Borrego Springs Watermaster
Board of Directors Meeting
February 10, 2022
AGENDA ITEM V.B

To: Board of Directors

From: Andy Malone, Technical Consultant

Date: February 7, 2022

Subject: Annual Change in Basin Storage for DWR Reporting

☐ **Recommended Action** ☐ **Provide Direction to Staff** ✓ **Information and Discussion**

☐ **Fiscal Impact** ☐ **Cost Estimate: $**

Background and Previously Related Actions by the Board

The Borrego Springs Watermaster is required to submit an annual report for the Borrego Springs Groundwater Subbasin (Annual Report) to the California Department of Water Resources (DWR) pursuant to the requirements of the Sustainable Groundwater Management Act (SGMA). One element of the Annual Report is an estimate of the annual change in groundwater in storage for the preceding water year.

The Watermaster Board showed considerable interest and concern with the change in groundwater storage estimates that were prepared for the 2020 Annual Report. Topics of concern included the data and methods used to estimate storage change, the storage-change results, and the messaging that the storage-change results send to the BPA Parties and the public.

In WY 2022, the Board has asked the Technical Advisory Committee (TAC) to provide advice and guidance to the Technical Consultant on the methods to estimate annual storage change for the WY 2021 Annual Report to the DWR.

Discussion

The TAC met on November 9, 2021. At the meeting, the TAC reviewed the current methodology to estimate storage changes used in prior Annual Reports and recommended certain changes to the current methodology. The Technical Consultant prepared a draft technical memorandum to describe an updated methodology to estimate annual storage change. The TAC has had the opportunity to review, comment, and suggest revisions. Attached to this memorandum is the draft-final technical memorandum that describes the updated methodology. The Technical Consultant is proceeding with this methodology to estimate the storage change that occurred within the Borrego Springs Subbasin over the period Spring-2020 to Spring-2021.

At the February 10, 2022 Board meeting, the Technical Consultant will:

1. Review the updated methodology to estimate annual storage change.
2. Review the preliminary storage change results.

Next Steps

1. The Technical Consultant will document the storage change results in a technical memorandum and circulate with the TAC members for their review and comment.
2. The Technical Consultant will address TAC comments/suggestions and will finalize:
    i. The storage-change estimate for Spring-2020 to Spring-2021.
    ii. The technical memorandum titled: *Methods to Estimate Annual Storage Change in the Borrego Springs Subbasin*.
3. The Technical Consultant will include the storage change results in the draft Annual Report by March 3, 2022 for Board review.

Enclosures

Technical Memorandum: *Methods to Estimate Annual Storage Change in the Borrego Springs Subbasin* (draft final)

Agenda Item V.B

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TECHNICAL MEMORANDUM

DATE: February 4, 2022

Project No.: 940-80-21-02 (120)
SENT VIA: EMAIL

TO: Technical Advisory Committee of the Borrego Springs Watermaster

FROM: Andy Malone, Technical Consultant

SUBJECT: Methods to Estimate Annual Storage Change in the Borrego Springs Subbasin (draft final)

Background and Objectives

The Borrego Springs Watermaster is required to submit an annual report for the Borrego Springs Groundwater Subbasin (Annual Report) to the California State Department of Water Resources (DWR) pursuant to the requirements of the Sustainable Groundwater Management Act (SGMA), specifically Article 7, Section 356.2—Annual Reports, of the California Code of Regulations (CCR).[1]

A portion of the annual reporting requirements include the annual changes in groundwater levels and groundwater in storage: [2]

- Groundwater elevation data from monitoring wells identified in the monitoring network shall be analyzed and displayed as follows:
    - Groundwater elevation contour maps for each principal aquifer in the basin illustrating, at a minimum, the seasonal high and seasonal low groundwater conditions.
    - Hydrographs of groundwater elevations and water year type using historical data to the greatest extent available, including from January 1, 2015, to current reporting year.
- Change in groundwater in storage shall include the following:
    - Change in groundwater in storage maps for each principal aquifer in the basin.
    - A graph depicting water year type, groundwater use, the annual change in groundwater in storage, and the cumulative change in groundwater in storage for the basin based on historical data to the greatest extent available, including from January 1, 2015, to the current reporting year.

So far, the Watermaster has submitted two Annual Reports to the DWR: the first one prepared by DUDEK in 2020 covering Water Year (WY) 2016 through 2019; the second one prepared by West Yost for WY 2020. The Watermaster Board showed considerable interest and concern with the change in groundwater storage estimates that were prepared for the 2020 Annual Report. Topics of concern included the data

[1] Title 23, Division 2, Chapter 1.5, Subchapter 2 of the California Code of Regulations, which is commonly referred to as the Groundwater Sustainability Plan Regulations (GSP Regulations).
[2] California Code of Regulations, Title 23 § 356.2.

and methods used to estimate storage change, the storage-change results, and the messaging that the storage-change results send to the BPA Parties and the public.

In WY 2022, the Board has asked the TAC to provide advice and guidance to the Technical Consultant on the methods to estimate annual storage change for the WY 2021 Annual Report to the DWR. The TAC met on November 9, 2021. At the meeting, the TAC reviewed the current methodology used in prior Annual Reports and recommended certain changes to the current methodology.

TAC Recommendations

The consensus of the TAC is the following:

1. The main objective is to establish a standard method that ensures technically-defensible estimates of annual storage changes and timely annual reporting to the DWR by April 1 of each year. The storage change estimates derived by this method are not intended to be used to change management actions under the Physical Solution. Detailed evaluations of changes in groundwater conditions will be performed every five years consistent with the SGMA and the Physical Solution.

2. The Watermaster should continue using the methods employed for past annual reports[3] (attached) with some revisions. The recommended revisions include the following:
   - If groundwater-elevation data are not available for a well in the monitoring network during the period of interest, a groundwater elevation should be estimated for that well, based on the best available information, so that the spatial distribution of groundwater-elevation data remains relatively consistent year-to-year.
   - Estimates of change in storage should be computed for two spatial domains: (i) across the entire domain of the Subbasin, as was done for past annual reports and (ii) only the area of the Subbasin where groundwater-elevation data are present.

3. The reasoning for this recommended approach is:
   - Using methods that are similar to the methods used in past efforts will produce results that are consistent with past estimates of storage change.
   - The methods should include steps to minimize the influence of the methods themselves on the storage-change results.
   - The methods should include QA/QC steps to check on the reasonableness of the results.

The specific methods recommended by the TAC to estimate annual storage change for the WY 2021 Annual Report to the DWR are described below.

General Approach to Estimate Annual Storage Change in the Subbasin. The change in groundwater elevations across the Subbasin between water years 2020 and 2021 will be calculated by subtracting groundwater elevation in Spring 2021 from groundwater elevation in Spring 2020. This will produce a map of change in groundwater elevations across the Subbasin. The change in storage will be computed by mapping the change in groundwater elevation and the depth-averaged Specific Yield of the aquifer sediments (effective porosity), as defined in the Borrego Valley Hydrologic Model (BVHM), onto a

[3] Dudek. 2021. *Borrego Springs Subbasin Annual Report Change in Storage Calculation Methodology*. Prepared for Samantha Adams, West Yost. March 26, 2021.

regularly spaced "Storage Change Grid" GIS shapefile. The grid was originally prepared by Dudek for past estimates of storage change and has a spatial discretization of 1,000 feet by 1,000 feet, oriented in the north-south direction, with a spatial extent across the entire Subbasin. Change in storage will be calculated at the grid-cell level using the following equation:

$$\boldsymbol{Change\ in\ Storage_i = \left(GWE_i^{t1} - GWE_i^{t0}\right) \times S_{y_i} \times A}$$

where,

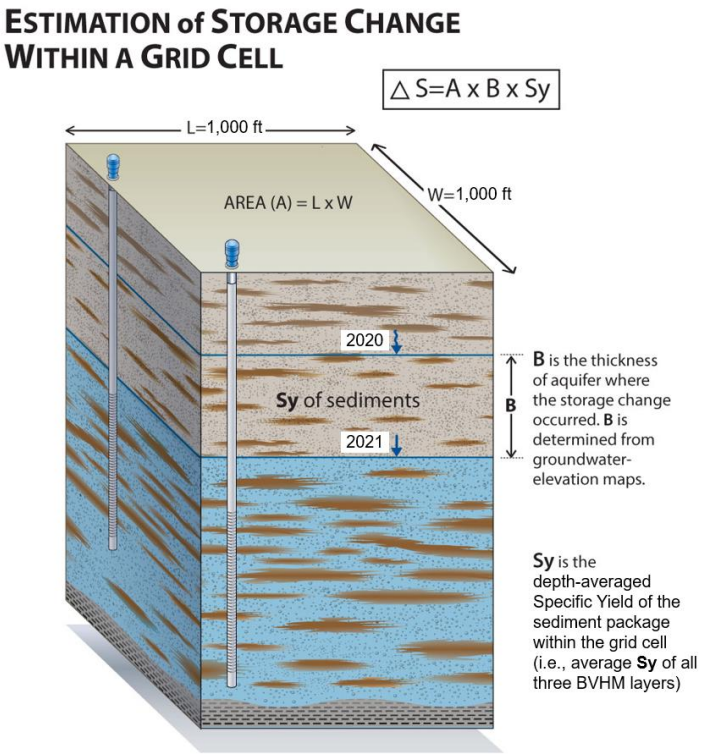
$\boldsymbol{i}$ represents a unique cell within the storage change calculation grid

$\boldsymbol{GWE}$ is the interpolated groundwater elevation at cell $\boldsymbol{i}$

$\boldsymbol{Sy}$ is the specific yield defined at cell $\boldsymbol{i}$

$\boldsymbol{A}$ is the area of each cell

$\boldsymbol{t1}$ and $\boldsymbol{t0}$ are the two years between which storage change is calculated



The conceptual grid cell above is a graphical representation of the proposed method to estimate annual storage change within a grid cell.

Specific Steps to Estimate Annual Storage Change in the Subbasin

1. Check and upload all groundwater elevation data measured at wells during WY 2021 to the HydroDaVE database management system.
2. For each well, inspect the time-series chart of groundwater elevation in the HydroDaVE Explorer interface and select a "true static" groundwater elevation for Spring 2021 (*i.e.,* April 1, 2021 plus or minus 30 days). If a "true static" groundwater elevation measurement is not available for the well, an "estimated static" groundwater elevation can be selected based on the professional judgment of the Technical Consultant. The choice of an "estimated static" groundwater elevation could be based on, but not limited to: recent trends in groundwater elevation at the well; recent trends in groundwater elevation at nearby wells; and knowledge of the influence of nearby pumping.
3. Prepare time-series charts of groundwater elevations for each well including the "true static" or "estimated static" groundwater elevations for Spring 2021.
4. Prepare a rasterized surface of interpolated "true static" groundwater elevations across the Subbasin for Spring 2021 using an inverse distance weighting scheme with a power of 1. The interpolation can be performed with Golden Software Surfer, ArcGIS Spatial Analyst, or similar interpolation tool. The spatial resolution and dimensions of the raster shall be consistent with rasterized surface produced by Dudek for the WY 2020 Annual Report.
5. Import the rasterized surfaces of interpolated groundwater elevations across the Subbasin for Spring 2021 and Spring 2020[4] to GIS. Using raster algebra in GIS, subtract the raster of groundwater elevations in Spring 2020 from the raster groundwater elevation in Spring 2021 to generate a raster of change in groundwater elevation, apply a color ramp, and inspect the raster as a check on reasonableness of the estimated change in groundwater elevation across the Subbasin. Negative values will indicate a decline in groundwater levels; positive values will indicate an increase in groundwater levels; zero values will indicate no change in groundwater levels or areas on the extreme edges of the basin where no information was available to estimate the specific yield of the aquifer sediments.
6. Create a polygon shapefile in GIS to define the area where groundwater-elevation data exists for Spring 2021 ("Polygon Mask").
7. Import the Storage Change Grid shapefile to GIS. The shapefile attribute table contains the depth-averaged Specific Yield values from the BVHM for each grid cell, the surface area of each grid cell, and the X-Y coordinates of the centroid of each grid cell.
8. Using the geometric centroid of each grid cell, assign the raster values to the shapefile attribute table for: (i) groundwater elevation for Spring 2020; (ii) groundwater elevation for Spring 2021; (iii) change in groundwater elevation between Spring 2020 and Spring 2021; and (iv) whether the grid cell resides within or outside the Polygon Mask.
9. Import the Storage Change Grid attribute table into Microsoft Excel to calculate the change in storage by grid cell using the $Change\ in\ Storage_i$ equation referenced above. The sum of the change in storage values by grid cell will provide an estimate of the total annual change in storage in the Subbasin. Perform the same calculation for only those grid cells within the Polygon Mask.

[4] The rasterized surface of interpolated groundwater elevations for Spring 2020 was prepared by Dudek, using similar methods, for the Annual Report to the DWR for WY 2020.

Compare the two results as a check on reasonableness of the results, which may reveal errors in execution of the methods or errors introduced by the methods themselves.

10. Display the storage-change results graphically in GIS by applying a color ramp to the Storage Change Grid shapefile for storage-change volume by grid cell. Inspect the results as a check on reasonableness, which may reveal errors in execution of the methods or errors introduced by the methods themselves.

Next Steps

The Technical Consultant will present the methods to the Board at its February 10, 2022 meeting. The Technical Consultant will use the TAC-recommended method to estimate annual storage change for the WY 2021 Annual Report to the DWR.

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DRAFT MEMORANDUM

To:	Samantha Adams, West Yost
From:	Trey Driscoll, PG No. 8511, CHG No. 936, Devin Pritchard-Peterson, Trevor Jones, PhD
Subject:	Borrego Springs Subbasin Annual Report Change in Storage Calculation Methodology
Date:	March 26, 2021
cc:	Geoff Poole, Borrego Water District, Jim Bennett, County of San Diego
Attachment(s):	

At the March 23, 2021 Interim Borrego Springs Watermaster Board of Directors (Watermaster Board) Meeting, the Watermaster Board determined that the methodology employed in the Borrego Springs Subbasin (Subbasin) 2020 Annual Report (Annual Report) to calculate change in groundwater in storage needs to be consistent with the methodology used in the 2019 Annual Report. The objective of this memorandum is to detail the methodology used in the 2019 Annual Report to calculate change in storage.

1 Methodology

The change in storage estimates reported in the 2019 Annual Report were calculated by comparing spring groundwater elevations between water years 2015 and 2019. Annual change in storage was computed by mapping depth-averaged aquifer properties[1], defined in the Borrego Valley Hydrologic Model, and spring groundwater elevations onto a regularly spaced grid generated in a Geographic Information System (GIS). The grid was defined using a spatial discretization of 1,000 feet by 1,000 feet, oriented in the north-south direction, and constructed to extend across the entire Subbasin. The resulting grid contained 103 rows and 72 columns. Change in storage was calculated at the grid-cell level using the following equation:

$$Change\ in\ Storage_i = \left(GWE_i^{t1} - GWE_i^{t0}\right) \times S_{y_i} \times A$$

where *i* represents a unique cell within the storage change calculation grid, *GWE* is the interpolated groundwater elevation at cell *i*, Sy is the specific yield defined at cell *i*, A is the area of each cell, and *t1* and *t0* are the two years between which storage change is calculated.

The interpolated groundwater elevations (*GWE)* defined each spring were generated by contouring groundwater elevations measured in the monitoring network using the software Surfer 17.1.288 (Golden Software, LLC). Groundwater contours were generated in Surfer using an inverse distance weighting scheme with a power of 1. Dimensions of the GIS-generated storage change grid were imported into Surfer to ensure that specific yield and contoured groundwater elevations were defined at the same point in space.

[1] Depth-averaged aquifer properties were mapped onto the change in storage grid in GIS using a one-to-one spatial join using the closest match option.

The interpolated groundwater elevations generated by Surfer were exported as a ".dat xyz file type". This export format saves the Easting and Northing of each cell center and the corresponding interpolated groundwater elevation. The interpolated groundwater elevations were imported into Microsoft Excel and matched with the specific yield values that corresponded to the same location to calculate the change in storage by grid cell using the equation referenced above. The sum of the change in storage values by grid cell provided an estimate of the total annual change in groundwater in storage in the Subbasin. Results were displayed graphically by importing the storage change values by grid cell into GIS and applying a graduated color scheme to categorize values.

Comparison of the change in groundwater storage using the interpolation method described above with the simulation results from the Borrego Valley Hydrologic Model over the years in which modeled and measured data overlapped reasonably reproduced change in groundwater storage values.