TAC RECOMMENDATION REPORT

DATE: January 27, 2023

TO: Board of Directors
Borrego Springs Watermaster

FROM: Technical Advisory Committee
Borrego Springs Watermaster

SUBJECT: Scope of Work to Redetermine the Sustainable Yield by 2025 –
Water Years 2023 and 2024

BACKGROUND AND OBJECTIVES

The Borrego Valley Hydrologic Model (BVHM) and its supporting tools, the Basin Characterization Model (BCM) and MODFLOW-OWHM (version 1.0) with the Farm Process (FMP; version 3), were used to characterize the water budget for the Borrego Springs Subbasin (Basin) and estimate the Sustainable Yield for the Basin at 5,700 acre-feet per year (afy). Section II.E of the Judgment[1] established the initial Sustainable Yield at 5,700 afy and requires it to be redetermined by January 1, 2025, and every five years thereafter through 2035.

In 2021, the Technical Advisory Committee (TAC) identified the ability of the BVHM to accurately estimate historical and future pumping as the top priority issue to address in the 2025 redetermination of the Sustainable Yield. The TAC recommended to the Watermaster Board a technical scope-of-work and budget for water years (WYs) 2022 and 2023, which also included an estimate for the work necessary in WY 2024 to redetermine the Sustainable Yield by January 1, 2025. The work for WYs 2022, 2023 and 2024 was included in a Sustainable Groundwater Management (SGM) grant application, summarized below:

- **WY 2022** (Budget in SGM grant application = $115,750). Collect historical DWR data; extend and run the BVHM through WY 2021; compare the FMP-estimated pumping to the Watermaster's newly metered pumping for WY 2021; and develop recommendations for additional model updates and/or model recalibration (if any) that are necessary to redetermine the Sustainable Yield by 2025.
- **WY 2023** (Budget in SGM grant application = $31,500). Essentially, repeat the WY 2022 scope of work to validate or revise the conclusions and recommendations of the work performed in WY 2022.
- **WY 2024** (Budget in SGM grant application = $155,000). Refine the BVHM if necessary and use BVHM model runs to redetermine the Sustainable Yield in collaboration with the TAC.

Watermaster's Technical Consultant West Yost completed the WY 2022 scope of work and through meetings and discussions with the TAC developed the following main findings and recommendations:

[1] Borrego Water District v. All Persons Who Claim a Right To Extract Groundwater in the Borrego Valley Groundwater Subbasin No. 7.024 Whether Based on Appropriation, Overlying Right, or Other Basis of Right, and/or Who Claim a Right to Use of Storage Space in the Subbasin; et al. (Case No. 37-2020-00005776).

- The Farm Process package within the BVHM underestimated the groundwater pumping by 4,456 acre-feet (af) in WY 2021 (42% difference). This underestimation of pumping could represent a significant deficiency in the BVHM; however, it was only a one-year evaluation.
- There were several other discrepancies identified in the BVHM that could directly impact the ability of the BVHM to accurately estimate the water budget of the Basin, and hence, the redetermination of the Sustainable Yield.

Subsequently, the TAC requested that West Yost prepare options for a revised scope-of-work to address the identified deficiencies in the BVHM and then use the BVHM to redetermine the Sustainable Yield by 2025. Based on input from the TAC, West Yost developed seven (7) potential tasks for consideration by the TAC, which are listed below in Table 1 along with the estimated cost to complete each task. Attachment A of this report is a more detailed line-item cost estimate for each task that was prepared by West Yost to support the TAC deliberations on the potential scope of work.

Table 1. Potential Tasks to Include in a Revised Scope of Work to Redetermine the Sustainable Yield by 2025 -- *WY 2023 and WY 2024*

Task No.	Task	Cost Estimate
1	Compare FMP-estimated Pumping to Actual Pumping for WY 2022	$20,222
2	Update Water-Use Factors in the FMP	$39,196
3	Correct Errors Identified in 2021 BVHM	$22,577
4	Develop and Implement New Methods to Estimate Recharge	$74,276
5	Upgrade BVHM to Use the New Version of MODFLOW-OWHM	$81,656
6	Perform Model Recalibration	$128,510
7	Determine the Sustainable Yield (including documentation)	$137,699
	Total Cost for All Tasks	**$504,136**

The potential tasks were discussed at a TAC meeting held on November 2, 2022. West Yost conducted follow up with the TAC members via email and phone correspondence to clarify and articulate their recommendations. This report describes the TAC recommendation for the appropriate scope of work and budget to redetermine the Sustainable Yield by 2025, including any differences in TAC member opinions.

SUMMARY OF TAC RECOMMENDATION

Table 2 below shows each TAC member's recommendation of whether to perform each potential task (Yes "Y", or No "N"). Also shown in Table 2 is the total cost associated with each TAC member's recommendation, the previously approved budget for WY 2023 and/or in the SGM grant application, and the "variance" which represents the additional budget needed to execute the recommended tasks.

Table 2. Summary of TAC Recommendations for a Scope of Work to Redetermine the Sustainable Yield by 2025 -- *WY 2023 and WY 2024*

Task No.	Task	Cost Estimate	TAC Member Recommendations (Y/N)?				Tally of TAC Member Recommendations	
			County of San Diego	AAWARE	Rams Hill	BWD	Yes	No
1	Compare FMP-estimated Pumping to Actual Pumping for WY 2022	$20,222	Y	Y	Y	Y	4	0
2	Update Water-Use Factors in the FMP	$39,196	Y	Y	Y	Y	4	0
3	Correct Errors Identified in 2021 BVHM	$22,577	Y	Y	Y	Y	4	0
4	Develop and Implement New Methods to Estimate Recharge	$74,276	N	N	N	Y	1	3
5	Upgrade BVHM to Use the New Version of MODFLOW-OWHM	$81,656	N	N	N	N	0	4
6	Perform Model Recalibration	$128,510	Y	Y	Y	Y	4	0
7	Determine the Sustainable Yield (including documentation)	$137,699	Y	Y	Y	Y	4	0
	Total Cost of Recommended Tasks	**$504,136**	**$348,204**	**$348,204**	**$348,204**	**$422,480**		
	SGM Grant Budget	**$186,500**	**$186,500**	**$186,500**	**$186,500**	**$186,500**		
	Variance	**$317,636**	**$161,704**	**$161,704**	**$161,704**	**$235,980**		

The TAC recommendation is summarized as:

- Consensus recommendation to perform Tasks 1, 2, 3, 6, and 7.
- Consensus recommendation to not perform Task 5. However, the TAC generally agrees that the Watermaster should begin to explore the scope and costs to migrate the BVHM to a new modeling platform.
- One TAC member recommends performing Task 4, while the other three TAC members recommend to not perform Task 4 for the Redetermination of the Sustainable Yield by 2025.
- The additional budget needed to execute the recommended revised scope of work should be derived by "re-purposing" SGM grant funds.

A more detailed description of each potential task, the associated cost estimates, and the TAC recommendations are below.

EVALUATION OF REVISED SCOPE OF WORK TO COMPLETE THE REDEERMINATION OF SUSTAINABLE YIELD

This section describes the potential scope of work by task, including: a problem statement, the objective of the task to address the problem statement, a description of the work to complete the task, a cost estimate, the schedule to complete the task, a description of the consequences of not performing each task, and the TAC recommendation to perform the task, or not (including a description of differences in TAC member opinions, if any).

Attachment B provides a more detailed description of the individual TAC member's rationale to support their recommendations.

TASK 1 – COMPARE FMP-ESTIMATED PUMPING TO ACTUAL PUMPING FOR WY 2022

Problem Statement: In WY 2022, West Yost extended the BVHM from WY 2017 through WY 2021 (2021 BVHM). For this effort, the Farm Process (FMP) was used to estimate pumping at historically unmetered wells, and then the FMP-estimated pumping was compared against newly-metered pumping at those same wells (*i.e.,* Actual Pumping) during WY 2021 to understand the ability of the FMP to estimate pumping.[2,3] The result of this comparison was that the FMP underestimated Actual Pumping by 4,456 af in WY 2021—a 42% difference. The TAC considers this difference to be significant, which likely indicates that the BVHM is not sufficiently calibrated based on newly collected pumping data. However, the comparison in WY 2021 relied on only one year of actual pumping data. Additional comparisons of FMP-estimated pumping versus Actual Pumping are necessary to confirm, modify, or refute the conclusions of the extension of the BVHM through WY 2021.

Objective: The objective of this task is to confirm, modify, or refute the conclusions of the extension of the 2021 BVHM by extending the BVHM through WY 2022 and then comparing FMP-estimated pumping to Actual Pumping in WY 2022. This task was recommended by the TAC in May 2021 and approved by the Watermaster Board in July 2022 for inclusion in the WY 2023 budget with a budget of $31,598.

Task Description: In this task, the 2021 BVHM will be extended through WY 2022 and the FMP-estimated pumping in WY 2022 will be compared against Actual Pumping as metered by the Watermaster in WY 2022. Efforts for this task will include extending the Multi-Node Well Package (MNW2) using metered pumping data from WY 2022; extending the Streamflow Routing (SFR) and Flow and Head Boundary (FHB) packages through WY 2022; and extending the FMP through WY 2022. To reduce the cost of this task, it is recommended that the boundary conditions from WY 2021 be applied to the SFR and FHB packages and the FMP. The results and conclusions of this task will be summarized and distributed to the TAC via email. The email will request TAC feedback before the Technical Consultant proceeds with Task 2.

Budget: $20,222 [Note: A $31,500 budget for this task was approved by the Watermaster Board for WY 2023. The Watermaster Technical Consultant has re-estimated the scope and budget for this task.]

Schedule: February to March 2023

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[2] West Yost. 2022. *Extension of the Borrego Valley Hydrologic Model through Water Year 2021* (2021 BVHM TM).

[3] Pumping at a few unmetered wells was estimated by Watermaster staff in WY 2021.

Consequence of Not Completing Task 1: The ability of the FMP to estimate groundwater pumping is of upmost importance because groundwater pumping is a main stress to the Subbasin. If the FMP continues to significantly underestimate Actual Pumping in WY 2022, then it is likely that the FMP needs improvement and the BVHM needs re-calibration to accurately estimate the water budget and Sustainable Yield of the Subbasin as identified in the Judgment.

By not completing Task 1, the TAC will not be able to confirm the results and conclusions from the extension of the 2021 BVHM, and therefore, would be basing many of its subsequent recommendations for improvements to the FMP and BVHM on a single evaluation.

Consensus TAC Recommendation: Task 1 should be performed. Completing this task would confirm, modify, or refute the conclusions of the extension of the 2021 BVHM and would be valuable information to inform subsequent TAC recommendations for the appropriate improvements to the FMP and BVHM for the redetermination of the Sustainable Yield by 2025.

TASK 2 – UPDATE WATER-USE FACTORS IN THE FMP

Problem Statement: Water-use factors are used to estimate the consumptive use of water of different crop and land-use types in the FMP. The water-use factors currently used in the FMP were developed by the United States Geological Survey (USGS) during the initial development of the BVHM. The factors were initially based on various agricultural water-use studies (Allen et al., 1998[4]; Snyder et al., 1987a[5], Snyder et al., 1987b[6]) and adjusted during model calibration.

It appears from the results of the 2021 BVHM extension that the FMP significantly underestimates pumping. If so, this would indicate that the water-use factors currently used in the FMP are inaccurate. Since the FMP is an important component of the BVHM, inaccuracies in the FMP could significantly affect the ability of the BVHM to accurately estimate the water budget and Sustainable Yield of the Subbasin.

Objective: The objective of this task is to develop updated estimates of the water-use factors used in the FMP to improve the ability of the FMP to estimate groundwater pumping.

Task Description: To update the water-use factors, a new methodology will be developed. Previous efforts have been undertaken to estimate water-use factors in the Subbasin, which could be used to achieve the objective of this task. Specifically, in estimating the Baseline Pumping Allocation (BPA) for agricultural parties in the Subbasin, Dudek developed a method for estimating water-use factors for various crop types and documented the data sources and methodology. The methods used to estimate water-use factors in the FMP will need to be researched to determine if the water-use factors estimated by Dudek can be

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[4] Allen, R.G., Pereira, L.S., Raes, D., and Smith, M. 1998. Crop evapotranspiration—Guidelines for computing crop water requirements: Food and Agriculture Organization of the United Nations, Irrigation and Drainage Paper 56. Accessed December 12, 2022 on https://www.fao.org/3/X0490E/X0490E00.htm.

[5] Snyder, R.L., Lamina, B.J., Shaw, D.A., and Pruitt, W.O. 1987a. Using reference evapotranspiration (ET_o) and crop coefficients to estimate crop evapotranspiration (ET_c) for agronomic crops, grasses, and vegetable crops. Accessed December 12, 2022 on https://calisphere.org/item/e4408893-9141-4766-89f2-c25c667071a7/.

[6] Snyder, R.L., Lamina, B.J., Shaw, D.A., and Pruitt, W.O. 1987b. Using reference evapotranspiration (ET_o) and crop coefficients to estimate crop evapotranspiration (ET_c) for trees and vines Accessed December 12, 2022 on https://calisphere.org/item/fbc9dc78-de6e-4d99-a561-0028370f8107/.

directly compared to and used in the FMP. If a comparison cannot be made, additional methods will be evaluated for estimating water-use factors.

The updated water-use factors will be used to run the BVHM through WY 2022 and the updated FMP-estimated pumping will be compared to prior estimates of FMP-estimated pumping for the entire model simulation period (WY 1930-2022). Additionally, the updated FMP-estimated pumping will be compared to the Actual Pumping for WYs 2021 and 2022 to determine if the updated water-use factors improved the FMP's ability to estimate groundwater pumping. If the updated FMP still fails to accurately estimate Actual Pumping, the water-use factors will need to be adjusted during the model recalibration (Task 6). The approach and results from comparing FMP-estimated Pumping to Actual Pumping for WY 2022 (Task 1) and updating water-use factors in the FMP (Task 2) will be presented to the TAC.

Budget: $39,196

Schedule: March through April 2023

Consequence of Not Completing Task 2: By not completing Task 2, the FMP will continue to use the existing water-use factors initially developed by the USGS, and as a result, may continue to underestimate groundwater pumping. As noted under Task 1, the FMP's ability to estimate groundwater pumping is critical for redetermining the Sustainable Yield. If the FMP significantly underestimates pumping, then it is likely that the BVHM is not well calibrated, the BVHM cannot be satisfactorily re-calibrated, and any redetermined Sustainable Yield using the FMP and BVHM may not be accurate.

Consensus TAC Recommendation: Task 2 should be performed, but only if the results of Task 1 indicate that the FMP is continuing to significantly underestimate the metered agricultural pumping. Updating the water use factors in the FMP will likely improve the ability of the FMP to accurately estimate pumping, and hence, is a necessary step to improving the ability of the BVHM to simulate the water budget and Sustainable Yield of the Subbasin.

TASK 3 – CORRECT ERRORS IDENTIFIED IN THE 2021 BVHM TM

Problem Statement: During the 2021 BVHM extension, West Yost identified several errors and discrepancies in the BVHM and documented the errors and discrepancies in the technical memorandum *Extension of the Borrego Valley Hydrologic Model through Water Year 2021* (2021 BVHM TM). Some of these errors relate to the assignment of recharge in the BVHM, which may adversely impact the ability of the BVHM to accurately estimate the water budget and Sustainable Yield of the Subbasin.

Objective: The objective of this task is to fix known errors in the BVHM and quantify the influence of the errors on the BVHM results.

Task Description: In this task, the errors and discrepancies identified in the 2021 BVHM TM will be corrected. These corrections include fixing errors in the SFR, FHB, MNW2 packages, and in the FMP. Additionally, the screen depths of wells in the MNW2 package will be compared to well completion data to validate the depth distribution of pumping in the BVHM. Once all identified errors have been corrected, the BVHM will be run through WY 2022. The results from the corrected BVHM will be compared to the historical BVHM results to quantify the influence of the errors on the model results. The approach and results from completing this task will be presented to the TAC.

Budget: $22,577

Schedule: April through May 2023

Consequence of Not Completing Task 3: The known errors in the BVHM are virtually certain to impact the model estimates of:

- Subsurface inflows
- Stream inflows
- Groundwater pumping

While the magnitude of these errors on the BVHM results remains unknown, it is certain that the errors are influencing the model-estimated water budget, including the typically important sources of recharge. Estimates of historical recharge were used to establish the current Sustainable Yield of 5,700 afy.

By not completing Task 3, the known errors will remain in the BHVM and may adversely influence the BVHM-estimated water budget and Sustainable Yield. The impact of these errors on the BVHM results (*e.g.,* water budget, recharge, groundwater pumping, and the Sustainable Yield) will remain unknown.

Consensus TAC Recommendation: Task 3 should be performed. The known errors were identified and documented in the 2021 BVHM TM and the methods to address and resolve these errors will require minimal effort. Considering the potential influence of these errors on the BVHM results, these errors should be resolved and their influence on past BVHM results should be quantified.

TASK 4 – DEVELOP AND IMPLEMENT NEW METHODS TO ESTIMATE RECHARGE

Problem Statement: The natural recharge to the Subbasin occurs primarily via surface-water inflow from the surrounding watersheds (that translate into streambed infiltration overlying the Subbasin) and subsurface inflow from the surrounding mountain-front watersheds. This natural recharge is the most important component of the Sustainable Yield of the Subbasin. The TAC and West Yost have identified two key issues relating to the estimates of recharge that have historically been used in the BVHM:

1. Past modeling efforts by the USGS (initial BVHM), Dudek (2016 BVHM), and West Yost (2021 BVHM) have used inconsistent and non-reproducible methods for estimating surface-water inflows. As documented in the 2021 BVHM TM, the method for estimating surface-water inflow by the USGS could not be reproduced by Dudek during the 2016 BVHM extension, which resulted in Dudek developing a new methodology, which in turn, could not be reproduced by West Yost during the 2021 BVHM extension. The inability to reproduce methods and results is un-scientific and likely produces inaccurate estimates of this source of recharge.
2. In all past modeling efforts, the rates of subsurface inflow have been applied at a constant rate of approximately 1,367 afy. This rate was first established in the initial BVHM developed by the USGS as a "simplified" average rate of subsurface inflow over the simulation period (Faunt et al., 2015[7]). A constant rate of subsurface inflow is unrealistic because it does not account for hydrologic variations in the watershed (*e.g.,* more subsurface inflow to the Subbasin occurs

[7] Faunt, C.C., C.L. Stamos, L.E. Flint, M.T. Wright, M.K. Burgess, M. Sneed, J. Brandt, P. Martin, and A.L. Coes. 2015. Hydrogeology, hydrologic effects of development, and simulation of groundwater flow in the Borrego Valley, San Diego County, California: U.S. Geological Survey Scientific Investigations Report 2015-5150. Accessed on December 12, 2022 on https://pubs.usgs.gov/sir/2015/5150/sir20155150.pdf

during and after wet years/periods, and less subsurface inflow occurs during and after dry years/periods).

Developing reproducible methods for estimating recharge to the Subbasin was identified as a need by the TAC in their review of the 2021 BVHM TM.

Objective: The objective of this task is to evaluate and develop reproducible methods for estimating surface-water inflow and subsurface inflow to the Subbasin (*i.e.,* recharge) and use the methods to generate input data for the SFR and FHB packages in the BVHM.

Task Description: In this task, West Yost will research and develop potential new methods to estimate surface-water and subsurface inflows to the Subbasin and will then use those methods to produce new estimates of historical surface-water and subsurface inflows to the Subbasin. The new estimates will be compared against: (i) historical data (such as stream gage data and groundwater levels near the basin boundaries) to check for reasonableness of the new methods and (ii) past BVHM estimates of surface-water and subsurface inflows to characterize the difference between the new vs. current methods. The results of these efforts will be documented and presented to the TAC. Following TAC-approval of the proposed methods, the estimated inflows will be used to update the model input files in the SFR and FHB packages and the BHVM will be ran through WY 2022. The BVHM results using the updated inflow estimates will be compared to prior model results to determine the influence of the change in recharge on the water budget and groundwater levels. This comparison may reveal a need for recalibration of the BVHM. The results and recommendations from this task will be documented in a TM and presented to the TAC. The recommendation will be finalized based on TAC feedback and the agreed-upon methods will be used to estimate recharge during future extensions of the BHVM.

Budget: $74,276

Schedule: May through August 2023

Consequence of Not Completing Task 4: The natural recharge to the Subbasin is the most important component of the Sustainable Yield. The TAC and West Yost have noted that the methods used by the USGS, Dudek, and West Yost to generate estimates of recharge for the BVHM have been inconsistent and non-reproducible. In addition, the TAC and West Yost believe the current methods produce estimates of recharge that are not representative of the hydrologic variability that occurs in the watershed over time, and hence, the estimates of recharge are likely not accurate. By not completing Task 4, the Redetermination of Sustainable Yield by 2025 will use non-reproducible methods for estimating recharge and the recharge estimates will likely be inaccurate.

TAC Recommendation (Non-consensus): The TAC members have differing opinions on whether to perform Task 4, as follows. See attachment B for a more detailed description of the differences in TAC opinions.

- Three TAC members (representing County of San Diego, AAWARE, and Rams Hill) recommend not performing Task 4, and instead focusing on monitoring and data analysis going forward to better understand recharge.
- One TAC member (representing BWD) recommends performing Task 4 since estimating recharge is critical for determining the Sustainable Yield of the Subbasin and the current methods to estimate recharge are non-reproducible or defensible.

TASK 5 – UPGRADE BVHM TO USE THE NEW VERSION OF MODFLOW-OWHM

Problem Statement: The BVHM uses the MODFLOW numerical modeling code One-Water Hydrologic Flow Model (MODFLOW-OWHM). The first version of MODFLOW-OWHM is v1.0.0 which was released in 2014; this is the version of MODFLOW-OWHM that is used by the BVHM. During the 2016 and 2021 extensions of the BHVM, several "bugs" were identified in MODFLOW-OWHM v1.0.0. The term "bug" refers to a behavior or result that the model produces but was not designed to do. Examples of bugs identified in the current version of the BVHM include discrepancies between calculations produced by ZoneBudget and model listing file results and differences in the pumping estimated by individual packages vs. pumping reported in the model listing files (West Yost, 2021). The 2021 BVHM TM documented several of these "bugs" and identified that further investigation was warranted to identify why these inconsistencies exist.

In 2020, the USGS released an updated version known as MODFLOW-OWHM v2.2.0, which includes an updated version of the FMP and modifications to many MODFLOW packages. The TAC suggested to upgrade the BVHM from MODFLOW-OWHM v1.0.0 to MODFLOW-OWHM v2.2.0.

Objective: The objective of this task is to upgrade the BVHM from MODFLOW-OWHM v1.0.0 to MODFLOW-OWHM v2.2.0 to avoid the "bugs" that have been identified in MODFLOW-OWHM v1.0.0.

Task Description: In this task, West Yost will research the differences between MODFLOW-OWHM v1.0.0 and v2.2.0 to understand the correct process for converting from MODFLOW-OWHM v1.0.0 to MODFLOW-OWHM v2.2.0, such as revising model input files or defining parameters. Once it's understood how to convert between versions, the BVHM will be converted from MODFLOW-OWHM v1.0.0 to v2.2.0. The BVHM, using MODFLOW-OWHM v2.2.0, will be run through WY 2022 and the model results will be compared to the water budget and ZONEBUDGET output from MODFLOW-OWHM v1.0.0.

TAC member Trey Driscoll (representing BWD) has reported that his team had previously reviewed an un-released version of MODFLOW-OWHM v2.2.0 several years ago and found the version to contain many bugs. Although he was uncertain what fixes have since been made to MODFLOW-OWHM v2.2.0, he recommended a large effort may be necessary for converting the model input files between model versions and debugging MODFLOW-OWHM v2.2.0. The cost estimate for this task accounts for his professional opinion that there may be significant challenges associated with converting the BVHM from MODFLOW-OWHM v1.0.0 to MODFLOW-OWHM v2.2.0.

The TAC member representing Rams Hill recommends that a first step in future consideration of this work is for the Technical Consultant to prepare a "white paper" for review by the TAC comparing the pros/cons of continuing to use the MF-OWHM versus converting to MODFLOW 6.

Budget: $81,656

Schedule: August through December 2023

Consequence of Not Completing Task 5: By not completing Task 5, the BVHM will continue to use MODFLOW-OWHM v1.0.0, which contains bugs in the code and is no longer maintained by the USGS.

Consensus TAC Recommendation: Task 5 should not be performed now, but potentially be deferred to the future.

TASK 6 – PERFORM MODEL RECALIBRATION

Problem Statement: Past modeling efforts have indicated that the BVHM may require a recalibration. Examples include:

- The results from the 2016 BVHM extension found that the model underestimated hydraulic heads compared to measured values (Dudek, 2019).
- The results from the 2021 BVHM extension found that the FMP significantly underestimated groundwater pumping compared to Actual Pumping in the Subbasin (West Yost, 2021).
- The results from the 2021 BVHM extension identified several other discrepancies with the BVHM that could have adversely impacted its initial calibration, such as inaccurate estimates of recharge and errors in the SFR, FHB, and MNW2 packages and the FMP (West Yost, 2021).

If the BVHM is not appropriately calibrated, then the BVHM results, and interpretations derived from the BVHM results such as the Sustainable Yield, are likely inaccurate.

Objective: The objective of this task is to improve the ability of the BVHM to estimate groundwater elevations, groundwater pumping, the water budget, and the Sustainable Yield of the Subbasin by recalibrating the BVHM after completing the tasks to update the FMP and fix the errors in the BVHM.

Task Description: To recalibrate the BVHM, input files will be prepared to perform calibration using the parameter estimation code PEST. Selected measured pumping and head values will be used as calibration targets. During the model calibration, the values of aquifer parameters (such as hydraulic conductivity and storage coefficient) and, if needed, the water-use factors in the FMP will be adjusted to minimize the differences between the model estimated and measured pumping and head values. The calibration results will include time series of simulated vs. measured values, along with calibration statistics and calculated residuals. The approach and results of the calibration will be documented in a TM and presented to the TAC. The TM will be finalized based on TAC comments and the calibrated BVHM will be used in Task 7 to determine the Sustainable Yield.

Budget: $137,699

Schedule: December 2023 through May 2024

Consequence of Not Completing Task 6: By not completing Task 6, the BVHM results will continue to be produced from a model that likely is not sufficiently calibrated, which will result in inaccurate estimates of groundwater pumping, hydraulic heads, the water budget, and the Sustainable Yield.

Consensus TAC Recommendation: Task 6 should be performed. However, the results of the prior tasks (described above) will provide additional information regarding the sufficiency of the current calibration. The TAC will be able to provide a revised recommendation on model recalibration after the completion of the prior tasks.

TASK 7 – DETERMINE THE SUSTAINABLE YIELD (INCLUDING DOCUMENTATION)

Objective: The objective of this task is to determine the Sustainable Yield for WY 2026 through WY 2030 and document the methods, results, and conclusions of all work perform for this effort. This task is required by the Judgment and must be completed and adopted by the Board no later than January 1, 2025.

Task Description: Projection scenarios and methods to interpret model results will be developed and proposed to the TAC via a draft TM. The projection scenarios will include the Rampdown of pumping to the Sustainable Yield and future precipitation and ET based on climate projections, which may use either a change factor method or projected BCM data based on Coupled Model Intercomparison Project Phase 5 (CMIP5) climate models. The TAC will have the opportunity to provide feedback on the proposed projection scenarios and the methods for redetermining the Sustainable Yield. Once the projection scenarios and methods for redetermining the Sustainable Yield are finalized, the projection scenarios will be constructed and run with the BVHM. A draft report describing the methods and results of this task will be presented to the TAC for review and comment. The report will be finalized based on TAC comments. The final report and the TAC recommendation for the redetermined Sustainable Yield will be presented to the Watermaster Board for their consideration during the September 2024 Board meeting. The Watermaster Board will then have time to review the Sustainable Yield prior to approving it by December 2024.

Budget: $137,699 [Note: A $155,000 budget for this task was assumed in the SGM grant application. The Watermaster Technical Consultant has re-estimated the scope and budget for this task.]

Schedule: May through September 2024

Consequence of Not Completing Task 7: This task must be completed. Section III.F.3 of the Stipulated Judgement states that "By January 1, 2025, the Watermaster will, following receipt of input and recommendations from the Technical Advisory Committee, revise the determination of the Sustainable Yield for Water Years 2025/2026 through 2029/2030."

Consensus TAC Recommendation: Task 7 must be performed.

ATTACHMENTS

Attachment A. Cost Estimate for a Potential Scope of Work to Redetermine the Sustainable Yield by 2025

Attachment B. TAC Recommendations for a Scope of Work to Redetermine the Sustainable Yield by 2025

Attachment A

Cost Estimate for a Potential Scope of Work to Redetermine the Sustainable Yield by 2025 -- *WY 2023 and WY 2024*

Task No.	Task / Sub-Task	Labor Hours and Cost		
		Person Hours	Cost	
			Sub-Task	Task
1	**Compare FMP-estimated Pumping to Actual Pumping for WY 2022**	**84**		**$20,222**
1.1	Extend BVHM through WY 2022			
1.1.1	Extend MNW2 package using pumping data for non-FMP wells for WY 2022	8	$1,990	
1.1.2	Extend SFR package through WY 2022 using same boundary conditions as WY 2021	7	$1,671	
1.1.3	Extend FHB package through WY 2022 using same boundary conditions as WY 2021	7	$1,671	
1.1.4	Extend FMP through WY 2022 using same boundary conditions as WY 2021	7	$1,671	
1.2	Compare FMP-estimated Pumping to Actual Pumping in WY 2022			
1.2.1	Run the BVHM through WY 2022	30	$7,140	
1.2.2	Collect Actual Pumping data from WY 2022	8	$1,844	
1.2.3	Compare FMP-estimated Pumping to Actual Pumping in WY 2022	17	$4,235	
2	**Update Water-Use Factors in the FMP**	**168**		**$39,196**
2.1	Collect and compile data from Dudek's efforts to quantify crop type and water use factors	6	$1,518	
2.2	Update water-use factors (e.g., reference ET, crop coefficient) in the FMP for different crop types based on the collected data and results from Task 2.1	100	$22,636	
2.3	Run the BVHM with the updated FMP and compare FMP-estimated pumping to prior estimates			
2.3.1	Run the BVHM through WY 2022	26	$6,092	
2.3.2	Compare updated FMP-estimated pumping to prior FMP-estimated pumping	14	$3,504	
2.3.3	Compare updated FMP-estimated pumping to Actual Pumping for WYs 2021 and 2022	13	$3,355	
2.4	Prepare for and conduct a TAC meeting to review results of Tasks 1 and 2	9	$2,091	
3	**Correct Errors Identified in 2021 BVHM TM**	**100**		**$22,577**
3.1	Make corrections to the SFR package (e.g. units of streambed elevation, formatting of input file, and time step lengths)	7	$1,495	
3.2	Make corrections to FHB package (e.g. address errors of inflows being assigned to inactive cells)	9	$2,073	
3.3	Make corrections to MNW2 package (e.g. address unaccounted-for pumping and well histories) and validate/correct the depth distribution of pumping	14	$2,931	
3.4	Make corrections to the FMP (e.g. land use classification of water balance subregion 23)	7	$1,495	
3.5	Run BVHM through WY 2022 and compare results to BVHM-estimated historical water budget and Sustainable Yield	24	$5,352	
3.6	Quantify influence of errors on model results	30	$7,140	
3.7	Conduct a meeting with the TAC to review the results from addressing the model errors and validating the depth distribution of pumping in the MNW2 package	9	$2,091	
4	**Develop and Implement Methods to Estimate Recharge**	**318**		**$ 74,276**
4.1	Research and develop potential new methods and estimate surface-water inflow and subsurface inflow	180	$41,892	
4.2	Compare estimated recharge from new methods to historical data and past BVHM estimates of recharge to characterize difference between new vs. current methods	18	$4,200	
4.3	Present potential new methods for estimating recharge to TAC	9	$2,091	
4.4	Update model input files and run BVHM through WY 2022. Compare model results to prior model results from Task 1.	24	$5,352	
4.5	Prepare a draft TM summarizing the developed methods and model results for TAC review	54	$12,926	
4.6	Conduct TAC meeting	9	$2,091	
4.7	Address TAC comments and finalize TM	24	$5,724	
5	**Upgrade BVHM to Use the New Version of MODFLOW-OWHM**	**360**		**$ 81,656**
5.1	Research differences between MODFLOW-OWHM v1.0.0 and v2.2.0 and determine correct process for BVHM version conversion (e.g. model input files, defined parameters, etc.)	100	$22,916	
5.2	Convert BVHM from MODFLOW-OWHM v1.0.0 to the new version of MODFLOW-OWHM (v2.2.0)	140	$30,956	
5.3	Run BVHM, using MODFLOW-OWHM v2.2.0, through WY 2022 and compare model results to the water budget and ZONEBUDGET output from MODFLOW-OWHM v1.0.0	120	$27,784	

Attachment A

Cost Estimate for a Potential Scope of Work to Redetermine the Sustainable Yield by 2025 -- *WY 2023 and WY 2024*

Task No.	Task / Sub-Task	Labor Hours and Cost		
		Person Hours	Cost	
			Sub-Task	Task
6	**Perform Model Recalibration**	**554**		**$128,510**
6.1	Prepare the input files for model calibration with PEST	168	$37,992	
6.2	Calibrate the model	170	$38,606	
6.3	Prepare calibration results			
6.3.1	Develop time-series of simulated and measured values and other graphics	30	$6,946	
6.3.2	Generate calibration statistics and calculate residuals	30	$6,946	
6.4	Prepare a TM documenting the approach and results	107	$25,441	
6.5	Prepare for and conduct TAC meeting	9	$2,091	
6.6	Address TAC comments and finalize TM	40	$10,488	
7	**Determine the Sustainable Yield (including documentation)**	**444**		**$137,699**
7.1	Develop proposed projection scenarios.			
7.1.1	Research and develop different projection scenarios.		$17,221	
7.1.2	Draft projection scenarios and provide to the TAC for review.		$16,583	
7.2	Develop proposed methods to interpret model results for Sustainable Yield.	48	$11,904	
7.3	Prepare a TM to document projection scenarios and approach to interpret model results.	50	$11,434	
7.4	Conduct TAC meeting	9	$2,091	
7.5	Address TAC comments and finalize TM.	27	$6,461	
7.6	Construct input files and conduct model simulations for the scenarios described in the TM.	96	$21,408	
7.7	Determine Sustainable Yield for simulated projection scenarios	30	$6,558	
7.8	Prepare Draft Report.	92	$21,612	
7.9	Prepare for and conduct TAC meeting to review model results and Draft Report.	9	$2,091	
7.10	Address TAC comments.	36	$9,212	
7.11	Prepare Final Report.	31	$7,308	
7.12	Prepare presentation on the redetermined Sustainable Yield and present to Watermaster Board	16	$3,816	
	Total			**$504,136**

Attachment B

TAC Recommendations for a Scope of Work to Redetermine the Sustainable Yield by 2025 -- WY 2023 and WY 2024

Task No.	Task	Cost Estimate	TAC Member Recommendations			
			County of San Diego	AAWARE	Rams Hill	BWD
1	Compare FMP-estimated Pumping to Actual Pumping for WY 2022	$20,222	Recommended given that the task is being reduced in scope/cost from the $30,000 originally approved by the Watermaster Board for WY 2023.	This task was previously recommended by the TAC in May 2021 and approved by Watermaster Board in July 2022. Therefore, no objection to this task. However, moving forward, ag pumping will be quantified based on actual metered pumping data, and model-derived estimates will presumably become less critical	OK for this update.	This task is essential as pumping was identified as the number 1 model uncertainty.
2	Update Water-Use Factors in the FMP	$39,196	This item should be conducted to adjust pumping to more realistic values if they are indeed off by more than 40%. Suggest reviewing the conclusions from Task 1 to confirm two water years of data are showing water demand is substantially different from assumed values. *It is only recommended to conduct this task if WY2022 actual water demand is similar to actual water demand from WY2021.	No objection to the general concept and rationale of updating water-use factors. There are readily accessible sources for this information, such as FAO Irrigation and Drainage Paper No. 56. Other methods including remote sensing, spectral imaging, heat signatures might aid in establish Et values and crop coefficients.	Assess data from Task 1 before implementing (i.e., are there significant differences)?	This item should be conducted to adjust pumping if they are determined to not agree with the metered data. Pumping was identified as the number 1 model uncertainty. This task is foundational to the redetermination of the sustainable yield.
3	Correct Errors Identified in 2021 BVHM	$22,577		Concur with the stated objectives and task description.	Recommend this task be completed without delay.	
4	Develop and Implement Methods to Estimate Recharge	$74,276	Agricultural pumping is the most sensitive parameter assumed to be nearly 70% of the uncertainty in the model. The biggest reduction in uncertainty is going to be gained for the 2025 model update due to the use of metered data for irrigated fields. The subsurface underflow and streamflow recharge are estimated to be about 10% of the uncertainty and don't have readily available data to reduce uncertainty and therefore not recommended to pursue at this time. As was pointed out in summarized previous TAC meeting minutes from 4/27/21 regarding subsurface inflow: "This source of recharge is impossible to measure directly and difficult to estimate." Unfortunately there are few wells along the boundaries of the basin for comparison. Additionally, wells typically just go down year after year and don't show ups and downs typically of basins outside of the desert where rainfall is greater. The USGS may have developed the simplified method of fixed underflow given no satisfactory way to validate using other methods. According to the USGS, underflow represented only 3% For surface flow, stream gages also are limited and sporadic in a desert environment. With so little data available, evaluating other recharge methods is likely going to difficult. To improve understanding of stream flow recharge, more stream gauges was recommended from the GSP effort. It would be recommended to develop and implement this task for surface water recharge if and when more stream gauging data becomes available as part of adaptive management of the Basin.	It is noted by West Yost that there is not a reproducible method for estimating surface water inflow between various models (USGS, Dudek, West Yost). Overall, it seems like this task will be focused on finding new ways to evaluate a very limited number of inputs to the current model(s). In addition, the concept of an “average” recharge related to surface water inflow from mountain-front desert environments is problematic and difficult to measure. Developing new methods to estimate recharge will not offset the current lack of knowledge and data to quantify it. As metered production data and basin-wide water level monitoring data are collected, comparison of pumping with change in storage would probably provide the best estimate of actual recharge. TAC should consider deferring this task until sufficient production and monitoring data are available to develop updated, data-based inputs to the model.	Recommend we delete this task.	The lack of technical documentation by the USGS regarding stream flow inputs to the BVHM was previously identified as a model issue as part of the 2016 BVHM Update. In the model documentation, the USGS stated that they used runoff and recharge outputs from the BCM to calculate streamflow for each of the 24 sub-watersheds that drain into the model domain. The USGS provided GIS shapefiles containing the boundaries of the sub-watersheds. However, the USGS stated that they could not provide a detailed description of how streamflow was calculated and referred to the model documentation as containing all necessary information. The BCM output files were used to calculate streamflow and attempt to recreate the streamflow simulated in the USGS model from 1945 to 2010 using the sub-watershed boundaries to extract recharge and runoff output from the BCM. Two major issues occur when attempting to replicate the calculations of stream flow to the basin: 1) the raw runoff and recharge data from the BCM has to be multiplied by a factor to get the streamflow from each sub-basin defined in the input file, and it is unclear from the model documentation exactly what factors were used to calculate this data, and 2) there are instances where the BCM had runoff while the model input do not, and vice versa. This suggested that there may be some time delay component, or some other factor included in the USGS calculation of streamflow for the input file, and there is no clear documentation of what this might be. There is also a constant inflow from two watersheds in the model (Coyote Creek and a smaller unnamed watershed), which could not be recreated with BCM outputs. Finally, it is not clear how SFR segments/reaches are handled in areas with layer 1 inactive. The processing steps necessary to translate the BCM data to a timeseries of all major stream inflows into the BVHM is unclear and remains a model issue. Basin Characterization Model, version 8 (BCMv8) was released after the development of the BVHM. BCMv8 was refined to improve the accuracy of the water-balance components, particularly the recharge estimate. Use of improvements to BCMv8 for the BVHM update should be evaluated for development of past and future stream inflow inputs. All steps necessary to calculate streamflow inputs into the BVHM should be documented in a technical appendix. Add scope and fee to WY 2023 budget.
5	Upgrade BVHM to Use the New Version of MODFLOW-OWHM	$81,656	Concur with West Yost that upgrading the model at this time would open a host of new issues to address to fix bugs in the new model.	Concur with West Yost recommendation to defer task and may involve significant additional work to identify bugs in version of program.	Aquilogic recommends abandoning the MODFLOW-OWHM (MF-OWHM) platform as soon as feasible and transferring the BVHM to the MODFLOW 6 (MF 6) platform. Significant resources are being proposed to improve the "prediction" of agricultural pumping for this current update. In the future the FMP is likely not necessary because virtually all extraction wells are now metered and the current modeling objective is to estimate present and future sustainable yield. The Judgement already accepted that the USGS historical recharge estimate of 5,700 AFY is the initial sustainable yield, to be updated three times over the next 12 years. Recommend the WM prepare a white paper for review by the TAC comparing the pros/cons of continuing to use the MF-OWM (either version) versus MF6. Provide cost estimate for white paper. It seems likely that the usable outputs from the original BVHM and subsequent updates can be used as initial estimates for the historical portion of a MF 6 model, although the historical model is now only needed to provide initial conditions for simulating the recent past, present, and future. As it is already known that FMP underpredicts agricultural pumping in the Borrego Springs Subbasin, the available historical land-use and crop maps can be used to develop revised pumping estimates, as needed. Experience in the Salinas Valley has shown that MF-OWHM models are notoriously difficult to calibrate and vastly underestimated agricultural pumping in that basin as well. It should be noted that the support team and user community for MF 6 is significantly larger than that for MF-OWHM. Furthermore, the official USGS core MODFLOW platform is MF 6, not MF-OWHM, which is used by a niche community. Recommend moving to MF 6.	Cost benefit of upgrading BVHM to MODFLOW-OWHM v2.2.0 should be further evaluated. This task needs to better scoped as to what steps are necessary to upgrade the model in order to better estimate this cost. This task should be deferred to future update (i.e. 2030).
6	Perform Model Recalibration	$128,510		Concur with recommendation.	Critical to this update.	The model revisions appear to warrant and need to recalibrate the model.
7	Determine the Sustainable Yield (including documentation)	$137,699	Recommended given that the task is being reduced in scope/cost from the $150,000 originally approved by the Watermaster Board for WY 2024.		Concur with recommendation.	