Kern Fan Groundwater Storage Project

RESPONSE TO DEC REVIEW FINDINGS

Addendum No. 1: Arsenic Mitigation

July 1, 2020

Irvine Ranch WATER DISTRICT

Rosedale-Rio Bravo WATER STORAGE DISTRICT

Addendum No. 1 – Arsenic Mitigation

Design Estimating and Construction (DEC) Review

Finding #1:

Mitigation for Arsenic: There were no operational plans or contingencies to mitigate for Arsenic during start-up or if the MCL drops from 10 to 5 ppb. Current practice of blending was not addressed in feasibility study. The recommendation is to develop operational plans in the final document to monitor well discharge and adjust as necessary.

Response to Finding #1

- The Rosedale-Rio Bravo Water Storage District (RRBWSD or District) monitoring well data that is closest to the Kern Fan Groundwater Storage Project indicates that the Arsenic concentrations in the groundwater aquifer are going down over time.
- During the construction of the recovery water wells for the Kern Fan Groundwater Storage Project, efforts will be made to identify the high Arsenic concentration areas to be avoided so that a well casing design can be developed that avoids the higher Arsenic concentrations and results in a completed well with Arsenic below the maximum contaminant level (MCL).
- Water pumped from wells are blended together in order to ensure that the Arsenic concentration in the discharge water to the canal will be below the MCL.
- RRBWSD and IRWD will be able to manage and operate the wells in a manner that ensures the Arsenic concentrations are below the MCL prior to discharging to the Cross Valley Canal or the California Aqueduct. Arsenic concentrations are regulated by managing how the wells are pumped (which wells on or varying the speed of the VFD's) and also by blending of the recovery wells.
- It is important to note that pump-in operations are blended with several other local groundwater banking operations. Background Arsenic in the California Aqueduct is about 2.3 parts per billion (ppb). After receiving inflow from the various Kern County banking projects there is a modest increase to only 2.8 ppb, well below the MCL of 10 ppb or a potential 5 ppb MCL in the future.
- The RRBWSD will be responsible for the testing and monitoring of the recovery water wells. They will test the wells as required by the Kern County Water Agency (Cross Valley Canal) and the Department of Water Resources (California Aqueduct). They will be required to test the Arsenic concentration in the recovery wells every three years. In addition, they will test the Arsenic concentration at the discharge to the canal at the beginning of each recovery event when the wells are turned on and quarterly thereafter.
- Of course, water quality can change over time or water quality regulations can become more stringent such as the Arsenic MCL being reduced from 10 ppb to 5 ppb. RRBWSD and IRWD have contingency plans in place for these occurrences. These plans would enable the District to come into compliance for the new MCL without treating the water to remove Arsenic. These plans would involve further testing, and include the following alternatives:
    - Evaluate the cause of the water quality change in the well. Sometimes plugging of the well screen can impact the water quality. Plugging can restrict the portions of

the screen that yield lower Arsenic concentrations and thus increase the amount of water being drawn in from the higher Arsenic concentrations in other parts of the aquifer. In this event the District would remove the pump and mechanically and chemically rehabilitate the well to remove the plugging. Oftentimes this results in the well returning to its historic Arsenic concentrations.

- Reduce the well yield (pumping rate) by reducing the speed of the VFD. A direct correlation is sometimes achieved between the pumping rate and the Arsenic concentration. This is related to the fact that the shallow water has lower Arsenic and the deeper water has higher Arsenic. If the well is pumping less flow and the pump is above the screened interval, oftentimes the water is coming from primarily the upper portion of the well screen and thus reduces the concentration of Arsenic.
- There are District recovery water wells that have an Arsenic concentration less than 5 ppb. The District may utilize these wells as appropriate for blending purposes to ensure that the discharge water to the canal has an Arsenic concentration less than 5 ppb.
- Within the Kern groundwater basin, the deeper water is generally higher in Arsenic. The District can permanently seal a portion of the lowermost screened section of the well with concrete or bentonite in order to reduce the Arsenic level in the well. This will involve filling in a portion of the well bottom (from the bottom of the well casing up a certain distance on the lower screened interval) with concrete or bentonite and plug off the deeper portions of the well that have higher Arsenic concentrations. This will lower the Arsenic concentration in the well and bring the well back into compliance for Arsenic.

Arsenic Control Operations Plan

I. Introduction

Rosedale-Rio Bravo Water Storage District (RRBWSD or District) and the Irvine Ranch Water District (IRWD) have twenty-four (24) recovery water wells that have been developed in and around the area of the proposed project. Based upon this previous work, it is generally accepted that the Arsenic concentrations increase with depth and that wells can be completed in zones that yield Arsenic concentrations that are below the maximum contaminant level (MCL) of 10 ppb. These wells are summarized below and illustrate the Arsenic findings in the area. This data has been utilized to develop the anticipated construction of wells during the Kern Fan Groundwater Storage Project.

The majority of the District wells and agricultural wells in the area have depths in the range of 400-ft to 800-ft, with municipal supply wells usually deeper than those used for agricultural purposes. The direction of groundwater flow in the District is generally to the northwest due to the groundwater mounding that typically occurs under the Kern River which is south of the District. Figure 1 shows the location of the existing RRBWSD and IRWD wells and the proposed Project Phase 1 and Phase 2 locations.

Water quality monitoring for the recovery wells is performed by RRBWSD on a regular basis. The Department of Water Resources (California Aqueduct) and the Kern County Water Agency (Cross Valley Canal) require Title 22 water quality analyses be performed along with a short list of Constituents of Concern (COC) which include Arsenic, Bromide, Chloride, Nitrate, Sulfate, Organic Carbon, and Total Dissolved Solids. Monitoring is conducted for initial well start-up, periodic well re-testing, and on-going testing during operation. Well data should be no more than three years old. COC tests are required for all collection discharge locations at start-up and quarterly thereafter.

RRBWSD and IRWD must provide water of acceptable water quality in the design and construction of the water wells as well as in the management and operation of the recovery wells. The methods of design, construction, management and operations of the wells include mitigation measures for controlling Arsenic concentrations in blended deliveries to canals. These methods are described in greater detail in the sections below.

Redundant recovery capacity is built in by the project using an average well flow rate goal of 2,250 gpm. Flow capacities of wells are typically designed and constructed at 2,500-3,500 gpm (above the assumed average flow rate) so that if any of the mitigation measures are required the construction of additional recovery wells is unnecessary.

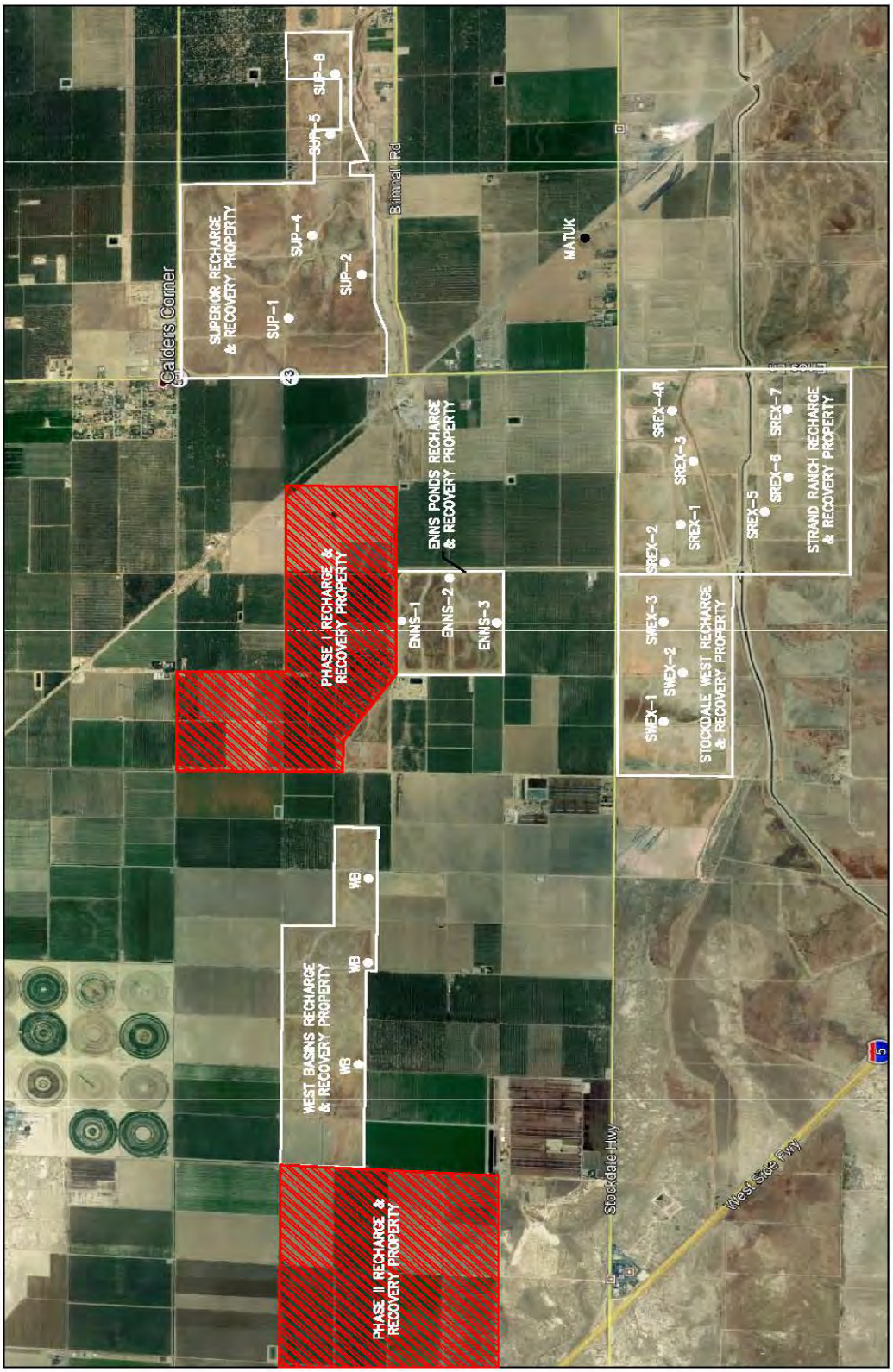

Figure 1: Well Location Map

II. Arsenic Trends Over Time

The District monitoring well data that is closest to the Kern Fan Groundwater Storage Project indicates that the Arsenic concentrations in the groundwater aquifer are going down over time. This is illustrated in Figure 2 below.

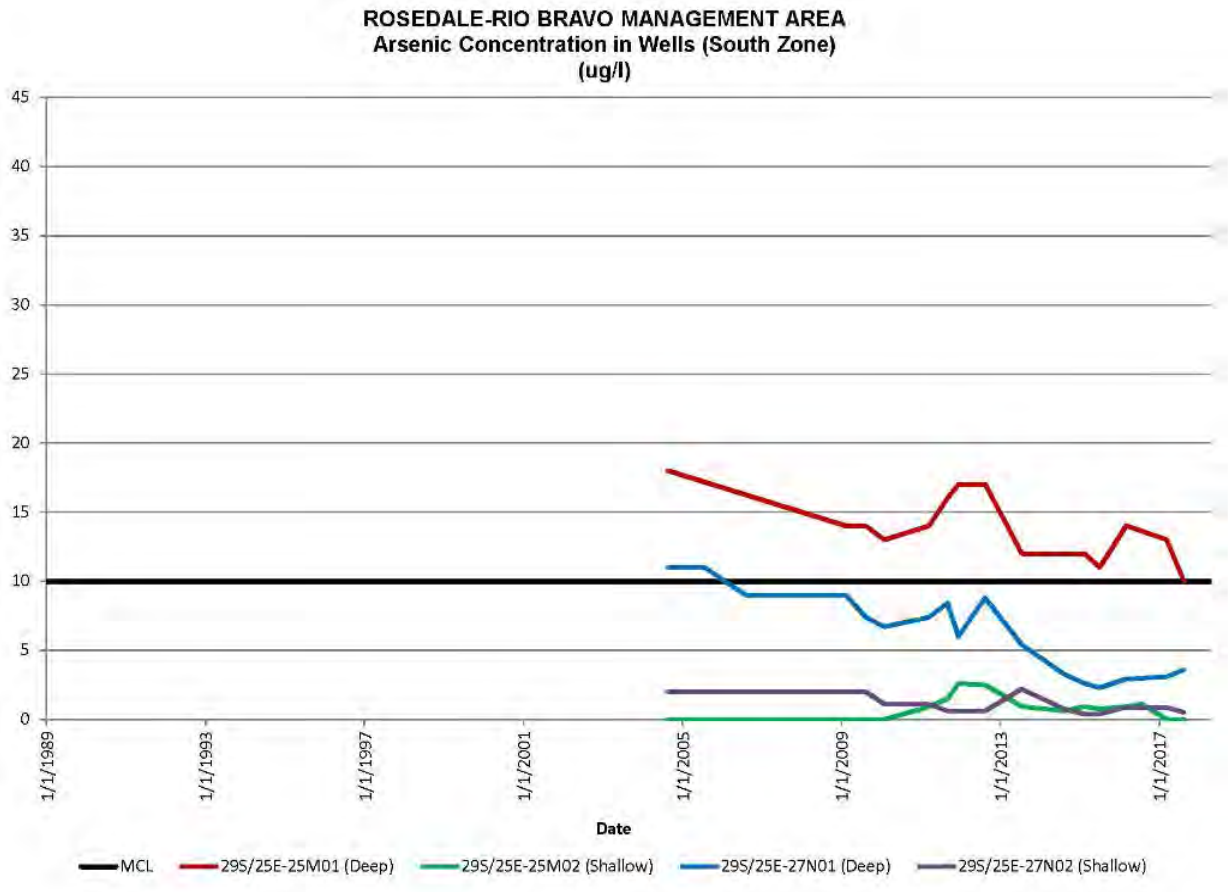

Figure 2: Arsenic Levels in Groundwater Aquifer

III. Previous Well Design and Construction Experience in Mitigating Arsenic Concentrations:

RRBWSD and IRWD have constructed approximately twenty-three (23) recovery wells in the immediate area of the proposed Phase I and Phase II Recharge Facilities for the Kern Fan Groundwater Storage Project. This past experience will be utilized in the design and construction of the project recovery wells. The construction of these previous wells and the Arsenic data compiled from that work is summarized below and tabularized in Table 1.

a. Superior Recovery Wells:

The IRWD and RRBWSD constructed six recovery wells as part of the Drought Relief Project.

SUP-1 is a 20-inch diameter well completed to a depth of 980-ft. The screened interval extends from 370-ft bgs to 535-ft bgs, 565-ft bgs to 660-ft bgs, and also from 790-ft bgs to 960-ft bgs. The Arsenic concentration at the well discharge is approximately 8.4 ppb.

SUP-2 is a 20-inch diameter well completed to a depth of 680-ft. Water quality zone depth sampling was performed in this pilot hole. At a depth of 510-ft bgs to 530-ft bgs the Arsenic concentration was 1.8 ppb. At a depth of 650-ft bgs to 670-ft bgs the Arsenic concentration was 27 ppb. The screened interval extends from 370-ft bgs to 430-ft bgs and also from 460-ft bgs to 630-ft bgs. The Arsenic concentration at the well discharge is approximately 7.6 ppb.

SUP-4 is a 20-inch diameter well completed to a depth of 800-ft. The screened interval extends from 365-ft bgs to 545-ft bgs, 570-ft bgs to 610-ft bgs, and also from 630-ft bgs to 725-ft bgs. The Arsenic concentration at the well discharge is approximately 17.0 ppb.

SUP-5 is a 20-inch diameter well completed to a depth of 690-ft. Water quality zone depth sampling was performed in this pilot hole. The screened interval extends from 370-ft bgs to 560-ft bgs and also from 600-ft bgs to 670-ft bgs. The Arsenic concentration at the well discharge is approximately 9.0 ppb.

SUP-6 is a 20-inch diameter well completed to a depth of 940-ft. Water quality zone depth sampling was performed in this pilot hole. At a depth of 580-ft bgs to 600-ft bgs the Arsenic concentration was 13 ppb. At a depth of 740-ft bgs to 760-ft bgs the Arsenic concentration was 1.2 ppb. At a depth of 1,040-ft bgs to 1,060-ft bgs the Arsenic concentration was 4.6 ppb. At a depth of 1,170-ft bgs to 1,190-ft bgs the Arsenic concentration was 11.0 ppb. The screened interval extends from 410-ft bgs to 610-ft bgs and also from 700-ft bgs to 920-ft bgs. The Arsenic concentration at the well discharge is approximately 15.0 ppb.

Matuk is a 20-inch diameter well completed to a depth of 620-ft. Water quality zone depth sampling was performed in this pilot hole. At a depth of 380-ft to 400-ft bgs the Arsenic concentration was 2.1 ppb. At a depth of 580-ft to 600-ft bgs the Arsenic concentration was 18 ppb. At a depth of 685-ft to 705-ft bgs the Arsenic concentration was 22 ppb. The screened interval extends from 350-ft bgs to 465-ft bgs and also from 495-ft bgs to 600-ft bgs. The Arsenic concentration at the well discharge is approximately 4.2 ppb.

Table 1
Superior Recovery Wells – Arsenic Concentrations

Well Name	Screened Interval	Arsenic Concentration
SUP-1	370-ft to 535-ft, 565-ft to 660-ft, & 790-ft to 960-ft	8.4 ppb
SUP-2	370-ft to 430-ft & 460-ft to 630-ft	7.6 ppb
SUP-4	365-ft to 545-ft, 570-ft to 610-ft, & 630-ft to 725-ft	17.0 ppb
SUP-5	370-ft to 560-ft & 600-ft to 670-ft	9.0 ppb
SUP-6	410-ft to 610-ft & 700-ft to 920-ft	15.0 ppb
Matuk	350-ft to 465-ft & 495-ft to 600-ft	4.2 ppb

The information in Table 1 demonstrates how the Arsenic concentration generally increases with depth in this area and that wells can be completed with Arsenic concentrations below the MCL of 10 ppb if completed generally above a depth of 920-ft. For the two wells above that exceed the MCL of 10 ppb, this was an intentional strategy in order to achieve a greater capacity in the well. It was pre-determined that SUP-4 and 6 would be operated with other Superior and Stockdale East wells and blended in the well discharge piping to a concentration less than 10 ppb prior to being discharged into the Cross Valley Canal.

b. Enns Recovery Wells:

The RRBWSD constructed three recovery wells as part of the Enns Ponds Recharge and Recovery Project. The construction of these previous wells and the Arsenic data compiled from that work is summarized below and tabularized in Table 2.

ENNS-1 is a 20-inch diameter well completed to a depth of 475-ft. Water quality zone depth sampling was performed in this pilot hole. At a depth of 285-ft bgs to 305-ft bgs the Arsenic concentration was <2 ppb. At a depth of 430-ft bgs to 450-ft bgs the Arsenic concentration was 2 ppb. At a depth of 615-ft bgs to 635-ft bgs the Arsenic concentration was 13 ppb. At a depth of 738-ft bgs to 758-ft bgs the Arsenic concentration was 33 ppb. At a depth of 920-ft bgs to 940-ft bgs the Arsenic concentration was 20 ppb. The screened interval extends from 185-ft below ground surface (bgs) to 455-ft below ground surface. The Arsenic concentration at the well discharge is approximately <2 ppb.

ENNS-2 is a 20-inch diameter well completed to a depth of 750-ft. The screened interval extends from 460-ft bgs to 750-ft bgs. The Arsenic concentration at the well discharge is approximately 11 ppb.

ENNS-3 is a 20-inch diameter well completed to a depth of 440-ft. The screened interval extends from 180-ft bgs to 420-ft bgs. The Arsenic concentration at the well discharge is approximately <2 ppb.

The water quality zone sampling performed in ENNS-1 was utilized in the design of all three wells. ENNS-2 was completed deeper and has a higher Arsenic concentration, however the three wells are blended together in order to mitigate the Arsenic level.

Table 2

Enns Recovery Wells – Arsenic Concentrations

Well Name	Screened Interval	Arsenic Concentration
ENNS-1	185-ft to 455-ft	<2 ppb
ENNS-2	460-ft to 750-ft	11 ppb
ENNS-3	180-ft to 420-ft	<2 ppb

As shown in Table 2, the blend of water from these wells was designed to be below the current MCL.

c. Stockdale West Recovery Wells:

The IRWD constructed three recovery wells as part of the Stockdale Integrated Banking Project. The construction of these previous wells and the Arsenic data compiled from that work is summarized below and tabularized in Table 3.

SWEX-1 is a 20-inch diameter well completed to a depth of 640-ft. Water quality zone depth sampling was performed in this pilot hole. At a depth of 461-ft to 481-ft bgs the Arsenic concentration was 2.0 ppb. At a depth of 569-ft to 589-ft bgs the Arsenic concentration was 4.8 ppb. At a depth of 671-ft bgs to 691-ft bgs the Arsenic concentration was 77 ppb. At a depth of 780-ft bgs to 800-ft bgs the Arsenic concentration was 94 ppb. At a depth of 906-ft bgs to 926-ft bgs the Arsenic concentration was 86 ppb. The screened interval extends from 420-ft bgs to 550-ft bgs and also from 570-ft bgs to 620-ft bgs. The Arsenic concentration at the well discharge is approximately 1.8 ppb.

SWEX-2 is a 20-inch diameter well completed to a depth of 650-ft. Water quality zone depth sampling was performed in this pilot hole. At a depth of 465-ft to 485-ft bgs the Arsenic concentration was 2.4 ppb. At a depth of 550-ft to 570-ft bgs the Arsenic concentration was 7.6 ppb. At a depth of 635-ft bgs to 655-ft bgs the Arsenic concentration was 27 ppb. At a depth of 770-ft bgs to 790-ft bgs the Arsenic concentration was 89 ppb. At a depth of 875-ft bgs to 895-ft bgs the Arsenic concentration was 91 ppb. The screened interval extends from 400-ft bgs to 510-ft bgs and also from 550-ft bgs to 610-ft bgs. The Arsenic concentration at the well discharge is approximately 5.9 ppb.

SWEX-3 is a 20-inch diameter well completed to a depth of 640-ft. Water quality zone depth sampling was performed in this pilot hole. At a depth of 490-ft to 510-ft bgs the Arsenic concentration was 2.6 ppb. At a depth of 605-ft to 625-ft bgs the Arsenic concentration was 27 ppb. At a depth of 670-ft bgs to 690-ft bgs the Arsenic concentration was 36 ppb. The screened interval extends from 390-ft bgs to 530-ft bgs and also from 590-ft bgs to 620-ft bgs. The Arsenic concentration at the well discharge is approximately 6.8 ppb.

Table 3

Stockdale West Recovery Wells – Arsenic Concentrations

Well Name	Screened Interval	Arsenic Concentration
SWEX-1	420-ft to 550-ft & 570-ft to 620-ft	1.8 ppb
SWEX-2	400-ft to 510-ft & 550-ft to 610-ft	5.9 ppb
SWEX-3	390-ft to 530-ft & 590-ft to 620-ft	6.8 ppb

The information in Table 3 demonstrates how the Arsenic concentration generally increases with depth in this area and that wells can be completed with Arsenic concentrations below the MCL of 10 ppb if completed generally above a depth of 620-ft.

d. Strand Ranch Recovery Wells:

The IRWD constructed six recovery wells as part of the Strand Ranch Integrated Banking Project. The construction of these previous wells and the Arsenic data compiled from that work is summarized below and tabularized in Table 4.

SREX-1 is a 20-inch diameter well completed to a depth of 670-ft. The screened interval extends from 380-ft below ground surface (bgs) to 650-ft below ground surface. The Arsenic concentration at the well discharge is approximately 6 ppb.

SREX-2 is a 20-inch diameter well completed to a depth of 630-ft. Water quality zone depth sampling was performed in this pilot hole. At a depth of 490-ft bgs to 510-ft bgs the Arsenic concentration was 3.5 ppb. At a depth of 560-ft bgs to 580-ft bgs the Arsenic concentration was 6.0 ppb. The screened interval extends from 410-ft bgs to 610-ft bgs. The Arsenic concentration at the well discharge is approximately 4.3 ppb.

SREX-3 is a 20-inch diameter well completed to a depth of 670-ft. The screened interval extends from 410-ft bgs to 530-ft below ground surface and also from 570-ft bgs to 650-ft bgs. The Arsenic concentration at the well discharge is approximately 5.8 ppb.

SREX-4R is a 20-inch diameter well completed to a depth of 660-ft. The screened interval extends from 410-ft bgs to 560-ft below ground surface and also from 600-ft bgs to 650-ft bgs. The Arsenic concentration at the well discharge is approximately 3.1 ppb.

SREX-5 is a 20-inch diameter well completed to a depth of 690-ft. Water quality zone depth sampling was performed in this pilot hole. At a depth of 250-ft to 270-ft bgs the Arsenic concentration was <2.0 ppb. At a depth of 400-ft to 420-ft bgs the Arsenic concentration was <2.0 ppb. At a depth of 600-ft to 620-ft bgs the Arsenic concentration was 26.0 ppb. The screened interval extends from 410-ft bgs to 505-ft bgs and also from 545-ft bgs to 650-ft bgs. The Arsenic concentration at the well discharge is approximately 16.0 ppb.

SREX-7 is a 20-inch diameter well completed to a depth of 680-ft. Water quality zone depth sampling was performed in this pilot hole. At a depth of 250-ft to 270-ft bgs the Arsenic concentration was <10.0 ppb. At a depth of 400-ft to 420-ft bgs the Arsenic concentration was <10.0 ppb. At a depth of 570-ft to 590-ft bgs the Arsenic concentration was 11.0 ppb. The screened interval extends from 410-ft bgs to 480-ft bgs and also from 520-ft bgs to 660-ft bgs. The Arsenic concentration at the well discharge is approximately 11.0 ppb.

Table 4
Strand Ranch Recovery Wells – Arsenic Concentrations

Well Name	Screened Interval	Arsenic Concentration
SREX-1	380-ft to 650-ft	6.0 ppb
SREX-2	410-ft to 610-ft	4.3 ppb
SREX-3	410-ft to 530-ft & 570-ft to 650-ft	5.8 ppb
SREX-4	410-ft to 560-ft & 600-ft to 650-ft	3.1 ppb
SREX-5	410-ft to 505-ft & 545-ft to 650-ft	16.0 ppb
SREX-6	195-ft to 492-ft	<2.0 ppb
SREX-7	410-ft to 480-ft & 520-ft to 660-ft	11.0 ppb

The information provided in Table 4 demonstrates how the Arsenic concentration generally increases with depth in this area and that wells can be completed with Arsenic concentrations below the MCL of 10 ppb if completed generally above a depth of 650-ft. For the two wells above that exceed the MCL of 10 ppb, this was an intentional strategy in

order to achieve a greater capacity in the well. It was pre-determined that SREX-5, 6, & 7 would be operated together and blended in the well discharge piping to a concentration less than 10 ppb prior to being discharged into the Cross Valley Canal.

e. West Basin Recovery Wells:

The RRBWSD constructed three recovery wells as part of the West Basins Recharge and Recovery Project. The construction of these previous wells and the Arsenic data compiled from that work is summarized below and tabularized in Table 5.

WB-1 is a 20-inch diameter well completed to a depth of 810-ft. The screened interval extends from 370-ft bgs to 480-ft bgs, 510-ft bgs to 550-ft bgs, and 610-ft bgs to 790-ft bgs. The Arsenic concentration at the well discharge is approximately 19 ppb.

WB-2 is a 20-inch diameter well completed to a depth of 760-ft. Water quality zone depth sampling was performed in this pilot hole. At a depth of 448-ft bgs to 518-ft bgs the Arsenic concentration was <2 ppb. At a depth of 600-ft bgs to 620-ft bgs the Arsenic concentration was 2.5 ppb. At a depth of 720-ft bgs to 740-ft bgs the Arsenic concentration was 14 ppb. At a depth of 850-ft bgs to 870-ft bgs the Arsenic concentration was 30 ppb. The screened interval extends from 380-ft bgs to 550-ft bgs and from 570-ft bgs to 740-ft bgs. The Arsenic concentration at the well discharge is approximately 2.1 ppb.

WB-3 is a 20-inch diameter well completed to a depth of 770-ft. The screened interval extends from 380-ft bgs to 515-ft bgs and from 540-ft bgs to 750-ft bgs. The Arsenic concentration at the well discharge is approximately 6.0 ppb.

The water quality zone sampling performed in WB-2 was utilized in the design of all three wells. The three wells are blended together in order to ensure that the Arsenic concentration in the discharge water to the canal is below the MCL of 10 ppb.

Table 5
West Basin Recovery Wells – Arsenic Concentrations

Well Name	Screened Interval	Arsenic Concentration
WB-1	370-ft to 480-ft, 510-ft to 550-ft, & 610-ft to 790-ft	19.0 ppb
WB-2	380-ft to 550-ft & 570-ft to 740-ft	2.1 ppb
WB-3	380-ft to 515-ft & 540-ft to 750-ft	6.0 ppb

As shown in Table 5, the blend of water from these wells was designed to be below the current MCL. It was pre-determined that the West Basin wells would be operated with other Enns wells and blended in the well discharge piping to a concentration less than 10 ppb prior to being discharged into the Cross Valley Canal.

f. Stockdale East Recovery Wells:

The RRBWSD constructed two recovery wells as part of the Stockdale Integrated Banking Project. The construction of these previous wells and the Arsenic data compiled from that work is summarized below and tabularized in Table 6.

SE-1 is a 20-inch diameter well completed to a depth of 700-ft. The screened interval extends from 325-ft bgs to 400-ft bgs and 430-ft bgs to 680-ft bgs. The Arsenic concentration at the well discharge is approximately 2.0 ppb.

SE-2 is a 20-inch diameter well completed to a depth of 700-ft. The screened interval extends from 340-ft bgs to 490-ft bgs and from 510-ft bgs to 680-ft bgs. The Arsenic concentration at the well discharge is approximately 1.3 ppb.

The water quality zone sampling performed in Matuk was utilized in the design of these two wells. The wells are blended together, along with the Superior wells, in order to ensure that the Arsenic concentration in the discharge water to the canal is below the MCL of 10 ppb.

Table 6
Stockdale East Recovery Wells – Arsenic Concentrations

Well Name	Screened Interval	Arsenic Concentration
SE-1	325-ft to 400-ft & 430-ft to 680-ft	2.0 ppb
SE-2	340-ft to 490-ft & 510-ft to 680-ft	1.3 ppb

As shown in Table 6, the blend of water from these wells was designed to be below the current MCL.

IV. Project Well Construction to Mitigate Arsenic Concentrations

As illustrated under Section III "Previous Well Design and Construction Experience in Mitigating Arsenic Concentrations", the Arsenic concentrations in this geographic area generally increase with depth. More specifically, Arsenic is known to increase in concentration as the geologic formations change in color from brown to grey in color (which depicts an anoxic condition). This informs the well design and construction and aids in avoiding the water bearing formations that have increased levels of Arsenic.

Prior to Kern Fan Groundwater Storage Project well construction, geophysical logging will be performed in each pilot hole that includes an electric log. The electric log shows the water bearing formations as illustrated in Figure 3 and Figure 4 below. This is a sample electric log from SWEX-2. The lithologic log for the pilot hole is shown on the left hand side of the log as well as the depths where water quality zone sampling was performed.

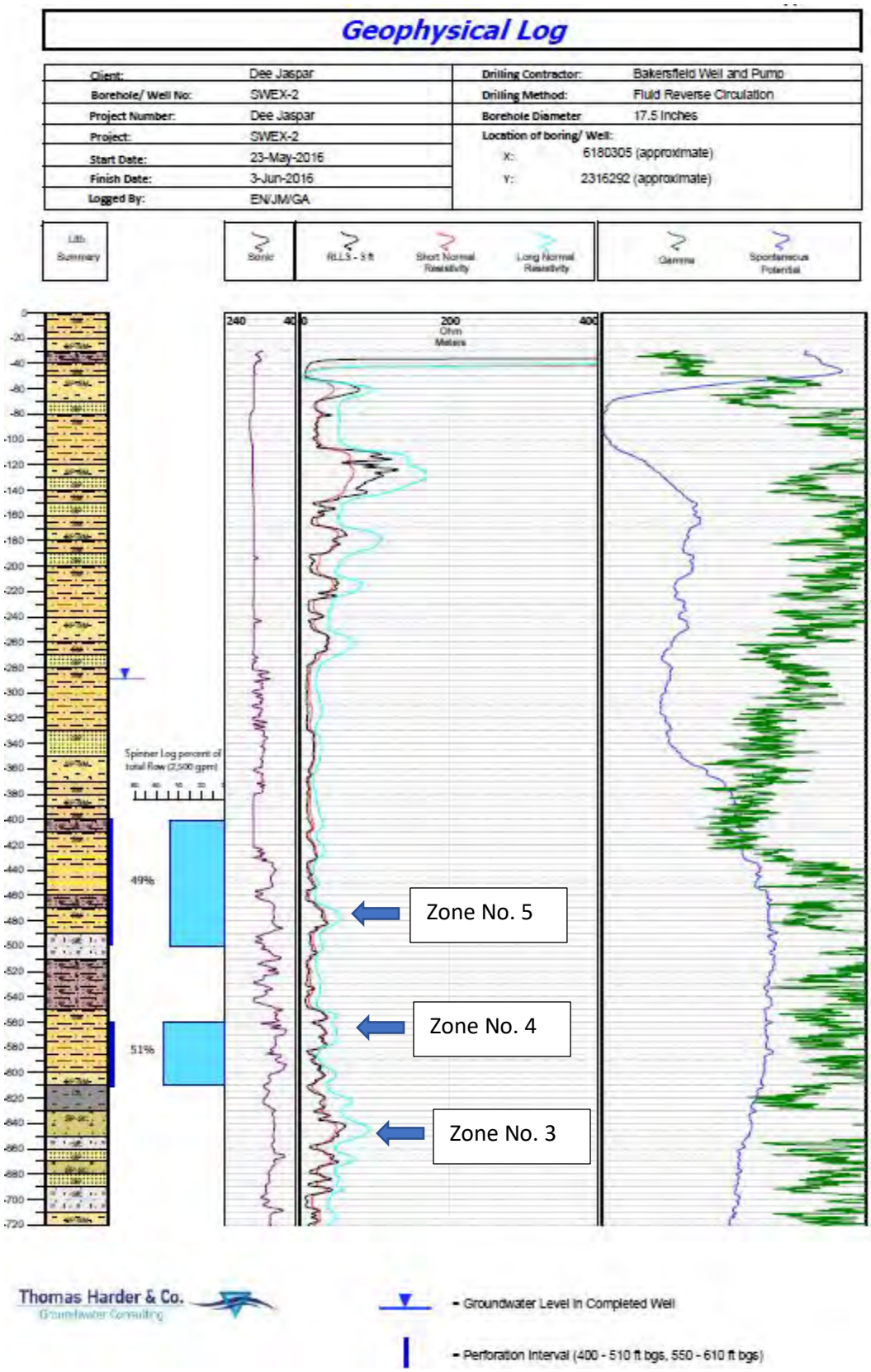

Figure 3: Typical Elog

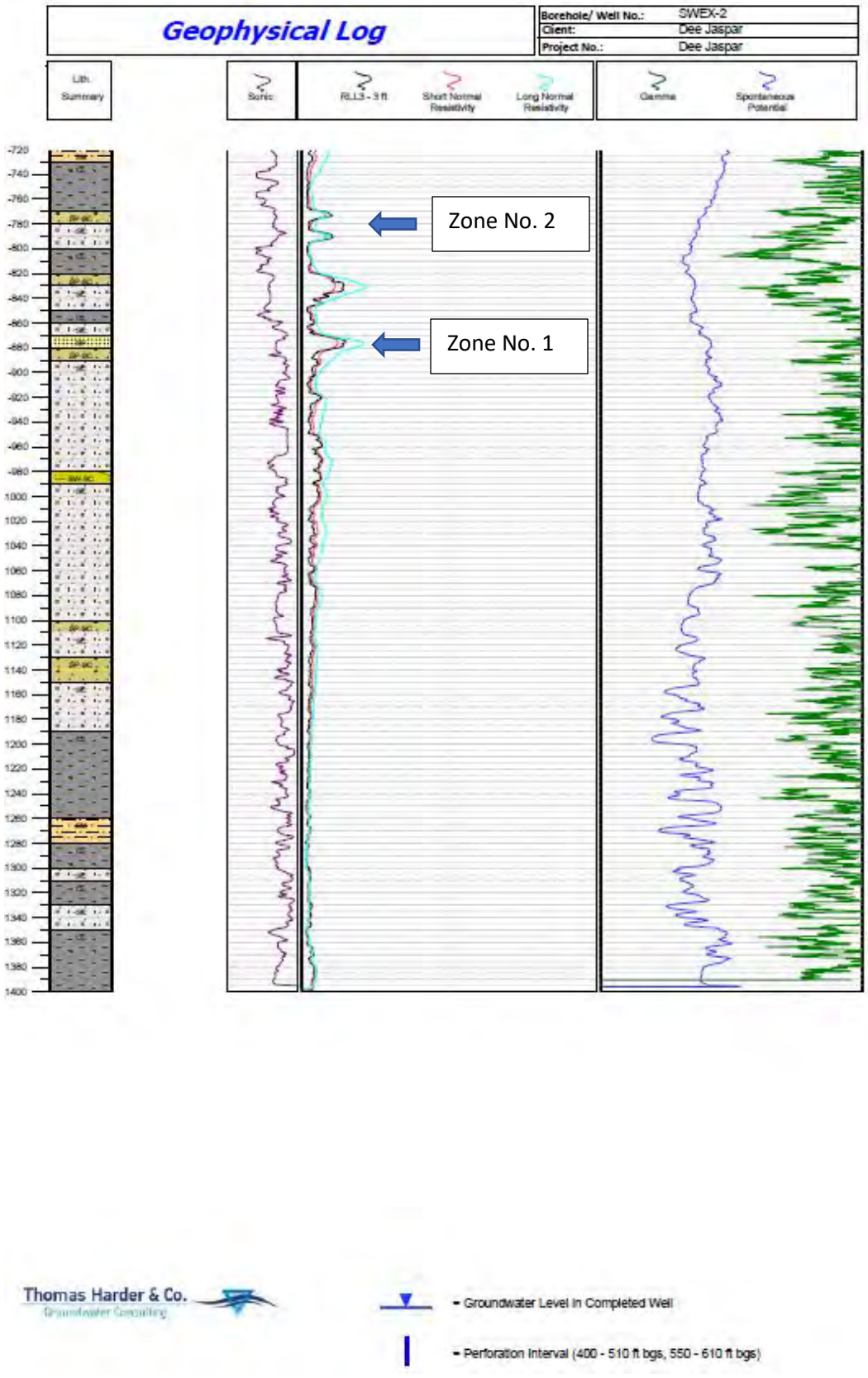

Figure 4: Typical Elog

During the construction of the recovery water wells for the Kern Fan Groundwater Storage Project, water quality depth sampling will be performed in each pilot hole that identifies the Arsenic concentrations with depth so that a well casing design can be developed that avoids the higher Arsenic concentrations and results in a completed well with Arsenic below the MCL of 10 ppb. An example of the water quality depth sampling results is illustrated in Figure 5 using an example from the SWEX-2 well.

Summary of Isolated Aquifer Zone Testing

SWEX-2

			Zone No. 1	2	3	4	5	
	Aquifer Property/ Constituent	Units	875 - 895 ft bgs[1]	770 - 790 ft bgs	635 - 655 ft bgs	550 - 570 ft bgs	465 - 485 ft bgs	Drinking Water Standards / MCL[2]
Water Level and Discharge Rate	Static Water Level	ft bgs	295	297	289	293	293	
	Pumping Water Level	ft bgs	388	349	333	330	386	
	Drawdown	ft	93	52	44	37	107	
	Discharge Rate	gpm[4]	49	144	134	134	78	
	Specific Capacity	gpm/ft	0.5	2.8	3.2	3.6	0.8	
Field Parameters	Temperature	°F[5]	84	79	76	75	74	
	EC	µS/cm[6]	324	198	288	216	346	
	TDS	ppm[7]	270	110	146	131	200	
	pH	Units	7.0	7.2	7.0	7.0	7.0	
Selected Water Chemistry Results	Arsenic	µg/L[8]	91	89	27	7.6	2.4	10[A]

Notes:

[1] ft bgs = Feet below ground surface.
[2] MCL = Maximum contaminant level.
[3] Incomplete recovery following zone testing.
[4] gpm = Gallons per minute.
[5] °F = Degrees Fahrenheit.
[6] µS/cm = Microsiemens per centimeter.
[7] ppm = Parts per million.
[8] µg/L= Micrograms per liter.

[A] California primary MCL.

Highlighted cells indicate results that exceed applicable regulatory standards.

Figure 5: SWEX-2 Zone Test Results

The design of the well casing and screened interval can then be designed to avoid Arsenic. In the above example of SWEX-2, the well was screened from 400-ft to 510-ft and from 550-ft to 610-ft which are the zones where the Arsenic concentration was 2.4 ppb to 7.6 ppb. The completed well had an overall Arsenic concentration of 5.9 ppb. The information above demonstrates that it is feasible to achieve completing wells that are below the MCL for Arsenic. For the wells noted above that exceed the MCL of 10 ppb, this was an intentional design strategy that desired to tap deeper portions of the aquifer. In these cases, it was predetermined that blending of the water with other wells would achieve the desired result of 10 ppb or less prior to discharge of the water to the Cross Valley Canal and the California Aqueduct.

V. Project Well Management and Operation

RRBWSD and IRWD will be able to manage and operate the Kern Fan Groundwater Storage Project wells in a manner that ensures the Arsenic concentration is below the MCL prior to discharging to the Cross Valley Canal or the California Aqueduct. Currently, RRBWSD regularly samples for the Constituents of Concern in the existing wells as required by the Department of Water Resources and the Kern County Water Agency and that sampling frequency is discussed herein.

RRBWSD is able to regulate the Arsenic concentrations by managing how they pump the wells (which wells on or varying the speed of the VFD's) and also by blending of the recovery wells. A blending analysis is outlined below.

Of course, water quality can change over time or water quality regulations can become more stringent such as the Arsenic MCL being reduced from 10 ppb to 5 ppb. RRBWSD and IRWD have contingency plans in place for these occurrences and that is discussed below.

VI. Project Well Arsenic Sampling Frequency

Water quality monitoring will be performed by the District on a regular basis. The Department of Water Resources (California Aqueduct) and the Kern County Water Agency (Cross Valley Canal) require Title 22 water quality analyses be performed along with a short list of Constituents of Concern (COC) which include Arsenic, Bromide, Chloride, Nitrate, Sulfate, Organic Carbon, and Total Dissolved Solids. Monitoring will be conducted for initial well start-up, periodic well re-testing, and on-going testing during operation. Well data should be no more than three years old. COC tests are required for all discharge locations at start-up and quarterly thereafter.

The RRBWSD will responsible for the testing and monitoring of the recovery water wells. They will test the wells as required by the Kern County Water Agency (Cross Valley Canal) and the Department of Water Resources (California Aqueduct). Table 7 shows the required sampling and water quality testing for Arsenic. RRBWSD is required to test the Arsenic concentration in the recovery wells every three years. In addition, they must test the Arsenic concentration at the discharge to the canal at the beginning of each recovery event when the wells are turned on and quarterly thereafter.

Table 7
Arsenic Sampling Frequency

Recovery Facility	Wellhead Sampling	Canal Discharge Sampling
Superior	Every 3 Years	Quarterly while Operating
Enns Ponds	Every 3 Years	Quarterly while Operating
Stockdale West	Every 3 Years	Quarterly while Operating
Strand Ranch	Every 3 Years	Quarterly while Operating
West Basins	Every 3 Years	Quarterly while Operating
Stockdale East	Every 3 Years	Quarterly while Operating

VII. Blending to Mitigate Arsenic Concentrations

Like most existing wells, the Kern Fan Groundwater Storage Project recovery water will connect to a conveyance pipeline that will collect the water from multiple wells prior to discharging into the Cross Valley Canal or in the instance of the Kern Fan Groundwater Storage Project, the project conveyance canal. If any of these wells exceed the MCL of 10 ppb for Arsenic they can be blended with the water from other wells to achieve an Arsenic concentration that is below the MCL. This can be achieved by the District in the following manners:

1. Control which wells are turned on for recovery in order to ensure a proper blend of well water that is less than 10 ppb for Arsenic.

2. Control the yield of the wells by limiting the speed of the variable speed drive (VFD) to ensure a proper blend of well water that is less than 10 ppb for Arsenic.

3. A combination of #1 and #2 above.

The blending of the recovery water wells is an acceptable method of ensuring that the Arsenic concentration is below acceptable limits for returning water to the Cross Valley Canal and California Aqueduct. Blending of multiple water sources prior to discharging water into the State Water Project via the Cross Valley Canal, the project conveyance canal, or the California Aqueduct is an acceptable and sometimes preferred means depending on the water quality of the project water.

Figure 6 below illustrates the “Pump-In” Water Quality Analysis that is performed as part of returning water to the Cross Valley Canal and the California Aqueduct prior to startup of wells. The “Pump-In” operations includes pump-in facilities which are the turn-ins into the Cross Valley Canal. The operation of these pump-in facilities involves the blending of recovery wells and is effective at keeping the Arsenic level below the MCL of 10 ppb. The rare instances when the Arsenic level is shown exceeding the MCL of 10 ppb is the result of not being able to blend with a well that is lower in Arsenic because it is temporarily off-line. Prior to the startup of Kern Fan Groundwater Storage Project wells, a similar “Pump-In” Water Quality Analysis will need to be performed that includes the project wells.

ROSEDALE-RIO BRAVO WATER STORAGE DISTRICT
PUMP-IN WATER QUALITY ANALYSES

Constituent »	Arsenic	Bromide	Chloride	Chromium	Cr+6	EC	NO3	Sulfate	TDS	DOC	123-TCP	Uranium
MCL »	10	—	250	50	—	900	45	—	500	—	0.005	20
Units »	µg/L	mg/L	mg/L	µg/L	µg/L	µmhos/cm	mg/L	mg/L	mg/L	mg/L	ug/L	pCi/L
Date	CENTRAL INTAKE ← Blending of Superior Wells											
2/20/2020	2.3	0.083	22	<0.50	0.55	249	4.7	21	170	0.51	<0.00053	2
3/2/2020	5	0.097	23	<0.50	0.83	249	5.7	20	160	0.55	0.0069	2.1
3/9/2020	2.3	0.11	24	0.97	0.96	262	6.5	20	160	0.55	<0.00053	2.5
3/17/2020	4.9	0.094	22	0.6	0.95	246	5.5	20	170	0.54	<0.00053	2.7
5/22/2020	9.9	0.11	24	1	1	258	5.7	19	170	0.52	<0.00053	2.2
Date	STRAND NTI-2 ← Blending of SREX-1 & SREX-2											
2/20/2020	2.6	0.49	92	1.6	1.8	459	9.5	25	250	0.82	<0.00053	3.5
3/2/2020	3.1	0.48	90	1.2	1.7	437	9.8	24	260	0.82	<0.00053	2.8
3/9/2020	2.7	0.48	90	1.9	1.8	447	10	24	270	0.46	<0.00053	2.7
3/17/2020	2.8	0.47	87	1.3	1.8	440	9.8	24	260	0.58	<0.00053	2.6
5/22/2020	4.6	0.45	83	1.5	1.8	438	9.2	24	260	0.62	<0.00053	2.4
Date	STRAND STI ← Blending of SREX-5, SREX-6, & SREX-7											
2/20/2020	9.7	0				70	11					12
3/2/2020	12	0				40	10					12
3/9/2020	8.8	0				56	10	30	270	0.4	<0.00053	11
3/17/2020	11	0				48	9.9	29	270	0.74	0.0044	11
5/22/2020	14	0				47	8.9	28	270	0.51	<0.00053	11
Date	STRAND NTI-1 ← Blending of SREX-3 & SREX-4R											
2/20/2020	<0.7	0.37	81	1.1	1.1	492	14					5.3
3/2/2020	1	0.36	78	0.66	1	463	13	33	290	0.47	0.0041	5.2
3/9/2020	1.7	0.35	77	1.3	1.1	477	13	33	280	0.58	0.0054	5.7
3/17/2020	1.6	0.35	76	0.71	1.1	467	13	32	290	0.75	0.0036	5.8
5/22/2020	2.1	0.38	83	1.1	1.1	510	14					4.5
Date	ROSEDALE INLET ← Blending of ENNS Wells & the WB Wells											
2/20/2020	8.4	0.3	62	1.2	1.2	457	18					10
3/2/2020	6.1	0.31	65	0.92	1.3	469	25					8.8
3/9/2020	5.2	0.31	66	1.4	1.4	487	25	32	300	0.57	0.014	8.5
3/17/2020	5.9	0.3	64	0.85	1.4	477	25	32	300	0.62	0.01	8.8
5/22/2020	6.7	0.28	62	1.4	1.4	488	24	31	300	0.53	<0.00053	7.8
Date	CVC @ TULE ELK BRIDGE											
3/2/2020	3.1	0.18	41	0.52	0.89	353	7	32	320	0.71	<0.00053	5.9
3/9/2020	4.1	0.19	44	0.96	0.96	385	7.9	33	230	0.73	0.0045	6.6
3/17/2020	4.5	0.16	41	0.58	0.95	370	7.1	34	230	0.65	<0.00053	6.1
5/22/2020	5.6	0.16	38	1.2	0.97	348	6.8	24	220	0.68	<0.00053	5.3
Date	CA AQUEDUCT DOWNSTREAM											
3/2/2020	1.7	0.19	61	<0.50	0.34	406	3.1	32	270	2.7	<0.00053	3.2
3/9/2020	1.5	0.2	63	<0.50	0.36	432	3.1	33	250	2.6	<0.00053	3.1
3/17/2020	1.3	0.16	58	<0.50	0.24	412	2.8	32	250	3.2	<0.00053	2.7
5/22/2020	3.3	0.17	48	0.77	0.59	404	3.2	32	250	2.2	<0.00053	4.1
Date	CA AQUEDUCT UPSTREAM											
—												
—												
—												
5/22/2020	1.8	0.19	70	<0.50	0.069	475	0.6	37	290	0.41	<0.00053	1.2

Arsenic elevated as SREX-6 is temporarily off-line due to needing to rehab the well

Figure 6: Pump-In Water Quality Analysis

It is important to note that pump-in operations are blended with many other local groundwater banking operations and the overall blending is modeled by the Kern County Water Agency (KCWA), which is the local State Water Contractor (SWP) and operator of the Cross Valley Canal. Prior to introducing any non-SWP water into the California Aqueduct, a Pump-In Proposal (PIP) must be prepared and submitted to the Department of Water Resources (DWR) for approval. The PIP is also reviewed by a State Water Contractor Facilitation Group which includes other SWP Contractors, who can submit comments on the PIP. The PIP must also include a pump-in blending model of all discharges combined with the proposed non-SWP water source from the PIP. The PIP and blending model must be approved by the DWR and Facilitation Group prior to operating any new project wells for discharge into the California Aqueduct. A PIP and blending model will have to be prepared for the Kern Fan Groundwater Storage Project.

Figure 7 below is an excerpt from KCWA's blending model which shows the background Arsenic in the California Aqueduct is about 2.3 ppb. After receiving inflow from the various Kern County banking projects there is a modest increase to only 2.8 ppb, well below the MCL of 10 ppb and below a potential future MCL of 5 ppb.

The approved PIP and blending model for the Strand Ranch wells was previously submitted to the Reclamation DEC Team on June 9, 2019, and it is resubmitted here as Exhibit "A". As shown in Exhibit "A", according to the DWR's Water Quality Policy, the blending of multiple water sources prior to inflow into the SWP is acceptable and may be preferred depending upon water quality of the PIP.

Manifold		Flow cfs	As ug/l
Semitropic*		0	-
CVC Pool 1		41	3.8
CVC Pool 2		67	4.8
CVC Pool 3		70	7.6
CVC Pool 4		81	2.4
CVC Pool 5		6	2.0
CVC Pool 6		41	2.8
CVC Subtotals	East	40	2.8
	West	265	4.6
River Canal		185	3.9
KWB Canal		281	1.6
West Kern		0	-
WRM6		20	2.2
WRM7		15	6.7
WRM8		0	-
WRM9		26	6.2
WRM9A-10		0	-
WRM13A		0	-
WRM15		0	-
WRMWSD Subtotal		61	5.0
Arvin-Edison		0	-
Well Blend in Aqueduct		792	3.4

	Units	Total Flow cfs	As ug/l
	MCL		10
Alejandro in District		0	No Flow
CVC Flow to ID4		0	2.8
CVC Flow into Friant		40	2.8
	Change	40	NA
	% of the MCL	NA	28%
Aqueduct Blends			
Background		1707	2.3
After Semitropic		1587	2.3
After CVC		1346	2.7
After KWB		1812	2.7
After West Kern		1812	2.7
After WRMWSD 6		1580	2.7
After WRMWSD 7		1531	2.7
After WRMWSD 8		1467	2.7
After WRMWSD 9		1450	2.8
After Arvin-Edison		1450	2.8
After WRMWSD 9A-10		1379	2.8
After WRMWSD 13A		1374	2.8
After WRMWSD 15		1320	2.8
	Total Change	-387	0.5
	% of the MCL	NA	4.7%

Figure 7: Pump-In Blending Model

VIII. Project Contingency Plans for Reduced Arsenic MCL

The District has contingency plans in the event the water quality of some Kern Fan Groundwater Storage Project wells changes to exceed the current Arsenic MCL or if the Arsenic MCL is reduced in the future from 10 ppb to 5 ppb. These plans would enable the District to come into compliance for the new MCL without treating the water to remove Arsenic. These plans would involve further investigation, but include the following alternatives:

1. Evaluate the cause of the water quality change in the well. Sometimes plugging of the well screen can impact the water quality. Plugging can restrict the portions of the screen that yield lower Arsenic concentrations and thus increase the amount of water being drawn in from the higher Arsenic concentrations in other parts of the aquifer. In this event the District would remove the pump and mechanically and chemically rehabilitate the well to remove the plugging. Oftentimes this results in the well returning to its historic Arsenic concentrations.

2. Reduce the well yield (pumping rate) by reducing the speed of the VFD. A direct correlation is sometimes achieved between the pumping rate and the Arsenic concentration. This is related to the fact that the shallow water has lower Arsenic and the deeper water has higher Arsenic. If the well is pumping less flow and the pump is above the screened interval, oftentimes the water is coming from primarily the upper portion of the well screen and thus reduces the concentration of Arsenic.

   This correlation is reflected by testing that was performed for the Superior Recovery Water Wells, see Figure 8 below. The well discharge rate was varied between 1,250 gpm and 4,600 gpm and Arsenic samples collected. The Arsenic concentration is lowest at the lower flow rates.

Summary of Arsenic Concentrations
Superior Wells

Well	Date Tested	Test Type	Discharge Rate[1] (gpm)[2]	Arsenic Concentration (µg/L)[3]
SUP-1	17-Aug-15	Step-Drawdown	2,500	4.0
SUP-1	17-Aug-15	Step-Drawdown	3,500	5.4
SUP-1	17-Aug-15	Step-Drawdown	4,500	6.0
SUP-1	20-Aug-15	Constant Rate	3,000	8.4
SUP-2	17-Sep-15	Constant Rate	2,500	7.6
SUP-4	23-Oct-15	Development	1,250	13.0
SUP-4	26-Oct-15	Step-Drawdown	2,000	12.0
SUP-4	26-Oct-15	Step-Drawdown	3,000	14.0
SUP-4	26-Oct-15	Step-Drawdown	4,000	19.0
SUP-4	28-Oct-15	Constant Rate	3,300	17.0
SUP-5	6-Nov-15	Development	4,300	9.5
SUP-5	10-Nov-15	Constant Rate	2,800	9.0
SUP-6	30-Sep-15	Development	4,600	8.1
SUP-6	5-Oct-15	Step-Drawdown	2,050	8.1
SUP-6	5-Oct-15	Step-Drawdown	3,500	11.0
SUP-6	5-Oct-15	Step-Drawdown	4,500	12.0
SUP-6	7-Oct-15	Constant Rate	3,000	15.0

Notes:

[1] Discharge rate at time of sample collection.
[2] gpm = Gallons per minute.
[3] µg/L= Micrograms per liter.

Figure 8: Arsenic Concentration varying with Flow

3. There are District recovery water wells that have an Arsenic concentration less than 5 ppb. The District may utilize these wells as appropriate for blending purposes to ensure that the discharge water to the canal has an Arsenic concentration less than 5 ppb.

4. As mentioned above, the deeper water is generally higher in Arsenic. The District can permanently seal a portion of the lowermost screened section of the well with concrete or bentonite in order to reduce the Arsenic level in the well. This will involve filling in a portion of the well bottom (from the bottom of the well casing up a certain distance on the lower screened interval) with concrete or bentonite and plug off the deeper portions of the well that have higher Arsenic concentrations. This will lower the Arsenic concentration in the well and bring the well back into compliance for Arsenic at less than 5 ppb.

Oftentimes the effectiveness of this modification is first tested with an inflatable packer before actually installing a cement or bentonite plug. The SUP-4 well and the SUP-6 well had Arsenic concentrations that exceed the MCL of 10 ppb. An inflatable packer was installed at different depths and the Arsenic measured. The packer assembly consisted of a 19-inch outer diameter rubber packer (uninflated diameter), inflation airline and a braided metal security cable. The inflatable packer was approximately 5-ft in length. The packer assembly was mounted on a 6-inch diameter pipe extension attached to the end of the test pump. The packer was mounted approximately 60-ft below the pump intake. The packer was inflated with nitrogen to pressures ranging from 250 to 290 psi. The results of the packer testing for each of these wells is shown in Figure 9 below.

Summary of Arsenic Concentrations and Specific Capacity
SUP-4 and SUP-6

Well	Date Tested	Test Type	Packer Setting (ft)	Active Perforated Interval(s) (ft)	Discharge Rate[1] (gpm)[2]	Arsenic Concentration (µg/L)[3]	Arsenic Concentration Verification Testing (µg/L)[3]	Specific Capacity (gpm/ft)[4]
SUP-4	22-Oct-15	Pumping Development	N/A	365-545, 570-610, 630-780	1,250	13	N/A	N/A
SUP-4	26-Oct-15	Step-Drawdown	N/A	365-545, 570-610, 630-780	2,000	12	N/A	60
SUP-4	26-Oct-15	Step-Drawdown	N/A	365-545, 570-610, 630-780	3,000	14	N/A	58
SUP-4	26-Oct-15	Step-Drawdown	N/A	365-545, 570-610, 630-780	4,000	19	N/A	56
SUP-4	28-Oct-15	Constant Rate	N/A	365-545, 570-610, 630-780	3,300	17	N/A	61
SUP-4	**23-May-16**	**Packer Test 1**	**725**	**365-545, 570-610, 630-725**	**2,500**	**<2 (1.4)**	**<2 (0.99)**	**50**
SUP-4	**24-May-16**	**Packer Test 2**	**680**	**365-545, 570-610, 630-680**	**2,500**	**<2 (1.9)**	**<2 (1.2)**	**50**
SUP-4	**26-May-16**	**Packer Test 3 Step 1**	**620**	**365-545, 570-610**	**1,500**	**<2 (1.4)**	**<2 (1.1)**	**34**
SUP-4	**26-May-16**	**Packer Test 3 Step 2**	**620**	**365-545, 570-610**	**2,000**	**<2 (1.5)**	**<2 (1.1)**	**31**
SUP-4	**26-May-16**	**Packer Test 3 Step 3**	**620**	**365-545, 570-610**	**2,500**	**<2 (1.6)**	**<2 (1.2)**	**30**
SUP-6	30-Sep-15	Pumping Development	N/A	410-610, 700-920	4,600	8.1	N/A	N/A
SUP-6	5-Oct-15	Step-Drawdown	N/A	410-610, 700-920	2,050	8.1	N/A	67
SUP-6	5-Oct-15	Step-Drawdown	N/A	410-610, 700-920	3,500	11	N/A	64
SUP-6	5-Oct-15	Step-Drawdown	N/A	410-610, 700-920	4,500	12	N/A	62
SUP-6	7-Oct-15	Constant Rate	N/A	410-610, 700-920	3,000	15	N/A	67
SUP-6	**8-Jun-16**	**Packer Test 1**	**800**	**410-610, 700-800**	**3,000**	**5.3**	**5.0**	**38**
SUP-6	**9-Jun-16**	**Packer Test 2**	**740**	**410-610, 700-740**	**3,000**	**7.8**	**6.3**	**36**
SUP-6	**14-Jun-16**	**Packer Test 3 Step 1**	**565**	**410-565**	**2,000**	**4.7**	**5.1**	**22**
SUP-6	**14-Jun-16**	**Packer Test 3 Step 2**	**565**	**410-565**	**2,500**	**4.7**	**4.5**	**21**
SUP-6	**14-Jun-16**	**Packer Test 3 Step 3**	**565**	**410-565**	**2,800**	**5.2**	**4.9**	**18**

Notes:
[1] Discharge rate at time of sample collection.
[2] gpm = Gallons per minute.
[3] µg/L= Micrograms per liter.
[4] gpm/ft = Gallons per minute per foot measured after 3 hours of pumping.
[5] N/A = Not applicable.
Highlighted yellow cells indicate arsenic concentrations above the Maximum Contaminant Level (MCL) of 10 µg/L.
Bold results are from packer testing.

Figure 9: Packer Testing to Reduce Arsenic Concentration

The packer was effective at reducing the Arsenic concentration in SUP-6 at all three packer depths. At a packer depth of 565-ft, the Arsenic concentration was able to be reduced to 5 ppb or lower while still maintaining the target design rate of 2,250 gpm or 5.0 cfs.

In addition to traditional inflatable packer testing there is an emerging water quality well profiling technology that would help identify Arsenic hot spots in the well profile. The USGS has published technical papers on the efforts of Noah Heller detailing the non-invasive effort to profile existing wells with the intention of blanking off portions of screen intervals that contribute to water quality issues.