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DRAFT TECHNICAL MEMORANDUM

DATE: August 9, 2021 **PROJECT #:** 9090.0601

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

CC: Brian Lockwood, P.G., C.Hg. and Casey Meusel, Pajaro Valley Water Management Agency

FROM: Patrick Wickham, Luis Mendez, and Cameron Tana, P.E.

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

SUBJECT: Projected Water Budget Analyses

GROUNDWATER BUDGETS

The Pajaro Valley Water Management Agency (PV Water) submitted a Groundwater Sustainability Plan (GSP) Alternative 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. PV Water's 2014 Basin Management Plan (BMP 2014, Carollo, 2014) serves as the primary document of the GSP Alternative and describes PV Water's projects and management actions to achieve sustainability. DWR's assessment of the GSP Alternative included a recommendation that PV Water include a projected water budget that incorporates implementation of BMP 2014 as follows:

- Recommended Action 4: DWR recommends that the Agency update the Basin Management Plan to include a projected water budget that demonstrates the anticipated response to Plan implementation. This recommendation is based on Department staff's understanding that modeling scenarios documented in the Alternative, including those projecting conditions into the future, include infrastructure and projects existing at the time of Alternative submittal, and that the results of those scenarios were used to develop the projects identified in the Basin Management Plan. Staff recommend that the Agency incorporate the proposed projects into the analysis of its projected water budget to provide an increased level of confidence that those projects are likely to have the intended effects on the water budget and groundwater conditions.

This technical memorandum presents historical, current, and projected water budgets in response to DWR's recommendation. The water budgets will be included in the Basin Management Plan: Groundwater Sustainability Update 2022 (GSU22) to be submitted as PV Water's 5-year Update of its GSP Alternative due to DWR by January 1, 2022. The water budgets are based on results

of simulations prepared by the U.S. Geological Survey using the updated Pajaro Valley Hydrologic Model (PVHM). In addition to incorporating projects and management actions, the projected water budgets incorporate climate change and sea level rise. To evaluate the effect of the BMP 2014 implementation for addressing DWR Recommended Action 4, the projected water budgets are compared against updated historical and current water budgets. Water budgets are reported in graphical and tabular formats, where applicable.

PROPOSED STATEMENT FOR PROJECTED WATER BUDGETS

Based on this technical memorandum, the following is the proposed language for the GSU22 Committee to consider as a statement for the PV Water Board to approve inclusion in the GSU22 submittal:

> The projected water budget results from the Pajaro Valley Hydrologic Model, updated in 2021, demonstrate that the Basin Management Plan Update (2014) projects and management actions are likely to achieve their intended effects, increasing groundwater in storage and reducing the rate of seawater intrusion, through 2040.

OVERVIEW OF WATER BUDGET DEVELOPMENT

Groundwater budget descriptions are divided into three subsections: (1) historical groundwater budget, (2) current groundwater budget, and (3) projected groundwater budgets. Each water budget is accompanied by a summary of key observations over time, including how climate, sea level rise (SLR), and variation in groundwater budget components influence water resources conditions in the Basin. A table summarizing the average annual amount of water contributed by each component is provided in addition to a graphical representation of the water budget components over time.

DWR's GSP regulations set numerical groundwater and surface water models as the standard tool for developing water budgets. The PVHM is an integrated groundwater and surface water model that meets SGMA requirements for estimating water budgets. DWR reviewed the PVHM report (Hanson et al., 2014) as part of its approval of PV Water's GSP Alternative:

> 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.

The USGS, in collaboration with PV Water, has updated and refined the PVHM since 2014. An overview of model updates and refinements implemented between now and BMP 2014 is

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provided in the accompanying technical memorandum *Pajaro Valley Hydrologic Model Updates Supporting GSU22 Analyses* (M&A, 2021). The USGS has also used the updated PVHM to simulate multiple climate change and sea level rise scenarios. This technical memorandum presents projected water budgets based on average projections for climate change and sea level rise to address DWR's Recommended Action 4 consistent with DWR guidance (DWR, 2018). A subsequent technical memorandum will present projected water budgets based on these additional scenarios to help evaluate uncertainty of achieving sustainability related to climate change and sea level rise.

GROUNDWATER BUDGET AREA

The groundwater budget is an inventory of groundwater inflows and outflows to and from the Basin. Some groundwater budget components can be measured, such as municipal groundwater pumping from a metered well. Other components of the groundwater budget are simulated by the model, such as recharge from precipitation, agricultural groundwater pumping, and change of groundwater in storage. The change of groundwater in storage is calculated by the model from simulated inflows minus outflows and is associated with change in groundwater levels.

The Basin-wide groundwater budgets presented here are calculated for the Basin's lateral extent, containing the Alluvial, Upper Aromas, Lower Aromas, and Purisima aquifers (labeled as Pajaro Valley Combined Area in Figure 1). Additional water budgets and presentations of key components in the Aromas (Upper Aromas and Lower Aromas) aquifer, the principal aquifer of the Basin, utilize 3 Basin subareas (Figure 2):

- The area (isocontour zone in cyan on Figure 2) seaward of the proposed 250 mg/L chloride isocontour developed for GSU22 as the seawater intrusion (SWI) minimum threshold (MT);
- The area in the Basin outside PV Water's jurisdictional area (non-jurisdictional area in green on Figure 2); and
- The remaining portion of the Basin inland of the 250 mg/L isocontour and within PV Water's jurisdictional area (light blue on Figure 2).

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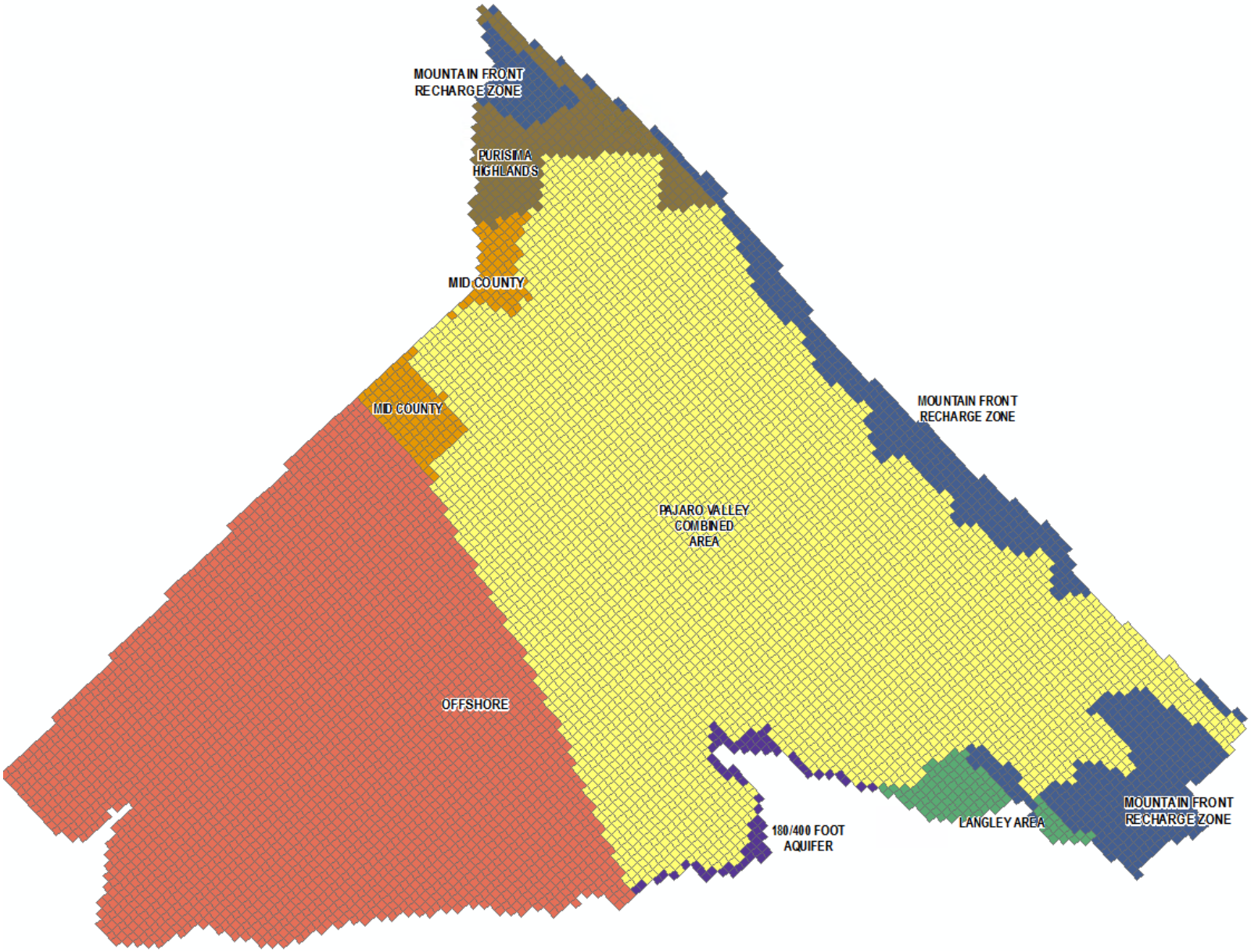

Figure 1. Basinwide Water Budget Area

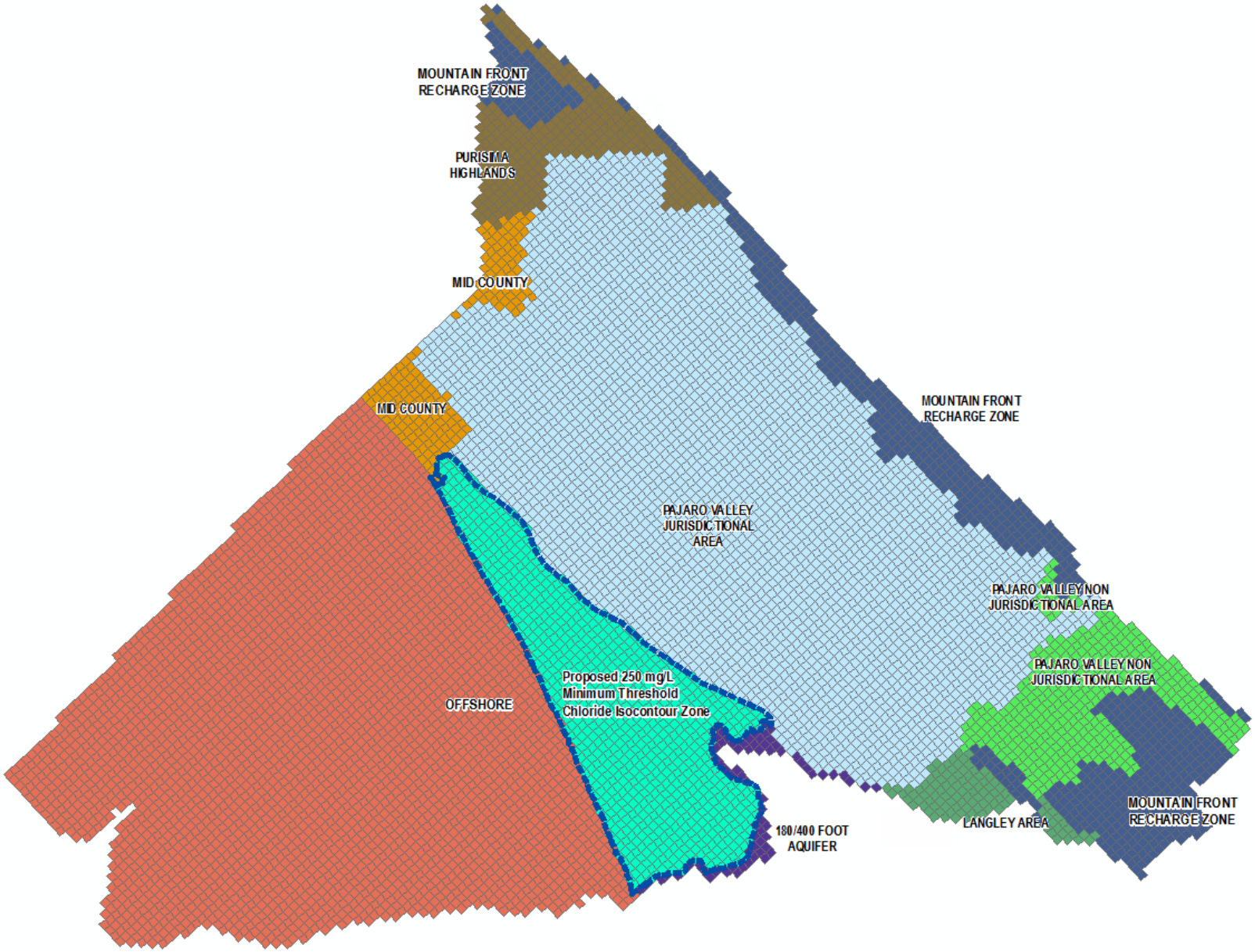

Figure 2. Groundwater Budget Subareas

GROUNDWATER BUDGET COMPONENTS

The groundwater budget represents flows in the saturated zone and is developed by extracting simulated groundwater components over the Basin zone budget area (Figure 1). Evaluation of the Basin-wide groundwater budget provides an understanding of Basin-wide trends in groundwater use, flows between neighboring basins, groundwater-surface water connection, and flows across the coastal boundary to and from offshore.

Groundwater budget components presented in this report are illustrated on Figure 3 and summarized in the subsection below.

Groundwater Inflows (shown with positive values on figures showing both inflows and outflows):

- **Deep Percolation** – Flow which percolates down from surface, eventually reaching groundwater.
- **Flow From Areas Outside Mapped Basins** – Flow from neighboring areas outside of mapped groundwater basins.
- **Flow From Neighboring Basins** – Flow from neighboring designated groundwater basins, namely Santa Cruz Mid-County Basin, Salinas Valley 180/400 Aquifer Subbasin, Salinas Valley Langley Area Subbasin and the Purisima Highlands Subbasin.
- **From Offshore** – Flow from offshore of the Basin.
- **Streambed Recharge** – Flow which percolates down to groundwater from stream channels, also known as seepage from streambed. The component of groundwater-surface water interaction where streamflow percolates down to groundwater under losing conditions.

Groundwater Outflows (shown with negative values on figures showing both inflows and outflows):

- **Flow To Neighboring Basins** – Flow to neighboring designated groundwater basins, namely Santa Cruz Mid-County Basin, Salinas Valley 180/400 Aquifer Subbasin, Salinas Valley Langley Area Subbasin and the Purisima Highlands Subbasin.
- **To Offshore** – Flow from the Basin to offshore.
- **Drain Return Flow –** Flow released to the surface when groundwater rises near ground surface.

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- **Groundwater Discharge to Streams** - Flow that discharges from groundwater into stream channels. The component of groundwater-surface water interaction where groundwater enters a stream under gaining conditions.
- **ET From Groundwater** – Direct groundwater evapotranspiration to atmosphere.
- **Municipal Pumping** - Groundwater extracted from wells for municipal use.
- **Rural Residential Pumping** - Groundwater extracted from wells for rural residential domestic use.
- **Agricultural Pumping** - Groundwater extracted from wells for agricultural use.
- **ASR Pumping** - Groundwater extracted from wells related to Aquifer Storage and Recovery (ASR) operations. This component does not reflect any recharge related to ASR operations, which is incorporated in the Deep Percolation component.

Net Change of Physical Groundwater in Storage:

The difference of the above inflows minus outflows, representing the physical volume of water gained (positive) or lost (negative) in the Basin's groundwater storage.

Approximate Change of Usable Groundwater in Storage:

Net offshore inflows can be incorporated to approximate an estimate of the loss of usable groundwater in storage due to intruded seawater. This estimate is considered very approximate because flows from offshore may not raise concentrations in groundwater to become unusable. The approximation is the net change of physical groundwater in storage minus inflows from offshore plus outflows to offshore.

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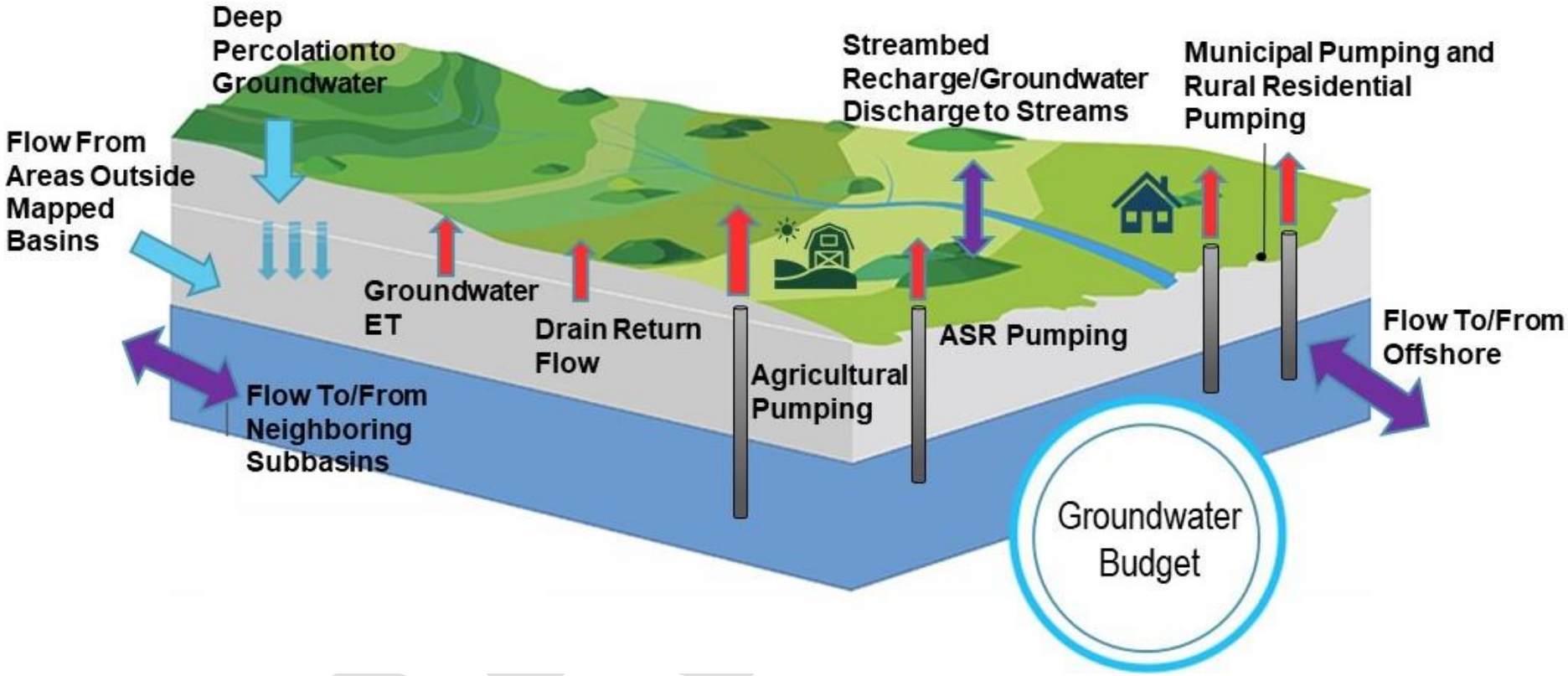

Figure 3. Illustration of Water Budget Components

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GROUNDWATER BUDGET TIME FRAMES

Groundwater budgets are presented for 3 different time frames: historical, current, and projected conditions. Although significant seasonal variation is simulated by the model (which operates on a monthly stress period), this report does not consider seasonal water budgets. All water budgets are developed for complete water years.

The historical water budget is intended to evaluate how past water supply availability has affected aquifer conditions and the ability of groundwater users to operate sustainably. The historical groundwater budget presented here spans water years (WY) 1976-2009 to be consistent with the hydrology used for PVHM simulations to evaluate projects and management actions for BMP 2014 (HydroMetrics WRI, 2013).

The current groundwater budget spans WY 2010-2018, the time period following the historical time span, through the most recent updates to PVHM by PV Water and the USGS. This period includes initial implementation of BMP 2014 (WY 2015-2018).

The projected groundwater budgets are intended to project Basin hydrogeologic conditions into the future and help evaluate the ability of BMP 2014 to achieve sustainability. The time spans presented for future water budgets are WY 2025-2039 and WY 2040-2069. Full implementation of the BMP 2014 Phase I projects is scheduled for 2025. The first time span is intended to evaluate the projected water budget of the fully implemented Phase I of BMP 2014 in the period before the SGMA deadline for the Basin to achieve sustainability. The second time span is intended to evaluate the rest of the planning horizon under SGMA.

SIMULATION OF BMP 2014 PROJECTS AND MANAGEMENTS ACTIONS

The BMP 2014 projects and management actions have intended effects of increasing groundwater in storage and reducing the rate of seawater intrusion to help achieve Basin sustainability. The BMP 2014 projects and management actions are designed to achieve these intended effects primarily by reducing agricultural groundwater pumping. Projects also provide supplemental recharge of the Basin. The following bullets summarize the model implementation of BMP 2014 projects and management actions. 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.

- **Harkins Slough Managed Aquifer Recharge and Recovery Project improvements**: Surface water is diverted for recharge at an infiltration pond site and extracted at an ASR recovery well site. The model diverts up to 1,200 acre-feet per year in November through May beginning in 2022.
- **Watsonville Slough Managed Aquifer Recharge and Recovery Project**: Surface water is diverted for recharge at an infiltration pond site and extracted at an ASR

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recovery well site. The model diverts up to 1,200 acre-feet per year November through May beginning in 2025.

- **College Lake Integrated Resources Management Project:** Surface water is diverted and delivered to coastal farms via the Coastal Delivery System. The model diverts up to 2,400 acre-feet per year in November through May.
- **Recharge Net Metering Sites:** Two recharge basins directly recharge 300 acre-feet per year of water each, beginning in 2020. These sites provide coarse model representation of recharge at existing recharge net metering sites and the proposed Murphy Crossing Project.
- **Recycled Water Deliveries:** Recycled water deliveries are sent to the Coastal Delivery System beginning in WY 2002. Historical deliveries are based on measured historical recycled water deliveries. Projected deliveries result in roughly 4,000 acre-feet per year.

PROJECTED CLIMATE CHANGE AND SEA LEVEL RISE SCENARIO

The projected water budgets incorporate projected climate, projected sea level rise, and simulation of projects described in the BMP 2014. The projected water budgets presented here represent average change in projected climate and sea level rise under a high emissions scenario (Representative Concentration Pathway or RCP 8.5). The model scenario used to develop the projected water budgets simulates implementation of existing and planned Basin groundwater sustainability projects.

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 projected water budgets presented in this technical memorandum are based on the average climate scenario, CCSM4. This will meet DWR Recommended Action 4 consistent with DWR guidance for climate change evaluation under SGMA (DWR, 2018). Figure 4 shows cumulative departure from average historical precipitation simulated at the Watsonville Waterworks station. The CCSM4 scenario has a moderate reduction in precipitation compared to the dry MIROC-esm scenario and as opposed to the wet CNRM scenario. Figure 5 presents mean annual potential ET that increases with expected rise in temperature due to climate change, which shows the

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CCSM4 scenario has a moderate increase in ET comparable to CNRM scenario and lower than the MIROC scenario. A subsequent technical memorandum will present projected water budgets using the dry and hot MIROC scenario to show the climatic uncertainty of projected water budgets.

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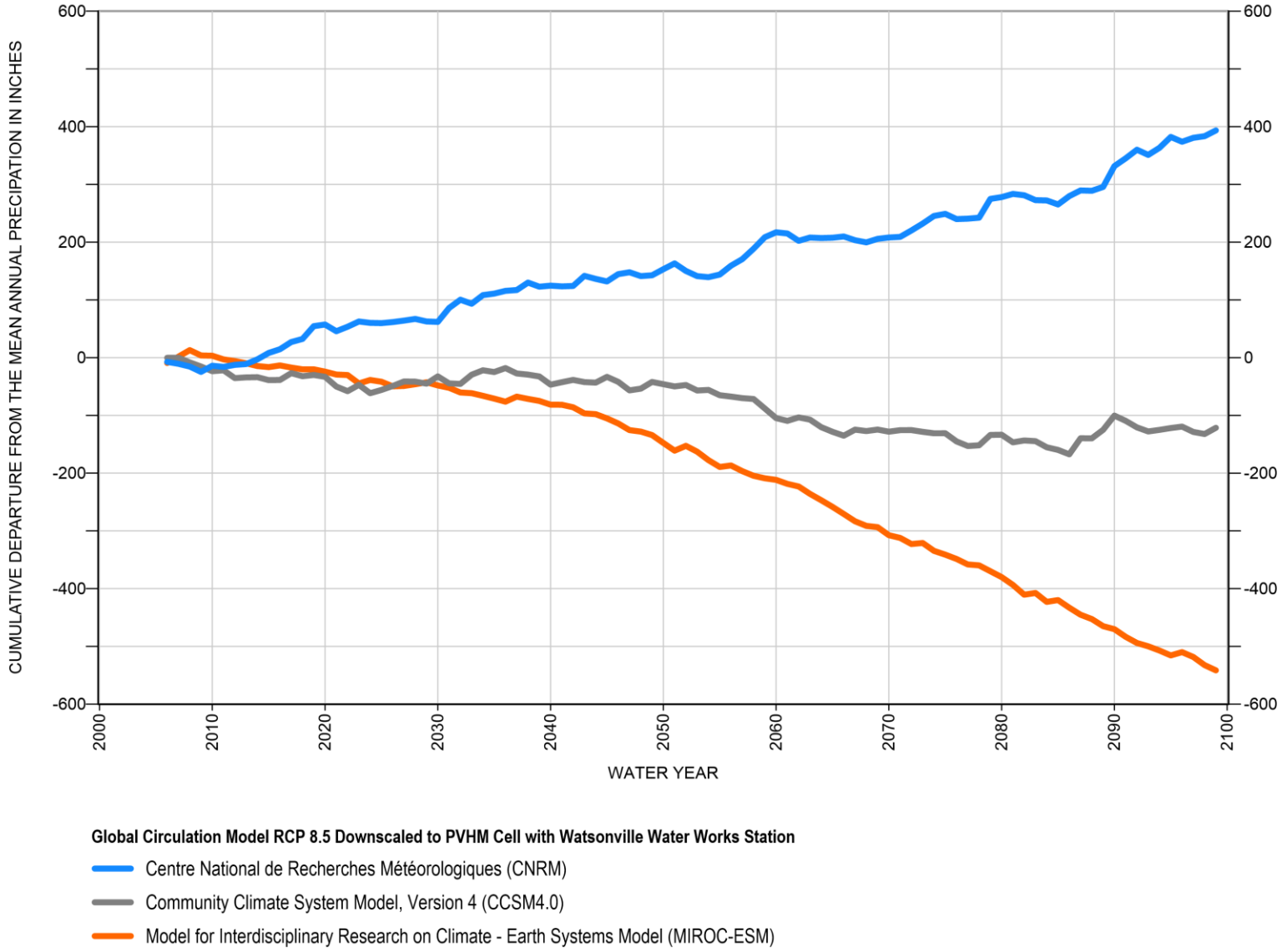

Figure 4. Cumulative Departure from Average Precipitation in Projected Scenarios

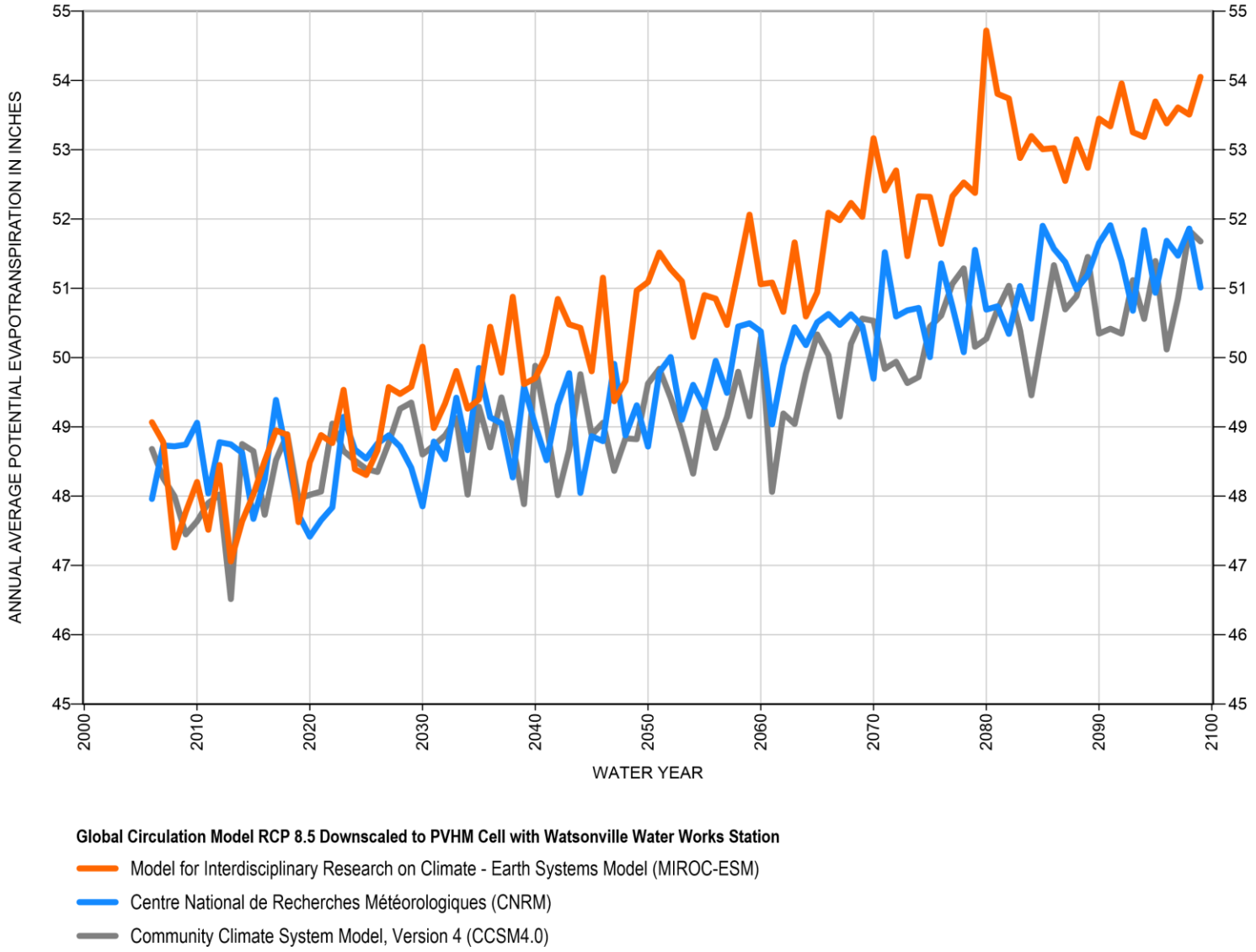

Figure 5. Mean Annual Potential Evapotranspiration in Projected Model Scenarios

Previously presented simulation results for future conditions (Henson and Earll, 2018) were based on sea level rise (SLR) projections from 99.9th percentile (maximum) sea level rise projected by the California's 4th 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. The projected water budgets presented in this technical memorandum to address DWR's recommended action 4 are based on the 50th percentile (median) of SLR from CanESM2 under RCP 8.5 at the Monterey station. This is consistent with DWR guidance (2018) to use median sea level rise projections for groundwater sustainability evaluations.

Figure 6 shows the 99.9th percentile for CanESM2 at San Francisco and Monterey (dark blue lines), the 50th percentile for CanESM2 at Monterey (bright cyan line) used for the projected water budgets presented below, and other water sea level rise projections at the 50th and 95th percentile for various global circulation models (CalAdapt, 2021). CalAdapt does not provide sea level projections from the CCSM4 global circulation model used to represent average projected climate change in the PVHM model scenarios, but Figure 6 shows that the long-term trend for the 50th percentile sea level rise projection does not vary substantially for the various global circulation models.

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.

A subsequent technical memorandum will present projected water budgets based on a scenario using the maximum (99.9th percentile) of SLR. These projected water budgets will be used to evaluate uncertainty for achieving groundwater sustainability related to sea level rise.

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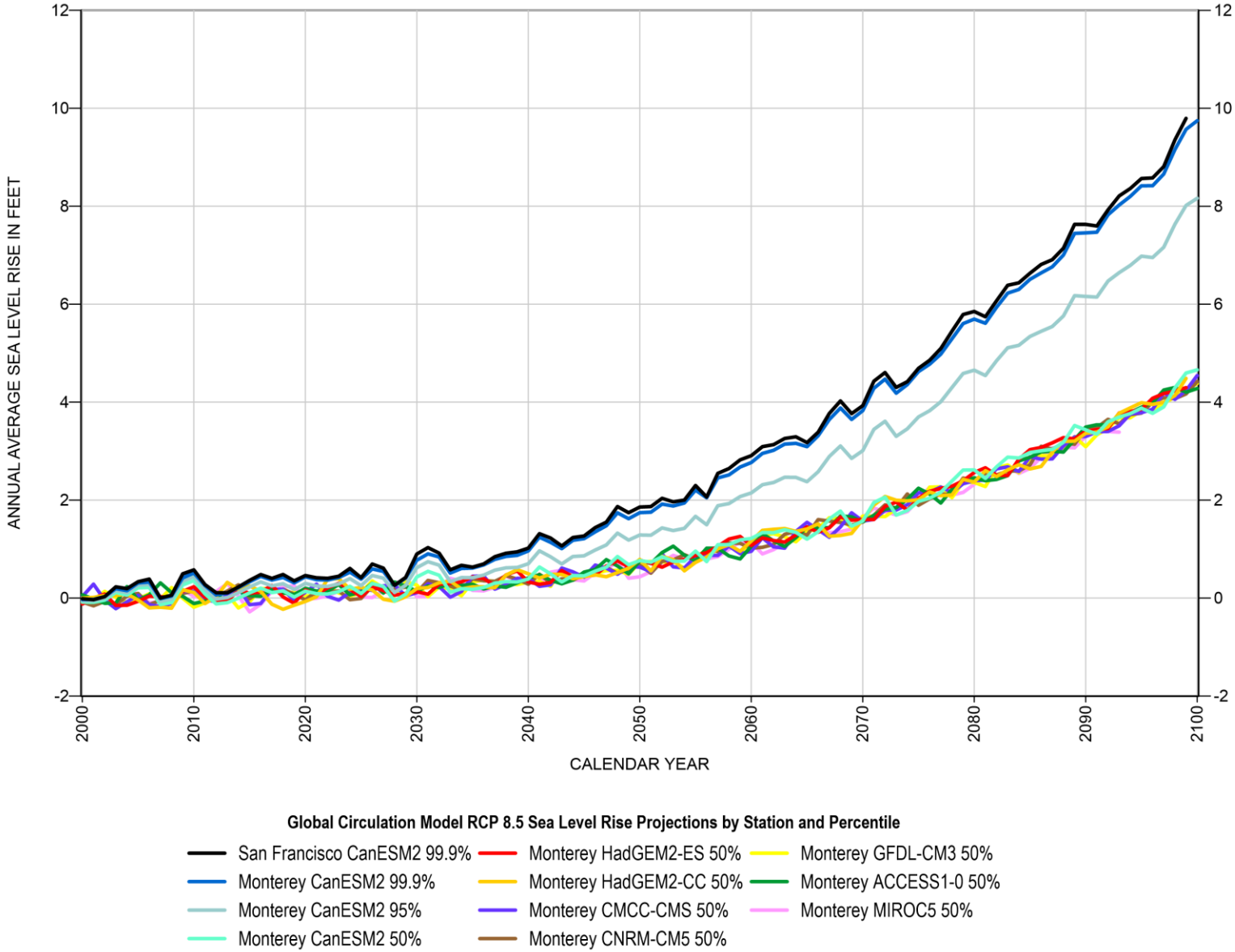

Figure 6. Projected Sea Level Rise for Various Global Circulation Models with Different Probabilities (Cal Adapt, 2021)

GROUNDWATER BUDGET RESULTS

Groundwater budget results based on PVHM simulations by USGS are presented below. Updated historical and current groundwater budgets are presented as a baseline for comparing the projected groundwater budgets. Comparison of projected groundwater budgets to the historical and current budgets will help evaluate the effects of the BMP 2014 projects and management actions under projected climate change and sea level rise.

BASIN HISTORICAL AND CURRENT GROUNDWATER BUDGETS

The complete historical and current annual groundwater budgets are summarized in Table 1 and Table 2, and presented in time series on Figure 1. Table 1 presents the average annual volumes of groundwater components over the historical (WY1976-2009) and current (2010-2018) time periods, while Table 2 presents annual average volumes by water year type over the entire period from 1976-2018. The largest inflow to the groundwater budget is deep percolation, which comprises roughly 40% of total inflow in the historical and current budgets. The largest outflow is agricultural pumping, which comprises roughly 60% of total outflow.

Average net change of physical groundwater in storage (change in storage) is an increase of 960 acre-feet per year over the historical period, and depletion of 490 acre-feet per year over the current period. The largest drivers for this change between periods are decreases in average net streambed recharge and deep percolation, both tied to a relatively drier climate in recent years, notably the recent drought from 2011-2015. The running average of net change in storage over the entire period hovers just above zero for most of the historical and current period, indicating that physical groundwater in storage has generally been in balance.

Net flows from offshore into the Basin (offshore inflows) are inflows from offshore minus outflows from the Basin to offshore across the coastal boundary. BMP 2014 projects and management actions are intended to reduce net offshore inflows representing potential seawater intrusion. Table 1 shows that the updated PVHM simulates average historical and current flows from offshore into the Basin exceeding flows from the Basin to offshore by 6,530 and 6,810 acre-feet per year respectively.

Net offshore inflows can be incorporated into the storage calculations as a very approximate estimate of the loss of usable groundwater in storage due to intruded seawater. This estimate is considered very approximate because flows from offshore may not raise concentrations in groundwater to become unusable. Subtracting net offshore inflows from change in storage results in an estimated average net usable storage loss of 5,570 acre-feet per year for the historical period and 7,300 acre-feet per year for the current period.

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The influence of BMP 2014 projects and management actions can be seen in the current groundwater budget, as ASR pumping is significantly increased and agricultural pumping is slightly decreased despite the drier and warmer climate.

Table 2 shows the variation in the groundwater budget based on climate by showing average for the water year type classifications defined by PV Water for its SGMA annual reports (PV Water, 2021) based on precipitation at the Watsonville Waterworks station. Figure 1 shows the water year type classification by year as background colors. Table 2 shows there is depletion of physical groundwater in storage in average to very dry years but increases in wet and very wet years. There are net flows from offshore in all water year type classifications, but these are reduced in wetter years.

Table 1. Historical and Current Annual Groundwater Budget Summary (1976-2009 and 2010-2018)

	Component	Historical Average (1976-2009)	Current Average (2010-2018)
Inflows	Flow from Areas Outside Mapped Basins	860	1,160
	Flow from Offshore	7,610	7,740
	Flow from Mid-County	8,010	7,850
	Flow from Salinas	4,440	4,470
	Flow from Purisima Highlands	1,350	1,380
	Net Streambed Recharge	13,220	12,670
	Deep Percolation	24,400	23,960
Outflows	Flow to Offshore	1,080	930
	Rural Residential Pumping	2,020	890
	Flow to Mid-County	1,280	1,130
	Flow to Salinas	2,190	2,620
	Flow to Purisima Highlands	330	330
	Drain Return Flow	7,650	7,040
	ET From Groundwater	2,840	2,520
	Municipal Pumping	6,020	7,870
	Ag pumping	35,570	35,160
	ASR Pumping	210	1,170
Storage	Net Change of Physical Groundwater in Storage	960	-490
	Net Change of Groundwater in Storage Excluding Net Offshore Inflows (To Approximate Usable Groundwater in Storage)	-5,570	-7,300

*All values are in acre-feet per year (AFY), rounded to the nearest 10 AFY. Small discrepancies between inflow minus outflow and change in storage may occur due to rounding and model error.

Table 2. Historical and Current Annual Groundwater Budget Summary by Water Year Type (1976-2018)

	Component	Average in Very Dry Years	Average in Dry Years	Average in Average Years	Average in Wet Years	Average in Very Wet Years
Inflows	Flow From Areas Outside Mapped Basins	230	1,190	800	1,100	800
	Flow From Offshore	8,130	7,980	7,700	7,410	6,820
	Flow From mid-County	8,240	7,880	8,120	7,870	7,880
	Flow From Salinas	4,440	4,550	4,350	4,490	4,340
	Flow From Purisima Highlands	990	1,360	1,400	1,380	1,510
	Net Streambed Recharge	6,870	10,600	11,810	15,880	20,620
	Deep Percolation	17,190	22,010	24,470	26,410	30,050
Outflows	Flow to Offshore	1,070	950	1,080	1,040	1,190
	Rural Residential Pumping	1,700	1,620	1,970	1,760	1,830
	Flow To mid-County	1,150	1,190	1,260	1,270	1,410
	Flow To Salinas	2,390	2,500	2,240	2,200	1,930
	Flow To Purisima Highlands	260	330	340	330	370
	Drain Return Flow	4,750	6,870	7,410	8,090	10,170
	ET From Groundwater	2,620	2,910	2,730	2,720	2,790
	Municipal Pumping	4,880	7,800	6,040	6,400	5,450
	Ag pumping	33,070	37,990	36,000	35,080	31, 540
	ASR Pumping	330	690	290	380	210
Storage	Net Change of Physical Groundwater in Storage	-6,130	-6,910	-340	5,250	15,040
	Net Change of Groundwater in Storage Excluding Net Offshore Inflows (To Approximate Usable Groundwater in Storage)	-13,190	-13,940	-6,960	-1,120	9,410

*All values are in acre-feet per year (AFY), rounded to the nearest 10 AFY. Small discrepancies between inflow minus outflow and change in storage may occur due to rounding and model error.

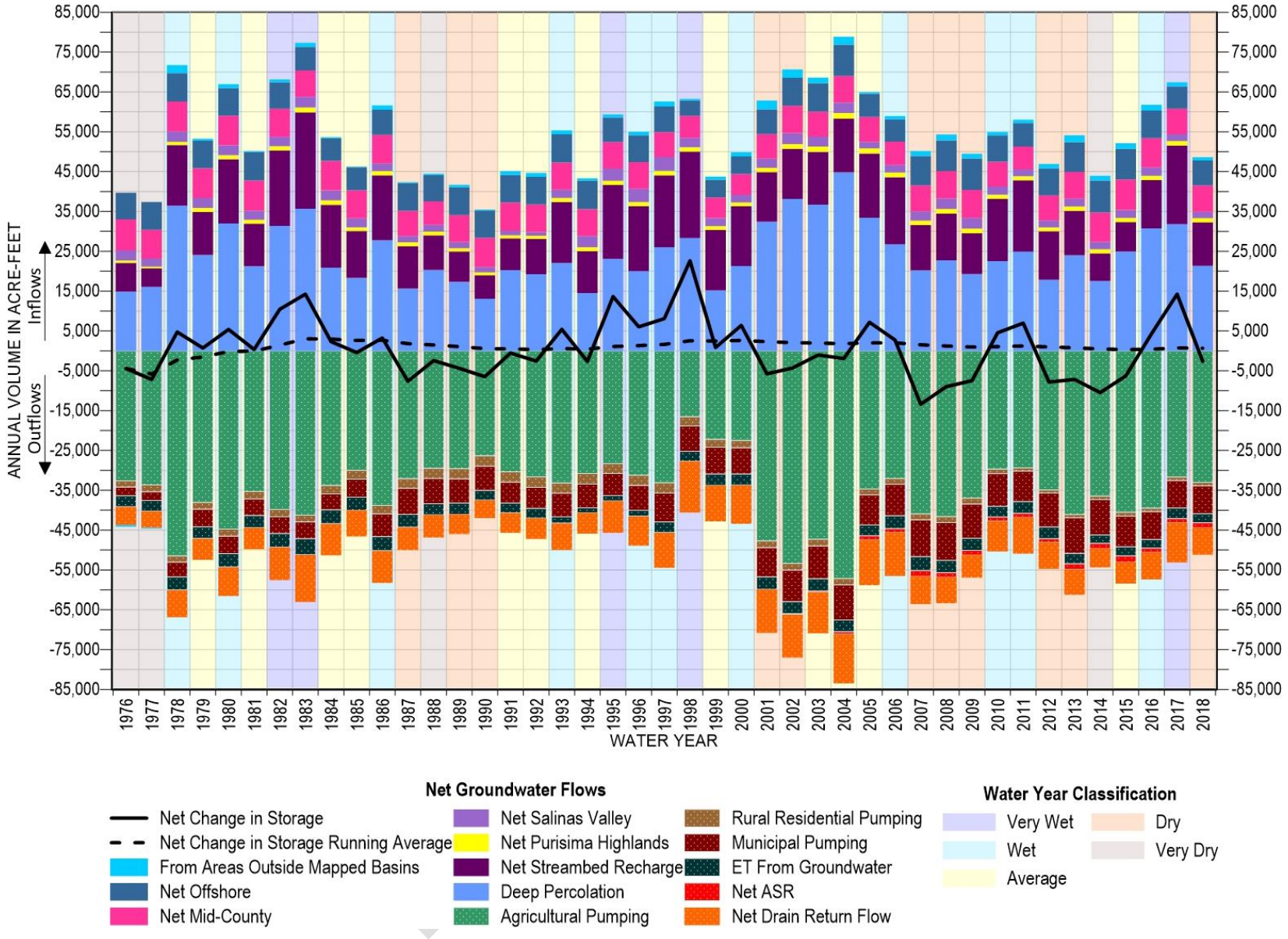

Figure 1. Historical and Current Groundwater Budgets

BASIN PROJECTED GROUNDWATER BUDGETS

The projected annual groundwater budgets for the Basin are summarized in Table 3 and Table 4, and presented in time series on Figure 2. Table 3 presents the average annual volumes of groundwater components separately over the WY 2025-2039 and WY 2040-2069 time periods, while Table 4 presents annual average volumes by water year type over the entire period from WY 2025-2069.

As compared to historical, both projected periods are marked by decreasing net flow from offshore into the Basin (offshore inflows), decreased agricultural pumping, decreased rural residential pumping, and increased groundwater change in storage. The WY 2025-2039 period displays significant positive changes in the groundwater budget as compared to the combined historical and current periods. Notably, change of groundwater in storage is increased by 1,620 acre-feet per year (246%) from the combined historical and current period.

Net offshore inflows are also decreased from 6,590 acre-feet per year for WY 1976-2018 to 3,980 acre-feet per year for WY 2025-2039, a reduction of 40%. Net reduction of groundwater in storage excluding net offshore inflows is also decreased, reducing the approximate usable storage loss by 74% from the 1976-2018 average. These positive changes in groundwater budget components are attributed to successful implementation of BMP 2014 projects and management actions, which help reduce and offset groundwater pumping. Conservation programs in BMP 2014 are focused on reduction of groundwater pumping and that is reduced 22% from the 1976- 2018 average.

While the WY 2040-2069 period generally presents an improved groundwater budget when compared to the historical and current periods, groundwater budget components suggest that currently planned BMP 2014 projects may not be able to maintain sustainability in the Basin as successfully during this period. Notably, average annual change of physical groundwater in storage becomes negative during period, decreasing roughly 118% from the combined historical and current period. The dashed line in Figure 2 shows the declining trend of average annual change of physical groundwater in storage.

Similar trends can be observed in groundwater pumping, which increases as compared to the 2025-2039 period, and net offshore inflows, which increase as compared to the 2025-2039 period. This decline in groundwater sustainability after 2040 is likely driven by an increasingly dry climate in the Basin. The projected climate classification (as presented on Figure 3 through

Figure 6) predicts more dry and very dry years, and less wet and very wet years.

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Table 3. Projected Groundwater Budget Summary (2025-2039 and 2040-2069) , Acre-Feet per year

	Component	Historical/Current Average (WY 1976-2018)	WY 2025-2039 Average	WY 2025-2039 % Change from Historical/Current	WY 2040-2069 Average	WY 2040-2069 % Change from Historical/Current
Inflows	From Areas Outside Mapped Basins	920	1,140	24%	1,100	20%
	Flow From Offshore	7,640	5,730	-25%	6,680	-13%
	Flow From mid-County	7,980	7,290	-9%	7,810	-2%
	Flow From Salinas	4,440	4,290	-3%	4,390	-1%
	Flow From Purisima Highlands	1,360	1,370	1%	1,340	-1%
	Net Streambed Recharge	13,110	15,290	17%	14,840	13%
	Deep Percolation	24,310	24,360	<1%	22,670	-7%
Outflows	Flow to Offshore	1,050	2,020	93%	1,840	75%
	Rural Residential Pumping	1,780	890	-50%	890	-50%
	Flow To mid-County	1,250	1,230	-2%	1,180	-6%
	Flow To Salinas	2,280	3,340	46%	3,050	34%
	Flow To Purisima Highlands	330	330	<1%	320	-3%
	Drain Return Flow	7,520	9,400	25%	8,530	13%
	ET From Groundwater	2,770	3,840	38%	3,900	41%
	Municipal Pumping	6,410	7,220	13%	7,850	22%
	Ag pumping	35,480	27,840	-22%	30,650	-14%
	ASR Pumping	410	1,060	157%	1,160	183%
Storage	Net Change of Physical Groundwater in Storage	660	2,280	246%	-570	-186%
	Net Change of Groundwater in Storage Excluding Net Offshore Inflows (To Approximate Usable Groundwater in Storage)	-5,570	-1,430	-74%	-5,410	-3%

*All values are in acre-feet per year (AFY), rounded to the nearest 10 AFY. Small discrepancies between inflow minus outflow and change in storage may occur due to rounding.

Table 4. Projected Groundwater Budget Summary By Water Year Type (2025-2069)

	Component	Average in Very Dry Years	Average in Dry Years	Average in Average Years	Average in Wet Years	Average in Very Wet Years
Inflows	Flow From Areas Outside Mapped Basins	2,270	1,200	1,670	1,530	1,520
	Flow From Offshore	6,550	6,680	6,170	5,970	5,540
	Flow From mid-County	7,730	7,810	7,580	7,510	7,270
	Flow From Salinas	4,470	4,430	4,440	4,400	4,350
	Flow From Purisima Highlands	1,710	1,620	1,680	1,740	1,770
	Net Streambed Recharge	15,940	12,160	13,720	13,860	14,530
	Deep Percolation	21,970	16,970	23,730	27,030	31,110
Outflows[1]	Flow to Offshore	2,010	1,840	2,050	2,080	2,200
	Rural Residential Pumping	880	850	900	900	880
	Flow To mid-County	1,460	1,330	1,410	1,400	1,410
	Flow To Salinas	3,510	3,170	3,420	3,440	3,620
	Flow To Purisima Highlands	410	400	410	420	430
	Drain Return Flow	10,000	6,990	8,990	9,400	10,810
	ET From Groundwater	4,850	4,190	4,270	4,130	4,070
	Municipal Pumping	7,920	7,780	7,630	7,600	7,660
	Ag pumping	39,190	29,380	32,870	30,480	28,300
	ASR Pumping	1,350	930	1,100	1,140	1,110
Storage[2]	Net Change of Groundwater in Storage	-10,990	-6,010	-4,100	1,010	5,520
	Net Change of Groundwater in Storage Excluding Net Flows from Offshore (To Approximate Usable Groundwater in Storage)	-15,530	-10,850	-8,220	-2,880	2,180

*All values are in acre-feet per year (AFY), rounded to the nearest 10 AFY. Small discrepancies between inflow minus outflow and change in storage may occur due to rounding.

[1] Outflows shown as positive flows in tables for flows exiting the Basin. In figures that show both inflows and outflows, inflows are shown as positive, and outflows are shown as negative.

[2] Net change of groundwater in storage is positive for an increase of groundwater in storage (Inflows>Outflows) and negative for a decrease of groundwater in storage (Outflows<Inflows). This sign convention is also used in figures.

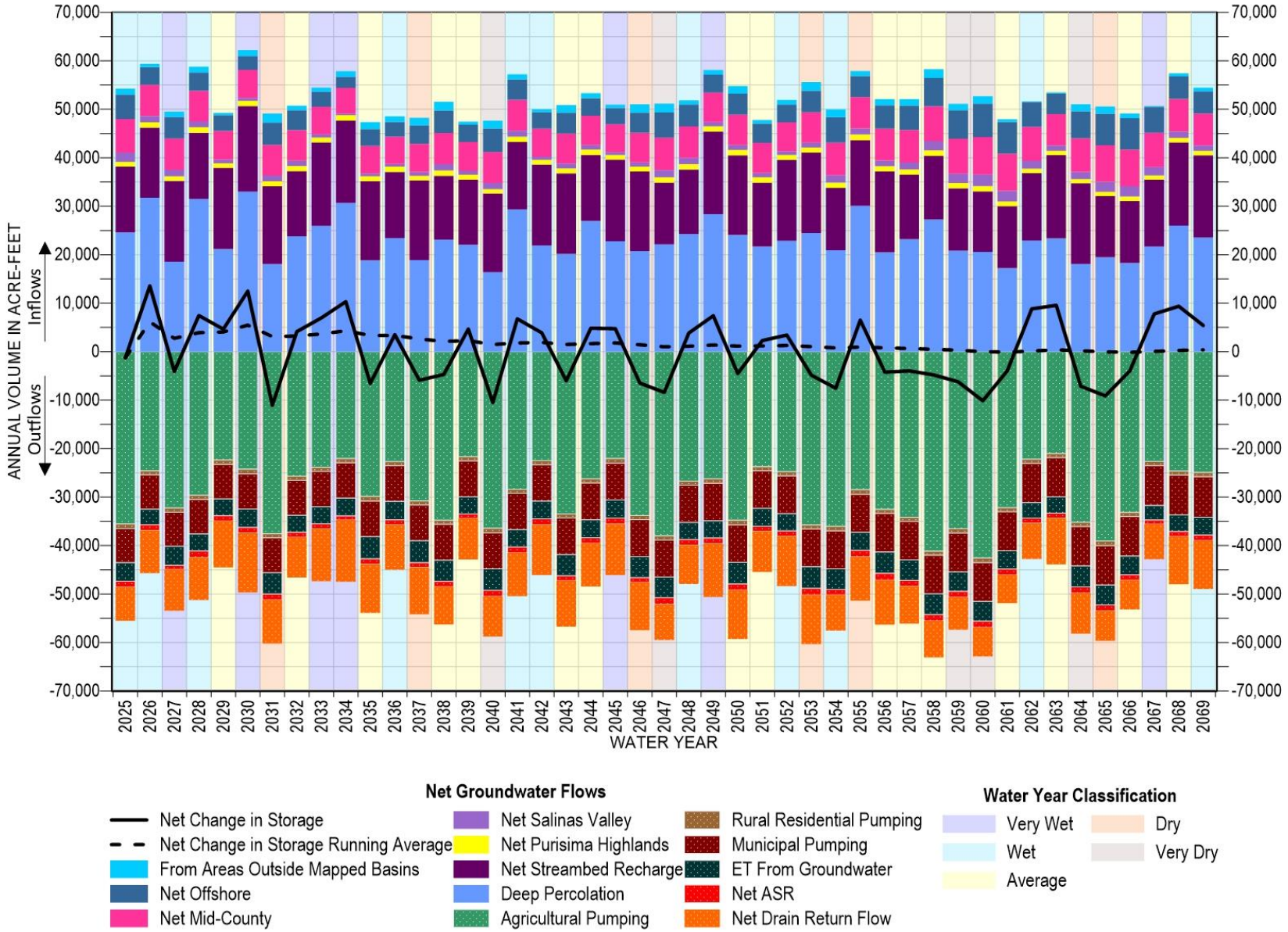

Figure 2. Projected Groundwater Budget

GROUNDWATER BUDGET COMPONENTS FOR AROMAS AQUIFER

The GSP Alternative defines the Aromas aquifer as the principal aquifer of the GSP Alternative and BMP 2014 projects and management actions focus on improving sustainability of the Aromas aquifer. Groundwater budget flows for the Aromas aquifer help evaluate the intended effects of the BMP 2014 projects and management actions. Line charts of key groundwater budget flows for the Aromas aquifer simulated over the historical, current, and projected periods are presented on Figure 3 through

Figure 6.

Figure 3 presents net flows from offshore into the Basin (offshore inflows) for the Aromas aquifer (upper and lower aromas). BMP 2014 project implementation appears to significantly reduce the potential for seawater intrusion in the Aromas aquifer starting in 2025, lowering total net offshore inflows by roughly 1,300 acre-feet per year on average (46%) when comparing the 2010-2018 and 2024-2039 periods. The BMP 2014 estimated the effect of projects and management actions based on reduction of net offshore inflows in the Aromas aquifer and the overlying Alluvium as 90% using a methodology that did not account for all flows across the coastal boundary (HydroMetrics WRI, 2013). As required for water budgets, the projected water budget accounts for all flows across the coastal boundary and shows the combined net offshore inflows in the Aromas and Alluvial aquifers as decreased by roughly 3,000 (42%) acre-feet with the incorporation of climate change and updated sea level rise projections, when comparing the 2010-2018 and 2024-2039 periods. However, net offshore inflows begin to increase post-2040, eventually reaching just under historical levels.

Although the BMP 2014 evaluated potential seawater intrusion based on reduction of net offshore inflows, the GSU22 has established the 250 mg/L SWI MT isocontour (Figure 2) to address a recommended action from DWR and for consistency with DWR regulations. Chloride concentrations rising above 250 mg/L inland of the SWI MT isocontour in the Aromas aquifer would be a MT exceedance. The potential for seawater to advance inland of the SWI MT isocontour in the Aromas aquifer can be evaluated based on projected flows in the Aromas aquifer across the isocontour. Figure 4 displays net isocontour flows moving inland across the isocontour in the Aromas aquifer. Figure 4 shows net historical flows moving inland (positive flows). Although these flows have not resulted in increasing chloride concentrations inland of the SWI MT isocontour, continuation of these flows into the future would represent a risk of increasing chloride concentrations and SWI MT exceedances and undesirable results. Figure 4 shows that BMP implementation results in a reversal of these flows so that net flow is towards the coast from the mid-2020s to the mid-2050s. Net flow towards the coast at this location should prevent seawater intrusion from advancing inland of the SWI MT isocontour and prevent undesirable results during that period. However, climate change and sea level rise results in

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projected flows again flowing inland across the isocontour in the 2060s, resulting in potential risk of SWI undesirable results.

Figure 5 presents net groundwater pumping in the Aromas aquifer, which the BMP 2014 projects and management actions are meant to reduce. Starting in 2025, BMP 2014 projects reduce groundwater extraction down from recent highs in the 2010-2018 period. Groundwater extraction is decreased by roughly 5,600 acre-feet per year on average (22%) when comparing the 2010-2018 and 2024-2039 periods. Post-2040 groundwater pumping increases slightly but remains lower than historical values on average.

Figure 6 presents net change of physical groundwater in storage (change in storage) for the Aromas aquifer, including running averages for net change in storage over each model simulation period. Similar to the previous 2 figures, and mirroring Basin-wide water budget statistics presented above, trends in net change in storage significantly improve from roughly 2025-2040 as a result of BMP 2014 project implementation. Post 2040, benefits begin to reduce as the effects of climate change and sea level rise continue to influence the Basin's hydrogeologic cycle. The increase of groundwater in storage over the full projected period indicates that approved SMC for groundwater in storage will be achieved and maintained, but climate change and sea level rise make sustainability for this indicator more difficult as time goes on.

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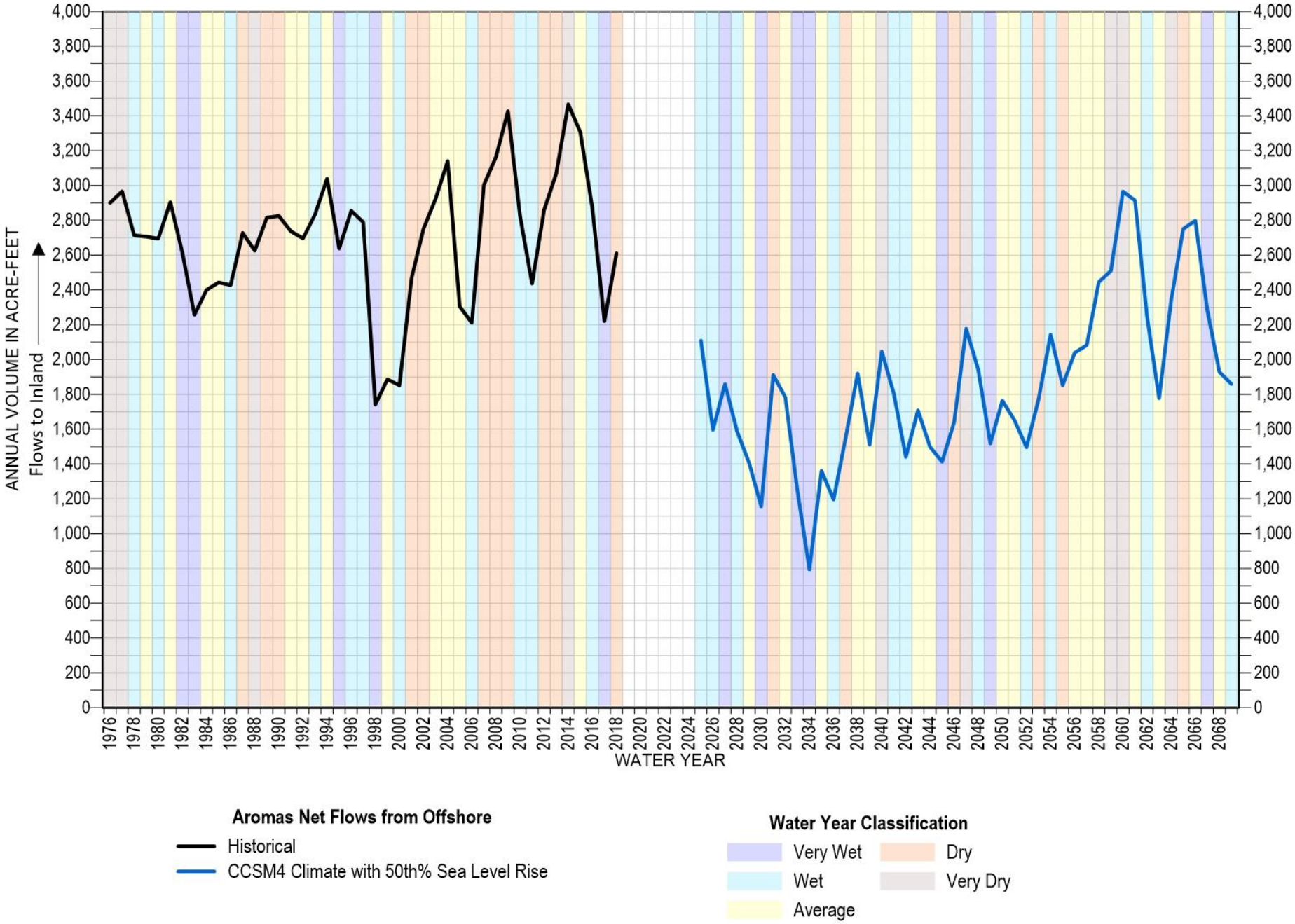

Figure 3. Aromas Aquifer Net Flows from Offshore

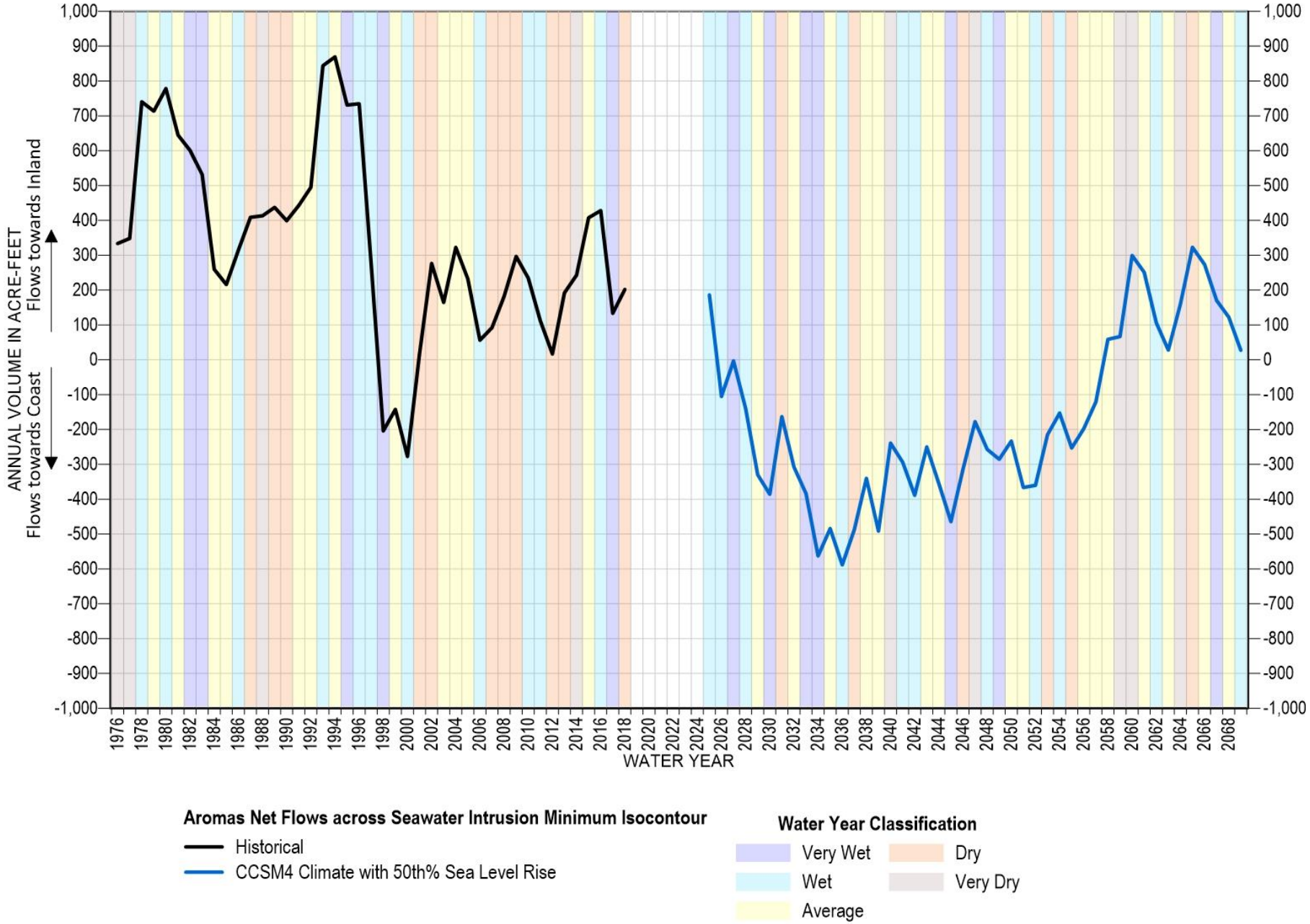

Figure 4. Aromas Aquifer Net Flows Across SWI MT Isocontour

Figure 5. Aromas Aquifer Net Groundwater Pumping

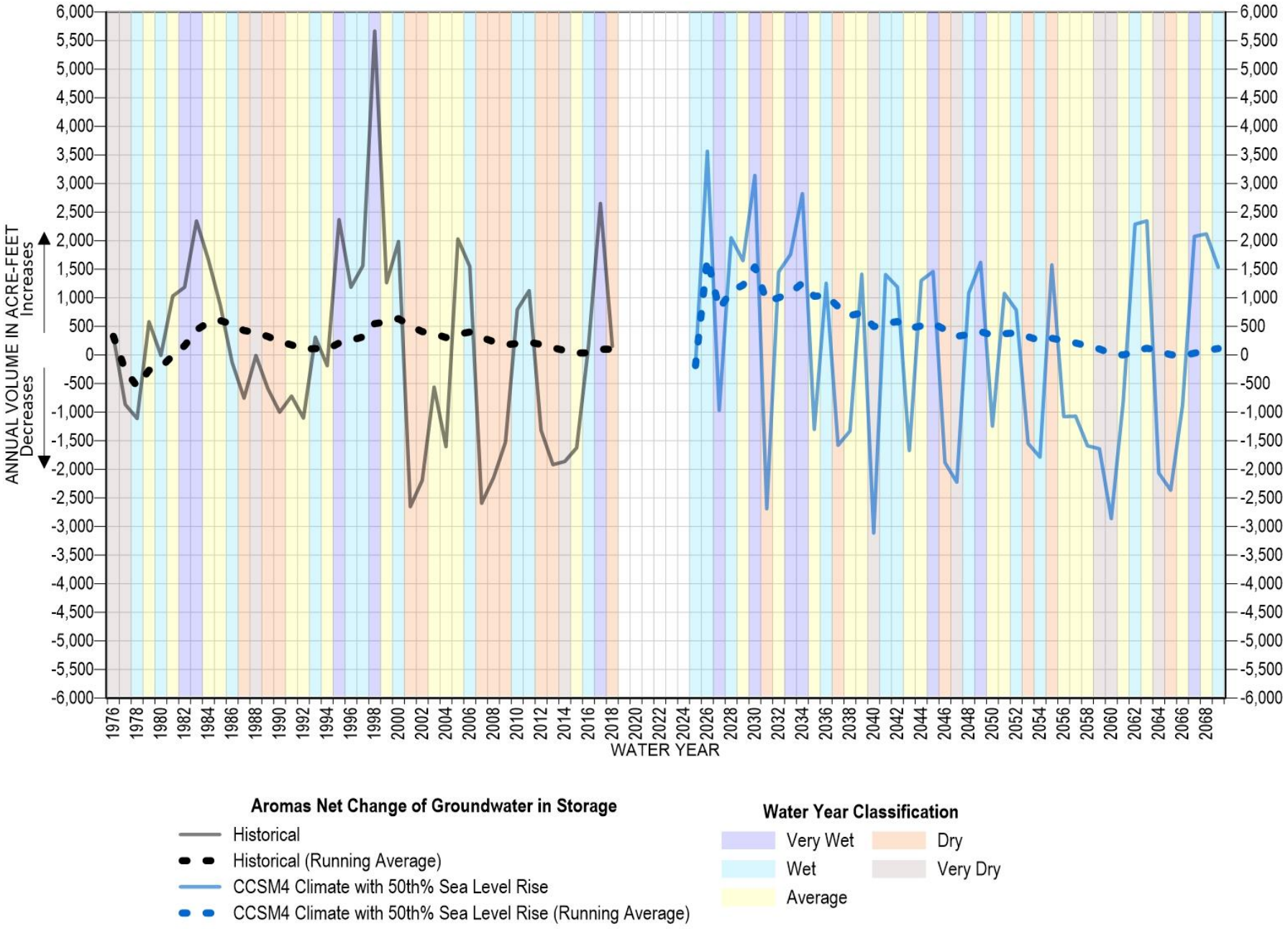

Figure 6. Aromas Aquifer Basinwide Change of Groundwater In Storage

NON-JURISDICTIONAL AREA ASSESMENT

Intra-aquifer flows occurring between PV Water's jurisdictional area and the non-jurisdictional area can be examined to determine the typical magnitude and directionality of flow volume and the influence of BMP 2014 projects on flow between the non-jurisdictional and jurisdictional areas. The zones presented on Figure 2 illustrate the jurisdictional and non-jurisdictional portions of the Basin as implemented in the model and are used for groundwater budget component calculation. Table 5 summarizes average annual net flows from the non-jurisdictional area into the jurisdictional area, while Figure 7 presents this component over time for the Aromas aquifer. As shown here, a consistent flow of roughly 2,500-2,900 acre-feet crosses from the non-jurisdictional area into the jurisdictional area annually. Most of this flow occurs in the Aromas and Purisima aquifers, shown on Figure 7. These flows vary inter-annually with climate; inflows from the non-jurisdictional area into the jurisdictional area appears higher during dry periods when groundwater elevations in the center of the Basin are lower. Despite this inter-annual variation, relatively consistent volumes during the WY 1976-2018 time periods indicate that flow to and from the non-jurisdictional area is not significantly influenced by BMP 2014 implementation.

This evaluation also provides an example of how future plans for projects and management actions in either the jurisdictional or non-jurisdictional areas can be evaluated for effects across the jurisdictional boundary. Along with additional monitoring to be described in the monitoring plan, modeling evaluations will be part of how PV Water will assess the non-jurisdictional area going forward as recommended by DWR's Recommended Action 1 (DWR, 2019):

> Staff recommend that the Agency define how it will assess, on an ongoing basis, the non-jurisdictional portion of the Subbasin and demonstrate that activities in that area are not adversely impacting successful implementation of the Plan within the Agency's jurisdictional area, or adversely affected by implementation of the Plan or by groundwater use in the area not subject to that Plan. That assessment may include, but is not limited to, additional monitoring in the non-jurisdictional areas and agreements with other entities.

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Table 5. Average Annual Net Flows Across Jurisdictional Area from Non-Jurisdictional Area by Aquifer and Time Period, Acre-Feet

Aquifer	Historical (1976-2009)	Current (2010-2018)	Projected (2025-2039)	Projected (2040-2059)
Alluvial	130	130	140	150
Upper and Lower Aromas	1,340	1,120	1,260	1,360
Purisima	1,400	1,290	1,460	1,370
Total	2,870	2,540	2,860	2,880

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Figure 7. Non-Jurisdictional Flows in Historical and Projected Water Budgets

KEY FINDINGS

Key findings derived from analysis of the groundwater budgets are summarized below.

- BMP 2014 projects and management actions increase Basin groundwater sustainability as evidenced by reductions in groundwater pumping, increases of groundwater in storage, and reductions of flows from offshore into the Basin prior to the sustainability deadline of 2040. These results demonstrate that BMP 2014 projects and management actions are likely to have intended effects.

- BMP 2014 projects and management actions result in net flow towards the coastline across the SWI MT isocontour for approximately 15 years past the sustainability deadline of 2040. The direction of this net flow would likely prevent seawater intrusion inland of the SWI MT isocontour and SWI undesirable results.

- After 2040, the efficacy of BMP 2014 projects in maintaining sustainability reduces; net offshore inflows into the Basin and reductions of groundwater in storage begin to increase back to historical levels. After 2055, flows across the SWI MT isocontour again flow inland, increasing the risk of SWI undesirable results.

- BMP 2014 projects planned for the PV Water's jurisdictional area do not appear to have a significant effect on groundwater conditions in the non-jurisdictional area of the Basin.

Continued investment in implementing current and planned BMP 2014 projects, and potentially the addition of new groundwater sustainability projects or project improvements, may be required to maintain Basin sustainability through 2070.

REFERENCES

Chang, S. W., Clement, P., Simpson, M., Lee, K., 2011. Does sea-level rise have an impact on saltwater intrusion? Advances in Water Resources 34(10):1283-1291.

DWR, 2016, Best Management Practices for the Sustainable Management of Groundwater, Water Budget.

_____, 2018, Guidance for Climate Change Data Use During Groundwater Sustainability Plan Development, Guidance Document for Sustainable Management of Groundwater, July.

Earll, M., and Henson, W., 2020, Pajaro Valley Hydrologic Model Update, USGS California Water Science Center presentation, May

Hanson, R.T., et al, 2014, Integrated Hydrologic Model of Pajaro Valley, Santa Cruz and Monterey Counties, California, USGS Scientific Investigations Report 2014–5111, Prepared in cooperation with Pajaro Valley Water Management Agency.

Henson, W. and Earll, M., 2018, Pajaro Valley Hydrologic Model Updates, and Future Projections, USGS California Water Science Center presentation to PV Water Board of Directors, June 20.

HydroMetrics WRI, 2013, Hydrologic Model Analysis of Bain Management Plan Alternatives, prepared for Pajaro Valley Water Management Agency, July.

Montgomery & Associates (M&A), 2021, Pajaro Valley Hydrologic Model Updates Supporting GSU22 Analyses, draft technical memorandum to Ad Hoc Sustainable Groundwater Planning Advisory Committee (GSU22 Committee), August.

Pajaro Valley Water Management Agency (PV Water), 2021, Pajaro Valley Subbasin Water Year 2020 Annual Report, March, https://www.pvwater.org/images/about-pvwma/assets/annual_reports_assets/SGMA-WY/PVWater_AR_WY2020.pdf.

Werner AD, Simmons CT. 2009. Impact of sea-level rise on sea water intrusion in coastal aquifers. Ground Water 2009;47(2):197–204. doi:10.1111/j.1745-6584.2008.00535.x.

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