Borrego Springs Watermaster
Technical Advisory Committee Meeting
December 18, 2023
AGENDA ITEM VI

To: Technical Advisory Committee (TAC)

From: Andy Malone, PG (West Yost), Technical Consultant

Date: December 11, 2023

Subject: Discuss Potential Methods for Task 5 to Redetermine the Sustainable Yield – *Determine the Sustainable Yield*

Background

The Judgment defines the Sustainable Yield of the Borrego Springs Subbasin (Basin) consistent with SGMA (Water Code, § 10721(w)) as: "The maximum quantity of water, calculated over a base period representative of long-term conditions in the Basin, that can be cumulatively pumped on an annual basis from the Basin without causing an Undesirable Result." The Judgment also requires the Sustainable Yield be redetermined by January 1, 2025, and every five years thereafter through 2035. If the redetermination results in a changed Sustainable Yield, then the Rampdown rate is adjusted accordingly to bring pumping in the Basin within the Sustainable Yield by 2040.

The Borrego Valley Hydrologic Model (BVHM) and its supporting tools, the Basin Characterization Model (BCM) and the Farm Process (FMP), were originally developed by the United States Geological Survey (USGS) and were used to improve the hydrogeologic understanding of the Basin and evaluate future management scenarios that would eliminate conditions of overdraft (initial BVHM).[1]

The initial BVHM was updated and extended by Dudek and used to simulate historical groundwater conditions in the Basin from October 1929 through September 2016 (2016 BVHM).[2] Dudek estimated average inflows of 6,770 acre-feet per year (afy) from 1945–2016 and determined that this was a reasonable estimate of inflows because it captured a wide range of climatic conditions. Dudek estimated average outflows (besides pumping) to be 1,021 afy for the most recent 10 years (2007–2016) and determined that this was representative of current outflows because the change in land use (i.e., loss of native phreatophytes) had decreased outflow from evapotranspiration in the Basin over the model period. Using these assumptions, the difference between inflows over outflows for the Basin was estimated to be approximately 5,750 afy.

Based on these studies, Section II.E of the Judgment established the initial Sustainable Yield at 5,700 afy. The studies also included future projections of groundwater conditions under various future land

[1] USGS. 2015. *Hydrogeology, Hydrologic Effects of Development, and Simulation of Groundwater Flow in the Borrego Valley, San Diego County, California*. Scientific Investigations Report 2015–5150.
[2] DUDEK. 2019. *Update to USGS Borrego Valley Hydrologic Model for the Borrego Valley GSA (draft final)*. Prepared for the County of San Diego, Planning and Development Services.

use, water use, and climatic conditions, which were used to set sustainable management criteria in the Groundwater Management Plan (GMP) (*e.g.,* Minimum Thresholds for groundwater elevations).

During the August 29, 2023 TAC meeting, the TAC began to discuss the appropriate period to redetermine the Sustainable Yield in 2025, noting that the period should be multi-year to multi-decadal because (i) a long time-period is required by the Sustainable Management Groundwater Act (SGMA) and (ii) desert environments, such as Borrego Springs, experience infrequent but significant storm events and a longer period is required to capture the important effect of these storm events on recharge.

For the November 1, 2023 TAC meeting, West Yost prepared a technical memorandum (TM) and facilitated continued discussion on this topic. Following the November 1, 2023, some TAC member submitted written comments and feedback, which are summarized in Exhibit 1. Below is a summary of the topics discussed and TAC feedback:

1. What domain of the BVHM should be used to estimate water budget of the Basin, and hence, form the basis of redetermined Sustainable Yield? The BVHM domain currently covers an area containing both the Borrego Valley Subbasin and the Ocotillo Wells Subbasin.

   TAC Feedback: The model domain containing only the Borrego Springs Subbasin should be used to calculate the water budget of the Basin. The model domain overlying the Ocotillo Wells Subbasin should be excluded from the calculation of the water budget and Sustainable Yield.

2. Should the Sustainable Yield be based on the long-term annual average recharge to the Basin or long-term annual average *net* recharge (accounting for natural discharge) as estimated by the BVHM?

   TAC Feedback: The Sustainable Yield should be based on the long-term annual average *net* recharge, where outflows from the model domain (evapotranspiration of shallow groundwater and subsurface outflow) are subtracted from inflows (stream recharge, unsaturated zone recharge, and subsurface inflow). These water budget components are consistent with those listed in Table 2.2-9 *Estimated Surplus of Inflows Over Outflows* in the GMP, which was used to establish the current Sustainable Yield of 5,700 afy. Table 1 is an excerpt of Table 2.2-9 from the GMP and identifies the annual average inflows and outflows calculated by the BVHM.

Table 1. Excerpt from GMP Table 2.2-9 *Estimated Surplus of Inflows Over Outflows*

Water Budget Components	Acre-Feet/Year
INFLOWS (Model Update 1945- 2016)	
Stream Recharge	3,905
Unsaturated Zone Recharge	1,497
Underflow (Inflow from Adjacent Basins)	1,367
Total Inflows	**6,770**
OUTFLOWS BESIDES PUMPING (Most Recent 10 Years, 2007-2016)	
Evapotranspiration	498
Underflow (Flow out of Southern End)	523
Total Outflows	**1,021**

3. Should the period used to estimate the Sustainable Yield be the historical calibration period of the BVHM (e.g., 1945-2022) or a future BVHM projection that accounts for the effects of climate change and future land/water uses that could affect natural recharge?

   TAC Feedback: The historical calibration period should be used to redetermine the Sustainable Yield. Specifically, the entire calibration period (1945-2022) should be used to estimate inflows. A more recent historical period (2007-2022) should be used to estimate outflows because it is more representative of current and future conditions.

All TAC discussion and feedback were considered when preparing the proposed methods to perform Task 5 – *Determine the Sustainable Yield.*

Proposed Methods to Redetermine the Sustainable Yield

This section describes a proposed approach for redetermining the Sustainable Yield by 2025. Some of these steps describe various options, which are meant to facilitate TAC feedback and recommendations.

1. **Compute the water budget of the Basin using the recalibrated BVHM.** As described in the Task 4 memorandum – *Model Recalibration,*[3] the final calibration of the BVHM will result in an annual water budget table for the period 1945-2022. The water budget will be calculated for the portion of the BVHM domain that overlies the Basin (*i.e.,* ignores the portion of the BVHM that overlies the Ocotillo Wells Subbasin).

2. **Estimate the long-term average annual *net recharge* to the Basin to establish the *Preliminary* Sustainable Yield.** Using the water budget estimated by the recalibrated BVHM, the long-term average annual *net* recharge is calculated as the difference between the long-term average annual inflow to the model domain (stream recharge, unsaturated zone recharge, and subsurface inflow) and the long-term average annual outflow (ET of shallow groundwater and subsurface outflow) from the model domain. The long-term average annual inflow is calculated for the entire model simulation period (1945-2022) to capture the variability of climatic conditions. The long-term average annual outflow is calculated for a recent period (2007-2022), which should be more reflective of current/future conditions of lower groundwater levels and lesser outflow by ET of shallow groundwater. This is a similar approach that was used to estimate the current Sustainable Yield of 5,700 afy.

3. **Develop a future groundwater pumping scenario to simulate the Rampdown of pumping to the *Preliminary* Sustainable Yield by 2040 and beyond.** The objective of this task is to develop the requisite information to prepare the input file(s) for future pumping that: (i) will comply with a Rampdown of pumping to the *Preliminary* Sustainable Yield by 2040 and (ii) will be used in BVHM projection simulations for the period 2024-2070.

   The following are options and considerations for the execution of this step:

[3] Refer to the memo included in this TAC Agenda Package for Agenda Item V. Task 4 – *Model Recalibration*.

a. The Rampdown of pumping could be implemented by linear reductions in pumping at all active pumping wells across the Basin to achieve a basin-wide pumping rate at the *Preliminary* Sustainable Yield by 2040 and thereafter. This is a similar approach that was used to estimate the current Sustainable Yield of 5,700 afy. This is a straightforward approach but would not likely result in a probable spatial distribution of future pumping in the Basin.

b. The Rampdown of pumping could be implemented by collecting information on future land use and water supply plans of the BPA holders and using the information to develop a future pumping scenario that achieves a Basin-wide pumping rate at the *Preliminary* Sustainable Yield by 2040 and thereafter. This is a more labor-intensive approach but would likely result in a more probable spatial distribution of future pumping in the Basin.

c. If (b.) is executed, more than one scenario may need to be developed and simulated to characterize the uncertainty in future pumping.

d. During recalibration of the BVHM over the period 1945-2022, the FMP will be used to estimate pumping for agricultural irrigation. The use of the FMP to simulate future agricultural pumping is challenging because (i) the future of land uses, crop types, and irrigation efficiencies is uncertain and (ii) a specific Rampdown of agricultural pumping will need to be implemented to achieve a basin-wide pumping rate at the *Preliminary* Sustainable Yield by 2040 and thereafter. If the FMP is used to project agricultural pumping, this would likely be an iterative step to ensure the Rampdown achieves the *Preliminary* Sustainable Yield by 2040 and thereafter. If the FMP is not used to project agricultural pumping (*e.g.,* pumping is assigned to wells instead), it could still be used to simulate irrigation return flows and other processes; or alternative methods could be developed and used to simulate these processes.

These options and considerations should be discussed by the TAC to assist in the development of the most prudent strategy to develop the future pumping scenario(s).

4. **Perform uncertainty analysis for future climate change and climate variability**. The modeling work performed to establish the current Sustainable Yield recognized the important influence of long-term climate change and the shorter-term climatic variability on the future recharge to the Basin. Hence, that modeling work included multiple projection scenarios of the pumping Rampdown paired with various climatic futures, including:

    a. Repeat of the historical climate from 1960-2010 for the period 2020-2070. [see attached Figure 3.3-2 from the GMP]

    b. Application of DWR change factors for 2030 and 2070 to the historical climate from 1960-2010 as outlined in the DWR climate guidance for GSPs.[4] This analysis indicated

[4] 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

that the DWR climate change factors had a relatively small influence on the long-term recharge and change-in-storage. [see attached Figure 3.3-2 from the GMP]

c. A Monte Carlo Simulation (MCS) uncertainty analysis of the Rampdown period 2020-2040 using 53 random 20-year periods of the historical climate time series from 1945-2010. This analysis indicated that shorter-term climatic variability had a relatively large influence on the long-term recharge and change-in-storage. The 20th percentile change-in-storage scenario was used to set Minimum Thresholds for groundwater elevations at most Representative Monitoring Sites in the Basin. [see attached Figure 3.3-3 from the GMP]

West Yost concurs that long-term climate change and shorter-term climatic variability are crucial factors to consider when evaluating the update to the Sustainable Yield and the potential for Undesirable Results (e.g., potential exceedance of Minimum Thresholds in the future). There are two general approaches to implement this evaluation for this redetermination of the Sustainable Yield:

a. Use the same (or similar) procedures listed in the bullet points a, b, and c above for the uncertainty analysis of the current Sustainable Yield.

b. Use different procedures and/or datasets to perform the uncertainty analysis. For example, newly published climate projections for downscaled precipitation and temperature are now available for use in model projections, such as: NASA Earth Exchange (NEX) Downscaled Climate Projections (NEX-DCP30)[5], NASA Earth Exchange Global Daily Downscaled Projections (NEX-GDDP-CMIP6)[6], and CMIP6 Downscaling Using the Weather Research and Forecasting model (WRF-CMIP6)[7].

These options and considerations should be discussed by the TAC to assist in the development of the most prudent strategy to include climatic uncertainty in the redetermination of the Sustainable Yield.

5. **Analyze the BVHM results from the future scenario(s).** The BVHM results of the future scenario(s) should be analyzed against the Sustainable Management Criteria in the GMP (e.g., Minimum Thresholds, Measurable Objectives, and Interim Milestones) to determine the potential for Undesirable Results that could occur under the *Preliminary* Sustainable Yield. The types of analyses that could be performed are described below for the applicable Sustainability Indicators:

- *Chronic lowering of Groundwater Levels*. Projected heads should be compared to the Minimum Thresholds established for Representative Monitoring Wells to identify if groundwater levels are projected to decline below the Minimum Thresholds established in the GMP.

[5] https://ds.nccs.nasa.gov/thredds/catalog/bypass/NEX-CP30/bcsd/catalog.html
[6] https://www.nccs.nasa.gov/services/data-collections/land-based-products/nex-gddp-cmip6
[7] https://dept.atmos.ucla.edu/alexhall/downscaling-cmip6

- *Reduction in Groundwater Storage*. Projected cumulative change in groundwater storage should be compared to the Minimum Threshold established for the Basin to identify if storage is projected to decline below the Minimum Threshold established in the GMP.
- *Degradation of groundwater quality*. Model results will not be used to assess Undesirable Results for groundwater quality because the BVHM does not simulate solute concentrations and/or transport.

6. **Adjust the Sustainable Yield based on the analysis of the future scenarios, if necessary.** If the BVHM results of the future scenario(s) show that Minimum Thresholds are projected to be exceeded, then the *Preliminary* Sustainable Yield would need to be reduced, and then steps 3-5 would be repeated until the Minimum Thresholds are not exceeded. At this point, the Sustainable Yield would be redetermined for 2025-2030.

   Alternatively, the Sustainable Management Criteria could be adjusted, if such adjustments are substantiated with defensible reasoning and/or new data and information.

Next Steps

At the December 18, 2023 TAC meeting, West Yost will provide an overview of the methods proposed in this Task 5 TM and solicit verbal feedback from the TAC. TAC members are requested to provide comments on this TM to Andy Malone (amalone@westyost.com) and Lauren Salberg (lsalberg@westyost.com) by **Monday, January 8, 2023**. West Yost will present the preliminary methodology to perform Task 5 – *Determine the Sustainable Yield* and the associated TAC feedback to the Watermaster Board during its February 8, 2024 regular meeting.

Enclosures

Exhibit 1. TAC Comments received on November 1, 2023 TAC Memo on Task 5

Figure 3.3-2 from the GMP – *BVHM Model Runs Addressing Future Climate and Pumping Reductions*

Figure 3.3-3 from the GMP – *Monte Carlo Simulation Time Varying Recharge 1945 to 2010 and Forecasted Cumulative Overdraft*

Exhibit 1. Responses to TAC Comments/Recommendations on Task 5 - Redetermine the Sustainable Yield

TAC Comments/Recommendations	TAC Members					Technical Consultant Responses
	AAWARE *Bob Wagner*	BWD *Trey Driscoll*	County of San Diego *Jim Bennett*	T2 Borrego *Tom Watson*	Roadrunner Club *John Peterson*	
Water-budget components to use to redetermine the Sustainable Yield						
Long-term annual average recharge as estimated by the BVHM				X		We agree with the majority TAC opinion that net recharge to the Basin will be calculated as the difference between long-term annual average recharge and discharge. The water budget terms defined in Table 2.2-9 of the GMP should be used to redetermine the Sustainable Yield.
Long-term annual average recharge minus discharge (subsurface outflow and evapotranspiration [ET] of groundwater)	X	X[1]	X[1]			
Time period to use to redetermine the Sustainable Yield						
Historical calibration period (1945-2022)		X[2]	X[3]	X		We agree with the majority TAC opinion that the historical calibration period should be used to redetermine the Sustainable Yield. Specifically, the entire calibration period (1945-2022) should be used to estimate inflows. A more recent historical period (2007-2022) should be used to estimate outflows because it is more representative of current and future conditions.
Future BVHM projection that accounts for the effects of climate change and future land/water uses that could affect natural recharge	X					
Model Domain to use to calculate the water budget						
Entire BVHM domain (Borrego Springs Subbasin and Ocotillo Wells Subbasin)						We agree with the majority TAC opinion that the BVHM domain used to estimate the water budget and redetermine the Sustainable Yield should include only the portion of the domain that overlies the Borrego Springs Subbasin (*i.e.,* exclude the portion of the domain overlying the Ocotillo Wells Subbasin).
Portion of the BVHM domain that contains only the Borrego Springs Subbasin		X[4]	X	X	X[5]	
More discussion is needed	X					

Notes:

1. Recommendation to use the inflow and outflow components listed in Table 2.2-9 of the GMP to estimate the Sustainable Yield. Table 2.2-9 identifies inflows as stream recharge, unsaturated zone recharge, and underflow, and outflows as evapotranspiration of groundwater and underflow.

2. Recommendation to use a more recent historical time period for calibration which better reflects current land use and, therefore, ET from native and non-native vegetation (*e.g.* loss of native phreatophytes which has decreased ET). ET estimates from external sources, such as OpenET could be used to check the model estimate.

3. This approach is consistent with the existing GMP and indirectly addresses climate change and future land/water uses by coupling the change in storage threshold to the chronic lowering of groundwater levels threshold. Natural recharge to Borrego Springs is highly variable and there is much greater uncertainty associated with precipitation and recharge than climate change projections. The Monte Carlo Simulation uncertainty analysis performed to redetermine the Sustainable Yield established the minimum threshold for the chronic lowering of groundwater levels using the variability in recharge to the Basin.

4. Recommendation that if the model domain is revised, underflow from the southern end of the of the model should be evaluated in terms of the outflows used in the provisional estimate of Sustainable Yield.

5. Verbal comment from the November 1, 2023 TAC meeting.

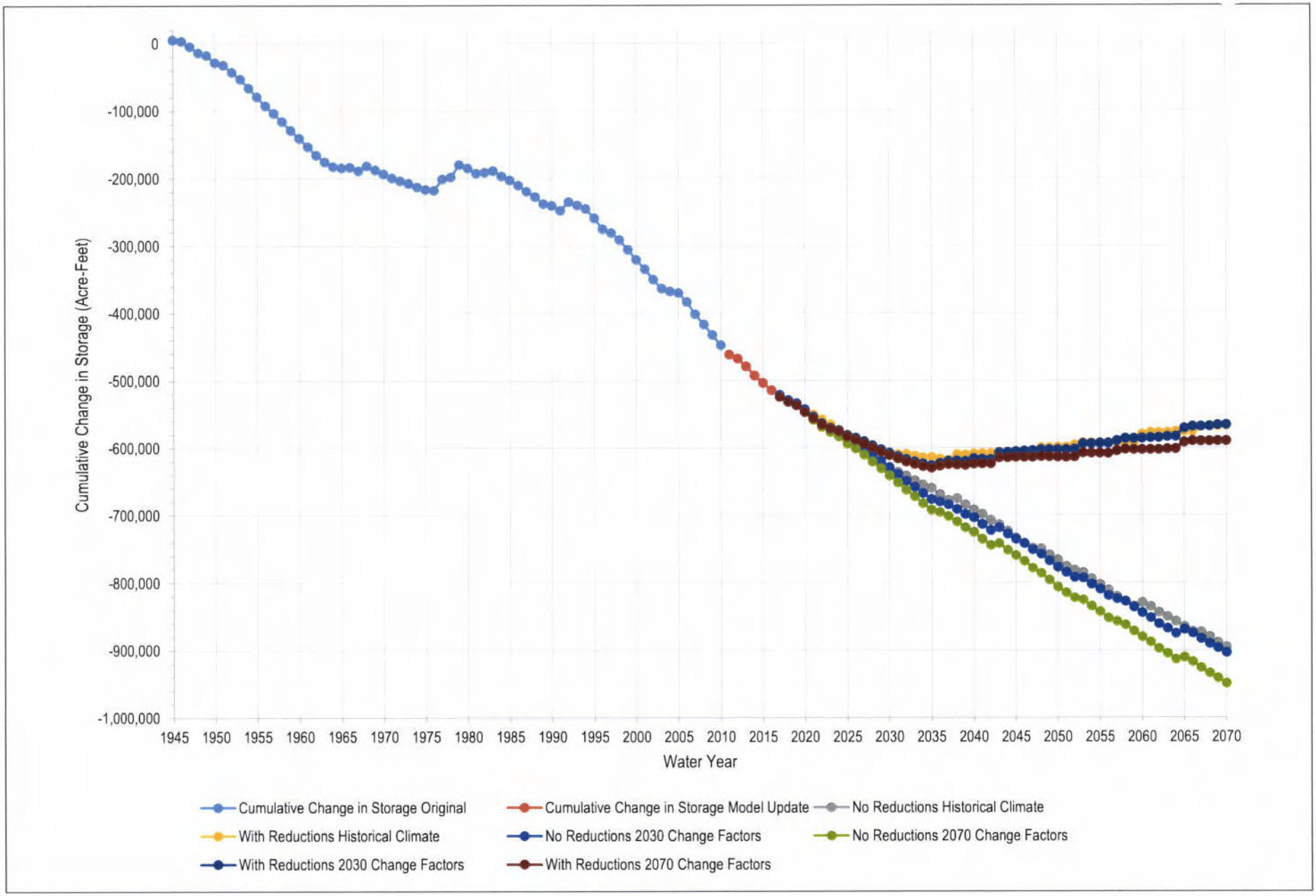
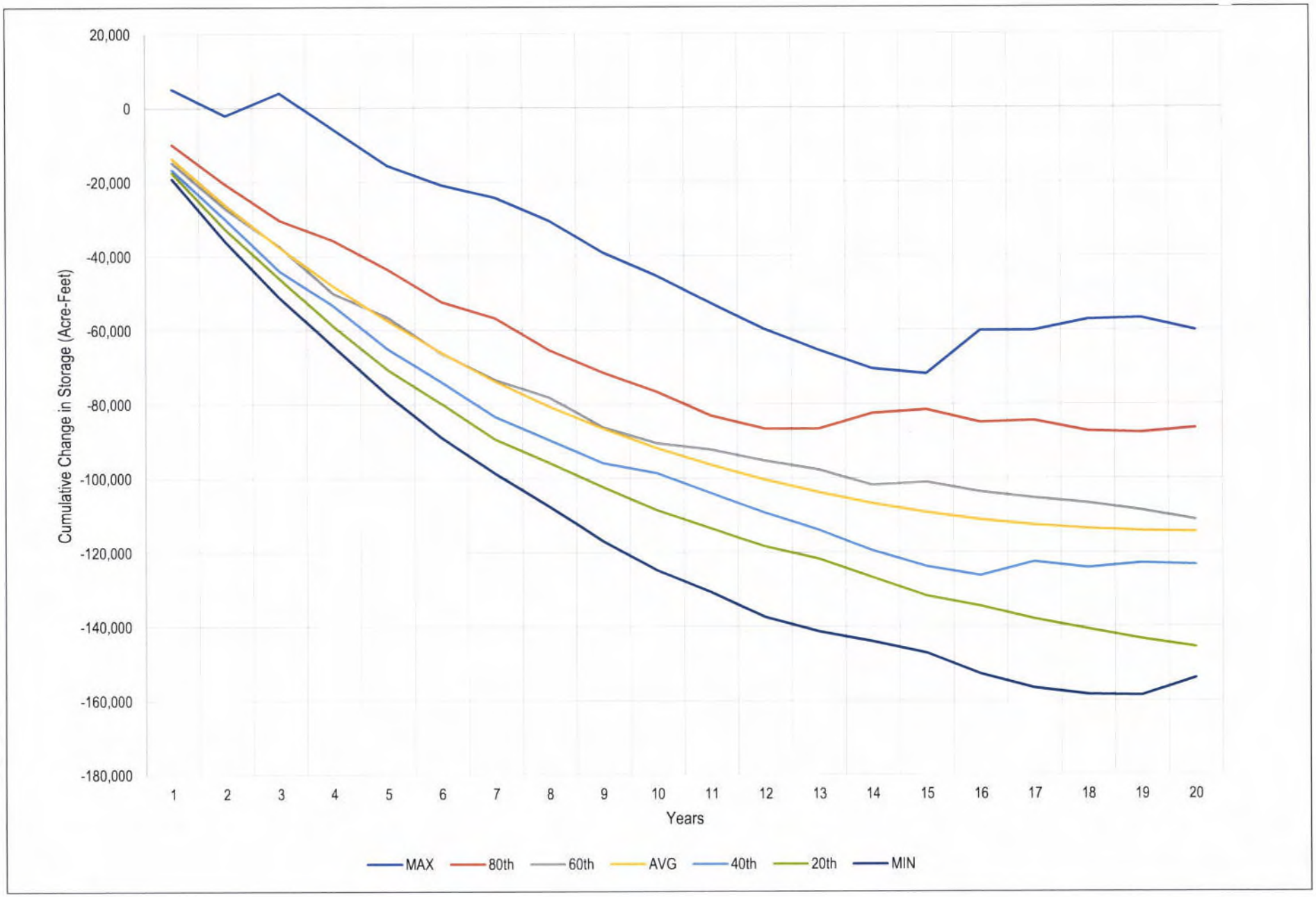


FIGURE 3.3-2

BVHM Model Runs Addressing Future Climate and Pumping Reductions

Groundwater Management Plan for the Borrego Springs Groundwater Subbasin



SOURCE: ENSI 2018

FIGURE 3.3-3

Monte Carlo Simulation Time Varying Recharge 1945 to 2010 and Forcasted Cumulative Overdraft

Groundwater Management Plan for the Borrego Springs Groundwater Subbasin