EXHIBIT 29-A

SUMMARY OF OPERATIONS

MONTEREY PENINSULA
ASR PROJECT

WATER YEAR 2018

Prepared for:

Monterey Peninsula Water Management District

JUNE 2019

DRAFT

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EXHIBIT 29-A

June 28, 2019
Project No. 18-0092

Monterey Peninsula Water Management District
Post Office Box 85
Monterey, California 93942-0085

Attention: Mr. Jonathan Lear, Senior Hydrogeologist

Subject: Monterey Peninsula ASR Project; Draft Water Year 2018 Summary of Operations Report

Dear Jon:

For your review and comments, we are transmitting one digital image (PDF) of the subject draft report documenting operations of the Monterey Peninsula ASR Project during Water Year 2018 (WY 2018). WY 2018 was classified as a “Dry” Water Year on the on the Monterey Peninsula, and as a result a limited volume of water totaling approximately 530 acre-feet (af) was able to be diverted from the Carmel River system for recharge in the Seaside Groundwater Basin (SGB) via the ASR-1 through ASR-4 wells. To date, a total volume of approximately 7,960 af of excess Carmel River system water has been successfully injected, stored, and recovered in the SBG since the ASR project was initiated in 2001.

We appreciate the opportunity to provide ongoing assistance to the District on this important community water-supply project. Please contact us with any questions.

Sincerely,

PUEBLO WATER RESOURCES, INC.

Robert C. Marks, P.G., C.Hg.
Principal Hydrogeologist

Stephen P. Tanner, P.E.
Principal Engineer

Copies submitted: 1 digital (PDF)

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INTRODUCTION

GENERAL STATEMENT

Presented in this report is a summary of operations of the Monterey Peninsula Aquifer Storage and Recovery (ASR) Project during Water Year 2018 (WY 2018)[1]. During WY 2018, approximately 530 acre-feet (af) of excess flows were diverted from the Carmel River system for recharge, storage, and subsequent recovery in the Seaside Groundwater Basin (SGB). This report presents a summary of the project operations during WY 2018, an assessment of ASR well performance, aquifer response and water-quality data, and provides recommendations for ongoing operation of the project.

BACKGROUND

The Monterey Peninsula ASR Project is cooperatively implemented by the Monterey Peninsula Water Management District (MPWMD or District) and California American Water (CAW) and involves the diversion of excess winter and spring time flows from the Carmel River system for recharge and storage in the Seaside Groundwater Basin (SGB). The excess water is captured by CAW wells in the Carmel Valley during periods when flows in the Carmel River exceed fisheries bypass flow requirements, treated to potable drinking water standards, and then conveyed through CAW's distribution system to ASR facilities in the SGB.

Aquifer recharge is accomplished via injection of these excess flows into specially designed ASR wells drilled in the SGB. The locations of the ASR wells and associated project monitoring wells in the SGB are shown on **Figure 1**. The recharged water is temporarily stored underground utilizing the available storage space within the aquifer system. During periods of high demand, other existing CAW production wells in the SGB and/or the ASR wells can be used to recover the previously recharged water, which in turn allows for reduced extractions from the Carmel River system during seasonal dry periods.

The District and CAW have been cooperatively developing an ASR project on the Monterey Peninsula since 1996. These efforts have evolved over time, from the performance of various technical feasibility investigations, leading to the construction and testing of pilot- and then full-scale ASR test wells to demonstrate the viability and operational parameters for ASR wells in the SGB. Based on the success of the ASR demonstration testing program, MPWMD and CAW are in the process of implementing a full-scale permanent ASR Project.

The Phase 1 ASR Project (a.k.a. Water Project 1) includes two ASR wells (ASR-1 and ASR-2) located at the Santa Margarita (SM) ASR Facility at 1910 General Jim Moore Blvd. in Seaside. The Phase 1 Project is capable of recharging up to the State Water Resources Control

[1] Water Year 2018 is the period of October 1, 2017 through September 30, 2018.

Board (SWRCB) water right[2] maximum annual diversion limit of 2,426 acre-feet per year (afy) at a combined permitted injection rate of approximately 3,000 gallons per minute ([gpm] maximum diversion rate of 6.7 cubic feet per second [cfs]), with an average annual yield of approximately 920 afy. ASR-1 is designed for an injection capacity of 1,000 gpm and ASR-2 is designed for an injection capacity of 1,500 gpm. As-built schematics of ASR-1 and ASR-2 are presented on **Figures 2 and 3**, respectively.

The Phase 2 ASR Project (a.k.a. Water Project 2) also includes two ASR wells (ASR-3 and ASR-4) located at the Seaside Middle School (SMS) ASR Facility at 2111 General Jim Moore Blvd. in Seaside. The Phase 2 Project is designed to be capable of recharging up to the SWRCB water right[3] maximum annual diversion limit of 2,900 afy at a combined permitted injection rate of approximately 3,600 gpm (maximum diversion rate of 8.0 cfs), with an average annual yield of approximately 1,000 afy. ASR-3 and ASR-4 are both designed for injection capacities of 1,500 gpm. As-built schematics of ASR-3 and ASR-4 are presented on **Figures 4 and 5**, respectively.

A graphical summary of historical ASR operations in the SGB is shown on **Figure 6**. Shown are the annual injection and recovery volumes since the inception of injection operations at the Santa Margarita ASR Facility in WY 2001 through the current period of WY 2018. Also presented is a delineation of the various phases of project implementation, starting with the Santa Margarita Test Injection Well (SMTIW) in 2001, which became ASR-1 as the project transitioned from a testing program to a permanent project in WY 2008 (Phase 1 ASR Project), through construction and operation of the second well (ASR-2) at the facility in 2010. As shown, having the Santa Margarita Facility in full operation with both ASR-1 and ASR-2 injecting simultaneously in WY 2010 and WY 2011 (combined with above normal rainfall and Carmel River flows during those years) resulted in significant increases in the annual volume injected. During WY 2012 through WY 2015, relatively low volumes were injected due to the extended drought conditions during that period. WY 2017 was the first year of above normal rainfall and Carmel River flows with all four ASR wells in full operation, and as shown on **Figure 6** over 2,300 af of excess river flows were captured and successfully injected into the SGB. This volume represents over twice the previous largest annual volumes injected (in WY 2010 and WY 2012), and approximately one quarter of the Monterey Peninsula's average annual water supply.

PURPOSE AND SCOPE

The overall purpose of the ongoing ASR program is to recharge the SGB with excess treated Carmel River system water when it is available during wet periods for storage and later extraction (recovery) during dry periods. ASR benefits the resources of both systems by raising water levels in the SGB during the recharge and storage periods and reducing extractions from the Carmel River System during dry periods.

[2] SWRCB water right 20808A for the Phase 1 ASR Project is held jointly by MPWMD and CAW.
[3] The SWRCB water right 20808C for the Phase 2 ASR Project is held jointly by MPWMD and CAW.

The scope of the ongoing data collection, analysis, and reporting program for the ASR program can be categorized into issues generally associated with:

1) ASR well hydraulics and performance;
2) Aquifer response to injection, and;
3) Water-quality issues associated with geochemical interaction and mixing of injected and native groundwaters.

The ongoing data collection and reporting program is intended to monitor and track ASR well performance and aquifer response to injection (both hydraulic and water quality) and to comply with the requirements of the Central Coast Regional Water Quality Control Board (RWQCB) for submitting annual technical reports for the project pursuant to Section 13267 of the California Water Code[4] and the existing General Waiver for Specific Types of Discharges (Resolution R3-2014-0041).

FINDINGS

WY 2018 ASR OPERATIONS

General Recharge Procedures

Recharge of the SGB occurs via injection of diverted flows from the CAW distribution system into ASR wells during periods of available excess Carmel River system flows. The ASR recharge source water is potable (treated) water provided from the CAW distribution system. The water is currently diverted by various production well sources in Carmel Valley and (after treatment and disinfection to potable standards) then conveyed through the Segunda-Crest pipeline network to the ASR Pipeline in General Jim Moore Blvd and then to the Santa Margarita and Seaside Middle School ASR facilities.

Injection water is introduced into the ASR wells via the pump columns. Injection rates are controlled primarily by downhole flow control valves (FCV's) installed on the pump columns, and secondarily by modulating the automatic flow control valves (i.e., Cla-Vals) installed on the ASR wellhead piping. Injection flow rates and total injected volumes are measured with rate and totalizing meters at each of the wellheads. Positive gauge pressures are maintained at the wellheads during injection to prevent cascading of water into the wells (which can lead to air-binding). Continuous water-level data at each of the ASR wells are collected with submersible pressure transducer data loggers.

Injection generally occurs at each of the ASR wells on a continuous basis when flows are available, interrupted only for periodic backflushing, which typically occurs on an approximate weekly basis. Most sources of injection water contain trace amounts of solids that slowly

[4] Letter from Roger W. Briggs, Executive Officer of the Central Coast RWQCB, to Joseph Oliver, Water Resources Manager for MPWMD, dated April 29, 2009.

accumulate in the pore spaces in the well's gravel pack and adjacent aquifer materials, and the CAW source water is no exception. Periodic backflushing of the ASR wells is therefore necessary to maintain well performance by removing materials deposited/accumulated around the well bore during injection. The procedure is similar to backwashing a media filter to remove accumulated material deposited during filtration.

The trigger for backflushing is when the amount of water-level drawup during injection equals the available drawdown (as measured from the static water level to the top of the pump bowls) in the well for backflushing, or one week of continuous injection, whichever occurs first. This helps to avoid over-pressurization and compression of plugging materials, thereby maximizing the efficiency of backflushing and limiting the amount of residual plugging. This factor is the basis for the maximum recommended drawup levels referenced in the following section.

The general procedure consists of temporarily stopping injection and then pumping the wells at rates of approximately 2,000 to 3,000 gpm (i.e., at least twice the rate of injection) for a period of approximately 15 to 20 minutes and repeated as necessary to effectively remove particulates from the well screen / gravel pack / aquifer matrix. Backflush water is discharged to the Santa Margarita ASR Facility backflush pit, where it percolates back into the groundwater basin.

Injection Operations Summary

A summary of injection operations at the four ASR wells is presented in **Table 1** below. Field data collected during injection operations are presented in **Appendix A** (not included in draft).

Table 1. WY 2018 Injection Operations Summary

Well	Injection Season		Active	Injection Rate (gpm)			Total Vol
	Start	End	Days	Min	Max	Avg	(af)
ASR-1	--	--	0	--	--	--	0.00
ASR-2	3/7/18	4/18/18	40	422	1,940	1,347	233.97
ASR-3	3/2/18	4/18/18	45	1,050	1,650	1,442	281.23
ASR-4	3/2/18	4/3/18	8	450	1,000	620	15.29
						Total	**530.49**

As shown in **Table 1**, recharge operations were performed during the period March 2 through April 18, 2018. WY 2018 was classified as a "Dry" Water Year[5] on the Carmel River with up to 45 days of active injection and a total volume of approximately 530 acre-feet (af) of water was available for diversion from the CAW system for recharge in the SGB. The recharge water was injected at three of the four ASR wells (ASR-1 was not operational during WY 2018) into the

[5] Based on 32,170 af of unimpaired Carmel River flow at the Sleepy Hollow Weir in WY 2018.

Santa Margarita Sandstone aquifer with per-well average injection rates ranging from approximately 420 to 1,940 gpm.

It is noted that the variability in injection rates at the ASR wells during the injection season is controlled by various factors, including the number of active sources to the CAW system, customer demands on the CAW system, and the ability of CAW's distribution system to maintain piping pressure at the ASR wellheads.

Water-level data collected at ASR-1 through ASR-4 during WY 2018 are presented in **Figures 7 through 10**, respectively, and briefly summarized below:

- ASR-1: The well was out of service during the WY 2018 injection season and no water-level transducer was installed in the well.

- ASR-2: The injection water-levels ranged between approximately 255 to 300 feet bgs and were maintained below the minimum recommended water level of 250 feet bgs at all times.

- ASR-3: The injection water-levels ranged between approximately 195 to 250 feet bgs and were maintained below the minimum recommended water level of 190 feet bgs at all times.

- ASR-4: During the limited period of injection at this well, the injection water-level only reached approximately 300 feet bgs, well below the below the minimum recommended water level of 160 feet bgs.

In summary, injection water levels at ASR-1 through ASR-4 were maintained below the respective maximum drawup levels at all times during WY 2018. The effects of these injection water levels on residual well plugging and well performance is discussed below.

Recovery Operations Summary

When the injected water is recovered via delivery through the CAW system, the recovered water is offset by reduced pumping by CAW from the Carmel River system during the low-flow, high demand periods of the year. During WY 2017, both ASR-1 and other CAW production wells in the SGB were utilized for recovery of previously injected water As shown on **Figure 6**, 561 and 649 af (1,210 af total) of recharged water was recovered into the CAW system. It is noted that of the total volume recovered during WY 2018, 680 af was carryover storage from WY 2017 (with 483 af remaining in aquifer storage from WY 2017 and carried over into WY 2019).

It is noted that ASR recovery in the SGB is essentially an accounting / allocation of CAW's various water rights and pumping from the basin, SGB and does not represent a "molecule-for-molecule" recovery of the injected water; rather, the volume recharged in any given year increases the operational yield of the SGB by a commensurate amount and can be "recovered" by any of CAW's wells in the SGB and / or the ASR wells themselves.

WELL PERFORMANCE

Well performance is generally measured by specific capacity (pumping) and / or specific injectivity (injection), which is the ratio of flow rate (pumping or injection) to water-level change in the well (drawdown or drawup) over a specific elapsed time. The value is typically expressed as gallons per minute per foot of water level change (gpm/ft). The value normalizes well performance by taking into account differing static water levels and flow rates. As such, specific capacity / injectivity data are useful for comparing well performance over time and at differing flow rates. Decreases in specific capacity / injectivity are indicative of decreases in the hydraulic efficiency of a well due to the effects of plugging and/or particle rearrangement.

Injection Performance

Injection performance has been tracked at ASR-1 since the inception of the ASR program in WY 2002 by measurement and comparison of 24-hour injection specific injectivities (a.k.a. injection specific capacity), and summaries of 24-hour specific injectivity for ASR-1 through ASR-4 through WY 2018 are presented in **Tables 2 through 5** below:

Table 2. Injection Performance Summary - ASR-1

Water Year	Injection Rate (gpm)	24-hour DUP (feet)	Specific Injectivity (gpm/ft)	Water Year Change	Comments
WY2002					
Beginning Period	1,570	81.7	19.2		FCV not installed yet in WY2002. No recovery pumping performed.
Ending Period	1,164	199.8	6.4	-67%	
WY2003					
Beginning Period	1,070	70.0	15.5		Recovery pumping performed following WY2003 Injection
Ending Period	1,007	49.7	20.3	+31%	
WY2004					
Beginning Period	1,383	183.4	7.5		Recovery pumping performed following WY2004 Injection
Ending Period	1,072	67.4	15.9	+112%	
WY2005					
Beginning Period	1,045	46.6	22.4		Injectate dechlorinated in WY2005. No recovery pumping performed.
Ending Period	976	94.1	10.4	-54%	
WY2006					
Beginning Period	1,039	71.5	15.0		Injection procedures consistent and performance stable in WY2006. No recovery pumping performed.
Ending Period	1,008	62.2	17.5	+17%	

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Water Year	Injection Rate (gpm)	24-hour DUP (feet)	Specific Injectivity (gpm/ft)	Water Year Change	Comments
WY2007					
Beginning Period	1,098	92.4	11.9	--	Only one injection period in WY2007. No recovery pumping performed.
Ending Period	--	--	--		
WY2008					
Beginning Period	979	25.5	38.4	-17%	Formal rehabilitation performed prior to WY2008 injection
Ending Period	1,063	33.4	31.8		
WY 2009					
Beginning Period	1,119	56.1	19.9	+56%	Beginning period low specific injectivity due to high plugging rate during initial injection period. No recovery pumping performed.
Ending Period	1,069	34.3	31.1		
WY 2010					
Beginning Period	1,080	35.6	30.3	-19%	Observed decline in performance due to residual plugging.
Ending Period	1,326	54.0	24.6		
WY 2011					
Beginning Period	1,367	53.0	25.8	-10%	Observed slight decline in performance due to residual plugging.
Ending Period	1,454	63.7	22.8		
WY 2012					
Beginning Period	NA	NA	NA	NA	No injection at this well this year.
Ending Period	NA	NA	NA		
WY 2013					
Beginning Period	NA	NA	NA	NA	No injection at this well this year.
Ending Period	NA	NA	NA		
WY 2014					
Beginning Period	NA	NA	NA	NA	No injection at this well this year.
Ending Period	NA	NA	NA		
WY 2015					
Beginning Period	NA	NA	NA	NA	No beginning period due to datalogger malfunction.
Ending Period	1,018	40.7	25.0		
WY 2016					
Beginning Period	NA	NA	NA	NA	No beginning period due to datalogger malfunction.
Ending Period	460	14.4	31.9		

Water Year	Injection Rate (gpm)	24-hour DUP (feet)	Specific Injectivity (gpm/ft)	Water Year Change	Comments
WY 2017					
Beginning Period	970	39.5	24.6	-13%	Observed slight decline in performance due to residual plugging.
Ending Period	1,295	60.2	21.5		
WY 2018					
Beginning Period	NA	NA	**NA**	**NA**	**See discussion below**
Ending Period	NA	NA	**NA**		

Table 3. Injection Performance Summary - ASR-2

Water Year	Injection Rate (gpm)	24-hour DUP (feet)	Specific Injectivity (gpm/ft)	Water Year Change	Comments
WY 2010					
Beginning Period	1,017	156.5	6.5		Significant residual plugging.
Ending Period	237	85.0	2.8	-57%	
WY 2011					
Beginning Period	1,497	39.5	37.9		Significant improvement as a result of well rehabilitation. No residual plugging during year.
Ending Period	1,292	34.3	37.7	-0.5%	
WY 2012					
Beginning Period	1,830	56.1	32.6		Observed decline in performance due to residual plugging.
Ending Period	1,817	63.4	28.7	-12%	
WY 2013					
Beginning Period	1,087	32.7	33.2		No residual plugging during year.
Ending Period	1,508	44.2	34.1	+3%	
WY 2014					
Beginning Period	NA	NA	NA		No injection at this well this year.
Ending Period	NA	NA	NA	NA	
WY 2015					
Beginning Period	1,456	38.9	37.4		Observed decline in performance due to residual plugging.
Ending Period	1,574	49.1	32.1	-14%	
WY 2016					
Beginning Period	1,270	34.9	36.4		Observed significant decline in performance due to residual plugging.
Ending Period	1,620	63.9	25.4	-30%	
WY 2017					
Beginning Period	822	24.2	33.9		Observed decline in performance due to residual plugging.
Ending Period	907	30.7	29.5	-13%	
WY 2018					
Beginning Period	950	30.5	**31.1**		**See discussion below**
Ending Period	1,537	53.7	**28.6**	**-8%**	

Table 4. Injection Performance Summary – ASR-3

Water Year	Injection Rate (gpm)	24-hour DUP (feet)	Specific Injectivity (gpm/ft)	Water Year Change	Comments
WY 2013					
Beginning Period	1,044	87.0	12.0		See discussion below.
Ending Period	822	99.6	8.3	-31%	
WY 2014					
Beginning Period	NA	NA	NA		No injection at this well this year.
Ending Period	NA	NA	NA	NA	
WY 2015					
Beginning Period	NA	NA	NA		No beginning period data.
Ending Period	892	90.3	9.9	NA	
WY 2016					
Beginning Period	948	83.6	11.3		Slight increase observed.
Ending Period	897	74.1	12.1	+7%	
WY 2017					
Beginning Period	936	107.5	8.7		Slight increase observed.
Ending Period	986	105.2	9.4	+8%	
WY 2018					
Beginning Period	1,050	64.8	**16.2**		**See discussion below.**
Ending Period	1,440	115.4	**12.5**	**-23%**	

Table 5. Injection Performance Summary – ASR-4

Water Year	Injection Rate (gpm)	24-hour DUP (feet)	Specific Injectivity (gpm/ft)	Water Year Change	Comments
WY 2017					
Beginning Period	1,506	91.3	16.5		Significant increase.
Ending Period	1,068	41.3	25.9	+58%	
WY 2018					
Beginning Period	920	38.1	**24.1**		**See discussion below.**
Ending Period	NA	NA	**NA**	**NA**	

Injection Performance Summary. As shown in **Table 2** and discussed previously, no injection occurred at ASR-1 during WY 2018.

As shown in **Table 3**, at ASR-2 the 24-hour specific injectivity at the beginning of WY 2018 was 31.1 gpm/ft and at the end was 28.6 gpm/ft, representing a slight decrease of approximately 8 percent.

ASR-3 underwent formal rehabilitation prior to the WY 2018 injection season (documented in **Appendix B**, not included in draft). As shown in **Table 4**, at the beginning of WY 2018 the specific injectivity was 16.2 gpm/ft, representing an approximate 72 percent improvement in performance compared to the end of WY 2017, but at the end was 12.5 gpm/ft, representing a significant decrease of approximately 23 percent compared to the beginning of the WY 2018 season.

Injection at ASR-4 occurred for only 7 days during WY 2018; therefore, there are insufficient data for comparison.

Pumping Performance and Residual Plugging

Experience at injection well sites around the world shows that all injection wells are subject to some amount of plugging, because no water source is completely free of particulates, bionutrients, or oxidants, all of which can contribute to well plugging; the CAW source water is no exception. During injection, trace amounts of suspended solids are continually being deposited in the gravel pack and aquifer pore spaces, much as a media filter captures particulates in the filter bed. The effect of plugging is to impede the flow of water from the injection well into the aquifer, causing increased injection heads in the well to maintain a given injection rate, or reduced injection rates at a given head level. Well plugging reduces injection and extraction capacity and can result in decreased useful well life if not mitigated.

Relative measurements of the particulate matter in the injectate have historically been made at the Santa Margarita site through Silt Density Index (SDI) testing during the injection season. The SDI was originally developed to quantitatively assess particulate concentrations in reverse-osmosis feed waters. The SDI test involves pressure filtration of source water through a 0.45-micron membrane, and observation of the decrease in flow rate through the membrane over time; the resulting (dimensionless) value of SDI is used as a comparative value for tracking relative declines in well plugging rates associated with particulate plugging during an injection season (i.e., plugging rates tend to increase directly with SDI). During WY 2017 injection operations, SDI values were only measured at the very beginning of the injection season and ranged between 2.13 and 5.12.

Following routine backflushing operations and periods of water-level recovery, controlled 10-minute specific-capacity tests are typically performed to track well pumping performance, similar to the tracking of injection performance from 24-hour specific injectivity discussed above. Residual plugging is the plugging that remains following backflush pumping. Residual plugging increases drawdown during pumping and drawup during injection and is manifested as declining specific capacity / injectivity. The presence of residual plugging is indicative of incomplete removal of plugging particulates during backflushing and has the cumulative effect of reducing well performance and capacity over time.

As discussed previously, routine 10-minute specific capacity tests were performed at the ASR wells as part of backflushing events during WY 2018. Presented in **Table 9** below is a summary of the residual plugging calculations for the ASR wells during WY 2018.

Table 9. Pumping Performance and Residual Plugging Summary

Well	Test	Pumping Rate (gpm)	10-min Drawdown (ft)	10-min Q/s[1] (gpm/ft)	Normalization Ratio[2]	Normalized Drawdown[2] (ft)	Residual Plugging (ft)
ASR-1	Pre-Injection	NA	NA	--	--	--	--
	Post-Injection	NA	NA	--	--	--	--
ASR-2	Pre-Injection	2,700	82.2	32.8	1.11	91.3	--
	Post-Injection	2,700	84.1	32.1	1.11	93.4	2.1
ASR-3	Pre-Injection	2,700	167.5	16.1	1.11	186.1	--
	Post-Injection	2,400	167.5	14.3	1.25	209.4	23.3
ASR-4	Pre-Injection	2,900	147.3	19.7	1.03	152.4	--
	Post-Injection	2,900	151.8	19.1	1.03	157.0	4.7

Notes:
1 - Specific Capacity. Ratio of pumping rate to drawdown.
2 - Normalized based on ratio of 3,000 gpm to actual test pumping rate.

As shown on **Figures 7 through 10**, injection water levels were maintained below the recommended maximum available drawup levels at all of the ASR wells during WY 2018; however, as shown in **Table 9**, only ASR-3 experienced significant residual plugging of approximately 23 feet. The residual plugging at ASR-3 was manifested as decline in both the injection and pumping performance of the well. These results indicate that injection water levels at all of the ASR wells should be maintained below the recommended minimum levels below ground surface during the injection season to avoid excessive drawup and over pressurization of plugging constituents. These results also indicate that the injection rate at ASR-3, which was as high as approximately 1,650 gpm during WY 2018, should be limited to a rate of approximately 1,000 gpm as recommended in the 2017 SOR in order to limit residual plugging and maintain long-term performance.

AQUIFER RESPONSE TO INJECTION

The response of the regional aquifer system to injection has been monitored since the SMTIW project was initiated in WY 2002. Submersible water-level transducer/data logger units have been installed at seven offsite monitoring well locations in the SGB as well as three onsite monitoring wells. The locations of each offsite monitoring well are shown on **Figure 1**, and water-level hydrographs for the monitoring wells during WY 2018 are graphically presented on

Figures 11 through 18. A summary of the regional water-level observations during the WY 2018 injection season is presented in **Table 10** below.

Table 10. Aquifer Response Summary

Well ID	Distance from Nearest Active ASR Well (feet)	Aquifer Monitored	Fig. No.	Pre-Injection DTW (ft. bgs)	Shallowest Injection DTW (ft. bgs)	Maximum Drawup Response (ft.)
SMS (Shallow)	25 (ASR-3)	QTp	**11**	No Discernable Response		
SMS (Deep)		Tsm		366.6	298.8	**67.8**
SM MW-1	190 (ASR-2)	Tsm	**12**	NA	339.0	**NA**
Paralta Test	650 (ASR-2)	QTp & Tsm	**13**	NA	NA	**NA**
Ord Terrace (Shallow)	2,550 (ASR-2)	Tsm	**14**	NA	NA	**NA**
FO-7 (Shallow)	3,700 (ASR-3)	QTp	**15**	No Discernable Response		
FO-7 (Deep)		Tsm		492.2	480.3	**11.9**
FO-9 (Deep)	6,130 (ASR-3)	Tsm	**16**	142.2	130.7	**11.5**
PCA East (Shallow)	6,200 (ASR-3)	QTp	**17**	No Discernable Response		
PCA East (Deep)		Tsm		90.9	78.8	**12.1**
FO-8 (Deep)	6,450 (ASR-3)	Tsm	**18**	401.9	391.0	**10.9**

Notes:
QTp – Quaternary / Tertiary-age Paso Robles Formation aquifer
Tsm – Tertiary-age Santa Margarita Sandstone aquifer
DTW – Depth to Water

As shown, water levels in the Santa Margarita Sandstone (Tsm) aquifer at the start of the WY 2018 recharge season ranged between approximately 20 to 30 feet below sea level. Positive response to injection during WY 2018 was observed at all 5 of the monitored wells completed in the Tsm aquifer, with apparent water-level responses ranging between approximately 11 to 68 feet, generally decreasing with distance from the ASR wells, which is the typical and expected aquifer response to hydraulic stresses (i.e., injection or pumping).

The available water-level data also continue to show that at the majority of the offsite Tsm-only monitoring wells, water levels consistently remained below sea level throughout WY 2018, including during the injection season. In addition, the limited available data for wells completed in the Paso Robles Formation (QTp) also continue to show no discernible response to injection and water levels in the QTp aquifer remained higher than the water levels in the underlying Tsm aquifer during WY 2018. Under these overall basin water-level conditions, little to no flow from the Tsm aquifer to the ocean nor to the QTp aquifer would be expected to occur; as such, any “losses” associated with ASR project operations are likely very limited.

WATER QUALITY

General

Source water for injection is supplied from the CAW municipal water system, primarily from Carmel River system wells, which is treated at the CAW Begonia Iron Removal Plant (BIRP) for iron and manganese removal. The BIRP product water is also disinfected and maintains a free chlorine residual. A phosphate-based corrosion inhibitor (Zinc Orthophosphate) is also added to the filtered water before entering the CAW distribution system. The finished product water meets all California Department of Public Health (CADPH) Primary and Secondary water quality standards.

As in previous years, water quality was routinely monitored at the ASR well sites during WY 2018 injection and aquifer storage operations. Far-field water quality was also monitored at the PCE-East Deep monitoring well (PCA-E Deep)[6]. Summaries of the collected water-quality data during WY 2018 are presented in **Tables 11 through 18** below. Analytic laboratory reports are presented in **Appendix C** (not included in draft). A discussion of the water-quality data collected during WY 2018 is presented below.

Injection Water Quality

Injection water quality from the CAW system during WY 2018 is presented in **Table 11** below, and the data show injection water quality was typical of recent years. Levels of Trihalomethanes (THM) and Haloacetic Acid (HAA) compounds, as well as bionutrients (dissolved oxygen, nitrogen, phosphorous, and organic carbon), were all present at levels similar to previous years.

Water Quality During Aquifer Storage

Tables 12 through 15 present summaries of water-quality data collected at the four ASR wells. **Tables 16 and 17** present similar data collected at the on-site monitoring wells SM MW-1 and SMS Deep, respectively; and **Table 18** presents the water-quality data collected at the off-site monitoring well PCA-E Deep. Data for the ASR wells include baseline water quality taken prior to WY 2018 injection (end of WY 2017 Storage) and stored water quality (WY 2018 Storage) collected periodically from the aquifer after WY 2018 injection operations were terminated.

Review of water-quality parameters gathered at the ASR wells, including major anions and cations, redox potential (ORP), and conductivity all showed very limited effects of dilution / intermixing of injected water with native groundwater (NGW) during aquifer storage compared to previous water years.

[6] Note: CAW's Paralta production well was non-operational during planned sampling periods during WY 2018 due to mechanical problems.

Disinfection Byproducts (DBPs) parameters for the on-site wells collected during the WY 2018 storage period are graphically presented on **Figures 23 through 28** and are summarized below:

- ASR-1: Three samples were collected from ASR-1 after the conclusion of the WY 2018 injection season, which showed limited ingrowth of THMs at after 89 days, and subsequent decline to 27 ug/L after 160 days of storage; it is noted however, that no injection occurred at ASR-1 during WY 2018; therefore, the results reflect the influence of water injected at ASR-2.
- ASR-2: Only one sample was collected from ASR-2 after 55 days of storage, which showed significant ingrowth of THMs at 90 ug/L, exceeding the MCL of 80 ug/L.
- ASR-3: Two samples were collected from ASR-3; one after 66 days and another after 160 days of storage. The initial sample at 66 days showed significant ingrowth exceeding the THM MCL with a level of 119 ug/L, declining to below the MCL at a level of 75 ug/L after 160 days of storage.
- ASR-4: Two samples were collected from ASR-4; one after 56 days and another after 160 days of storage. Both samples were below the THM MCL, with the initial sample at 56 days showed ingrowth to a level of 69 ug/L, declining to a level of 40 ug/L after 160 days of storage.
- SM MW-1: Four samples were collected at SM MW-1 on an approximate monthly basis during the storage period, which showed limited ingrowth of THMs over a period of 54 days reaching a level of 52 ug/L, followed by a significant decline after 159 days of storage to a level of only 1 ug/L.
- SMS Deep: Four samples were collected at SMS Deep on an approximate monthly basis during the storage period, which showed steady ingrowth exceeding the THM MCL over a period of 111 days and reaching a peak level of 106 ug/L, followed by a decline after 159 days of storage to below the MCL with a level of 71 ug/L.

Historically, THMs at the ASR wells typically show an initial and significant ingrowth during the storage period, which is a result of reactions between free chlorine and trace levels of organic compounds in the injected water and/or the aquifer matrix. THM ingrowth typically peaks in concentration approximately 60 to 80 days after the cessation of injection, followed by a gradual decline during the remainder of the storage period. After approximately 150 to 180 days of storage, THMs typically degrade to below the initial injection levels. (Note: evidence from MPWMD's historical ASR well operations as well as other ASR facilities suggests that the onset of THM degradation does not commence until anoxic/anaerobic redox conditions occur within the aquifer.)

As described above, the results during WY 2018 generally followed this historically observed pattern for the project ASR wells at ASR-1, ASR-2, ASR-4, and SM-MW-1, but THMs did not degrade below the initial injection levels at ASR-3 and SMS-Deep. In reviewing the overall water quality data from all wells, it is apparent that during this recharge season the injected volume of recharge water remained substantially intact, with little or no intermixing with the surrounding native ground water (NGW). Because of this lack of intermixing and migration, the highly oxidized redox conditions within the recharge water volume remained intact for an extended period, and redox conditions did not decline as rapidly as in previous years. This could be due to the absence of pumping from the Paralta well, which was out of service due to mechanical problems (Paralta well production creates a significant localized gradient, which promotes recharge water migration and intermixing with NGW).

HAA levels at the wells (where sufficient data was collected) generally showed their typical pattern of limited (if any) ingrowth during the initial storage period, followed by complete to near-complete degradation by the end of the storage season. Unlike THM's, HAA compounds are known to degrade under aerobic redox conditions, which are already present in the oxygenated and chlorinated recharge water. In addition, HAA's are much less stable compounds than THM's; their auto-degradation is therefore unremarkable.

Water Quality at Off-Site Monitoring Wells

Water-quality data were collected from only one of the off-site wells in WY 2018 (PCA-E Deep) and are presented in **Table 18**. As shown, at PCA-E Deep the absence of DBP's and the consistent and high level of chloride ion during the period suggest that this area is comprised of intact NGW, and the influence of recharge operations is negligible to date at this location. Paralta is the nearest CAW production well to the ASR wells and is typically sampled as part of the project Sampling and Analysis Plan; however, the well was non-operational (due to pump-related issues) during planned sampling periods during WY 2018.

Additional Water Quality Investigations

As discussed in the WY 2015 Summary of Operations Report (SOR), at the commencement of WY 2013 recovery pumping of ASR-1, a sample collected by CAW[7] had a Mercury (Hg) concentration of 4 µg/L, exceeding the State MCL of 2 µg/L. Hg is a member of the family of elements known as Transition Metals, which also includes Iron (Fe), Zinc (Zn), Copper, (Cu), and Cadmium (Cd); the family of transition metals have similar chemical and reactive characteristics, and often react with one another under varying redox and geochemical conditions. Although the occurrence of Hg and other transition metals in surface water and groundwater has been documented elsewhere in the Monterey Bay region, the 2013 detection of Hg in SGB water was unusual. The initial Hg detection was followed up with additional sampling at ASR-1 to verify the presence of Hg, and the subsequent sampling identified sporadic, but detectable levels of Hg (as well as other transition metals), although below the MCL. The fact that detectable Hg was identified, and at levels above historical NGW and injectate concentrations, led to the development of an ongoing investigation of Hg occurrence at the 4 ASR wells.

[7] Collected on October 24, 2013.

As described in previous technical memoranda and reports regarding this issue, it has been hypothesized that the origin of the sporadic occurrences of Hg could be the result of one or more mechanisms, including the following:

A. Soluble or insoluble Hg present in the Carmel River System source water that could have accumulated as particulate (insoluble) compounds in the well bore area, similar to the accumulation of other particulate matter originating from the treated Carmel River product water and the CAW conveyance system. Such accumulation would be released during routine backflushing operations and/or early stages of stored water recovery operations as insoluble/particulate Hg.

B. Solubilization of naturally occurring Hg minerals present in the Tsm geologic matrix, which could result from geochemical interactions between the injection source water, NGW and aquifer minerals.

C. Mobilization of insoluble (i.e., particulate) Hg from the Tsm matrix via the dissolution of cementitous materials and subsequent migration of particulate Hg compounds towards the well bore during recovery/pumping operations.

D. Other anthropogenic sources of Hg in well components or other off-site sources.

A thorough assessment of well construction and operational records was performed in 2014/2015, which found no evidence of any Hg-containing materials in the well casings, screens, pumping equipment, lubricants, or other component materials: this, along with the sporadic detection of low level Hg in other wells, dissuaded further consideration of item (D) above as a realistic possibility.

During WY 2016, a Supplemental Sampling and Analysis Plan[8] (SSAP) was developed for additional investigation of the Hg occurrence. In addition to the collection of Hg samples utilizing a variety of EPA-approved laboratory methods and detections limits, the suite of analytes included transition metals as well as other constituents that are known to affect (or directly react with) Hg and/or Hg compounds. The sampling performed during WY 2016 resulted in the following preliminary findings:

- The ASR wells showed sporadic detections of Hg, predominantly at levels well below MCL's; however, there appeared to be a direct correlation between declining turbidity and decreasing Hg levels as the duration of pumping increased during well backflushing operations. Almost all Hg detections occurred from samples collected during or immediately after well backflushing events.
- Injection source waters from the Begonia Iron Removal Plant (BIRP) indicated detectable Hg levels in the raw well water plant influent and in the finished product water; however, the Hg levels were all far below MCL's, and even below the detection

[8] Dated September 4, 2015

limits of conventional EPA 200.8 analysis methods, with the Hg detections at sub-parts-per-trillion levels.

The data collected during WY 2016 suggested that there was a meaningful correlation between Hg content, Turbidity, and pumping time in the produced water from ASR-1 during well backflushing operations. The possible explanation for this phenomenon is that the trace-level Hg present in the Carmel River System injection source waters was accumulating in the near-well-bore area during injection operations, and then released when reverse flows associated with backflushing or recovery operations occurred (per hypothesis (A) above).

Because the occurrence of elevated Hg levels in ASR-1 appeared to be directly correlated to elevated turbidity levels in initial well flush waters, a revised protocol consisting of a new triple-surge well flushing procedure (refer to the WY 2016 SOR for details) was recommended for all regular and special operations in WY 2017. The addition of an on-line Turbidity analyzer at ASR-1 was also recommended to serve as a safeguard against the possible conveyance of turbid (and potentially Hg-noncompliant) waters into the distribution system during ASR recovery (i.e., production) operations.

WY 2018 Investigation. Assessment of the 2017 ASR operations and water-quality data resulted in several recommendations for the WY 2018 ASR program. Among those recommendations related to water quality, the following items were identified:

1. Continue investigations of Hg and Transition Metal occurrence to support or eliminate each of the 4 previously identified mechanisms of Hg occurance.
2. Obtain cuttings from the Tsm aquifer minerals and analyze for Transition Metals
3. Continue to monitor well backflush waters and analyze backwash sludge residue if high Hg concentrations are detected
4. If sufficiently high concentrations of Hg in backwash sludge are detected, implement further analyses to determine the full speciation of any Hg-containing compounds.

Among the 4 issues cited above, the one issue that was able to be fully implemented was the collection and analysis of Tsm mineral cuttings from the recently constructed DIW-2 well as part of the Pure Water Monterey (PWM) groundwater replenishment program. The DIW-2 borehole penetrated the Tsm between the depths of 380 to 575 feet below ground surface (bgs) – a thickness of 195 feet. Cuttings were obtained at 5- to 10-foot intervals in order to precisely identify the presence and location of various mineral species occurring within the lithologic section. Of the 38 samples collected within the Tsm, 18 visually distinct samples were selected for analysis; of these 18 samples, only one was found to be absent of Hg (i.e., less than the 6 ppb detection limit of the method). The remaining 17 samples all showed detectable levels of naturally occurring Hg, ranging from 6 to 98 ppb (i.e., ug/kg) Hg on a dry weight basis. The average Hg concentration of all samples was 21 ppb.

This is a significant finding in that it substantially confirms the presence of naturally occurring Hg within the Tsm matrix. Additionally, the analyses indicate that the lowest Hg concentrations generally occurred in the coarse-grained sands of the Tsm, while the highest concentrations occurred in the silty/clay horizons and especially those in the lower Tsm most proximate to the underlying Monterey Shale (Tm) formation. The sampling, selection, and analysis of cuttings was documented in a January 2019 Technical Memorandum.

The confirmed presence of Hg and other transition metals within the Tsm suggests that of the (above) 4 previously proposed mechanisms of Hg occurrence, Items B and C (solubilization and/or mobilization of naturally occurring Tsm Hg) are realistic possibilities.

Next Steps. Based on the additional data gathered during the WY 2018 program, it appears that there is sufficient evidence to continue the investigation of the potential mechanisms of Hg solubilization and/or mobilization within the Tsm aquifer mineralogy. Unfortunately, the occurrence of Hg has always been sporadic, and the pursuit of more data will be largely dependent on obtaining samples of water, backwash sludge, or cuttings that contain a sufficiently high concentration of Hg/transition metals to allow quantitative analysis by appropriate analytic laboratories. Because such analyses are costly (up to $7,500/sample), it is recommended that all samples are pre-screened for elemental/bulk Hg content prior to quantitative speciation analysis. Once such speciation is confirmed, geochemical modeling can be leveraged to ascertain the specific reaction mechanism(s) resulting in mobilization. It is therefore prudent to continue with the ongoing sampling of backflushing waters and sludge during injection operations, and to collect and analyze stored water samples for Transition Metals and related parameters (ORP, DO, Cl, and pH) at all wells on a monthly basis.

Table 11. Summary of WY 2018 Water Quality Data – Injectate

				Results	
				CAW Injectate	
Parameter	Unit	PQL	MCL	3/2/18	4/17/18
		Sample Description		Injectate	
Major Cations					
Calcium	mg/L	0.5		48	
Magnesium	mg/L	0.5		16	
Potasium	mg/L	0.5		3.36	
Sodium	mg/L	0.5		52	
Major Anions					
Alkalinity, Total (as CaCO3)	mg/L	2		144	
Chloride	mg/L	1	250	32	
Sulfate	mg/L	1	250	92	
Nitrate (as N)	mg/L	1	10	ND	
General Physical					
pH	Std Units			7.7	
Specific Conductance (EC)	uS	1	900	541	
Total Dissolved Solids	mg/L	10	500	349	
Metals					
Arsenic (Total)	ug/L	1	10	ND	
Barium (Total)	ug/L	10	1000	71	
Iron (Dissolved)	ug/L	10		16	
Iron (Total)	ug/L	10	300	56	
Lithium	ug/L	1		5	
Manganese (Dissolved)	ug/L	10		ND	
Manganese (Total)	ug/L	10	50	ND	
Mercury	ug/L	0.5	2	ND	
Molybdenum	ug/L	1	1000	2	
Nickel	ug/L	10	100	3	
Selenium	ug/L	2	50	2	
Strontium (Total)	ug/L	5		245	
Uranium (by ICP/MS)	ug/L	1	30	ND	
Vanadium (Total)	ug/L	1	1000	ND	
Zinc (Total)	ug/L	10	5000	250	
Miscellaneous					
Ammonia-N	mg/L	0.05		ND	
Boron	mg/L	0.05		ND	
Chloramines	mg/L	0.05		0.07	0.10
Gross Alpha	pCi/L		15	0.847±0.983	
Kjehldahl Nitrogen (Total)	mg/L	0.5		ND	
Methane	ug/L	0.1		1.50	
o-Phosphate-P	mg/L	0.05		0.35	
Phosphorous (Total)	mg/L	0.03		0.45	
Radium 226	pCi/L		3	0.000±0.044	
Organic Analyses					
Haloacetic Acids (Total)	ug/L	1.0	60.0	24.0	10.0
Organic Carbon (Dissolved)	mg/L	0.2		1.8	
Organic Carbon (Total)	mg/L	0.2		1.8	
Trihalomethanes (Total)	ug/L	1.0	80.0	60.0	24.0
Field Parameters					
Temperature	^{0}C	0.1		14.8	19.6
Specific Conductance (EC)	uS	1.0	900	470	446
pH	Std Units	0.1	6.5 - 8.5	7.5	7.0
ORP	mV	1.0		492	680
Free Chlorine Residual	mg/L	0.1	2 - 5	0.9	2.1
Dissolved Oxygen	mg/L	0.01		4.3	3.4
Silt Density Index	Std Units	0.1		?	?
H_2S	mg/L	0.1		ND	ND

Notes:

Constituents exceeding MCLs denoted in **BOLD** type

Table 12. Summary of WY 2018 Water-Quality Data – ASR-1

Parameter	Unit	PQL	MCL	SM ASR-1				
				3/21/01	11/29/17	6/12/18	7/16/18	9/25/18
		ASR Operational Phase		NGW	WY 2017 Storage	WY 2018 Storage		
Elapsed Storage Time	Days			--	**183**	**55**	**89**	**160**
Major Cations								
Calcium	mg/L	*0.5*		85	44			47
Magnesium	mg/L	*0.5*		19	14			14
Potasium	mg/L	*0.5*		5.3	3.0			3.3
Sodium	mg/L	*0.5*		88	48			53
Major Anions								
Alkalinity, Total (as CaCO3)	mg/L	*2*		224	137			146
Chloride	mg/L	*1*	*250*	120	29			40
Sulfate	mg/L	*1*	*250*	95	71			78
Nitrate (as N)	mg/L	*1*	*10*	ND	0.3			0.2
General Physical								
pH	Std Units			7.1	7.5			7.4
Specific Conductance (EC)	uS	*1*	*900*	**1015**	503			558
Total Dissolved Solids	mg/L	*10*	*500*	**618**	300			343
Metals								
Arsenic (Total)	ug/L	*1*	*10*	ND	4			ND
Barium (Total)	ug/L	*10*	*1000*	52	55			39.6
Iron (Dissolved)	ug/L	*10*			< 10			ND
Iron (Total)	ug/L	*10*	*300*	120	18			ND
Lithium	ug/L	*1*			7			9
Manganese (Dissolved)	ug/L	*10*			< 10			ND
Manganese (Total)	ug/L	*10*	*50*	40	< 10			2
Mercury	ug/L	*0.5*	*2*		< 0	ND		ND
Molybdenum	ug/L	*1*	*1000*		5			5.8
Nickel	ug/L	*10*	*100*		2			1.6
Selenium	ug/L	*2*	*50*	ND	4			8
Strontium (Total)	ug/L	*5*			244			102
Uranium (by ICP/MS)	ug/L	*1*	*30*		0.8			1.3
Vanadium (Total)	ug/L	*1*	*1000*		< 2			1.6
Zinc (Total)	ug/L	*10*	*5000*	10	166			93
Miscellaneous								
Ammonia-N	mg/L	*0.05*		0.33	0.1			ND
Boron	mg/L	*0.05*		0.14	0.05			ND
Chloramines	mg/L	*0.05*			ND	ND	ND	ND
Gross Alpha	pCi/L		*15*		2.13 ± 1.27			3.22±2.16
Kjehldahl Nitrogen (Total)	mg/L	*0.5*			ND			ND
Methane	ug/L	*0.1*			0.42			0.85
o-Phosphate-P	mg/L	*0.05*		0.46	ND			0.1
Phosphorous (Total)	mg/L	*0.03*						0.15
Radium 226	pCi/L		*3*		0.000 ± 0.088			0.465±0.219
Organic Analyses								
Haloacetic Acids (Total)	ug/L	*1.0*	*60.0*		ND	ND	ND	ND
Organic Carbon (Dissolved)	mg/L	*0.2*			2.2			1.3
Organic Carbon (Total)	mg/L	*0.2*		6.3	1.5			1.7
Trihalomethanes (Total)	ug/L	*1.0*	*80.0*		67	44	46	27
Field Parameters								
Temperature	^{0} C	*0.1*			16.5	17.4	17.1	17.4
Specific Conductance (EC)	uS	*1.0*	*900*	1015	459	439	434	508
pH	Std Units	*0.1*	*6.5 - 8.5*	7.1	7.28	7.17	7.2	6.9
ORP	mV	*1.0*			74	128	51	159
Free Chlorine Residual	mg/L	*0.1*	*2 - 5*		0.43	0.37	0.25	0.2
Dissolved Oxygen	mg/L	*0.01*			2.19	2.08	NA	1.45
Silt Density Index	Std Units	*0.1*			NA	NA		
H_2S	mg/L	*0.1*		1.5	ND	ND	ND	ND

Notes:
Constituents exceeding MCLs denoted in **BOLD** type

Table 13. Summary of WY 2018 Water Quality Data – ASR-2

Parameter	Unit	PQL	MCL	Results SM ASR-2 10/4/17	1/11/18	6/12/18
		ASR Operational Phase		WY 2017 Storage		WY 2018 Storage
Elapsed Storage Time	Days			**127**	**226**	**55**
Major Cations						
Calcium	mg/L	*0.5*		38	41	
Magnesium	mg/L	*0.5*		14	14	
Potasium	mg/L	*0.5*		2.8	3.1	
Sodium	mg/L	*0.5*		43	46	
Major Anions						
Alkalinity, Total (as CaCO3)	mg/L	*2*		134	138	
Chloride	mg/L	*1*	*250*	28	28	
Sulfate	mg/L	*1*	*250*	70	70	
Nitrate (as N)	mg/L	*1*	*10*	0.2	0.2	
General Physical						
pH	Std Units			7.4	7.5	
Specific Conductance (EC)	uS	*1*	*900*	495	493	
Total Dissolved Solids	mg/L	*10*	*500*	297	**311**	
Metals						
Arsenic (Total)	ug/L	*1*	*10*	< 1	ND	
Barium (Total)	ug/L	*10*	*1000*	62	62	
Iron (Dissolved)	ug/L	*10*		11	27	
Iron (Total)	ug/L	*10*	*300*	66	**1220**	
Lithium	ug/L	*1*		7	8	
Manganese (Dissolved)	ug/L	*10*		ND	< 20	
Manganese (Total)	ug/L	*10*	*50*	< 10	40	
Mercury	ug/L	*0.5*	*2*	< 0	1	ND
Molybdenum	ug/L	*1*	*1000*	6	6	
Nickel	ug/L	*10*	*100*	2	6	
Selenium	ug/L	*2*	*50*	3	3	
Strontium (Total)	ug/L	*5*		208	258	
Uranium (by ICP/MS)	ug/L	*1*	*30*	2.4	1.6	
Vanadium (Total)	ug/L	*1*	*1000*	< 2	ND	
Zinc (Total)	ug/L	*10*	*5000*	209	298	
Miscellaneous						
Ammonia-N	mg/L	*0.05*		ND	ND	
Boron	mg/L	*0.05*		< 0.05	< 0.05	
Chloramines	mg/L	*0.05*		N.D.		ND
Gross Alpha	pCi/L		*15*	2.04 ± 1.15	2.09 ± 1.29	
Kjehldahl Nitrogen (Total)	mg/L	*0.5*		ND	ND	
Methane	ug/L	*0.1*		0.70	0.49	
o-Phosphate-P	mg/L	*0.05*		0.26	< 0.02	
Phosphorous (Total)	mg/L	*0.03*		0.30	0.30	
Radium 226	pCi/L		*3*	0.090 ± 0.124	0.045 ± 0.089	
Organic Analyses						
Haloacetic Acids (Total)	ug/L	*1.0*	*60.0*	4	ND	10
Organic Carbon (Dissolved)	mg/L	*0.2*		1.9	1.6	
Organic Carbon (Total)	mg/L	*0.2*		1.4	1.6	
Trihalomethanes (Total)	ug/L	*1.0*	*80.0*	**87**	63	**90**
Field Parameters						
Temperature	^{0} C	*0.1*		19.4	16.4	16.8
Specific Conductance (EC)	uS	*1.0*	*900*	428	386	443.0
pH	Std Units	*0.1*	*6.5 - 8.5*	7.1	7.4	6.7
ORP	mV	*1.0*			86	155
Free Chlorine Residual	mg/L	*0.1*	*2 - 5*		0.31	-0.09
Dissolved Oxygen	mg/L	*0.01*		2.03	1.89	3.21
Silt Density Index	Std Units	*0.1*				
H_2S	mg/L	*0.1*			ND	ND

Notes:
Constituents exceeding MCLs denoted in **BOLD** type

Table 14. Summary of WY 2018 Water Quality Data – ASR-3

Parameter	Unit	PQL	MCL	Results			
				SMS ASR-3			
				10/22/10	1/11/18	6/13/18	9/25/18
		ASR Operational Phase		NGW	WY 2017 Storage	WY 2018 Storage	
Elapsed Storage Time	Days				**226**	**56**	**160**
Major Cations							
Calcium	mg/L	*0.5*		76	43		42
Magnesium	mg/L	*0.5*		18	13		14
Potasium	mg/L	*0.5*		5	3.6		3.1
Sodium	mg/L	*0.5*		102	46		44
Major Anions							
Alkalinity, Total (as CaCO3)	mg/L	*2*		304	128		137
Chloride	mg/L	*1*	*250*	107	41		31
Sulfate	mg/L	*1*	*250*	56	70		74
Nitrate (as N)	mg/L	*1*	*10*	1	0.2		0.1
General Physical							
pH	Std Units			7.7	7.2		7.4
Specific Conductance (EC)	uS	*1*	*900*	**954**	529		504
Total Dissolved Solids	mg/L	*10*	*500*	**575**	331		306
Metals							
Arsenic (Total)	ug/L	*1*	*10*	4	10		5.3
Barium (Total)	ug/L	*10*	*1000*	50	52		55.9
Iron (Dissolved)	ug/L	*10*		21	792		61
Iron (Total)	ug/L	*10*	*300*	21	**1530**		106
Lithium	ug/L	*1*		36	14		6
Manganese (Dissolved)	ug/L	*10*		27	56		12
Manganese (Total)	ug/L	*10*	*50*	27	**63**		14
Mercury	ug/L	*0.5*	*2*		ND	ND	ND
Molybdenum	ug/L	*1*	*1000*	--	79		62.1
Nickel	ug/L	*10*	*100*	ND	4		2.9
Selenium	ug/L	*2*	*50*	ND	5		37
Strontium (Total)	ug/L	*5*		403	262		101
Uranium (by ICP/MS)	ug/L	*1*	*30*	--	3.8		1.5
Vanadium (Total)	ug/L	*1*	*1000*	--	ND		1.4
Zinc (Total)	ug/L	*10*	*5000*	--	270		223
Miscellaneous							
Ammonia-N	mg/L	*0.05*		249	ND		ND
Boron	mg/L	*0.05*		ND	< 0.05		ND
Chloramines	mg/L	*0.05*		0.08		ND	ND
Gross Alpha	pCi/L		*15*	--	3.95±1.57		1.82±1.67
Kjehldahl Nitrogen (Total)	mg/L	*0.5*		ND	ND		ND
Methane	ug/L	*0.1*		ND	1.30		0.94
o-Phosphate-P	mg/L	*0.05*		ND	0.17		0.3
Phosphorous (Total)	mg/L	*0.03*		0.03	1.42		0.38
Radium 226	pCi/L		*3*	--	0.498±0.217		0.000±0.116
Organic Analyses							
Haloacetic Acids (Total)	ug/L	*1.0*	*60.0*	ND	2	25	7
Organic Carbon (Dissolved)	mg/L	*0.2*		0.71	3.0		1.5
Organic Carbon (Total)	mg/L	*0.2*		0.70	3.0		1.4
Trihalomethanes (Total)	ug/L	*1.0*	*80.0*	ND	68	**119**	75
Field Parameters							
Temperature	^{0}C	*0.1*		26.2	16.6	17.0	17.6
Specific Conductance (EC)	uS	*1.0*	*900*	991	446	459	466
pH	Std Units	*0.1*	*6.5 - 8.5*	7.0	6.97	6.72	6.5
ORP	mV	*1.0*		-82	-42.0	33	10
Free Chlorine Residual	mg/L	*0.1*	*2 - 5*	ND	0.32	0.29	0.14
Dissolved Oxygen	mg/L	*0.01*		--	2.8	2.69	1.78
Silt Density Index	Std Units	*0.1*		--			
H_2S	mg/L	*0.1*		0.60	ND	ND	ND

Notes:
Constituents exceeding MCLs denoted in **BOLD** type

Table 15. Summary of WY 2018 Water Quality Data – ASR-4

Parameter	Unit	PQL	MCL	Results			
				ASR-4			
				10/4/17	1/11/18	6/13/18	9/25/18
		ASR Operational Phase		WY 2017 Storage		WY 2018 Storage	
Elapsed Storage Time	Days			**127**	**226**	**56**	**160**
Major Cations							
Calcium	mg/L	*0.5*		36	41		43
Magnesium	mg/L	*0.5*		13	13		14
Potasium	mg/L	*0.5*		2.7	3.1		3.4
Sodium	mg/L	*0.5*		39	45		49
Major Anions							
Alkalinity, Total (as CaCO3)	mg/L	*2*		134	139		137
Chloride	mg/L	*1*	*250*	27	32		36
Sulfate	mg/L	*1*	*250*	70	67		67
Nitrate (as N)	mg/L	*1*	*10*	0.2	0.2		0.2
General Physical							
pH	Std Units			7.5	7.6		7.5
Specific Conductance (EC)	uS	*1*	*900*	487	509		511
Total Dissolved Solids	mg/L	*10*	*500*	297	323		323
Metals							
Arsenic (Total)	ug/L	*1*	*10*	8	6		4.4
Barium (Total)	ug/L	*10*	*1000*	60	59		53.4
Iron (Dissolved)	ug/L	*10*		18	29		9
Iron (Total)	ug/L	*10*	*300*	201	**319**		136
Lithium	ug/L	*1*		7	11		9
Manganese (Dissolved)	ug/L	*10*		13	< 20		ND
Manganese (Total)	ug/L	*10*	*50*	14	22		2
Mercury	ug/L	*0.5*	*2*	< 0	**4**	ND	ND
Molybdenum	ug/L	*1*	*1000*	55	77		12.2
Nickel	ug/L	*10*	*100*	23	11		17.1
Selenium	ug/L	*2*	*50*	10	5		28
Strontium (Total)	ug/L	*5*		206	276		120
Uranium (by ICP/MS)	ug/L	*1*	*30*	1.7	1.8		1.4
Vanadium (Total)	ug/L	*1*	*1000*	< 2	ND		1.7
Zinc (Total)	ug/L	*10*	*5000*	104	123		110
Miscellaneous							
Ammonia-N	mg/L	*0.05*		ND	ND		ND
Boron	mg/L	*0.05*		< 0.05	0.05		ND
Chloramines	mg/L	*0.05*		N.D.		ND	ND
Gross Alpha	pCi/L		*15*	2.02 ± 1.14	3.84 ± 1.50		3.10±2.10
Kjehldahl Nitrogen (Total)	mg/L	*0.5*		ND	ND		ND
Methane	ug/L	*0.1*		0.98	0.87		0.63
o-Phosphate-P	mg/L	*0.05*		0.16	0.21		0.1
Phosphorous (Total)	mg/L	*0.03*		0.17	0.14		0.16
Radium 226	pCi/L		*3*	0.000 ± 0.088	0.204 ± 0.147		0.000±0.102
Organic Analyses							
Haloacetic Acids (Total)	ug/L	*1.0*	*60.0*	2	ND	ND	ND
Organic Carbon (Dissolved)	mg/L	*0.2*		1.7	1.7		1.1
Organic Carbon (Total)	mg/L	*0.2*		1.3	1.7		1.3
Trihalomethanes (Total)	ug/L	*1.0*	*80.0*	59	39	69	40
Field Parameters							
Temperature	^{0} C	*0.1*		18.5	18.2	19.0	19.3
Specific Conductance (EC)	uS	*1.0*	*900*	415	481	444	459
pH	Std Units	*0.1*	*6.5 - 8.5*	6.43	7.32	7.52	7.08
ORP	mV	*1.0*		31	37	49	12
Free Chlorine Residual	mg/L	*0.1*	*2 - 5*	0.51	0.33	0.34	0.14
Dissolved Oxygen	mg/L	*0.01*		1.87	1.74	2.41	1.61
Silt Density Index	Std Units	*0.1*					
H_2S	mg/L	*0.1*		ND	ND	ND	ND

Notes:
Constituents exceeding MCLs denoted in **BOLD** type

Table 16. Summary of WY 2018 Water Quality Data – SM MW-1

Parameter	Unit	PQL	MCL	Results						
				SM MW-1						
				10/2/17	3/12/18	3/30/18	5/7/18	6/11/18	7/9/18	9/24/18
		Sample Description		WY 2017 Storage	WY 2018 Injection		WY 2018 Storage			
Elapsed Storage Time	Days			**125**	**0**	**0**	**19**	**54**	**82**	**159**
Major Cations										
Calcium	mg/L	*0.5*		48	45		46			
Magnesium	mg/L	*0.5*		13	11		14			
Potasium	mg/L	*0.5*		3.2	2.8		3.0			
Sodium	mg/L	*0.5*		48	44		48			
Major Anions										
Alkalinity, Total (as CaCO3)	mg/L	*2*		137	137		137			
Chloride	mg/L	*1*	*250*	28	29		32		31	37
Sulfate	mg/L	*1*	*250*	69	70		75			
Nitrate (as N)	mg/L	*1*	*10*	0.3	0.2		ND			
General Physical										
pH	Std Units			7.5	7.6		7.5			
Specific Conductance (EC)	uS	*1*	*900*	491	501		507			
Total Dissolved Solids	mg/L	*10*	*500*	326	311		317			
Metals										
Arsenic (Total)	ug/L	*1*	*10*	2	2		ND			
Barium (Total)	ug/L	*10*	*1000*	26	22		30			
Iron (Dissolved)	ug/L	*10*		14	ND		ND			
Iron (Total)	ug/L	*10*	*300*	ND	ND		ND			
Lithium	ug/L	*1*		4	7		6			
Manganese (Dissolved)	ug/L	*10*		ND	ND		ND			
Manganese (Total)	ug/L	*10*	*50*	ND	ND		ND			
Mercury	ug/L	*0.5*	*2*	ND	ND		0	ND	ND	ND
Molybdenum	ug/L	*1*	*1000*	5	4		3			
Nickel	ug/L	*10*	*100*	ND	1		5			
Selenium	ug/L	*2*	*50*	3	3		6			
Strontium (Total)	ug/L	*5*		213	251		226			
Uranium (by ICP/MS)	ug/L	*1*	*30*	1.0	1.7		1.5			
Vanadium (Total)	ug/L	*1*	*1000*	ND	ND		ND			
Zinc (Total)	ug/L	*10*	*5000*	40	ND		ND			
Miscellaneous										
Ammonia-N	mg/L	*0.05*		ND	ND		ND			
Boron	mg/L	*0.05*		ND	ND		ND			
Chloramines	mg/L	*0.05*		N.D.	ND	0.05	ND	ND	ND	ND
Gross Alpha	pCi/L		*15*	2.88 ± 1.29	4.00± 1.62		2.28 ± 1.90			
Kjehldahl Nitrogen (Total)	mg/L	*0.5*		0.8	ND		ND			
Methane	ug/L	*0.1*		ND	0.23		0.61			
o-Phosphate-P	mg/L	*0.05*		ND	ND		ND			
Phosphorous (Total)	mg/L	*0.03*		0.07	0.06		ND			
Radium 226	pCi/L		*3*	0.050 ± 0.120	0.316 ± 0.154		0.392 ± 0.160			
Organic Analyses										
Haloacetic Acids (Total)	ug/L	*1.0*	*60.0*	ND	1	12	ND	2	ND	ND
Organic Carbon (Dissolved)	mg/L	*0.2*		1.8	3.8		1.1			
Organic Carbon (Total)	mg/L	*0.2*		1.2	3.8		1.2			
Trihalomethanes (Total)	ug/L	*1.0*	*80.0*	71	52	55	48	52	32	1.0
Field Parameters										
Temperature	^{0}C	*0.1*		19.5	17.9	18.5	17.8	18.0	17.8	17.9
Specific Conductance (EC)	uS	*1.0*	*900*	475	462	470	442	436	500	497
pH	Std Units	*0.1*	*6.5 - 8.5*	7.08	7.01	5.15	6.65	7.27	7.1	6.9
ORP	mV	*1.0*			118	535	231	60	56	79
Free Chlorine Residual	mg/L	*0.1*	*2 - 5*		0.4	0.5	0.46	0.40	0.35	0.38
Dissolved Oxygen	mg/L	*0.01*		2.03	2.58	3.34	2.96	3.72	3.34	0.46
Silt Density Index	Std Units	*0.1*								
H_2S	mg/L	*0.1*			ND	ND	ND	ND	ND	ND

Notes:
Constituents exceeding MCLs denoted in **BOLD** type

Table 17. Summary of WY 2018 Water Quality Data – SMS Deep

Parameter	Unit	PQL	MCL	Results SMS Deep						
				10/2/17	1/12/18	3/27/18	5/7/18	6/11/18	7/9/18	9/24/18
		Sample Description		WY 2017 Storage		WY 2018 Injection	WY 2018 Storage			
Elapsed Storage Time	Days			**125**	**227**	**-22**	**19**	**54**	**82**	**159**
Major Cations										
Calcium	mg/L	*0.5*		48	46		49			
Magnesium	mg/L	*0.5*		14	12		14			
Potasium	mg/L	*0.5*		3.2	3.05		3.1			
Sodium	mg/L	*0.5*		48	46		46			
Major Anions										
Alkalinity, Total (as CaCO3)	mg/L	*2*		143	147		145			
Chloride	mg/L	*1*	*250*	29	34		30		29	30
Sulfate	mg/L	*1*	*250*	70	68		72			
Nitrate (as N)	mg/L	*1*	*10*	0.3	0.2		ND			
General Physical										
pH	Std Units			7.7	7.6		7.5			
Specific Conductance (EC)	uS	*1*	*900*	505	551		507			
Total Dissolved Solids	mg/L	*10*	*500*	308	328		323			
Metals										
Arsenic (Total)	ug/L	*1*	*10*	6	6		ND			
Barium (Total)	ug/L	*10*	*1000*	56	48		58			
Iron (Dissolved)	ug/L	*10*		ND	65		ND			
Iron (Total)	ug/L	*10*	*300*	ND	71		ND			
Lithium	ug/L	*1*		4	8		6			
Manganese (Dissolved)	ug/L	*10*		ND	< 20		ND			
Manganese (Total)	ug/L	*10*	*50*	ND	< 20		ND			
Mercury	ug/L	*0.5*	*2*	ND	< 0		ND	ND	ND	ND
Molybdenum	ug/L	*1*	*1000*	25	16		8			
Nickel	ug/L	*10*	*100*	ND	3		4			
Selenium	ug/L	*2*	*50*	4	8		5			
Strontium (Total)	ug/L	*5*		250	262		261			
Uranium (by ICP/MS)	ug/L	*1*	*30*	1.0	5.3		1.1			
Vanadium (Total)	ug/L	*1*	*1000*	ND	< 2		ND			
Zinc (Total)	ug/L	*10*	*5000*	61	73		101			
Miscellaneous										
Ammonia-N	mg/L	*0.05*		ND	ND		ND			
Boron	mg/L	*0.05*		ND	< 0.05		ND			
Chloramines	mg/L	*0.05*		N.D.	ND	0.16	0.10	ND	ND	ND
Gross Alpha	pCi/L		*15*	1.80 ± 1.09	6.00 ± 1.87		1.51 ± 1.61			
Kjehldahl Nitrogen (Total)	mg/L	*0.5*		ND	ND		ND			
Methane	ug/L	*0.1*		0.39	1.10		1.70			
o-Phosphate-P	mg/L	*0.05*		ND	0.15		0.25			
Phosphorous (Total)	mg/L	*0.03*		0.09	0.30		0.11			
Radium 226	pCi/L		*3*	0.149 ± 0.154	0.158 ± 0.133		0.486 ± 0.177			
Organic Analyses										
Haloacetic Acids (Total)	ug/L	*1.0*	*60.0*	6	2	9	6	17	11	ND
Organic Carbon (Dissolved)	mg/L	*0.2*		1.7	2.4		1.3			
Organic Carbon (Total)	mg/L	*0.2*		1.3	2.0		1.3			
Trihalomethanes (Total)	ug/L	*1.0*	*80.0*	**86**	65	26	**84**	**106**	**98**	71
Field Parameters										
Temperature	^{0} C	*0.1*		18.1	18.0	17.9	17.9	18.1	18.1	17.4
Specific Conductance (EC)	uS	*1.0*	*900*	444	478	480	452	463	423	448
pH	Std Units	*0.1*	*6.5 - 8.5*	7.11	7.49	6.85	6.99	7.21	7.38	6.68
ORP	mV	*1.0*		148	-14	642	527	83	134	108
Free Chlorine Residual	mg/L	*0.1*	*2 - 5*	0.41	0.49	1.48	0.45	0.27	0.27	0.36
Dissolved Oxygen	mg/L	*0.01*		3.48	2.78	3.86	3.30	3.21	6.91	2.45
Silt Density Index	Std Units	*0.1*								
H_2S	mg/L	*0.1*		ND	ND	ND	ND	ND	ND	ND

Notes:
Constituents exceeding MCLs denoted in **BOLD** type

Table 18. Summary of WY 2018 Water Quality Data – Off-Site Monitoring Wells

Parameter	Unit	PQL	MCL	Results	
				PCA-E Deep	
				9/11/17	7/3/18
		ASR Operational Phase		WY 2017 Storage	WY 2018 Storage
Major Cations					
Calcium	mg/L	0.5		57	57
Magnesium	mg/L	0.5		12	12
Potasium	mg/L	0.5		4.4	4.2
Sodium	mg/L	0.5		101	101
Major Anions					
Alkalinity, Total (as CaCO3)	mg/L	2		195	199
Chloride	mg/L	1	250	113	116
Sulfate	mg/L	1	250	33	42
Nitrate (as N)	mg/L	1	10	ND	0.7
General Physical					
pH	Std Units			7.4	7.4
Specific Conductance (EC)	uS	1	900	806	797
Total Dissolved Solids	mg/L	10	500	460	509
Metals					
Arsenic (Total)	ug/L	1	10		6.0
Barium (Total)	ug/L	10	1000	98	92.9
Iron (Dissolved)	ug/L	10		34	40
Iron (Total)	ug/L	10	300	33	40
Lithium	ug/L	1			35
Manganese (Dissolved)	ug/L	10		159	155
Manganese (Total)	ug/L	10	50	149	157
Mercury	ug/L	0.5	2		ND
Molybdenum	ug/L	1	1000		9.7
Nickel	ug/L	10	100		3.2
Selenium	ug/L	2	50		2
Strontium (Total)	ug/L	5			309
Uranium (by ICP/MS)	ug/L	1	30		ND
Vanadium (Total)	ug/L	1	1000		ND
Zinc (Total)	ug/L	10	5000		ND
Miscellaneous					
Ammonia-N	mg/L	0.05		ND	ND
Boron	mg/L	0.05		0.10	0.11
Chloramines	mg/L	0.05			ND
Gross Alpha	pCi/L		15		2.14 ± 2.10
Kjehldahl Nitrogen (Total)	mg/L	0.5			ND
Methane	ug/L	0.1			2.20
o-Phosphate-P	mg/L	0.05		ND	ND
Phosphorous (Total)	mg/L	0.03			ND
Radium 226	pCi/L		3		0.142±0.139
Organic Analyses					
Haloacetic Acids (Total)	ug/L	1.0	60.0		ND
Organic Carbon (Dissolved)	mg/L	0.2			0.5
Organic Carbon (Total)	mg/L	0.2		0.6	0.5
Trihalomethanes (Total)	ug/L	1.0	80.0		ND
Field Parameters					
Temperature	^{0} C	0.1		28.8	26.7
Specific Conductance (EC)	uS	1.0	900	660	682
pH	Std Units	0.1	6.5 - 8.5	7.38	7.65
ORP	mV	1.0		-64	-79
Free Chlorine Residual	mg/L	0.1	2 - 5	ND	0.43??
Dissolved Oxygen	mg/L	0.01		0.55	0.43
Silt Density Index	Std Units	0.1			
H_2S	mg/L	0.1		ND	ND

Notes:
Constituents exceeding MCLs denoted in **BOLD** type

CONCLUSIONS

Based on the findings developed from operation of Monterey Peninsula ASR Project during WY 2018, we conclude the following:

WY 2018 Recharge Operations

WY 2018 was classified as a Dry Water Year on the Monterey Peninsula and a total volume of 530 af of water was recharged into the Seaside Groundwater Basin at the Santa Margarita and Seaside Middle Schools ASR Facilities during the WY 2018 injection season.

ASR Well Performance

ASR-1. ASR-1 was not operational during WY 2018 due to mechanical issues with the pump assembly.

ASR-2. Pertinent well performance conclusions for ASR-2 during WY 2018 are summarized below:

- <u>Injection Rates:</u> Ranged between approximately 420 to 1,940 gpm, averaging approximately 1,350 gpm.
- <u>Water Levels:</u> Consistently more than 250 ft. bgs prior to backflushing and below the recommended maximum drawup level of 130 f at all times.
- <u>Specific Injectivity:</u> Ranged between approximately 29 to 31 gpm/ft with slight negative trend in 24-hr specific injectivity.
- <u>Residual Plugging:</u> A minimal level of approximately 2 ft of residual plugging occurred.
- <u>General Conclusions:</u> ASR-2 performed well during WY 2018 and experienced a limited level residual plugging. The well's performance suggests the injection rate at this well should be maintained at or below the design rate of 1,500 gpm in WY 2019.

ASR-3. Pertinent well performance conclusions for ASR-3 during WY 2018 are summarized below:

- <u>Injection Rates:</u> Ranged between approximately 1,050 to 1,650 gpm, averaging approximately 1,440 gpm.
- <u>Water Levels:</u> Ranged between approximately 195 to 250 feet bgs and were maintained below the minimum recommended water level of 190 feet bgs at all times.
- <u>Specific Injectivity:</u> Ranged between approximately 12.5 to 16.3 gpm/ft and a significantly negative trend in 24-hr specific injectivity.

- Residual Plugging: Approximately 23 feet of residual plugging occurred.

- General Conclusions: ASR-3 underwent formal rehabilitation prior to the WY 2018 injection season and an approximate 70 percent improvement in performance was achieved; however, ASR-3 performance subsequently declined significantly during WY 2018 with injection rates up to approximately 1,650 gpm, although water levels were maintained below the recommended maximum drawup level. These results suggest the injection rate should be reduced during WY 2019 to maintain performance.

ASR-4. Pertinent well performance conclusions for ASR-4 during WY 2018 are summarized below:

- Injection Rates: Ranged between approximately 450 to 1,000 gpm, averaging approximately 620 gpm.

- Water Levels: During the limited period of injection at this well, the injection water-level only reached approximately 300 feet bgs, well below the below the minimum recommended water level of 160 feet bgs.

- Specific Injectivity: The 24-hr specific injectivity was 24.1 gpm/ft; there, was insufficient injection during WY 2018 to establish a trend.

- Residual Plugging: Approximately 4.7 feet of residual plugging occurred.

- General Conclusions: Based on the limited performance data available during WY 2018, the performance was generally consistent with the performance observed during the WY 2017 baseline injection testing program.

Water Quality

Significant conclusions regarding the water-quality investigation during WY 2018 include the following:

- Consistent with previous observations, no significant ion exchange, acid-base, or precipitation reactions were observed at the ASR sites.

- THMs during WY 2018 generally followed this historically observed pattern for the project ASR wells at ASR-1, ASR-2, ASR-4, and SM-MW-1, but THMs did not degrade below the initial injection levels at ASR-3 and SMS-Deep. Due to a lack of intermixing and migration, the highly oxidized redox conditions within the recharge water volume remained intact for an extended period, and redox conditions did not decline as rapidly as in previous years.

- HAAs at the wells with sufficient data generally showed their typical pattern of limited (if any) ingrowth during the initial storage period, followed by complete to near-complete degradation by the end of the storage season.
- Collection and analysis of Tsm mineral cuttings from the recently constructed DIW-2 well as part of the PWM groundwater replenishment program confirmed the presence of naturally occurring Hg within the Tsm matrix. Additionally, the analyses indicate that the lowest Hg concentrations generally occurred in the coarse-grained sands of the Tsm, while the highest concentrations occurred in the silty/clay horizons and especially those in the lower Tsm most proximate to the underlying Monterey Shale (Tm) formation. The confirmed presence of Hg and other transition metals within the Tsm suggests that, of the four previously proposed mechanisms of Hg occurrence, solubilization and/or mobilization of naturally occurring Tsm Hg are the likely mechanism(s) responsible.

RECOMMENDATIONS

Based on the WY 2017 ASR program results and our experience with similar ASR projects, we offer the following recommendations for continued and future operations of the Monterey Peninsula ASR Project wells:

ASR-1 Well Operational Parameters

- Injection Rate: No injection occurred at this well during WY 2018, therefore, the recommendations presented in the WY 2017 SOR are still applicable, with the injection limited to approximately **1,500 gpm or less** in order to limit residual plugging and maintain long-term performance.
- Water-Level Drawup: Under the present local water-level conditions, the amount of water-level drawup should be limited to approximately 100 feet and injection water levels should be maintained **greater than 260 feet bgs** at all times.
- Backflushing Frequency: During the recharge season, routine backflushing should continue to be performed on an approximate weekly basis, or when the amount of water-level drawup in the casing reaches a depth to water level of approximately **260 feet bgs**, whichever occurs first. Backflushing should consist of the triple-flush procedure initiated in WY 2017.

ASR-2 Well Operational Parameters

- Injection Rate: Based on the limited amount of residual plugging that occurred during WY 2018, we recommend the injection rate be maintained at the design rate of approximately **1,500 gpm or less** in order to limit residual plugging and maintain long-term performance.
- Water-Level Drawup: The amount of water-level drawup should be limited to approximately 130 feet and injection water levels should be maintained **greater than 250 feet bgs** at all times.
- Backflushing Frequency: During the recharge season, routine backflushing should continue to be performed on an approximate weekly basis, or when the amount of water-level drawup in the casing reaches a depth to water level of approximately **250 feet bgs**, whichever occurs first. Backflushing should consist of the triple-flush procedure initiated in WY 2017.

ASR-3 Well Operational Parameters

- Injection Rate: Based on the significant amount of residual plugging that occurred during WY 2018 with the well injecting up to 1,650 gpm, we recommend the injection rate be limited to **1,250 gpm** in order to limit residual plugging and maintain long-term performance.

- Water-Level Drawup: The amount of water-level drawup should be limited to approximately 170 feet and injection water levels should be maintained **greater than 190 feet bgs** at all times.
- Backflushing Frequency: During the recharge season, routine backflushing should continue to be performed on an approximate weekly basis, or when the amount of water-level drawup in the casing reaches a depth to water level of approximately **190 feet bgs**, whichever occurs first. Backflushing should consist of the triple-flush procedure initiated in WY 2017.

ASR-4 Well Operational Parameters

- Injection Rate: Based on the limited performance data during WY 2018 and the baseline injection testing performed during WY 2017, we recommend the injection rate be limited to the design rate of approximately **1,500 gpm or less** in order to limit residual plugging and maintain long-term performance.
- Water-Level Drawup: The amount of water-level drawup should be limited to approximately 200 feet and injection water levels should be maintained **greater than 160 feet bgs** at all times.
- Backflushing Frequency: During the recharge season, routine backflushing should continue to be performed on an approximate weekly basis, or when the amount of water-level drawup in the casing reaches a depth to water level of approximately **160 feet bgs**, whichever occurs first. Backflushing should consist of the triple-flush procedure initiated in WY 2017.

Supplemental Water Quality Investigations

Based on the additional data gathered during the WY 2018 program, it appears that there is sufficient evidence to continue the investigation of the potential mechanisms of Hg solubilization and/or mobilization within the Tsm aquifer mineralogy. It is therefore prudent to continue with the ongoing sampling of backflushing waters and sludge during injection operations, and to collect and analyze stored water samples for Transition Metals and related parameters (ORP, DO, Cl, and pH) at all wells on a monthly basis. It is recommended that all such samples collected during WY 2019 be pre-screened for elemental/bulk Hg content to determine those that contain a sufficiently high concentration of Hg/transition metals to allow quantitative speciation analysis. Once such speciation is confirmed, geochemical modeling can then be leveraged to ascertain the specific reaction mechanism(s) resulting in mobilization.

CLOSURE

This report has been prepared exclusively for the Monterey Peninsula Water Management District for the specific application to the ASR Project on the Monterey Peninsula. The findings and conclusions presented herein were prepared in accordance with generally accepted hydrogeologic and engineering practices. No other warranty, express or implied, is made.

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