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DRAFT TECHNICAL MEMORANDUM

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TO: Ad Hoc Sustainable Groundwater Planning Advisory Committee (GSU22 Committee)

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PROJECT: Basin Management Plan: Groundwater Sustainability Update 2022 (GSU22)

SUBJECT: Pajaro Valley Hydrologic Model Updates Supporting GSU22 Analyses

INTRODUCTION

The Pajaro Valley Water Management Agency (PV Water) submitted a Groundwater Sustainability Plan (GSP) Alternative for the Pajaro Valley Subbasin (Basin) on December 31, 2016, to meet requirements under the Sustainable Groundwater Management Act (SGMA). The California Department of Water Resources (DWR) approved the GSP Alternative on July 17, 2019. Along with its approval, DWR provided 10 recommended actions for PV Water to consider when preparing its 5-Year Update, the GSU22, due January 1, 2022.

The Pajaro Valley Hydrologic Model (PVHM) is a numerical groundwater model of the Basin that supports analyses to meet 3 of the 10 recommended actions of DWR:

1. Projected water budget that incorporates the proposed projects of PV Water's Basin Management Plan Update 2014 (BMP 2014) (DWR Recommended Action 4)
2. Assessment of the non-jurisdictional portion of the Basin (DWR Recommended Action 1)
3. Measurable objectives for chronic depletion of groundwater levels sustainability indicator DWR Recommended Action 5)

In its review of PV Water's GSP Alternative, DWR reviewed the United States Geological Survey's (USGS) PVHM report (Hanson *et al.*, 2014) and concluded the following:

> *The hydrogeologic conceptual model and numerical model described in the PVHM report incorporate the relevant hydrologic processes in the entire Subbasin and the*

understanding of hydrogeologic conditions based on previous studies. The numerical model appears to be reasonably well-calibrated to support analysis presented in the Basin Management Plan. The numerical model is used to generate a detailed and thorough water budget that includes many of the components required by the GSP Regulations.

Since 2014, the USGS and PV Water have incorporated numerous updates to the PVHM. The USGS plans to document these updates and revised model calibration in a peer-reviewed scientific journal article. As this journal article is not yet available, this memorandum summarizes the PVHM updates for the GSU22 Committee as it considers projected water budgets and a non-jurisdictional assessment based on the PVHM. Descriptions are based on USGS presentations to PV Water Board (Henson and Earll, 2018) and staff (Earll and Henson, 2020) as well as personal communication from the USGS.

SUMMARY OF MODEL UPDATES

To support PV Water's ongoing use of the PVHM, such as for the GSU22, the USGS has updated the PVHM to improve simulation accuracy, represent BMP 2014 projects based on current information, extend the model timeframe, and to simulate projected future climate conditions. Specific updates include:

- Upgrade to newest version of MODFLOW One-Water Hydrologic Flow Model (OWHM)—Conjunctive Use Simulation Software, including implementation of Managed Aquifer Recharge and Recovery (MARR) projects within the MODFLOW Farm Process.
- Improvements to the simulation of the freshwater equivalent head along the coastal boundary.
- Improvements to model simulation of surface water.
- Addition of monitoring wells supporting SGMA to the head observation package.
- Improvements to simulation of multi-aquifer wells and incorporation of additional farm wells.
- Update of the historical model through 2018.

From April through June of 2021, additional areas of improvement were identified in the PVHM and addressed by Montgomery & Associates and the USGS. The improvements support use of the PVHM to address DWR Recommended Actions for the GSU22. Areas of improvement were identified in the following model components:

- General Head Boundary (GHB) File: The coastal and inland GHB conditions utilized in the model, originally in a mix of vertical datums, were converted to the NAVD88 datum. A scaling factor was applied in projected scenarios to increase inland GHB in tandem with sea level rise.
- Head Observation File (HOB): The well observations utilized in model HOB file, originally in a mix of vertical datums, were converted to NAVD88.

The implementation and timing of BMP 2014 projects and management actions in the model was also updated. Four projected runs encompassing 3 climate change scenarios and 2 sea level rise scenarios were implemented.

MODEL PLATFORM UPGRADE AND IMPROVEMENTS IN PHYSICAL SIMULATION

The USGS updated the PVHM to the newest version of MODFLOW One-Water Hydrologic Flow Model—Conjunctive Use Simulation Software (https://doi.org/10.3133/tm6a60), referred to as MF-OHWM2. This update incorporates upgrades to the MODFLOW Farm Process, which includes features improving the representation of physical processes.

The upgraded Farm Process improves the simulation of PV Water's Managed Aquifer Recharge and Recovery (MARR) operation. MARR pumping is represented as a "CROP" that demands diverted water from surface water bodies such as Harkins Slough to the infiltration pond "FARM" to percolate into the groundwater. These designations allow quantification of demand and deliveries and provide information on groundwater level beneath the infiltration ponds. The Harkins and Watsonville Slough diversions are set up with lower/upper limits based on fish requirements and water is diverted December through May and routed to the infiltration basins.

The formulation for the coastal head boundary to assess seawater intrusion has been modified to represent the density of saline water as a freshwater head equivalence with a mathematically robust representation tested within MODFLOW (Motz and Sedighi, 2013). The boundary heads were also converted to a consistent vertical datum, NAVD88.

Stream inflows generated from the Basin Characterization Model (BCM) (https://ca.water.usgs.gov/projects/reg_hydro/basin-characterization-model.html) watershed model now use a more realistic representation of runoff. Stream inflow measured at PAJARO R A CHITTENDEN CA was used to represent inflows to the model. Pajaro River flow is now output at 3 locations in the model domain, PAJARO R A CHITTENDEN CA, PAJARO R A WATSONVILLE CA, and PAJARO R A MURPHY CROSSING.

All observation wells for SGMA annual reporting and additional farm wells were added to the model. The representation of multi-aquifer wells within the model was also improved.

UPDATE OF HISTORICAL MODEL THROUGH 2018

The following model components were updated to extend the calibrated historical model through 2018, using data from the BCM and data provided by PV Water:

1. Land use
2. Climate arrays
3. HOBs, including update to reference consistent vertical datum, NAVD88
4. Wells, including municipal and industrial wells, multi-node wells, domestic pumping, and farm supply wells
5. GHBs for coast and adjacent basins
6. Stream Inflows
7. Diversions
8. Non-routed deliveries including Coastal Distribution System (CDS) deliveries.
9. Farm Process inputs

HEAD OBSERVATION FILE (HOB) UPDATES

Prior to model update observation wells present in the PVHM HOB files were implemented using reference point elevations (RPE) from multiple different datums, and were therefore not consistent with each other, the model layering (NAVD88), or the general head boundary conditions (discussed more below). A cataloging of RPE datums for all wells present in the HOB file was conducted, and RPE were converted to NAVD88 where appropriate. For wells with RPE in feet-mean sea level (ft-MSL), a universal shift of 2.956 feet was added to each RPE as consistent with known ft-MSL and ft-NAVD88 values at the Monterey National Oceanic and Atmospheric Administration (NOAA) station (https://tidesandcurrents.noaa.gov/datums.html?datum=NAVD88&units=1&epoch=0&id=9413450&name=Monterey&state=CA) For wells with RPE in the NGVD1926 datum, the NOAA online conversion system was used to transfer RPE into NAVD88 (https://www.ngs.noaa.gov/NCAT/). Where a datum was unknown, the NAVD88 Digital Elevation Model (DEM) value for ground surface at that well location was used as the RPE. The DEM was derived from a USGS led QL2 LiDAR survey conducted in 2018.

GENERAL HEAD BOUNDARY (GHB) UPDATES

Ocean GHB

An update of the ocean GHB condition contributed to an improved understanding and more accurate simulation of seawater intrusion. In a select number of cells in model layer 1, negative bathymetric heads were identified and adjusted to be positive. The ocean GHB was also corrected from ft-MSL to NAVD88, resulting in higher heads of 2.97 feet (https://tidesandcurrents.noaa.gov/datums.html?datum=NAVD88&units=1&epoch=0&id=9413450&name=Monterey&state=CA).

Inland GHB

Seven of the wells along the boundary with the Santa Cruz Mid-County subbasin, whose observations were used to generate the inland GHB, were determined to be in NGVD1929 rather than NAVD88. These were converted to NAVD88 using the NOAA online conversion service (https://www.ngs.noaa.gov/NCAT/). This conversion raised the GHB RPE and corresponding groundwater elevation observations by 2.76 feet on average. To better represent interbasin groundwater flows and the influence of sea-level rise on the Basin, inland GHB were also adjusted in the projected scenarios using a scaling factor, to increase the GHB in tandem with sea-level rise (Chang et al., 2011; Werner and Simmons, 2009).

UPDATED SIMULATION OF BMP 2014 PROJECTS

The following bullets summarize the model implementation of BMP 2014 projects and management actions.

- Recycled Water Deliveries: Deliveries are sent to the CDS beginning in WY 2002. Farm 19 was added, which receives deliveries from the CDS beginning in 2016.
- Harkins Slough Managed Aquifer Recharge and Recovery Project improvements; beginning in 2022, diverts up to 1,200 AFY November through May.
- Watsonville Slough Managed Aquifer Recharge and Recovery Project; beginning in 2025, diverts up to 1,200 AFY November through May.
- College Lake Integrated Resources Management Project, beginning in 2025, diverts up to 2,400 AFY November through May, water is delivered to coastal farms via the CDS.
- Recharge Net Metering Sites were added at 2 recharge basin locations beginning in 2020, recharges up to 300 AFY of water at each site.

CLIMATE CHANGE AND SEA LEVEL RISE SCENARIOS

The USGS has developed model scenarios representing 3 RCP 8.5 climate scenarios that it has identified as Wet, Average, and Dry (Henson and Earll, 2018):

- Wet: Centre national de recherches météorologiques (CNRM)
- Average: Community Climate System Model version 4 (CCSM4)
- Dry: Model for Interdisciplinary Research on Climate Earth System Model (MIROC-esm)

The USGS has also developed 2 sea level rise (SLR) projections from the 50th and 99.9th percentile sea level rise projected by the California's Fourth Climate Assessment global circulation model Canadian Earth System Model 2nd generation (CanESM2) under high emissions assumptions (RCP 8.5) from the San Francisco SCRIPPS buoy. Groundwater elevation rise that reflects the sea level rise projection is incorporated into the general head boundaries at both the ocean boundary condition and the model's inland periphery. Sea level rise is incorporated at the inland boundary to better represent inter-basin groundwater flows and the influence of SLR on the Basin (Chang *et al.*, 2011; Werner and Simmons, 2009). The data were aggregated into monthly averages for implementation in the GHB boundary conditions.

The 4 projected model runs incorporating the above climate change and SLR scenarios are summarized in Table 1 below.

Table 1. Summary of Climate Change and Sea Level Rise Scenarios

Run Name	Climate Scenario	Sea Level Rise (SLR) Scenario	Descriptive Name
BMP_CCSM4_rcp85_50p	Community Climate System Model version 4 (CCSM4)	CanESM- rcp85 50 percentile SLR	Central Tendency Climate and SLR
BMP_CCSM4_rcp85_99p	CCSM4	CanESM- rcp85 99.9th percentile SLR	Central Tendency Climate, Extreme SLR
BMP_CNRM_RCP85_50p	Centre national de recherches météorologiques (CNRM)	CanESM- rcp85 50 percentile SLR	Wet Climate, Central Tendency SLR
BMP_MIROC-esm_RCP85_50p	Model for Interdisciplinary Research on Climate Earth System Model (MIROC-esm)	CanESM- rcp85 50 percentile SLR	Dry Climate, Central Tendency SLR

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