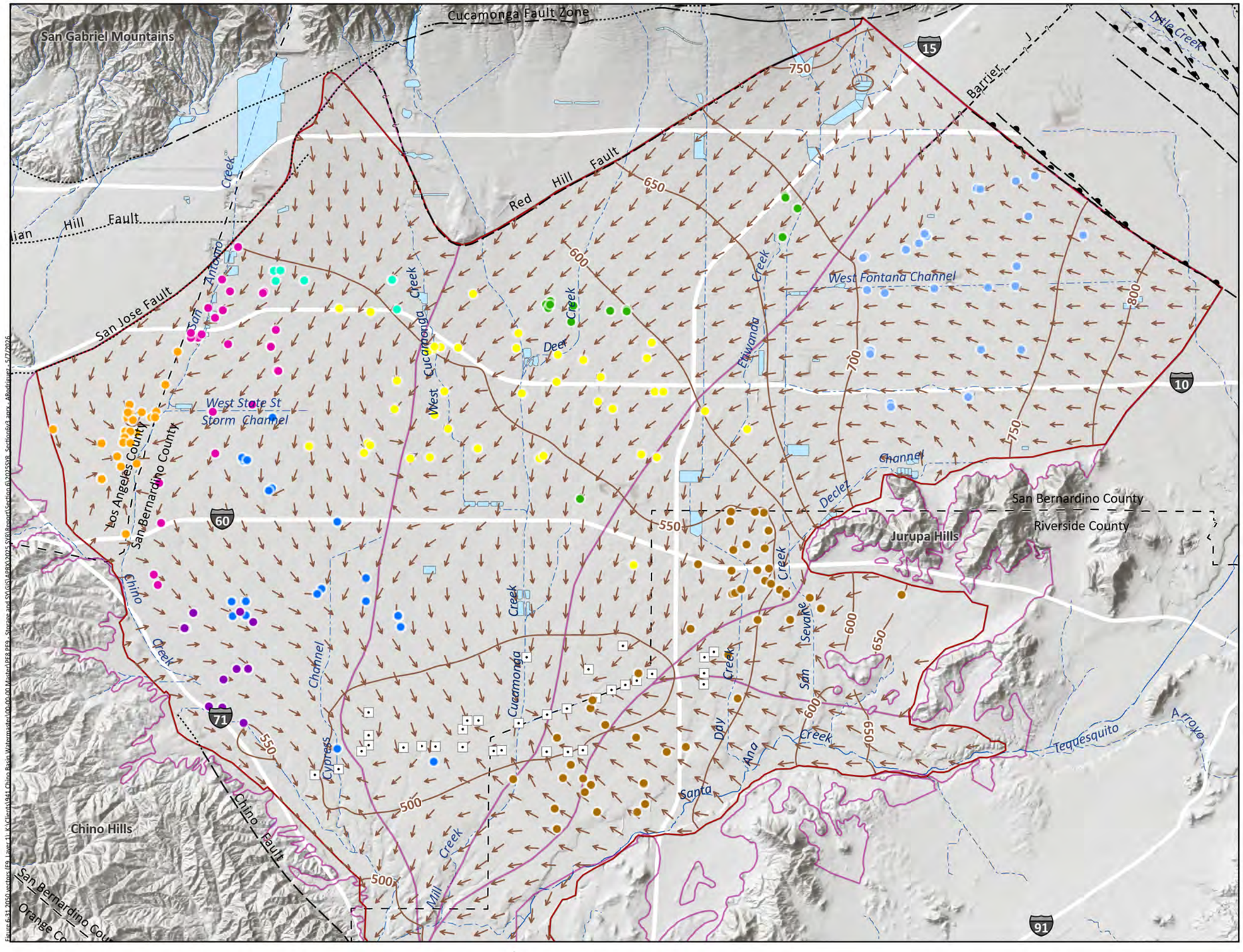
Prepared by: WEST YOST

N

0 2 4 Miles

0 3 6 Km

Prepared for:
**Chino Basin Watermaster**
**2025 Safe Yield Reevaluation**




2050 Groundwater Flow Vector - Model Layer 1

800 2050 Groundwater Elevation Contours (ft-amsl) - Model Layer 1

Appropriative Pool Pumping Wells

- City of Chino
- City of Chino Hills
- City of Ontario
- City of Pomona
- City of Upland
- Cucamonga Valley Water District
- Fontana Water Company
- Jurupa Community Services District
- Monte Vista Water District

Chino Desalter Well

Rivers and Streams

Flood Control and or Conservation Basins




OBMP Management Zones

*Faults*

- Location Certain
- Location Approximate
- Approximate Location of Groundwater Barrier
- Location Concealed
- Location Uncertain




Prepared by: WEST YOST

0 2 4 Miles

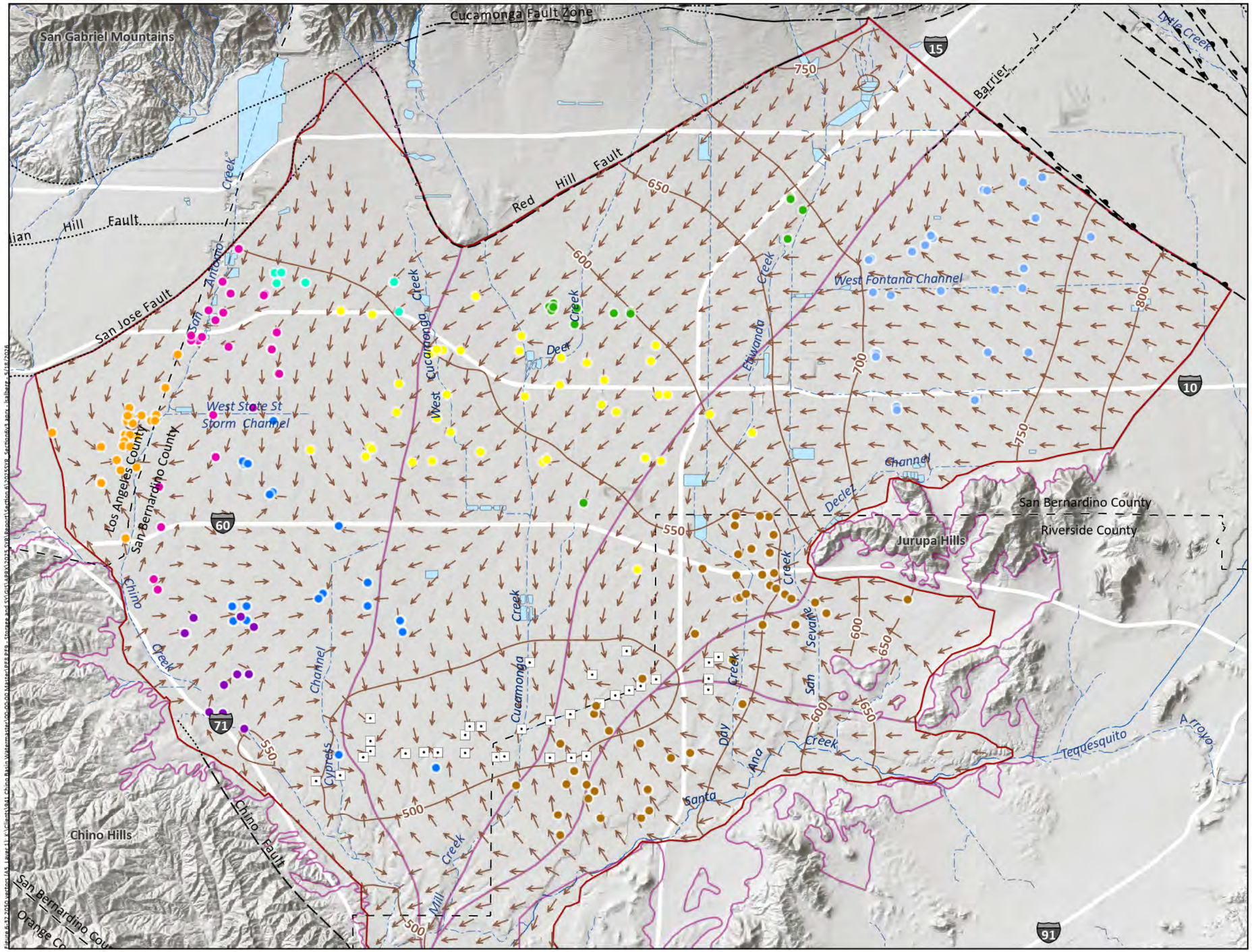
0 3 6 Km

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Chino Basin Watermaster
2025 Safe Yield Reevaluation

**Projected Groundwater Level Elevations and Flow Vectors for July 2050**

*Scenario E9, Layer 1*

**Figure 6-31**




2050 Groundwater Flow Vector - Model Layer 1

2050 Groundwater Elevation Contours (ft-amsl) - Model Layer 1

Appropriative Pool Pumping Wells

- City of Chino
- City of Chino Hills
- City of Ontario
- City of Pomona
- City of Upland
- Cucamonga Valley Water District
- Fontana Water Company
- Jurupa Community Services District
- Monte Vista Water District

Chino Desalter Well

Rivers and Streams

Flood Control and or Conservation Basins




OBMP Management Zones

*Faults*

- Location Certain
- Location Approximate
- Location Concealed
- Location Uncertain
- Approximate Location of Groundwater Barrier




Prepared by: WEST YOST

0 2 4 Miles

0 3 6 Km

Prepared for:
**Chino Basin Watermaster**
**2025 Safe Yield Reevaluation**

**Projected Groundwater Level Elevations and Flow Vectors for July 2050**
*Scenario A5, Layer 1*

**Figure 6-32**

# SECTION 7
# 2025 Safe Yield Reevaluation

## 7.1 BACKGROUND AND OBJECTIVES

This section presents the findings of the 2025 Safe Yield Reevaluation and documents the execution of Step 9 of the 2022 SYRM:

> 9. *Evaluate whether the groundwater production at the Tentative Safe Yield estimated in [8] above will cause or threaten to cause "undesirable results" or "Material Physical Injury." If groundwater production at Tentative Safe Yield will cause or threaten to cause "undesirable results" or "Material Physical Injury," then Watermaster will identify and implement prudent measures necessary to mitigate "undesirable results" or "Material Physical Injury," set the value of Safe Yield to ensure there is no "undesirable results" or "Material Physical Injury," or implement a combination of mitigation measures and a changed Safe Yield.*

Although the term "undesirable result" is referenced in the Judgment definition of Safe Yield, it is not explicitly defined. Common law defines "undesirable result" as "a gradual lowering of the ground water levels resulting eventually in depletion of the supply."[1] However, prior Safe Yield recalculations have consistently assessed groundwater conditions based on the definition of Material Physical Injury (MPI), which effectively captures and addresses the risks associated with undesirable results. Therefore, the MPI framework will be used to encompass both "undesirable results" as used in the Judgment and MPI as defined in the Peace Agreement.

### 7.1.1 Categories of Material Physical Injury

The Peace Agreement defines MPI as "[…] *material injury that is attributable to Recharge, Transfer, storage and recovery, management, movement or Production of water or implementation of the OBMP, including, but not limited to, degradation of water quality, liquefaction, land subsidence, increases in pump lift and adverse impacts associated with rising groundwater*." Watermaster has used this definition to guide the scope of prior Safe Yield recalculations,[2] considering the potential for MPI from operating at the Safe Yield. The following lists each category of MPI and describes whether and how Watermaster will evaluate for MPI in Step 9 for 2025 SYR:

- **Degradation of water quality:** The Safe Yield is the sustainable pumping rate from the Chino Basin, and by itself, does not influence groundwater quality. Therefore, water quality is not analyzed herein as potential MPI that could be caused by the Safe Yield. Instead, the Watermaster addresses water quality challenges through other forums:
  - The Watermaster's responsibilities to manage groundwater quality are defined by the Optimum Basin Management Program (OBMP) with the advice of the Advisory and Pool Committees. The current forum by which water quality challenges are identified and addressed is the Water Quality Management Program (WQMP).
  - Salt and nutrient management in groundwater is regulated by the Regional Water Quality Control Board through the Chino Basin Maximum Benefit Program.

[1] See *City of Los Angeles v. City of San Fernando* (1975) 14 Cal.3d 199, 278 (disapproved of on other grounds by *City of Barstow v. Mojave Water Agency* (2000) 23 Cal.4th 1224); see also *City of Pasadena v. City of Alhambra* (1949) 33 Cal.2d 908, 929.

[2] 2020 Safe Yield Recalculation Report

- Point-source groundwater contamination plumes are regulated by the Regional Water Quality Control Board and monitored/mitigated by the responsible parties.

- **Liquefaction:** While operating at the Safe Yield may result in groundwater-level changes, the risk of liquefaction in the Chino Basin is considered insignificant because the water table is generally greater than 40 feet below the ground surface in areas with sensitive overlying infrastructure. Therefore, liquefaction is not analyzed herein as potential MPI that could be caused by the Safe Yield.
- **Land subsidence:** Operating at the Safe Yield may result in groundwater-level changes in areas of the Chino Basin that are prone to aquifer-system compaction, and hence, land subsidence and ground fissuring. Therefore, land subsidence is analyzed herein as potential MPI that could be caused by operating at the Safe Yield.
- **Increases in pump lift (i.e., pumping sustainability):** Operating at the Safe Yield may result in groundwater-level changes which could affect the ability of the parties to pump their wells in a manner to satisfy their water demands. Therefore, pumping sustainability is analyzed herein as potential MPI that could be caused by operating at the Safe Yield.
- **Adverse impacts associated with rising groundwater:** The primary adverse impact associated with rising groundwater is the potential loss of hydraulic control.[3] Operating at the Safe Yield may result in higher groundwater levels in the southern portion of the Chino Basin which could cause a loss of hydraulic control. Therefore, the potential loss of hydraulic control is analyzed herein as potential MPI that could be caused by operating at the Safe Yield.

Based on the above discussion, the 2025 Safe Yield Reevaluation will analyze the TSY Ensemble results for the MPI categories of: land subsidence; pumping sustainability; and the loss of hydraulic control.

### 7.1.2 MPI Analysis Methods

The general methods that were employed to evaluate the TSY Ensemble results for MPI included the following steps:

1. Characterize future groundwater conditions in the Chino Basin (*i.e.,* changes in groundwater levels and groundwater-flow directions) over the projection period (2023-2080) for each Projection Realization of the TSY Ensemble. The future groundwater conditions are described in Section 6.
2. Define the physical thresholds for the occurrence of MPI at representative monitoring locations for each MPI category (site-specific MPI threshold).

[3] The attainment of hydraulic control is measured by demonstrating, from groundwater elevation data, either that all groundwater north of the desalter well fields cannot pass through the CDA wellfields (total hydraulic containment standard) or that groundwater discharge through the CDA wellfields is, in aggregate, less than 1,000 afy (de minimis standard). The Regional Board has agreed that compliance with the de minimis standard will be determined from groundwater monitoring data and the results of periodic calibrations of the Watermaster groundwater model and interpretations of the calibration results.

3. Define the thresholds for the occurrence of MPI in each area or subarea of the basin (e.g., Areas of Subsidence Concern) based on the magnitude or ratio of site-specific MPI threshold exceedances for a Projection Realization (subarea MPI thresholds).
4. For each area or subarea, compare future groundwater conditions (from Step 1) against the site-specific MPI thresholds at representative monitoring locations (from Step 2) for each Projection Realization of the TSY Ensemble and determine whether MPI is predicted to occur using the subarea MPI thresholds (defined in Step 3).
5. For each area or subarea, determine if the potential for MPI (identified in Step 4) occurs in 50 percent or more likelihood-weighted Projection Realizations. If this occurs, describe the drivers of the MPI and discuss the potential methods to avoid the MPI, including mitigation measures and/or a changed Safe Yield.

## 7.2 MPI ANALYSIS FOR THE TSY ENSEMBLE

This subsection describes the analysis of MPI that could be caused by the projected groundwater conditions of the TSY Ensemble for the MPI categories of:

- Land Subsidence
- Pumping Sustainability
- Loss of Hydraulic Control

### 7.2.1 Land Subsidence

Historically, permanent land subsidence, accompanied in some places by damaging ground fissuring, occurred across the western portion of the Chino Basin. Subsequent studies determined that the primary subsidence mechanism was permanent compaction of the aquifer-system sediments due to declines of groundwater levels that exceeded historical lows in groundwater levels (i.e., preconsolidation stress).

Historical aquifer-system compaction and land subsidence have generally been confined to the western portion of the Chino Basin where the underlying aquifer system is relatively rich in compressible clay layers (i.e., aquitards of varying thickness and lateral extent). To avoid future permanent land subsidence and ground fissuring, the Watermaster developed and implements an adaptive Subsidence Management Plan that defined five Areas of Subsidence Concern across western Chino Basin. Figure 7-1 is a map showing the five Areas of Subsidence Concern.

The Subsidence Management Plan includes a monitoring/testing program to understand the occurrences and mechanisms of the aquifer-system compaction and land subsidence, and based on this understanding, provides guidance to the pumpers and the Watermaster for groundwater management activities to minimize or abate the future occurrences of aquifer-system compaction and land subsidence. The program has shown that recent aquifer-system compaction primarily occurs due to head declines in the deeper portions of the aquifer system in the Areas of Subsidence Concern.

In this study, the potential for MPI due to land subsidence is analyzed in each Area of Subsidence Concern via comparison of projected groundwater elevations versus historical lows in groundwater elevations (or elevations previously identified in the Subsidence Management Plan as the preconsolidation stress for an

Area). The analysis preferentially focuses on the deeper portions of the aquifer system based on the results and conclusions of the monitoring/testing program.

#### *7.2.1.1 Site-Specific MPI Thresholds for Land Subsidence*

The first step to analyze for MPI associated with land subsidence (Step 2 of the MPI Analysis Methods) was to establish site-specific MPI thresholds at selected wells—herein referred to as land subsidence thresholds (LSTs). An LST is set at the historical low groundwater elevation measured at a well (or estimated based on trends in groundwater elevations at nearby wells). This was chosen to assume that groundwater elevations declining below the LST will cause new aquifer-system compaction in the vicinity of the well. The wells were preferentially chosen: (i) with well screens that penetrate the deeper portions of the aquifer system (the depths most susceptible to compaction) and (ii) to achieve an even spatial distribution across the Areas of Subsidence Concern. The exception is the PA-7 piezometer at the Ayala Park Extensometer in the Managed Area where, through extensive testing and data analysis, a "Guidance Level" elevation has been established as the preconsolidation stress threshold in the Subsidence Management Plan. Figure 7-1 is a map that shows the chosen wells and LST elevations across the five Areas of Subsidence Concern.

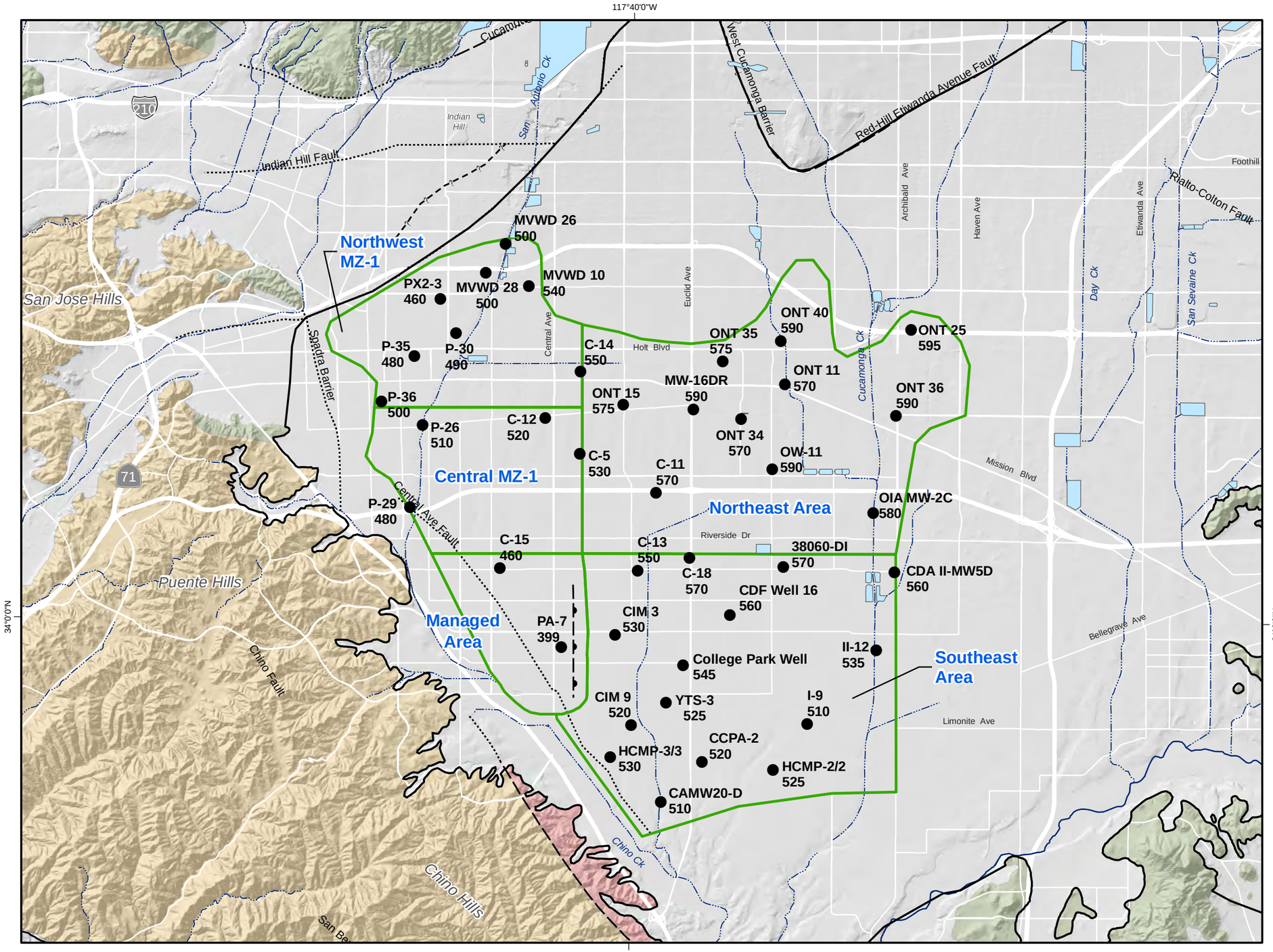
#### *7.2.1.2 Subarea MPI Thresholds for Land Subsidence*

The potential for MPI is identified by subarea (i.e., Area of Subsidence Concern). Therefore, the next steps to analyze for MPI associated with land subsidence (Steps 3, 4, and 5 of the MPI Analysis Methods) were to define the statistical thresholds for the occurrence of MPI in each Area of Subsidence Concern, for each Projection Realization, and for the entire TSY Ensemble:

- In each of the Areas of Subsidence Concern (excluding the Managed Area), MPI was identified if, by 2050, the projected groundwater elevation for CVM Layer 3 is below the LST at 50 percent or more of wells in 50 percent or more of the Projection Realizations in the TSY Ensemble.[4]
- For the Managed Area, MPI was identified if, by 2050, the projected groundwater elevation at the PA-7 piezometer is lower than the Guidance Level (399 ft-amsl) in more than 50 percent of the Projection Realizations in the TSY Ensemble.

The year 2050 was chosen for this MPI analysis because it reflects the time when managed storage is typically at or near zero in most projection realizations, and hence, groundwater levels are projected to be lowest. These criteria collectively account for the uncertainty in simulated groundwater elevations.

[4] Chino Well 15 was included with the wells used to evaluate MPI in Central MZ-1.




Well Name
550
Well with Land Subsidence Threshold (ft-amsl)

Area of Subsidence Concern

## Geology

*Water-Bearing Sediments*

Quaternary Alluvium

*Consolidated Bedrock*

Plio-Pleistocene Sedimentary Rocks

Cretaceous to Miocene Sedimentary Rocks

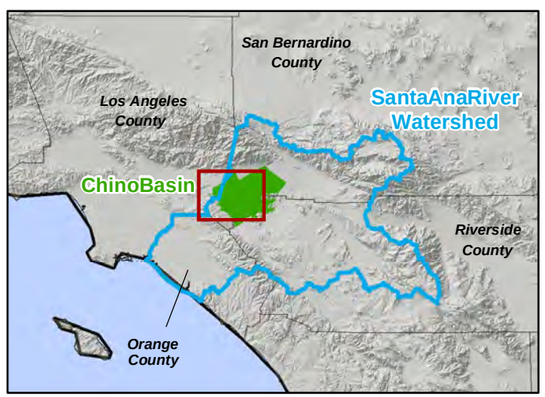
Pre-Tertiary Igneous and Metamorphic Rocks

Fault (solid where accurately located; dashed where approximately located or inferred; dotted where concealed)

## Hydrology

Streams & Flood Control Channels

Flood Control & Conservation Basins




Produced by:

WEST YOST
Water. Engineered.

Author: LMS
Date: 7/14/2025
Document Name: LST Analysis

0 1 2 3 4 5 Miles
0 2 4 6 8 KM

Prepared for:
**Chino Basin Watermaster**
2025 Safe Yield Reevaluation

**Site-Specific MPI Thresholds for Land Subsidence**

**Figure 7-1**

### 7.2.1.3 Results of MPI Analysis for Land Subsidence

Figures 7-2 through 7-5 are maps of each Area of Subsidence Concern (excluding the Managed Area) showing the likelihood-weighted average groundwater elevations for FY 2030 and 2050 relative to the LST for each monitoring well location. The wells are symbolized by color for distance above/below the LST. The figures also include:

- A "box-and-whiskers plot" that characterizes the distances above/below the LST for all wells by Projection Scenario (for all calibrated CVM realizations). Each dot represents one well in one Projection Realization. The red percentage at the bottom of the plot indicates the likelihood-weighted average percentage of groundwater elevations at all wells that are below the LST. These plots are useful in understanding the drivers of any identified MPI.
- A "heat map" of MPI by Projection Realization. Red squares indicate MPI associated with that Projection Realization. MPI for an Area of Subsidence Concern is identified if more than 50 percent of the Projection Realizations are determined to cause MPI (i.e., the projected groundwater elevation for CVM Layer 3 is below the LST at more than 50 percent of wells).

Figure 7-6 is a time-series chart of projected groundwater elevations at the PA-7 piezometer in the Managed Area for the TSY Ensemble and a heat map for all Projection Realizations. The chart shows that the likelihood-weighted average groundwater elevation at the PA-7 piezometer is always significantly higher (greater than 70 feet) than the Guidance Level (399 ft-amsl).

Based on the analysis above, the likelihood-weighted percentages of Projection Realizations that exceed the MPI threshold in FY 2050 for each Area of Subsidence Concern are:

- Central MZ-1: 7 percent
- **Northeast Area: 96 percent**
- Northwest MZ-1: 15 percent
- **Southeast Area: 97 percent**
- Managed Area: 0 percent

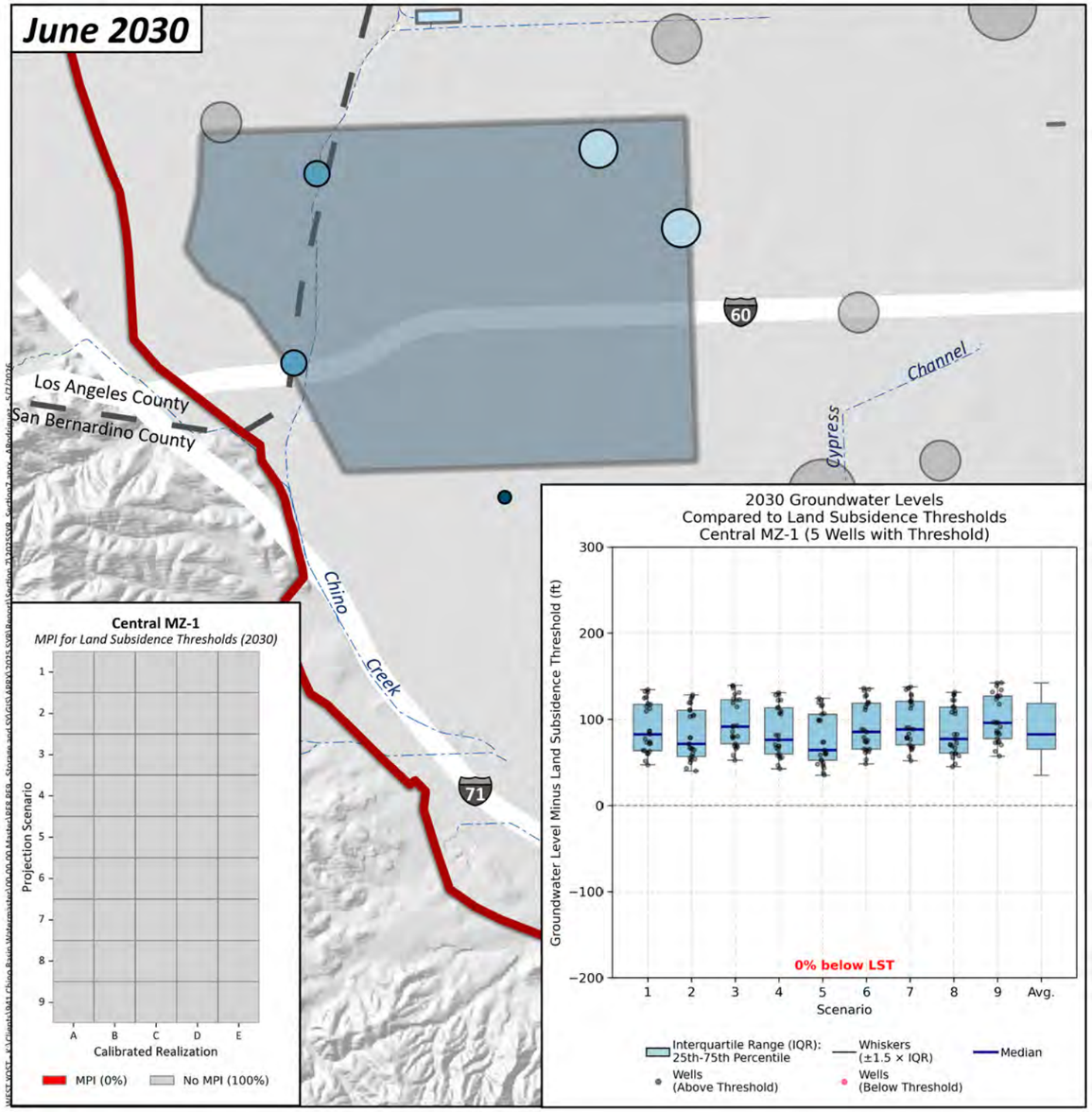
Hence, **the Northeast Area and the Southeast Area** have 50 percent or more likelihood-weighted Projection Realizations exceeding the subarea MPI threshold for land subsidence in FY 2050.

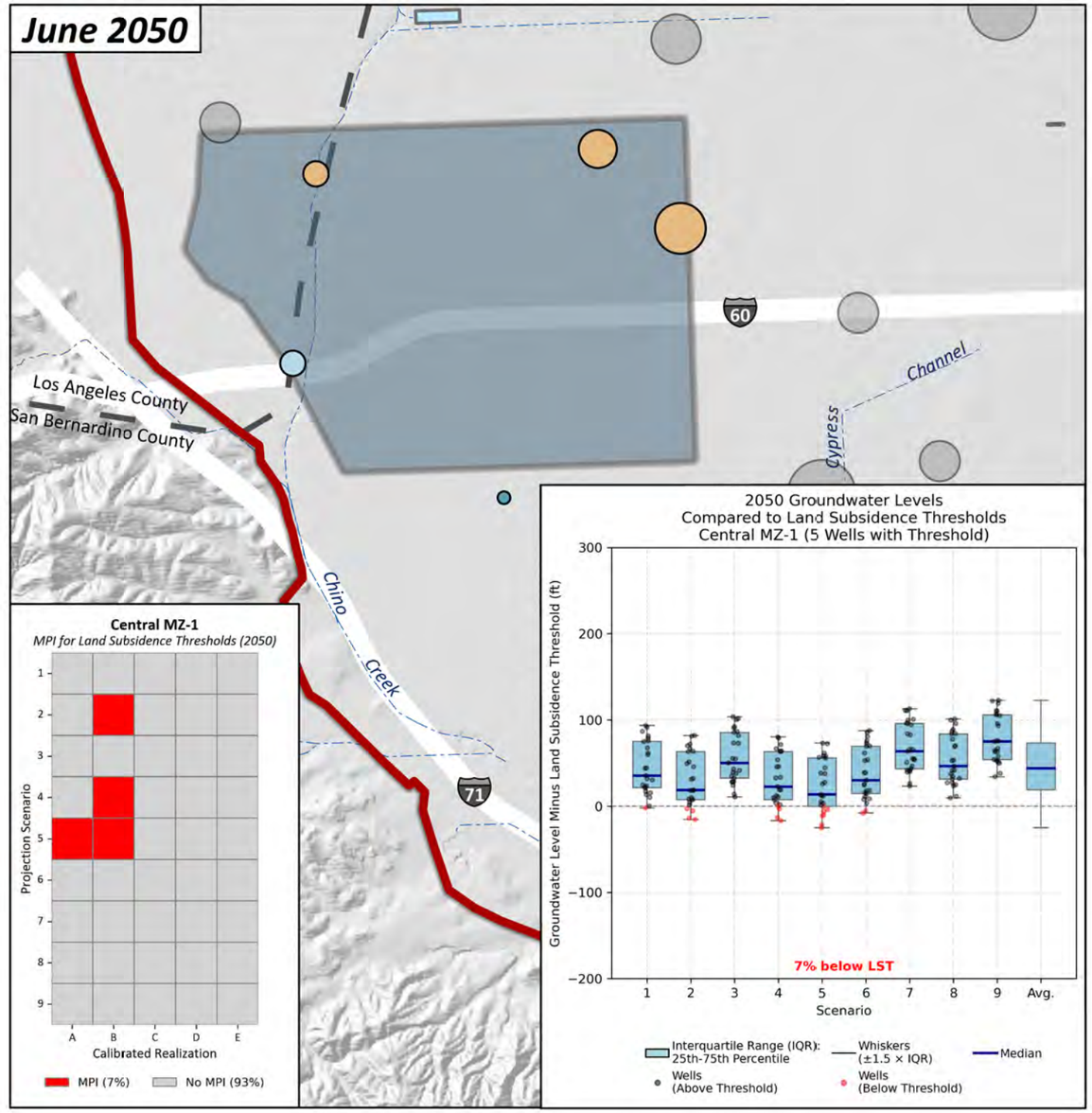
### 7.2.1.4 Discussion

Table 7-1 summarizes the MPI analysis for land subsidence, indicating the number of wells that have LSTs in each region, the average percentage of wells exceeding the LST for each scenario, and the likelihood-weighted average percentage of wells exceeding the LST for the TSY Ensemble. Figure 7-7 shows two heatmaps for all Projection Realizations depicting the number of Areas of Subsidence Concern with MPI (0 through 5) in FY 2030 and 2050.

**Table 7-1. Percentage of Wells Below Land Subsidence Thresholds, FY 2030 and FY 2050**

| Scenario | Likelihood Weight | Area of Subsidence Concern | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Central MZ-1 5 wells with LST Figure 7-2 | | Managed Area 1 well Figure 7-6 | | Northeast Area 11 wells Figure 7-3 | | Northwest MZ-1 8 wells Figure 7-4 | | Southeast Area 15 wells Figure 7-5 | |
| | | 2030 | 2050 | 2030 | 2050 | 2030 | 2050 | 2030 | 2050 | 2030 | 2050 |
| 1 | 4 | 0 | 4 | 0 | 0 | 11 | 91 | 0 | 5 | 24 | 84 |
| 2 | 2 | 0 | 16 | 0 | 0 | 26 | 100 | 0 | 23 | 45 | 93 |
| 3 | 2 | 0 | 0 | 0 | 0 | 0 | 80 | 0 | 0 | 8 | 75 |
| 4 | 2 | 0 | 16 | 0 | 0 | 15 | 100 | 0 | 18 | 25 | 97 |
| 5 | 1 | 0 | 28 | 0 | 0 | 47 | 100 | 0 | 23 | 53 | 100 |
| 6 | 1 | 0 | 8 | 0 | 0 | 6 | 95 | 0 | 10 | 11 | 87 |
| 7 | 2 | 0 | 0 | 0 | 0 | 2 | 53 | 0 | 0 | 19 | 64 |
| 8 | 1 | 0 | 0 | 0 | 0 | 16 | 86 | 0 | 3 | 35 | 79 |
| 9 | 1 | 0 | 0 | 0 | 0 | 0 | 27 | 0 | 0 | 8 | 33 |
| Likelihood-Weighted Average | | 0% | 7% | 0% | 0% | 12% | 84% | 0% | 8% | 25% | 81% |




0 0.5 1 Miles
0 1 2 Km

**Likelihood-Weighted Average Groundwater Level Above/Below the Land Subsidence Threshold (ft)**

- >100 ft
- 50–100 ft
- 0–50 ft
- 0 to -50 ft
- -50 to -100 ft
- <-100 ft

**Likelihood-Weighted Average Pumping (afy)**

- 0
- 1-100
- 101-500
- 501-1,000
- 1,001-2,000
- >2,000

**Other Layers**

- Other Wells
- 2025 CVM Domain
- Central MZ-1
- Rivers and Streams
- Flood Control and/or Conservation Basins

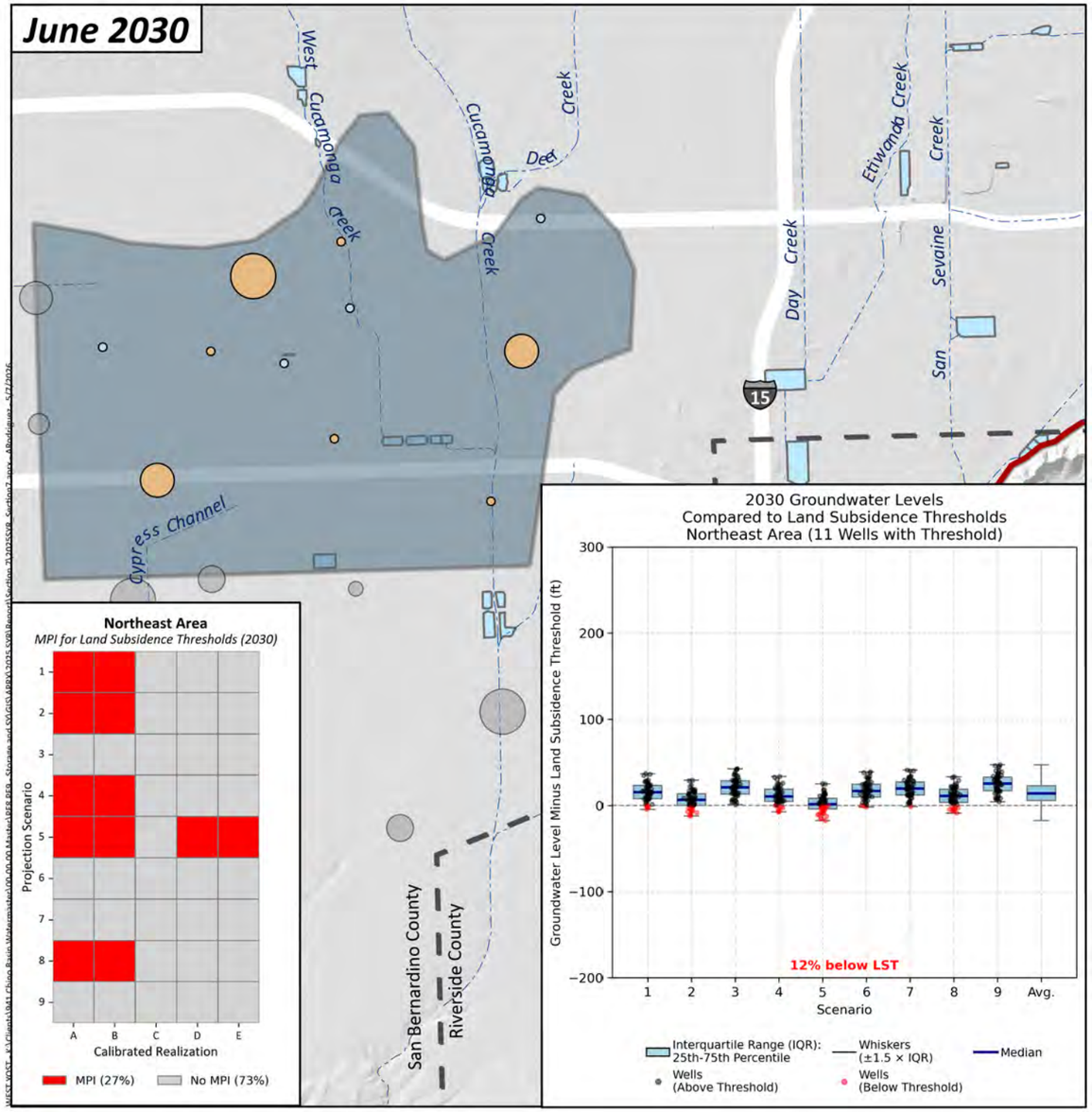
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Prepared for:
**Chino Basin Watermaster**
2025 Safe Yield Reevaluation

**Assessment of MPI due to Land Subsidence**
**2030 and 2050**
*Central MZ-1*

**Figure 7-2**

## June 2030

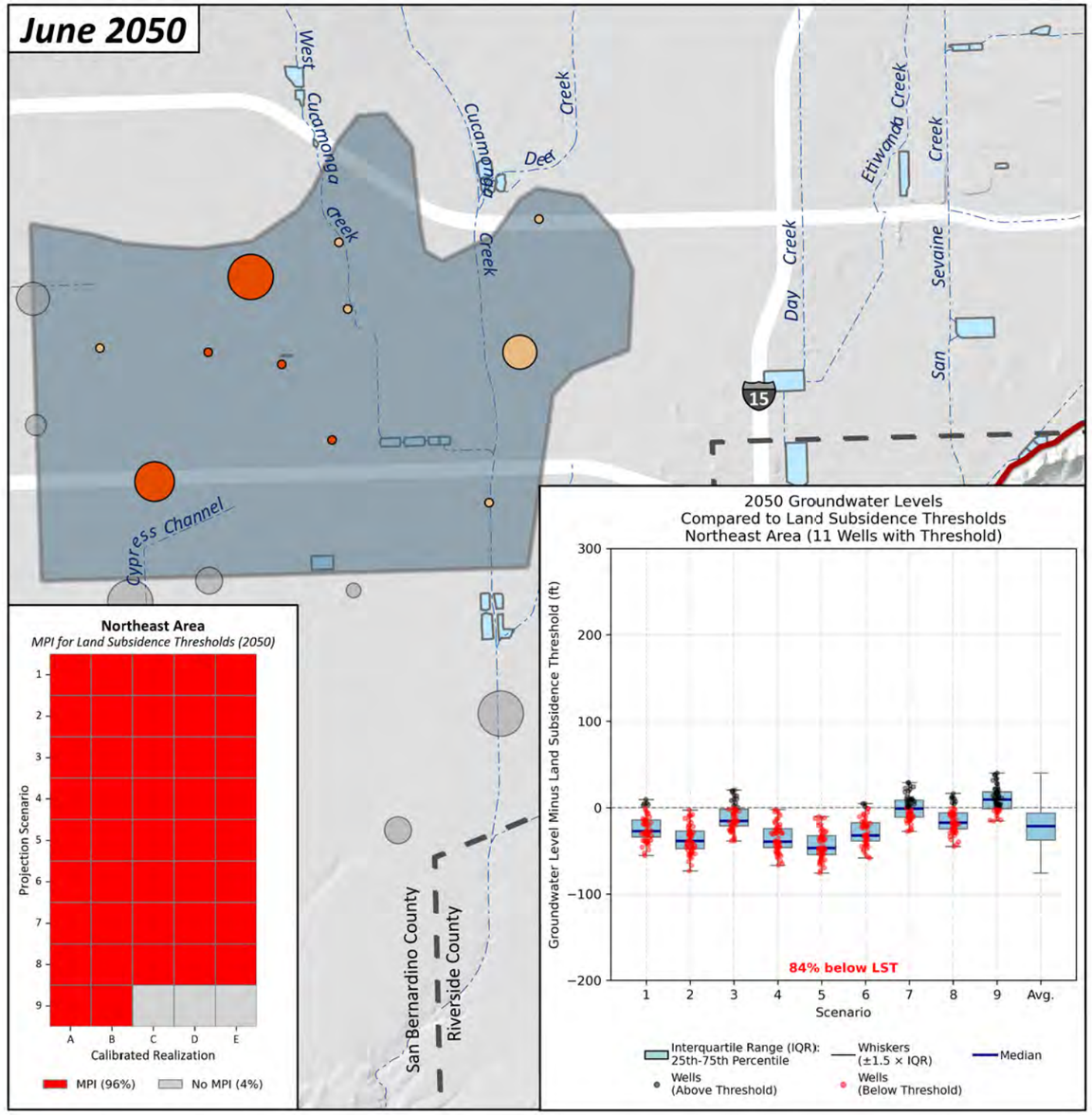








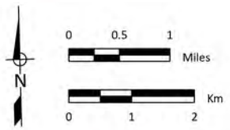

## June 2050










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**Likelihood-Weighted Average Groundwater Level Above/Below the Land Subsidence Threshold (ft)**

- >100 ft
- 50–100 ft
- 0–50 ft
- 0 to -50 ft
- -50 to -100 ft
- <-100 ft

**Likelihood-Weighted Average Pumping (afy)**

- 0
- 1-100
- 101-500
- 501-1,000
- 1,001-2,000
- >2,000

**Other Layers**

- Other Wells
- 2025 CVM Domain
- Northeast Area
- Rivers and Streams
- Flood Control and/or Conservation Basins

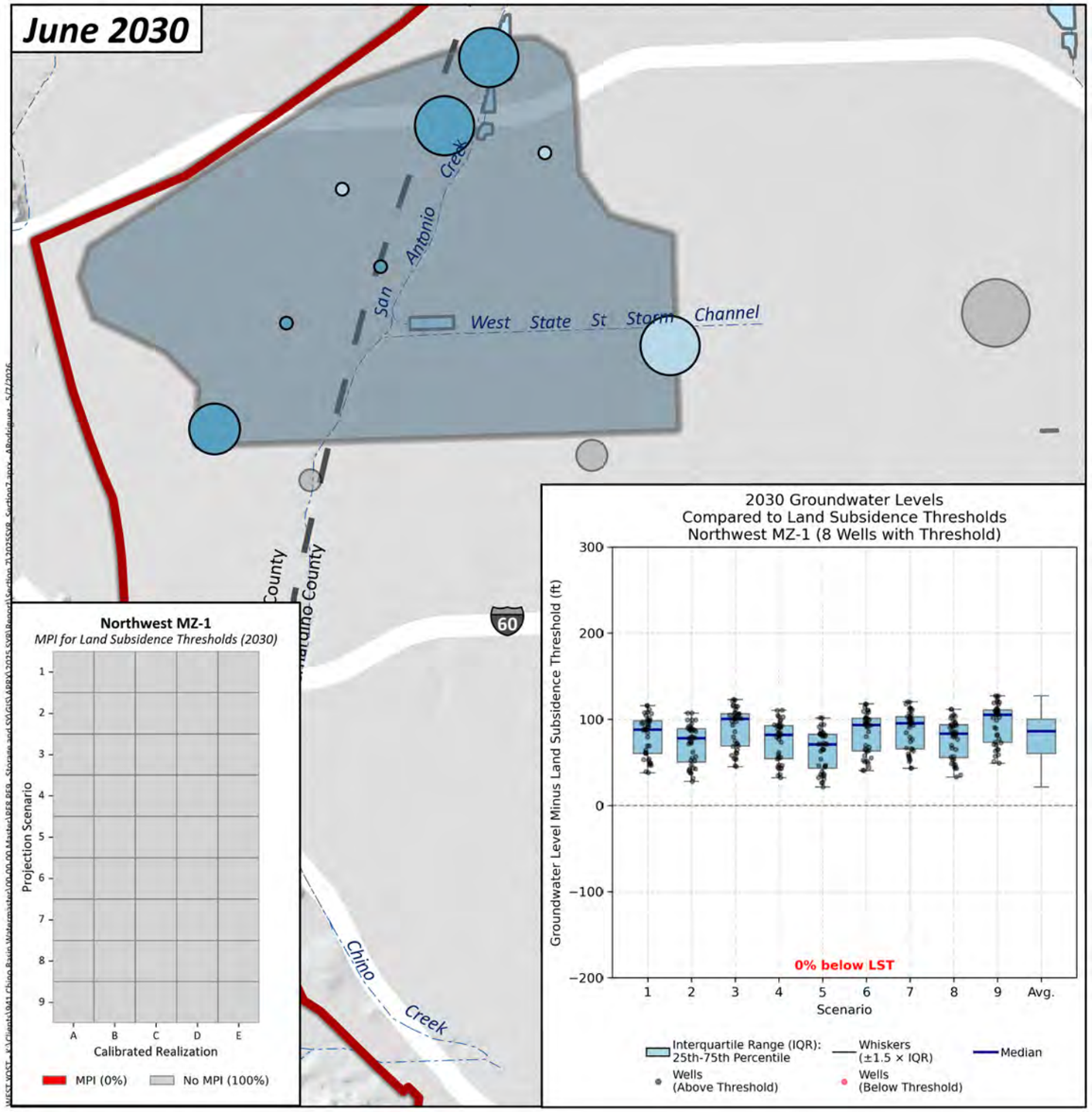
Prepared for:

**Chino Basin Watermaster**
2025 Safe Yield Reevaluation

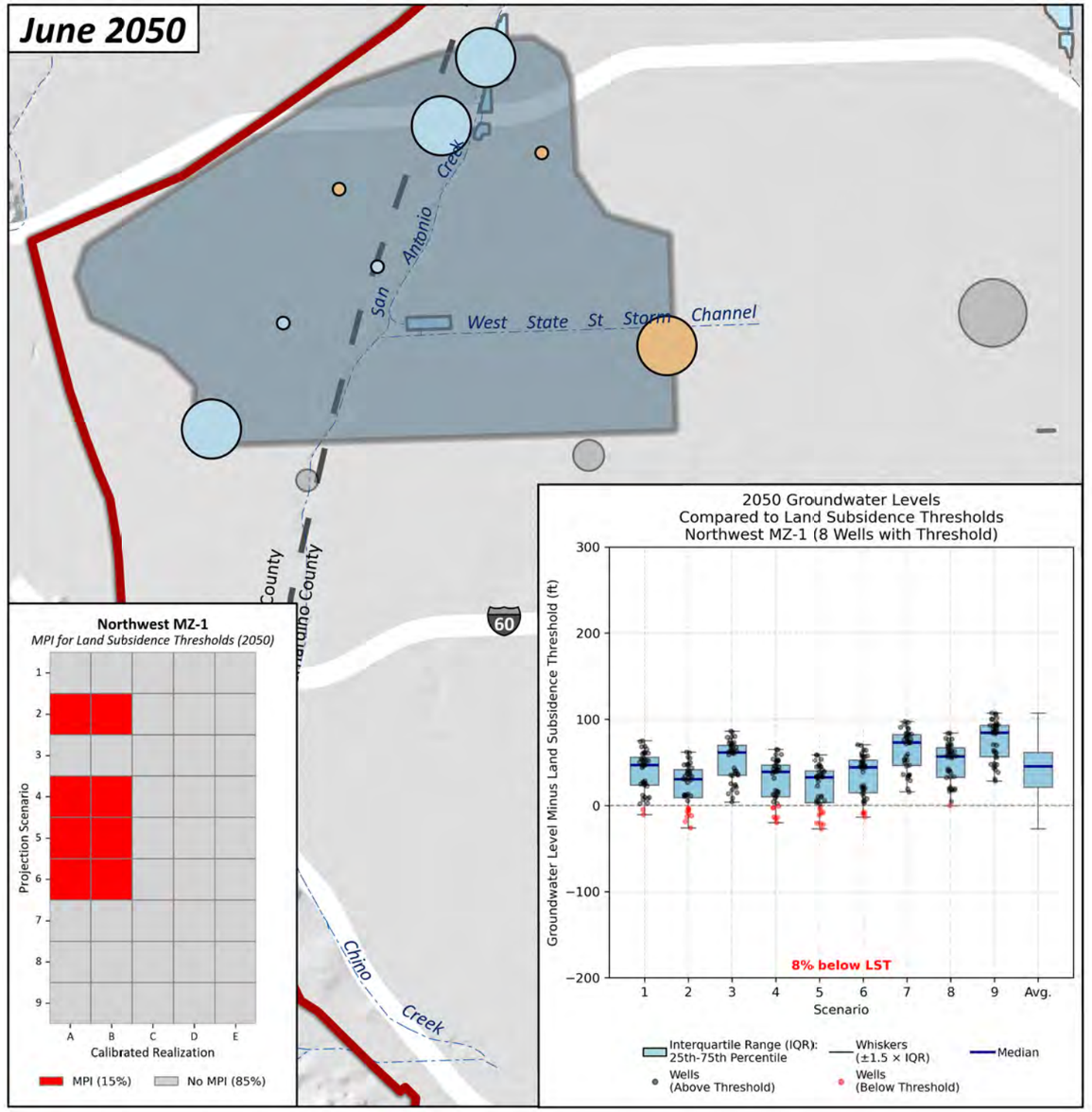
**Assessment of MPI due to Land Subsidence**
**2030 and 2050**
*Northeast Area*

**Figure 7-3**

## June 2030




## June 2050




0 0.5 1 Miles

0 1 2 Km

N

**Likelihood-Weighted Average Groundwater Level Above/Below the Land Subsidence Threshold (ft)**

- >100 ft
- 50–100 ft
- 0–50 ft
- 0 to -50 ft
- -50 to -100 ft
- <-100 ft

**Likelihood-Weighted Average Pumping (afy)**

- 0
- 1-100
- 101-500
- 501-1,000
- 1,001-2,000
- >2,000

**Other Layers**

- Other Wells
- 2025 CVM Domain
- Northwest MZ-1
- Rivers and Streams
- Flood Control and/or Conservation Basins

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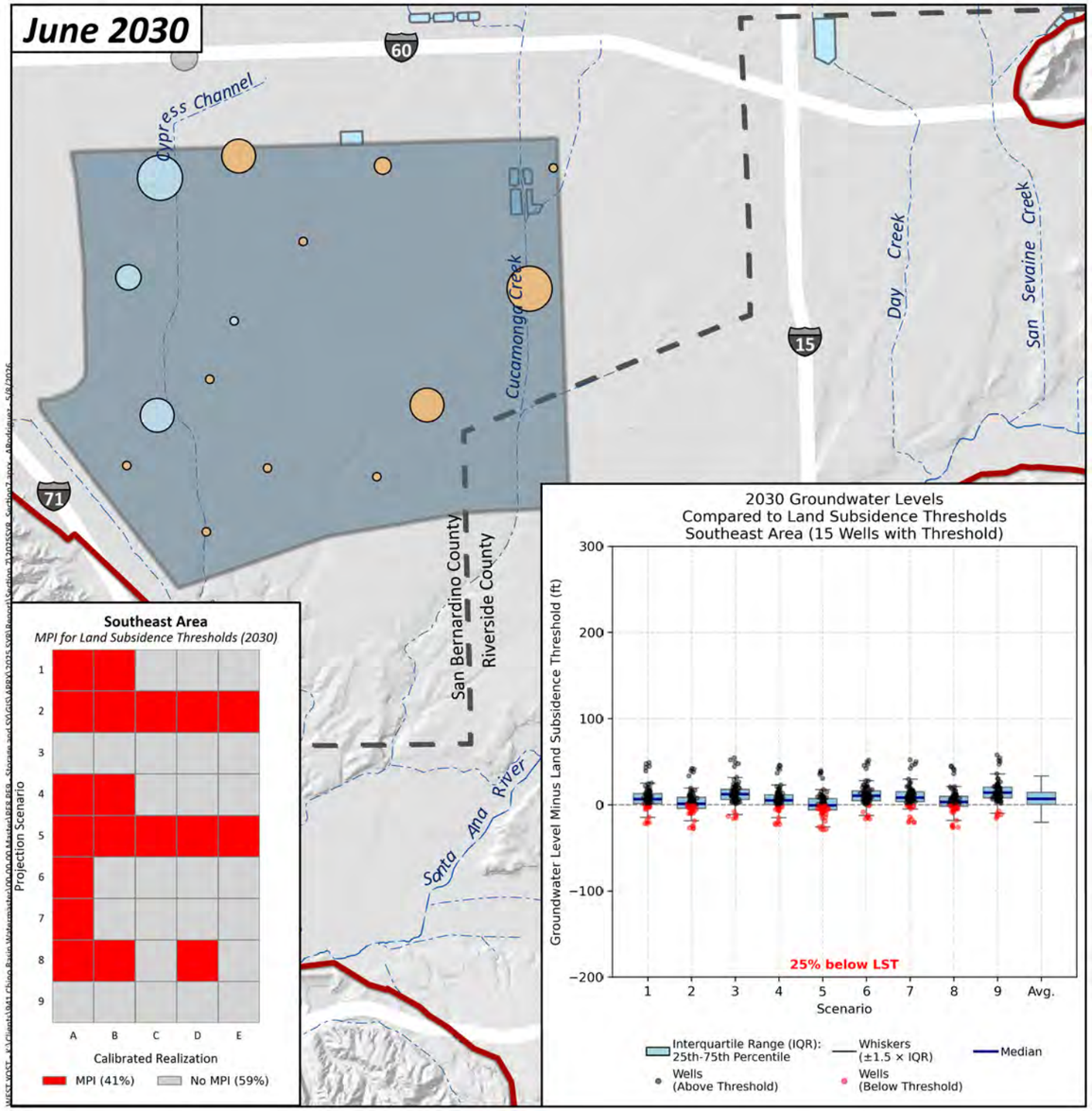
Prepared for:

**Chino Basin Watermaster**
2025 Safe Yield Reevaluation

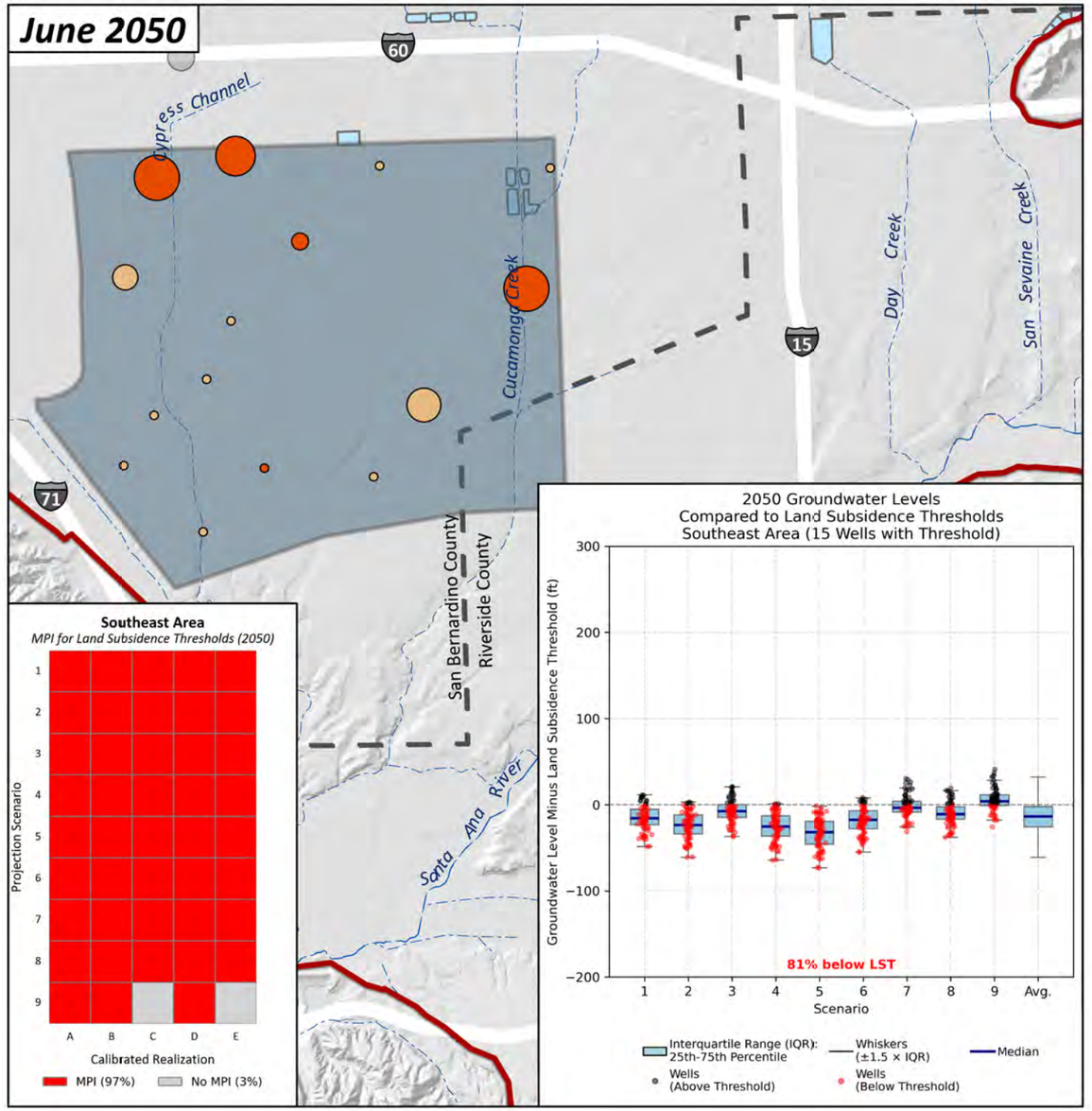
**Assessment of MPI due to Land Subsidence**
**2030 and 2050**
*Northwest MZ-1*

**Figure 7-4**

## June 2030




## June 2050




0 0.5 1 Miles

0 1 2 Km

N

Prepared by:

WEST YOST
Water. Engineered.

**Likelihood-Weighted Average Groundwater Level Above/Below the Land Subsidence Threshold (ft)**

- >100 ft
- 50–100 ft
- 0–50 ft
- 0 to -50 ft
- -50 to -100 ft
- <-100 ft

**Likelihood-Weighted Average Pumping (afy)**

- 0
- 1-100
- 101-500
- 501-1,000
- 1,001-2,000
- >2,000

**Other Layers**

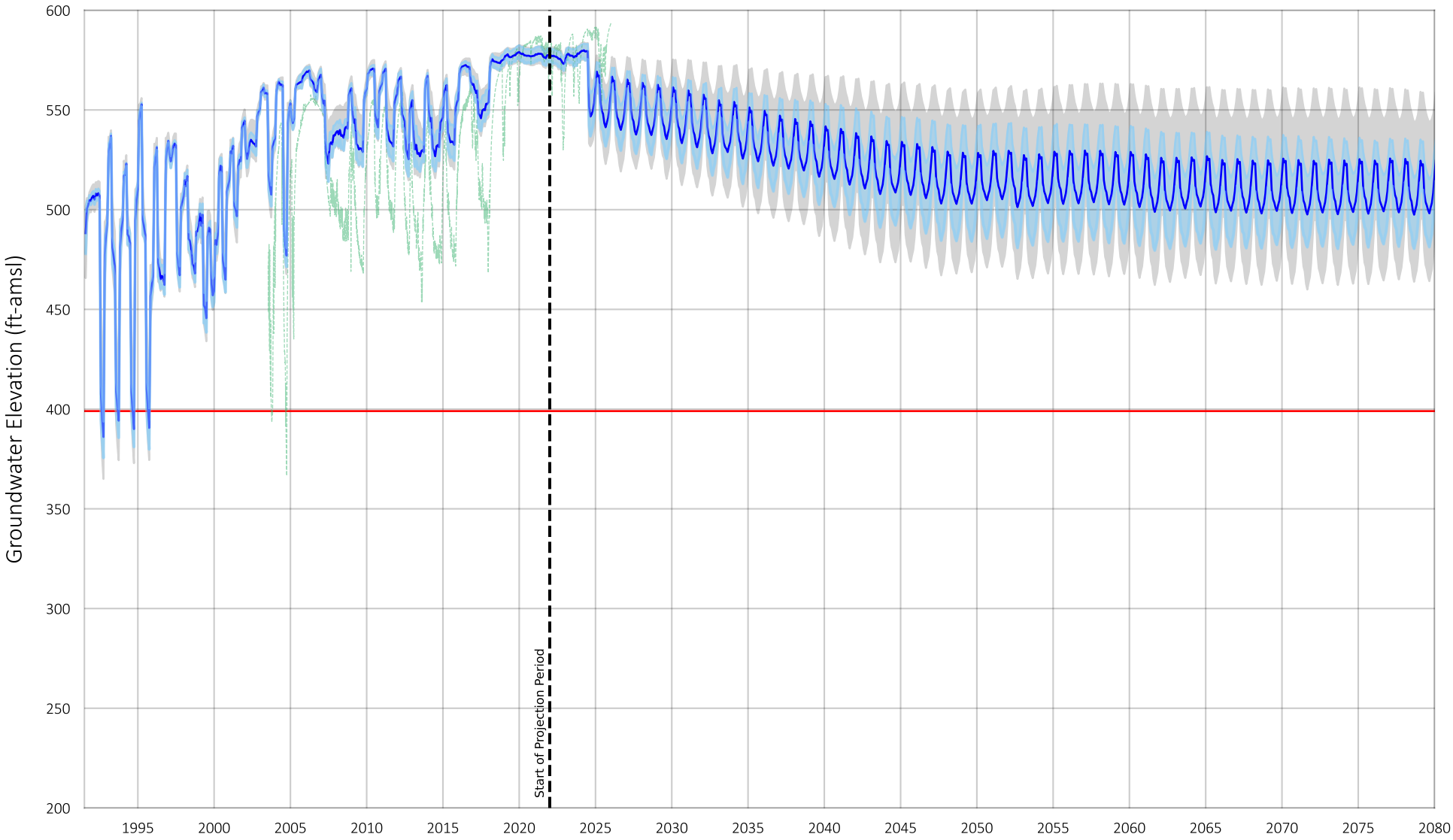
- Other Wells
- 2025 CVM Domain
- Southeast Area
- Rivers and Streams
- Flood Control and/or Conservation Basins

Prepared for:

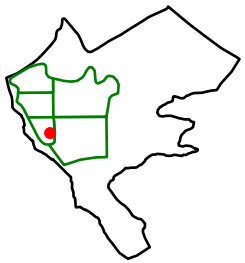
**Chino Basin Watermaster**
2025 Safe Yield Reevaluation

**Assessment of MPI due to Land Subsidence**
**2030 and 2050**
*Southeast Area*

**Figure 7-5**




Well Location &
Areas of Subsidence Concern



Legend

- Guidance Level
- Measured Groundwater Elevation
- Likelihood Weighted Mean Groundwater Elevation
- Minimum/Maximum Range in Simulated Groundwater Elevations
- 20th to 80th Percentile of Simulated Groundwater Elevations

Prepared by:

WEST YOST
Water. Engineered.

Simulated Groundwater Levels
Well Name: AP-PA7
Well Owner: Chino Basin Watermaster
Screen Interval (ft-bgs): 438 - 448

Figure 7-6

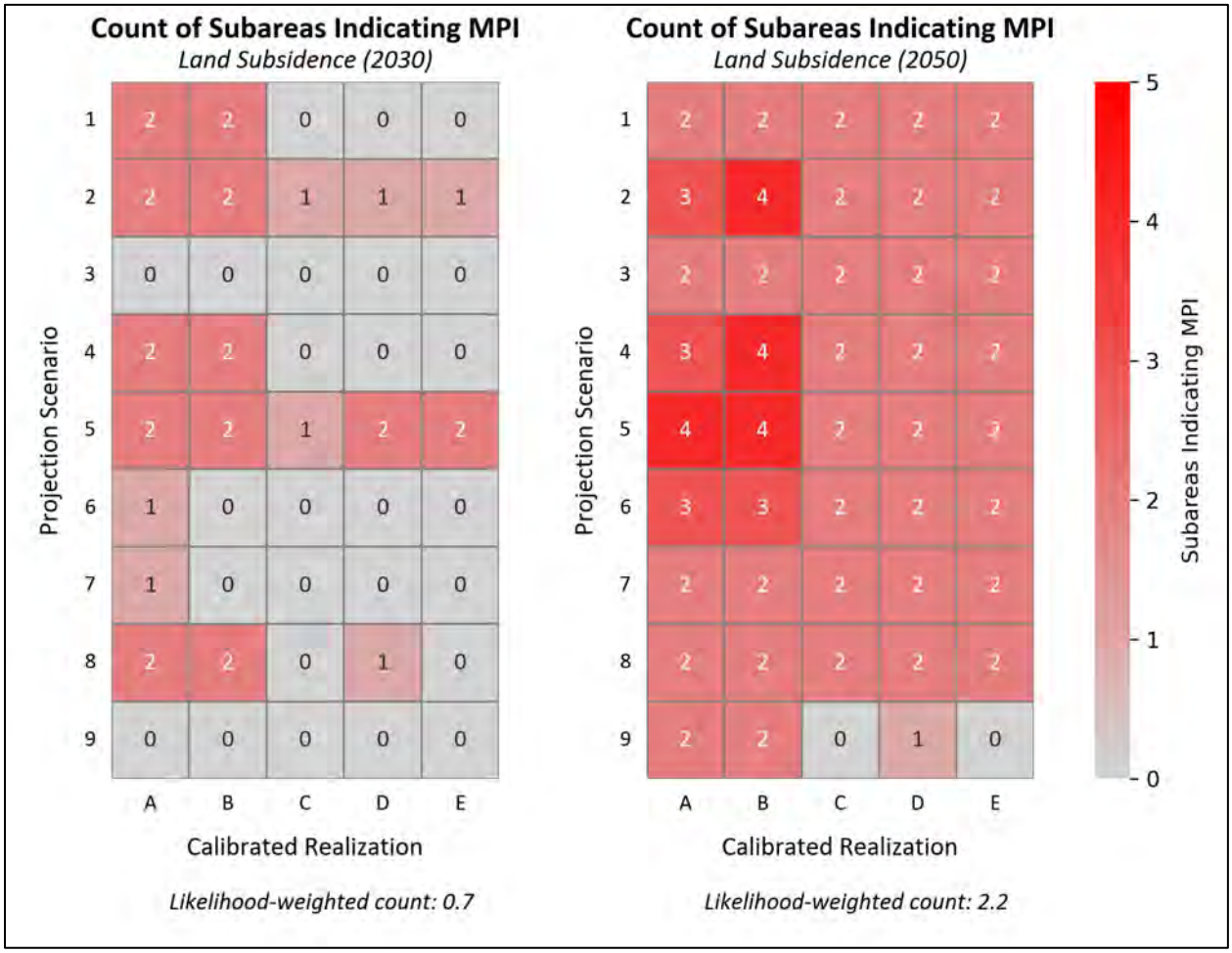



**Figure 7-7. Count of Subareas Indicating MPI for Land Subsidence for the TSY Ensemble (FY 2030 and 2050).**

Figure 7-7 shows that subsidence-related MPI increases from an average of 0.7 subareas in FY 2030 to 2.2 subareas in FY 2050. The degree of MPI varies between Projection Realizations, having the highest incidence in High Demand Scenarios (Projection Scenarios 4, 5, and 6) and the Hot/Dry Climate Scenarios (Scenarios 2 and 5).

### 7.2.1.4.1 Drivers of MPI for Land Subsidence

The primary drivers of MPI due to land subsidence are the extraction of water from managed storage (and high demand) and a hotter/drier climate.

Figure 7-8 shows the direct relationship between declining storage and the increasing MPI due to land subsidence, depicting the average change in storage from FY 2021-2050 versus the average number of subareas indicating MPI for land subsidence in FY 2050 for several subgroups of Projection Realizations.

- The High Demand Projection Realizations (Scenarios 4, 5, and 6) indicate MPI at an average of 2.6 subareas, compared to 1.7 subareas and 2.2 subareas for the Low Demand and Expected Demand Projection Realizations, respectively.

- The number of subareas indicating MPI increases by a factor of 1.8 (High Demand) to 3.2 (Low Demand) from FY 2030 to FY 2050.
- In all High Demand Projection Realizations, the balance of managed storage is zero by 2050, whereas the average managed storage is 409,000 af and 146,000 af in 2050 for the Low Demand and Expected Demand Projection Realizations, respectively.

Climate also drives subsidence-related MPI, but to a lesser degree than demand. The Hot/Dry Climate Projection Realizations (Scenarios 2, 5, and 8) indicate MPI at an average of 2.5 subareas, compared to 1.8 subareas and 2.2 subareas for the Cool/Wet and Average Climate Scenarios, respectively.

#### 7.2.1.4.2 Potential Methods to Avoid or Mitigate MPI due to Land Subsidence

The analysis above indicates that the groundwater-level declines that could lead to subsidence-related MPI are mainly driven by future extractions of groundwater from managed storage. These extractions from managed storage may be accelerated under hot/dry climate conditions and/or greater than expected water demands, but the extractions from managed storage are predicted to be the primary driver of future land subsidence. As discussed below in Section 7.3.2, a changed Safe Yield ***is not*** the most effective method to mitigate the potential for subsidence-related MPI. Instead, the Watermaster has the ability to employ alternative methods to mitigate the potential for MPI due to land subsidence, which include: subsidence management planning and implementation; recharge master planning and implementation; and storage management planning and implementation for both local storage and regional storage and recovery programs. Each method is summarized below:

- **Subsidence Management**. The Watermaster implements a Court-approved, adaptive Subsidence Management Plan under the supervision and guidance of a technical advisory committee called the Ground-Level Monitoring Committee (GLMC). The Subsidence Management Plan includes an adaptive monitoring and reporting program and guidance for subsidence management in certain Areas of Subsidence Concern. For example, through an extensive aquifer-system monitoring and testing investigation, the Subsidence Management Plan includes a "guidance" groundwater elevation for the deep aquifer system in the Managed Area. Maintaining groundwater elevations above the "guidance" level will avoid future land subsidence. The Watermaster monitors and reports on groundwater elevations in the Managed Area, so the pumpers in this area can voluntarily modify their pumping patterns to keep groundwater elevations above the "guidance" level. Similar efforts could be employed in other Areas of Subsidence Concern to minimize or avoid subsidence-related MPI.
- **Recharge Master Planning**. The Watermaster periodically updates a Recharge Master Plan that designs, evaluates, and recommends recharge improvement projects with the goals to enhance basin yield, manage groundwater levels, and improve water quality. Future updates to the Recharge Master Plan could include projects that support groundwater levels in areas predicted to experience subsidence-related MPI. The Recharge Master Planning process also provides an avenue through which Watermaster can meet its Peace Agreement obligations to ensure sufficient recharge capacity and direct recharge in the Basin.[5]

[5] See Sections 5.1(e)(ii) and 5.1(e)(iii) of the Peace Agreement.

- **Storage Management**. The Judgment provides the Watermaster with the authority to manage and control storage for both local storage by the parties and regional storage and recovery programs. To guide Watermaster's efforts to manage storage pursuant to its obligations in the Judgment and Peace Agreement, the Watermaster has developed and periodically updates a Storage Management Plan. Future updates to the Storage Management Plan could include projects, programs, and/or provisions that support groundwater levels in areas predicted to experience subsidence-related MPI. In addition, the Storage Management Plan can help facilitate Watermaster to meet its Peace Agreement obligations to evaluate MPI due to transfers from storage.[6]

## 7.2.2 Pumping Sustainability

Pumping sustainability is the ability to produce groundwater from a specific well at a desired pumping rate, given the groundwater level at that well, the well construction details, and the current pumping equipment. Pumping sustainability thresholds (PSTs) are groundwater levels that are defined by the producer for each well. Watermaster collects this information from the larger Appropriative Pool parties and the Chino Basin Desalter Authority (CDA). The Appropriative Pool parties typically specify PSTs as an elevation representing a depth above the pump setting elevation of a well (e.g., 40 feet above the pump setting elevation). Groundwater pumping at a well is assumed to be sustainable if the groundwater elevation at that well remains above the PST. If the projected groundwater elevation declines below (exceeds) the PST, the well owner will either lower the pumping equipment in their well, reduce pumping, or a combination of the two. The PST is the site-specific MPI threshold for pumping sustainability.

### *7.2.2.1 Evaluation Criteria and Methods*

MPI can be defined by a combination of the (1) number of impacted wells (i.e., wells that exceed the PST), (2) duration of impact, and/or (3) magnitude of impact (i.e., the difference between the projected groundwater level and the PST) within each management zone, area, or subarea. Because the concept of pumping sustainability is subjective and varies among different parties, it is necessary for Watermaster to develop a comprehensive definition of the pumping sustainability MPI thresholds.

#### 7.2.2.1.1 Party Input to Develop Site-Specific and Subarea MPI Thresholds

The parties have discretion as to their individual definitions of pumping sustainability. Therefore, as part of this process, Watermaster requested responses to the following questions from 12 of the Appropriative Pool parties for which PSTs are defined[7]:

1. How many of your wells need to fall below the sustainability metric[8] before it becomes difficult to pump the desired amount of groundwater?

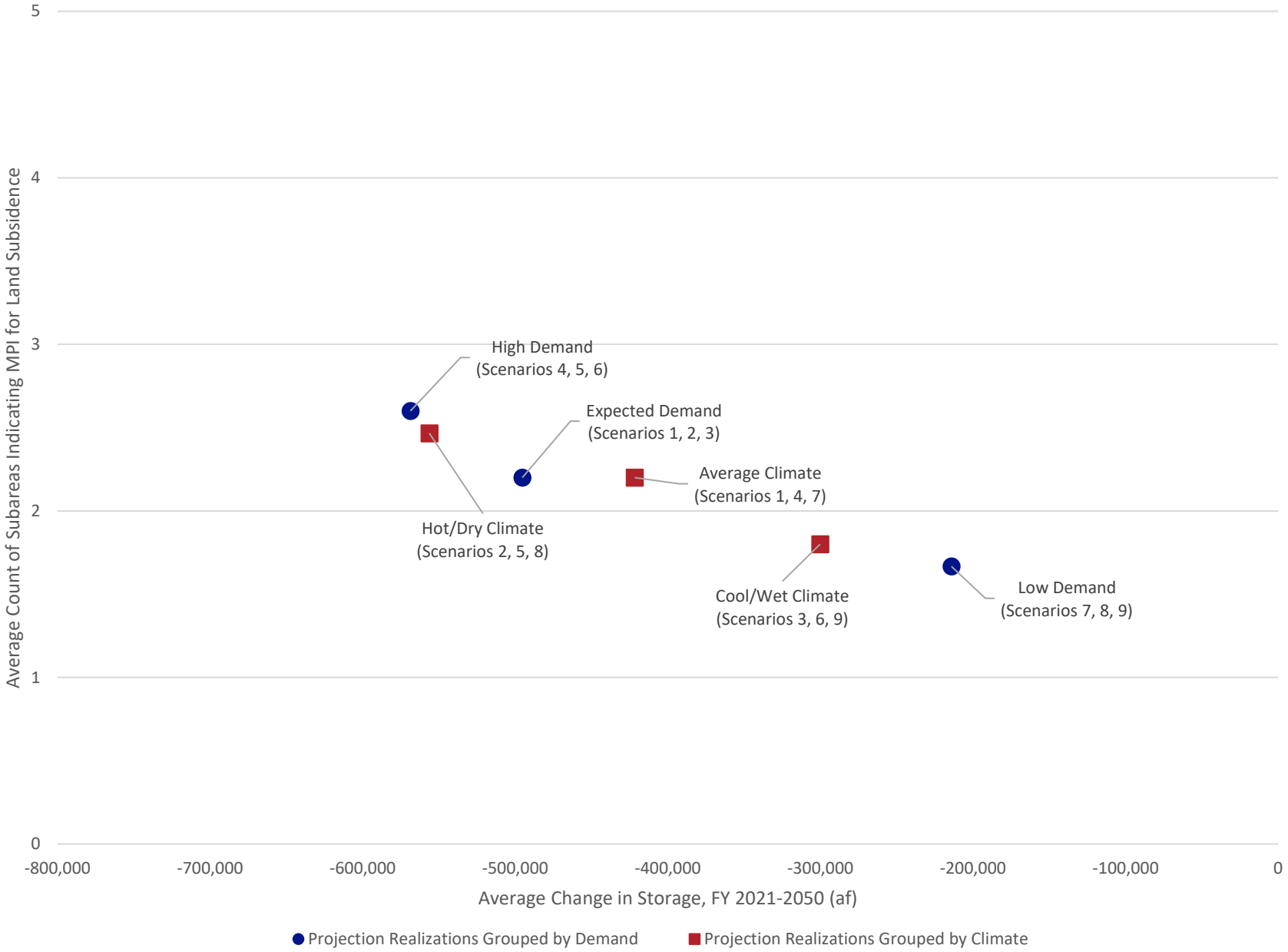
[6] See Section 5.1(e)(iv) of the Peace Agreement.

[7] Watermaster's Engineer contacted the Chino Desalter Authority, the cities of Chino, Chino Hills, Ontario, Pomona, and Upland, Monte Vista Water District, Jurupa Community Services District, Fontana Water Company, Cucamonga Valley Water District, Golden State Water Company, and San Antonio Water Company.

[8] This report uses the term "thresholds" to describe pumping sustainability, whereas the term "metrics" has been used historically by Watermaster and was used for the information request.

2. How long (in months or years) must the groundwater level at a single well remain below the sustainability metric before it becomes challenging to pump the desired amount of groundwater?

**Figure 7-8. Change in Storage and Prevalence of MPI for Land Subsidence**



Watermaster contacted the applicable Appropriative Pool parties to (1) answer the two questions above and (2) update or confirm information on their party's active production wells in the Chino Basin. Other parties (e.g., the State of California) were also invited to provide input related to the PSTs. A summary of the feedback from the parties is as follows:

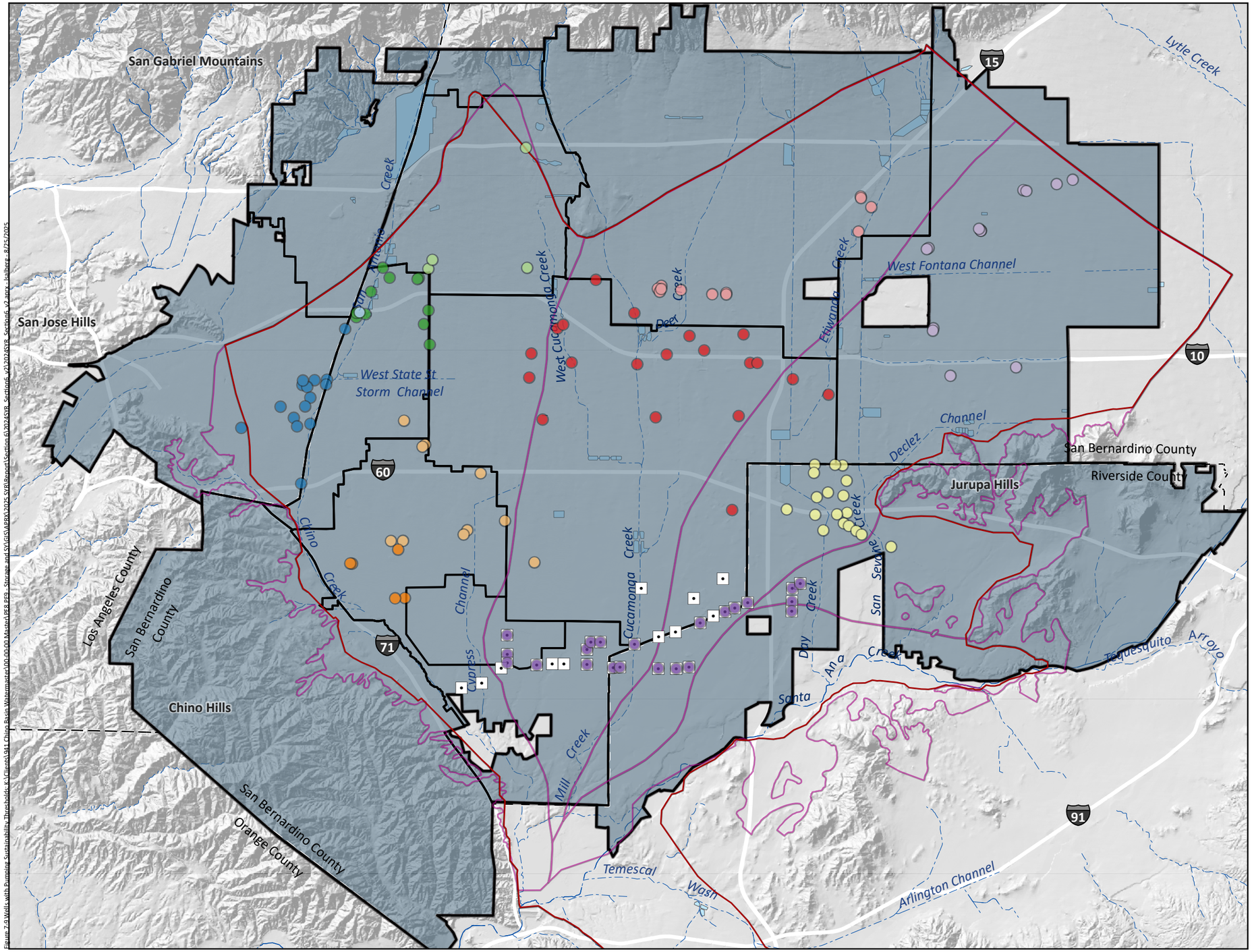
- **Adaptive Management**: The parties employ various strategies to maintain production, such as adjusting pump settings, adding extensions, and regularly rehabilitating wells.
- **Uncertainty**: The parties indicated significant uncertainty in predicting the exact impact and duration of wells falling below sustainability thresholds. Challenges contributing to this uncertainty include water quality, demands, and availability of other supplies.
- **Mitigation Efforts**: The parties discussed measures like system resiliency and redundancy, to ensure continued pumping operations and groundwater supply.
- **Duration Below PST**: The time a well can remain below the PST before it becomes challenging to pump groundwater varies widely. Some parties indicate that wells can operate below the PST for years with careful monitoring, while others suggest that concerns arise within months, especially under different hydrologic conditions. The exact duration is often uncertain due to numerous influencing factors.

Table 7-2 documents the feedback received from the parties that responded to the request regarding pumping sustainability. Figure 7-9 shows the wells in the Chino Basin that have PSTs.

#### 7.2.2.1.2 Subarea Threshold for MPI Due to Pumping Sustainability

The subareas for evaluating pumping sustainability are the wellfields for each of the AP parties for which PSTs are defined. The diversity of responses to questions regarding PSTs suggests that applying a single, generalized threshold to assess the risk of MPI due to pumping sustainability challenges may not be appropriate. Consequently, we evaluate the risk of MPI for the 12 retail AP parties using one of two approaches: (1) the party's individual definition of pumping sustainability, based on their responses to the above questions, or (2) if a party did not provide a clear response, by assessing the proportion of their well field that exceeds the PST for at least five consecutive years. Five years was chosen to acknowledge the uncertainty in simulated groundwater levels and ensure that short-term or anomalous conditions do not skew the assessment of sustainability.

Table 7-2 shows how the party feedback was interpreted to define criteria to evaluate MPI due to pumping sustainability for each party. The criteria include the minimum number of wells that exceed the PST and the consecutive time over which the wells must exceed the PST for MPI to occur. MPI for a party is identified if 50 percent or more Projection Realizations are determined to cause MPI based on the party-specific definition.




**Wells with Pumping Sustainability Thresholds**

- Golden State Water Company
- City of Pomona
- City of Upland
- Monte Vista Water District
- Cucamonga Valley Water District
- City of Ontario
- City of Chino
- City of Chino Hills
- Fontana Water Company
- Jurupa Community Services District
- Chino Basin Desalter Authority
- Other CDA Wells
- Rivers and Streams
- Flood Control and or Conservation Basins
- County Boundary
- 2025 CVM Domain
- Water Service Areas




OBMP Management Zones




Prepared by:

WEST YOST

0 2 4 Miles

0 3 6 Km

Prepared for:

**Chino Basin Watermaster**
**2025 Safe Yield Reevaluation**

**Wells with Pumping Sustainability Thresholds**

**Figure 7-9**

CHINO BASIN WATERMASTER
Case No. RCVRS 51010
Chino Basin Municipal Water District v. City of Chino, et al.

# PROOF OF SERVICE

I declare that:

I am employed in the County of San Bernardino, California. I am over the age of 18 years and not a party to the action within. My business address is Chino Basin Watermaster, 9641 San Bernardino Road, Rancho Cucamonga, California 91730; telephone (909) 484-3888.

On October 14, 2026, I served the following:

1. EXHIBIT A - PART 3 OF 4
   TO DECLARATION OF GARRETT RAPP IN SUPPORT OF MOTION REGARDING 2025 SAFE YIELD REEVALUATION, AMENDMENT OF RESTATED JUDGMENT, PARAGRAPH 6

/ X / BY MAIL: in said cause, by placing a true copy thereof enclosed with postage thereon fully prepaid, for delivery by the United States Postal Service mail at Rancho Cucamonga, California, addresses as follows:
***See attached service list:*** Mailing List 1

/___/ BY PERSONAL SERVICE: I caused such envelope to be delivered by hand to the addressee.

/___/ BY FACSIMILE: I transmitted said document by fax transmission from (909) 484-3890 to the fax number(s) indicated. The transmission was reported as complete on the transmission report, which was properly issued by the transmitting fax machine.

/ X / BY ELECTRONIC MAIL: I transmitted notice of availability of electronic documents by electronic transmission to the email address indicated. The transmission was reported as complete on the transmission report, which was properly issued by the transmitting electronic mail device.
***See attached service list:*** Master Email Distribution List

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

Executed on October 14, 2026, in Rancho Cucamonga, California.

By: Ruby Favela Quintero
Chino Basin Watermaster

PAUL HOFER
11248 S TURNER AVE
ONTARIO, CA 91761

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## Ruby Favela Quintero

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