CADIZ VALLEY WATER CONSERVATION, RECOVERY, AND STORAGE PROJECT

Addendum to the 2012 Environmental Impact Report

June 2019

ESA

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Prepared for

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CADIZ VALLEY WATER CONSERVATION, RECOVERY, AND STORAGE PROJECT

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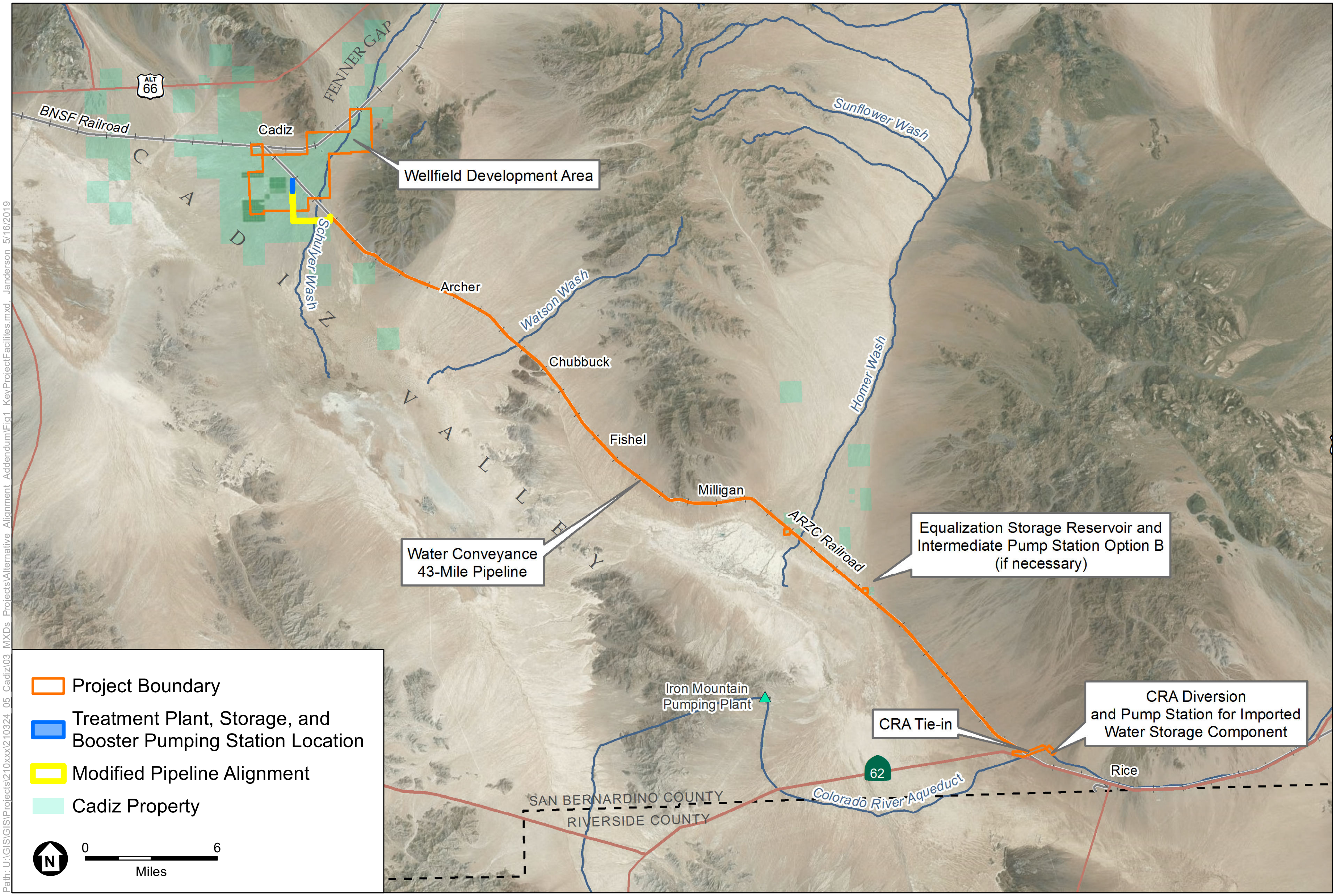
Introduction

The Cadiz Valley Water Conservation, Recovery and Storage Project (Project) is designed to actively manage the groundwater basin underlying a portion of the Cadiz and Fenner Valleys located in the eastern Mojave Desert portion of San Bernardino County, California (**Figure 1**). Cadiz, Inc. (Cadiz) owns approximately 34,000 contiguous acres of land in the Cadiz and Fenner Valleys (Cadiz Property). As part of a public-private partnership with Cadiz, the Santa Margarita Water District (SMWD) would carry-out and supervise the Project as the managing member of Fenner Valley Water Authority (FVWA), a joint powers authority (JPA) comprised of the Fenner Valley Mutual Water Company and SMWD. As lead agency under California Environmental Quality Act (CEQA) Guidelines section 15051, (a) and (b), SMWD prepared and certified an Environmental Impact Report (EIR) in July 2012.

The Project includes construction of an array of groundwater extraction wells and pumps, a wellfield manifold piping system, a 43-mile water conveyance pipeline, monitoring features, other appurtenances and fire suppression mechanisms. The conveyance pipeline would be constructed along the Arizona & California Railroad Company (ARZC) right-of- way (ROW) and tie into the Colorado River Aqueduct (CRA) (**Figure 1**).

In June 2011, the County of San Bernardino (County), as a Responsible Agency, and SMWD, entered into a Memorandum of Understanding (MOU), stating that Cadiz and SMWD would comply with the County's Groundwater Management Ordinance, through the preparation of a County-Approved Groundwater Management, Mitigation and Monitoring Plan (GMMMP). The County approved the Project's GMMMP (Appendix A) in October of 2012. Construction and operation of the Project would be subject to the 2012 EIR's Mitigation Monitoring and Reporting Program (MMRP) that also includes the Cadiz GMMMP focused on these critical resources:

- Groundwater aquifer system
- Natural springs in the watershed
- Brine resources
- Air quality
- Adjacent watersheds



SOURCE: Bing Maps, 2011; ESRI, 2010; Cadiz Inc., 2011; and ESA, 2011

Cadiz Groundwater Project

Figure 1
Project Location and Facilities

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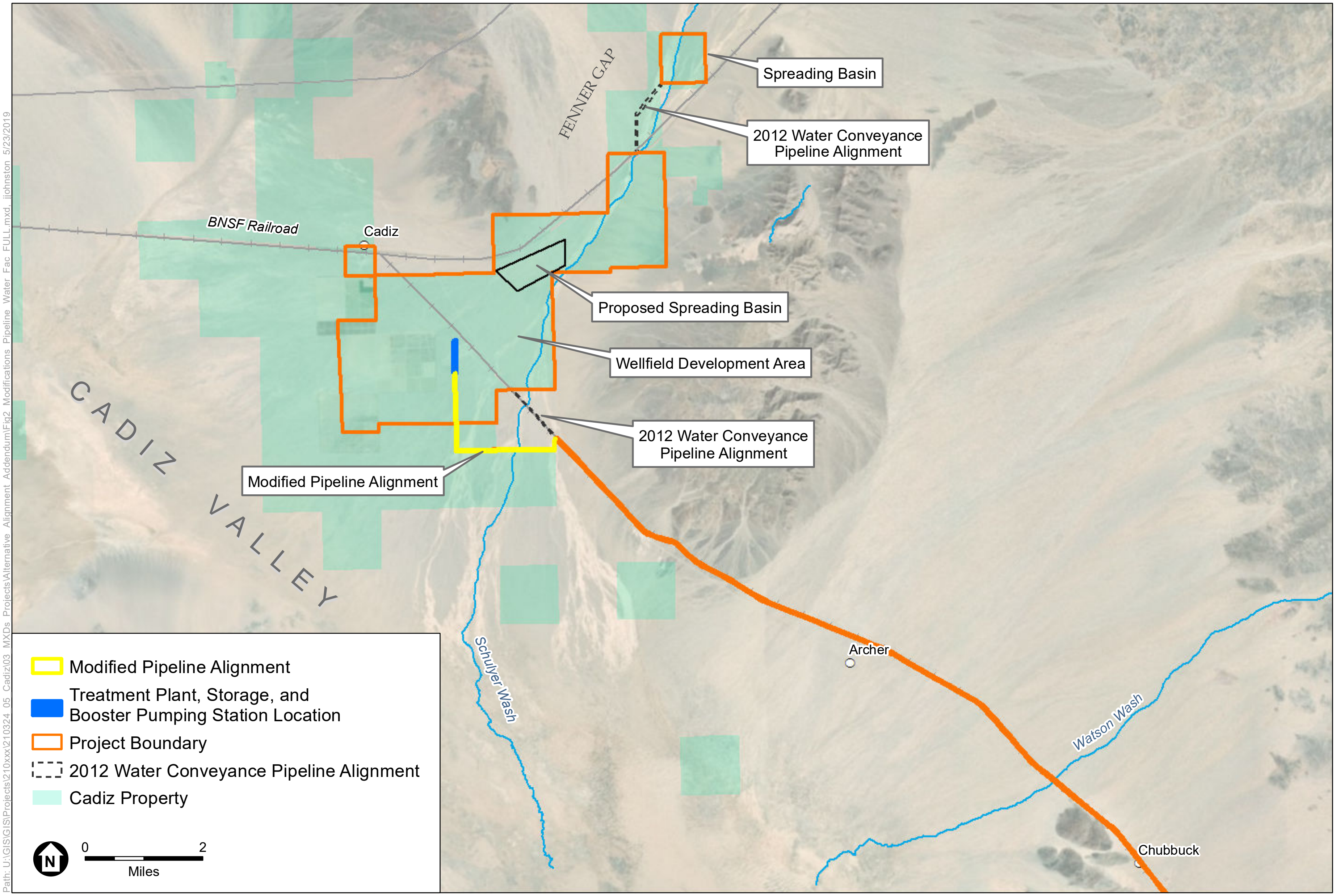


SOURCE: Bing Maps, 2011; ESRI, 2010; Cadiz Inc., 2011; and ESA, 2011

Cadiz Groundwater Project

Figure 2
Modifications to Pipeline and Water Treatment Facility

Since the certification of the EIR in 2012, 1) the Project pipeline alignment has been redesigned slightly; and 2) a groundwater treatment facility is proposed to ensure extracted water quality meets anticipated contractual requirements. The groundwater treatment facility would be comprised of a treatment plant, storage, and booster pumping station.

The FVWA is acting as Lead Agency for and further actions related to the implementation of the Project. The key JPA provisions that articulate FVWA's role in carrying out the Project are:

- Section 2.2.1 states that the purpose of the JPA is to accomplish "Project Objectives," including "to undertake the review and approval of the design, permitting and construction of the Project Facilities by Cadiz...." (JPA Article I defines "Project Facilities" as "any and all facilities deemed necessary, advisable or appropriate to extract convey or deliver Project water….")
- Section 3.1 (including subsections 3.1.1, 3.1.3 and 3.1.12) provides that FVWA "shall possess the power in its own name to" and "take all acts as are necessary and appropriate to carry out the Project Objectives," to "obtain rights, permits and other authorizations for, or pertaining to, the Project and Project Facilities…" and to "apply for… state…permits…from the State…necessary for the Authority's full exercise of its powers."

Public Resources Code section 21067 defines a "Lead Agency" as "the public agency which has the principle responsibility for carrying out or approving a project which may have a significant effect upon the environment." Given Sections 2.2 and 3.1 of the JPA, the decision to submit any permits is one that must be made by FVWA, making it the Lead Agency as it is the public agency responsible for carrying out the Project.

As a result, FVWA, acting as lead agency for the implementation of the Project, has prepared an Addendum pursuant to CEQA Guidelines Section 15164 evaluating the potential for any new significant impacts or a substantial increase in the severity of previously identified significant impacts to occur. This Addendum analyzes the two Project modifications described below, and also addresses certain studies that have been release since certification of the 2012 EIR relating to the local natural springs. Those studies are not relevant to the proposed Project modifications, but are discussed in this Addendum solely for informational purposes.

Description of Project Modifications

Water Conveyance Pipeline

As described in the EIR, the proposed project would construct a wellfield and manifold system and a 43-mile water conveyance pipeline between the Cadiz Property and the CRA, within the existing ARZC ROW, that would discharge into to the CRA. Since the certification of the 2012 EIR, the water conveyance alignment has been slightly modified by adding approximately 2 miles of pipeline to the 43-mile original alignment evaluated in the EIR. The modified alignment would connect the wellfield manifold system with the ARZC alignment at a different location than originally identified as illustrated in **Figure 2** and **Figure 3**. At mile 41 along the original alignment, the modified pipeline alignment would turn west for approximately 2 miles, then north for approximately 2 miles. The construction ROW for the pipeline modification would be 200 feet wide, the same width as the original alignment. A new 30-foot wide access road approximately 2 miles in length would be established for future maintenance along the modified alignment where no road currently exists. A small portion, approximately 41 linear feet, of the modified alignment would be installed within Bureau of Land Management (BLM) lands designated as National Conservation Lands (NCL). The FVWA would obtain an easement from BLM for construction and operation of the pipeline on approximately 4,200 square feet of BLM managed lands (Figure 3). As required under the National Environmental Policy Act (NEPA), impacts as a result of the segment of the modified pipeline alignment that would be installed on BLM managed lands would be determined by the BLM during review of the Project's *SF299 Application for Transportation and Utility Systems and Facilities on Federal Lands.* NEPA requires that federal agencies take their own steps to assess potential environmental impacts. As the managing federal agency, BLM would either grant or deny the easement for the 41-feet of pipeline upon completion of the NEPA process.

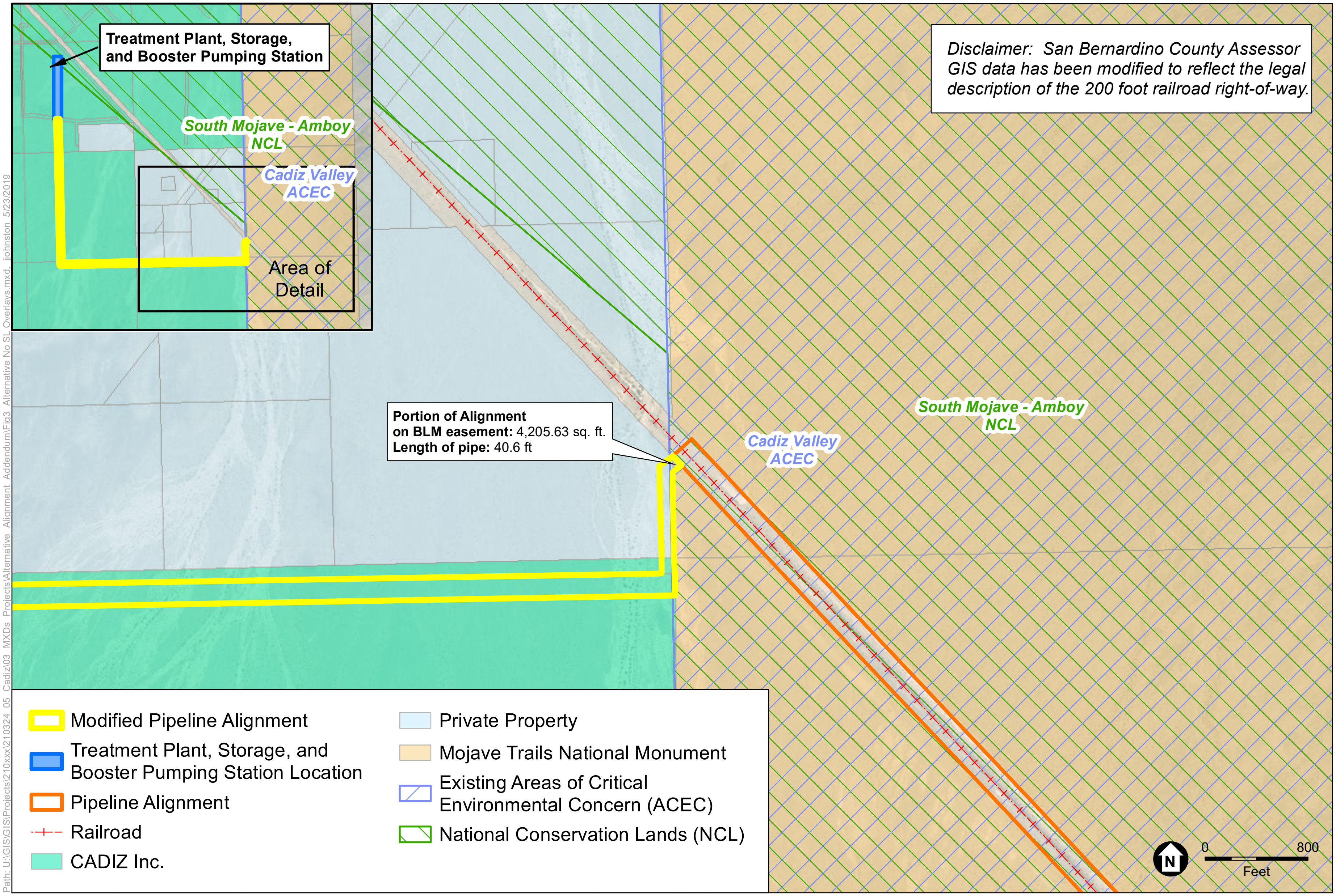
The water conveyance pipeline would consist of a single barrel, pressurized pipe with nominal design flow of up to 250 cubic-feet-per-second (cfs). As described in the 2012 EIR, page 3-26, the pipe diameter would be between 54 and 84 inches. Construction of the modified portion of the conveyance pipeline would be installed consistent with the Project as described in Chapter 3, Section 3.7, *Project Construction* of the 2012 EIR.

The pipeline and other Project materials would be delivered to the construction site using either the existing ARZC rail system or by truck. Construction equipment would be mobilized at the site to start trench and foundation excavations, foundation construction, pipe installation, and backfilling and grading. Staging areas would be required for the temporary storage of equipment and materials during construction of the Project modifications. The pipeline may be installed in multiple locations simultaneously. Equipment that would be required during construction of the Project modifications would be the same as identified in Table 3-5 of the 2012 EIR.

Water Treatment Facilities

Since the adoption of the 2012 EIR and subsequent discussions with MWD regarding implementation of the Project, the FVWA is developing a water treatment plant, storage, and booster pumping station to treat pump-in water to meet MWD requirements for specific naturally occurring minerals. The groundwater treatment system would be located near the Project wellfield and would remove naturally occurring minerals from the groundwater prior to pumping to the CRA, if required (as illustrated on Figure 1 through Figure 3).

The treatment facilities would be constructed near the Cadiz agricultural operations within the surveyed pipeline alignment (**Figure 4** and **Figure 5**). The treatment facilities would be designed to reduce iron, manganese, arsenic, nitrate, chromium, and hexavalent chromium levels to the treatment goals listed in **Table 1.** The treatment facilities will ensure that maximum allowable levels are not exceeded for any constituent.



SOURCE: ESRI; San Bernardino County GIS; BLM

Cadiz Groundwater Project

Figure 3
Pipeline Modification

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TABLE 1
CADIZ RAW WATER QUALITY, TREATMENT GOALS AND REGULATORY STANDARDS

Parameter	Treatment Goal	Regulatory Standard
Hexavalent chromium	2 μg/L	10 μg/L*
Total chromium	2 μg/L	50 μg/L
Arsenic	3 μg/L	10 μg/L
Iron	<45 μg/L	300 μg/L
Manganese	<10 μg/L	50 μg/L
Nitrate	0.5 mg/L as N	10 mg/L as N

Iron is added to the water during hexavalent chromium treatment and manganese dioxide is used for the filter media. The

μg/L = micrograms per liter

*On May 31, 2017, the Superior Court of Sacramento County issued a judgment invalidating the hexavalent chromium 10 μg/L MCL for drinking water. The State Water Resources Control Board has not established a new California MCL Currently, the California MCL for hexavalent chromium will not be enforced. The US Environmental Protection Agency (EPA) federal MCL is 100 μg/L.

The treatment for nitrate removal would utilize a biological denitrification process. The biological denitrification would occur in a mechanically mixed reactor tank prior to removal of other constituents and would be an anaerobic process. As part of the treatment process, a carbon source and specific nutrients would be added to the untreated feed water flow. After denitrification, aeration and filtration would occur to remove iron, manganese, arsenic, hexavalent chromium and total chromium by a reduction, coagulation, and filtration (RCF) process that uses ferrous chloride to convert hexavalent chromium to trivalent chromium, then air oxidation to precipitate iron followed by filtration (**Figure 5**). Approximately five percent of the water entering the treatment plant would be discharged as filter waste to the four backwash basins. After drying by evaporation, and recycling of supernatant back to the head of the RCF process, backwash solid waste would be disposed of in accordance with state and federal regulations.

This method of treatment for nitrate removal requires a carbon source and nutrient addition. The carbon source would likely be acetic acid, and typical doses would be approximately 1 to 3 milligrams per liter (mg/L). A small amount of a phosphorous-based nutrient may be added as well at a dose of less than 0.1 mg/L. The denitrification system evaluated in the pilot test used denitrifying bacteria encapsulated inside of porous beads. The beads are held in a tank that is exposed to the atmosphere and mixed continuously with turbine or paddle wheel mixers. The effluent nitrate concentration would be continuously monitored by a nitrate probe and the results used to adjust the feed of the carbon source, so that excess carbon is not added.

The RCF process for treatment for the reduction of iron, manganese, hexavalent chromium, total chromium, and arsenic would be approximately 2000 feet downstream of the nitrate removal process to allow for sufficient contact time in the pipeline. A 2-minute contact time would be provided for the ferrous chloride to reduce the hexavalent chromium to trivalent chromium. After the 2 minutes, an aeration system would introduce air into the transmission pipeline to oxidize the low levels of iron before the water is delivered to the RCF process. The 2000-foot distance would ensure that minimum contact times are maintained.

The RCF process would require a typical ferrous chloride dose of 1.5 mg/L, although the system would be designed for feeding up to 3.0 mg/L. The ferrous chloride would be fed into the system using metering pumps. Air would be added to oxidize the ferrous iron to ferric iron. Achieving the treated water iron goal of < 0.45 µg/L may require the use of a low dose of filter aid polymer for both north and south wellfields. Anticipated chemical use for the 75,000 AFY delivery is depicted in **Table 2**.

Some of the energy used to move the untreated water would be recaptured through hydropower. The hydroelectric energy recovery device would be installed within the northern most part of the water treatment facility boundary, in close proximity to a 1.6 million gallon (MG) denitrification tank (Figure 4), where it would recover energy from the higher-elevation North Wellfield to the northeast of the hydroelectric facility. The denitrification tank would be 24 feet in height and installed adjacent to a 5,000 square foot chemical feed and operations building. Two 6,000-gallon ferrous chloride storage tanks would be installed and housed in a covered metal-framed and concrete structure approximately 24 feet wide, 45 feet in length and 24 feet high, and would be part of the chemical feed and operations building. Nitrate removal would be followed by the RCF process for reduction of iron, manganese, hexavalent chromium, total chromium, and arsenic. The ferrous chloride would be purchased as bulk liquid and would be delivered by tank trucks. The pipeline would be connected to a series of 26 filter banks; each 10-foot wide and 50-foot long. The filter banks would be connected to two 1.0 MG, 85-foot diameter tanks for the forebay and booster pump station. The filter banks would be installed on concrete pads and above-ground structures would not exceed 24 feet in height. Four backwash basins would be located adjacent to the RFC treatment facility and would be covered to prevent the attraction of avian wildlife. The methods to cover the backwash basin may include one or more of the following: floating balls, floating membrane covers, or aluminum fixed covers. The backwash basins would be concrete basins excavated into the ground.

A booster pump station (BPS) would be installed after the treatment facilities to convey the treated water to the CRA. A forebay of steel tanks with approximately 1 hour of storage would be installed upstream of the booster pumps and downstream of the water treatment facilities. The storage to accommodate a flowrate of 113 cfs over an 11-month period is 3 million gallons. All pumps would use natural gas engines for driving the pumps.

The water treatment facilities would be centrally located near the agricultural operations occupying approximately 10 acres of land (Figure 2). The treatment facilities would treat up to 75,000 AFY while operating continuously for approximately 11 months per year.

The water treatment facilities would be sized to accommodate the maximum flowrate anticipated to be pumped to the CRA. As described in the 2012 EIR, the average annual deliveries would be 50,000 AFY and up to 75,000 AFY in a maximum delivery year. The flowrates associated with those two delivery options are 75 cubic feet per second (cfs) and 113 cfs, respectively, assuming an 11-month per year delivery schedule. The treatment plant would be sized to accommodate 113 cfs to meet the 75,000 AFY capacity goal.

TABLE 2
WATER TREATMENT PLANT CHEMICAL USAGE AND TRUCK TRIPS FOR 75,000 AFY (GALLONS/MONTH)

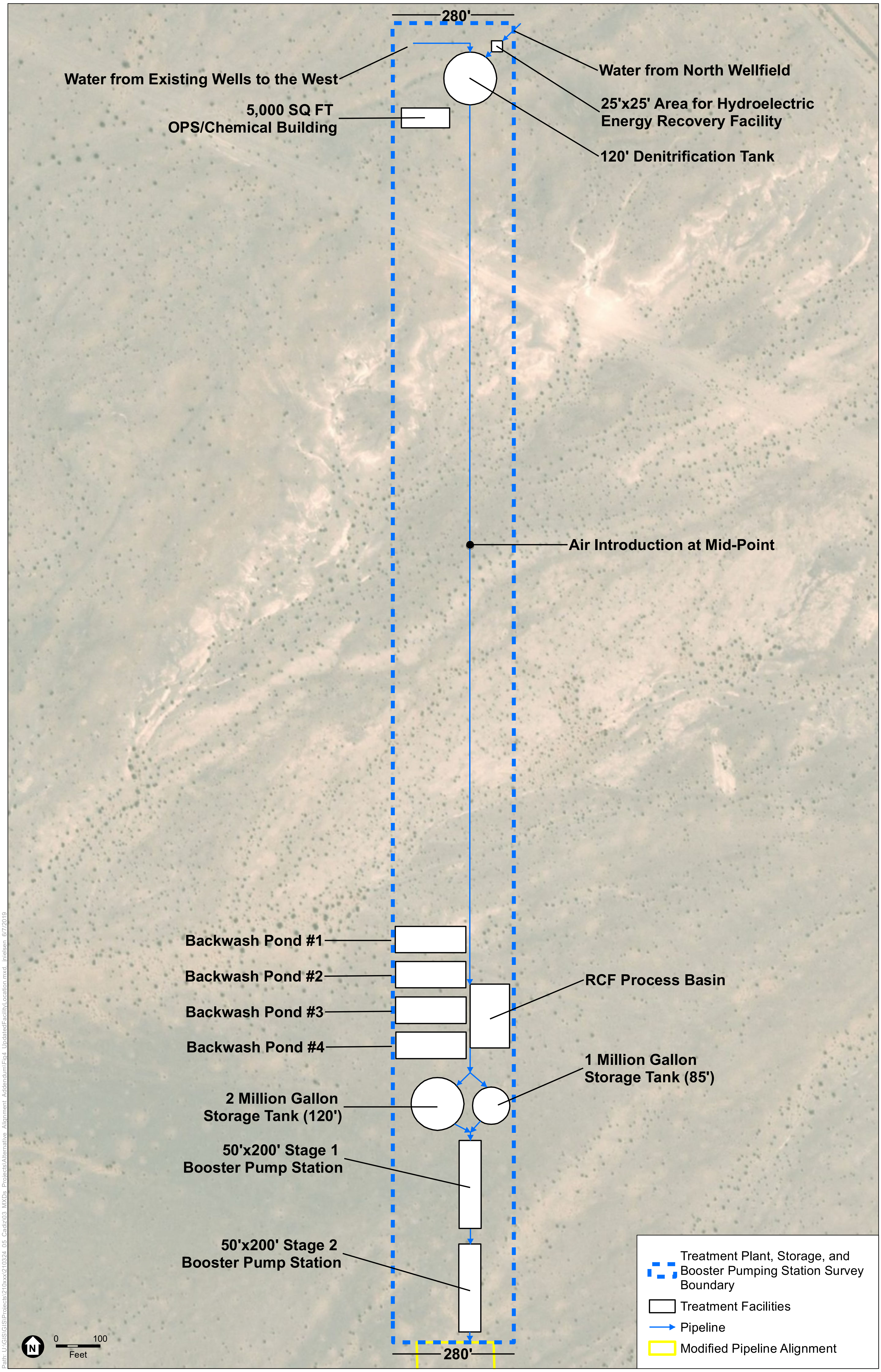
Chemical	Usage/month	Delivery Volume	Truck Trips/ Month
Ferrous Chloride	8900	4500	2
Nitrate Removal Chemicals	9000	4500	2
Phosphate/Nutrient Addition	400	400	1
Total			5

Note: Truck trips based on 50% acetic acid for nitrate removal, 40% ferrous chloride, and 97% phosphoric acid

Water Treatment Facilities Energy Requirements

Energy requirements associated with the treatment process are summarized in **Table 3**. The original Project design assumed that approximately 105 feet of pressure head would be captured from the North Wellfield by making a direct connection from those higher elevation wells to the main pipeline that would convey water to the CRA. The treatment process will break this pressure head, requiring additional energy to convey water through the 43-mile pipeline. A small-scale hydroelectric turbine energy recovery system will be installed before the water treatment plant, and a portion of the available pressure head from the North Wellfield would be captured to provide power for the energy needs of the water treatment facilities.

The water treatment facilities would require 315 HP as shown in **Table 3**. Much of the energy demand associated with the treatment process would be met with captured energy from the hydroelectric turbines. A small natural gas fired emergency generator would provide standby power for the water treatment facility energy requirements, but it would not be operated unless some element of the hydroelectric facility was inoperable due to maintenance or unplanned outage. Following the treatment plant, additional pumping provided by the BPS would be needed to convey water to the CRA. The BPS would have a combined HP of 5,828 for delivery of 75,000 AFY. This new energy demand would result from breaking the pressure head at the treatment plant. With these Project modifications, the Project total energy demand would be approximately 15,170 HP. The total power requirements for the Project will increase to 15,170 HP because of the addition of the water treatment facilities and the resulting need for the BPS.



SOURCE: ESRI, 2019; ESA, 2019.

Cadiz Groundwater Project

Figure 4
Water Treatment Facility

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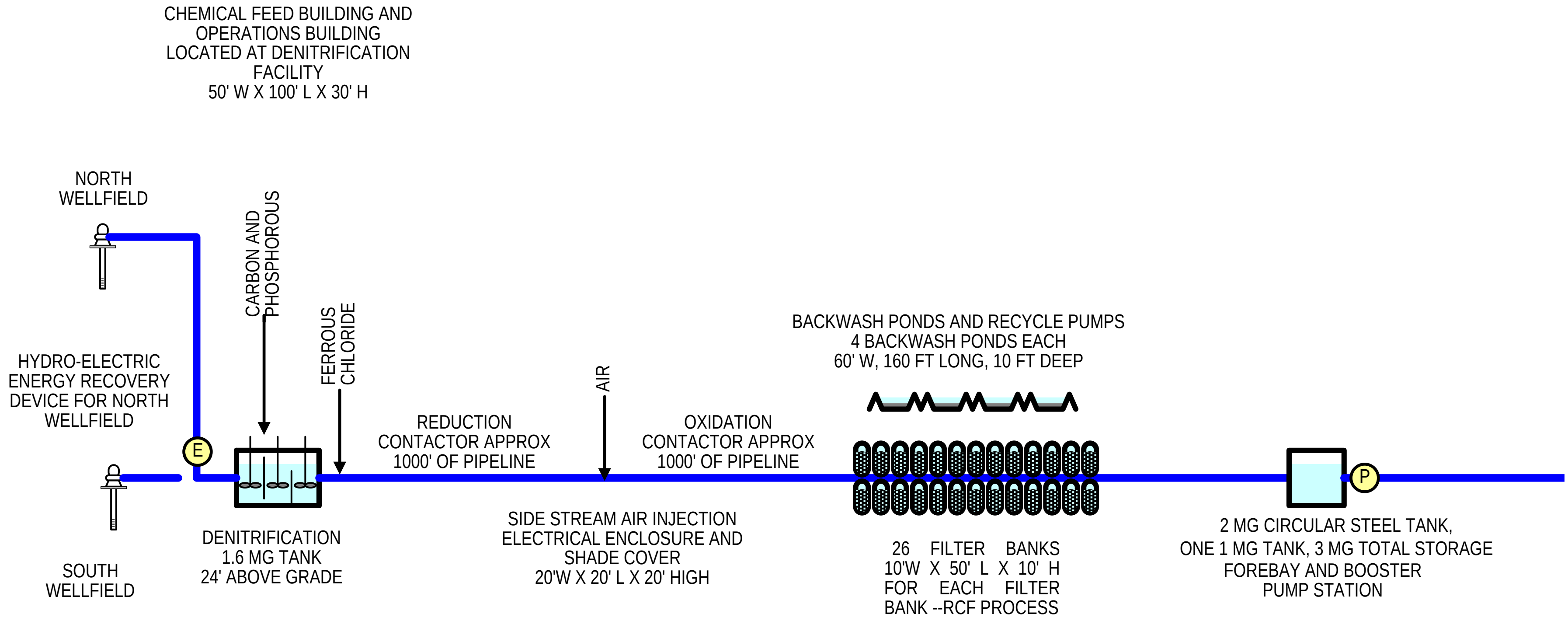


SOURCE: CH2M, Jacobs, 2019

Cadiz Groundwater Project

Figure 5
Process Flow Diagram

ESA

TABLE 3
WATER TREATMENT PLANT ENERGY DEMAND FOR 75,000 AFY DELIVERY OPTION

	Installed Capacity		Energy Demand
	HP	KW	kWh/Day
Nitrate Removal			
Nitrate Feed Pumps	2	1	36
Ops/Chemical Building	10	7	90
Nitrate Mixers	72	54	1,289
Total Nitrate Removal Requirements	**84**	**62**	**1,415**
Arsenic and Chromium Removal			
Chemfeed Pumps	2	1	36
Sidestream Pumps	150	112	2,686
Air compressors	4	3	72
Backwash Recycle Pumps	50	37	895
I&C Power	5	4	22
Ops/Chemical Building	20	15	179
Total Arsenic and Chromium Removal	**231**	**172**	**3,890**
Subtotal – Water Treatment Facility	**315**	**231**	**5,304**

Note: Power requirements for the energy needs of the water treatment facilities in this table will be provided by the hydroelectric facility on the North Wellfield pipeline.

CEQA Guidelines for Preparation of an Addendum

This Addendum has been prepared to determine whether the changes to the Project would result in any new significant impact or a substantial increase in the severity of any previously identified significant environmental impact compared with the impacts disclosed in the certified EIR. CEQA Guidelines Sections 15162 and 15164 set forth the criteria for determining the appropriate additional environmental documentation, if any, to be completed when there is a previously certified EIR covering a project for which a subsequent discretionary action is required.

Section 15162 of the CEQA Guidelines states that preparation of a subsequent EIR is not required unless one or more of the following conditions occur:

- Substantial changes are proposed in the project which would require major revisions of the previous EIR due to the involvement of new significant environmental effects or a substantial increase in the severity of previously identified significant effects;
- Substantial changes have occurred with respect to the circumstances under which the Project is undertaken which would require major revisions of the previous EIR due to the involvement of new significant environmental effects or a substantial increase the severity of previously identified significant effects; and

- New information of substantial importance, which was not known and could not have been known with the exercise of reasonable diligence at the time of the previous EIR was certified as complete and adopted, shows any of the following:
  - The project would have one or more significant effects not discussed in the previous EIR;
  - Significant effects previously examined would be substantially more severe than shown in the previous EIR;
  - Mitigation measures or alternatives previously found not to be feasible would in fact be feasible and would substantially reduce one or more significant effects of the project, but the project proponents decline to adopt the mitigation measure or alternative; or
  - Mitigation measures or alternatives which are considerably different from those analyzed in the previous EIR or negative declaration would substantially reduce one or more significant effects on the environment, but the project proponents decline to adopt the mitigation measures or alternative.

Section 15164 of the CEQA Guidelines states that:

- The lead agency or responsible agency shall prepare an addendum to a previously certified EIR if some changes or additions are necessary but none of the conditions described in Section 15162 calling for preparation of a subsequent EIR have occurred.
- An addendum may be prepared if only minor technical changes or additions are necessary or none of the conditions described in Section 15162 calling for the preparation of a subsequent EIR have occurred.
- An addendum need not be circulated for public review but can be included in or attached to the 2012 EIR.
- The decision making body shall consider the addendum with the 2012 EIR prior to making a decision on the project.
- A brief explanation of the decision not to prepare a subsequent EIR pursuant to Section 15162 should be included in an addendum to an EIR, the lead agency's findings on the Project, or elsewhere in the record. The explanation must be supported by substantial evidence.

This Addendum relies on the significance criteria established in Appendix G of the 2019 CEQA Guidelines and the resource analysis methodology, described in the 2012 EIR to assess the potential impacts related to the Project modifications. Each resource section presents a summary of the impacts and mitigation conclusions from the analysis in the 2012 EIR, as well as a determination as to whether the Project modifications would result in new significant impacts, or a substantial increase in the severity of the previously identified significant impacts. Resource impacts evaluated are presented in the same order as in the 2012 EIR. Although the 2012 EIR evaluated impacts to resources under each phase of the Project, impacts from Project modifications were evaluated as one.

In compliance with CEQA Guidelines §15150, this Addendum has incorporated by reference the EIR certified by SMWD in 2012 and all technical studies, analyses, and technical reports that were prepared as part of the Draft and Final EIR. In addition, this Addendum incorporates biological, air emissions and cultural technical studies conducted for the Project modifications.

CEQA Consistency Evaluation

I. Aesthetics

Summary of Project Impacts in the 2012 EIR

Table 4 summarizes the Impact and Mitigation Analysis in 2012 EIR for aesthetic resources. The EIR determined that the Project would have a less than significant effect from light and glare with implementation of Mitigation Measures AES-1 and AES-2.

TABLE 4
AESTHETIC IMPACTS AND MITIGATION SUMMARY

Proposed Project Impact	Mitigation Measure	Significance
Groundwater Conservation and Recovery Component		
Scenic Vistas	None required	Less than significant
Scenic Resources	None required	No impact
Visual Character	None required	Less than significant
Light and Glare	**AES-1** and **AES-2**	Less than significant with mitigation
Imported Water Storage Component		
Scenic Vistas	None required	Less than significant
Scenic Resources	None required	No impact
Visual Character	None required	Less than significant
Light and Glare	**AES-1** and **AES-2**	Less than significant with mitigation

Impact and Mitigation Analysis of Project Modifications

The viewsheds and aesthetic characteristics in the vicinity of the Project have not changed since the preparation of the 2012 EIR. The following impacts determination is based on the extent of project visibility from sensitive viewing areas. For the Project modifications, this would include views in every direction from the public road way rights-of-way including natural vistas, day and nighttime sky-views, and BLM Wilderness Areas as the backdrop.

Issues (and Supporting Information Sources):	Potentially Significant Impact	Less Than Significant with Mitigation Incorporated	Less Than Significant Impact	No Impact
AESTHETICS — Would the project:				
a) Have a substantial adverse effect on a scenic vista?	☐	☐	☒	☐
b) Substantially damage scenic resources, including, but not limited to, trees, rock outcroppings, and historic buildings within a state scenic highway?	☐	☐	☐	☒
c) In non-urbanized areas, substantially degrade the existing visual character or quality of public views of the site and its surroundings? (Public views are those that are experienced from publicly accessible vantage point). If the project is in an urbanized area, would the project conflict with applicable zoning and other regulations governing scenic quality?	☐	☐	☒	☐
d) Create a new source of substantial light or glare which would adversely affect daytime or nighttime views in the area?	☐	☒	☐	☐

Discussion

a) Scenic vistas are defined as expansive views of distant landforms and aesthetic features from public vantage points, including areas designated as official scenic vistas along roadway corridors or otherwise designated by local jurisdictions. Scenic vistas within the Project area include the expanse of the Cadiz Valley and surrounding mountains and hillsides. In general, public views of the proposed Project would be limited as access to the Cadiz Inc. property to the north and Metropolitan lands and the CRA to the south are private property and are not accessible to the general public. Cadiz-Rice Road, which runs parallel to the ARZC ROW between SR 62 and SR 66 in Cadiz, California, is open to the public. However, the dirt road is not well maintained, and therefore traffic along the road is infrequent and generally limited to employees of the mining, railroad, and agricultural operations.

Temporary visual impacts would occur to the scenic vistas during construction as heavy equipment would be in use and stockpiles of project materials would be visible. However, construction would be temporary in nature and limited to the immediate area where the treatment plant, storage, booster pumping station, and modified pipeline alignment is proposed. Further, most activities would be obstructed by existing topography and limited by the distance between public views and the Project area. Therefore, visual impacts at public viewpoints from the presence of construction activities within the Project area would be less than significant.

The conveyance pipeline would be installed underground and would not alter the local aesthetics once installed. Aboveground facilities associated with the modified pipeline alignment and the proposed treatment plant facilities, storage and booster pumping station would have a permanent position in the landscape of the Project area as permanent structures would be constructed. Structures associated with the modified pipeline alignment would not have the scale or massing to be seen from distant public views or significantly obstruct views of scenic vistas.

The treatment plant, storage and booster pumping station would occupy approximately 10 acres, would not exceed 24 feet in height, and be located within 150 acres of private land adjacent to operating agricultural fields. As described in the EIR (Page 4.1-16), the closest county-designated scenic route is Amboy Road which is approximately 13 miles to the west of the Project wellfield area. The treatment facilities would consist of a series of cleared and fenced areas four backwash basins, various size water tanks for storage and filtration, and underground water pipelines. The Project may be visible from Amboy Road in isolated spots as the topography allows. As described in the 2012 EIR (page 4.1-16), the distance from the Project facilities to public lands would minimize the potential to obscure or alter the visual character of the region. The water treatment facilities would appear similar to other small man-made structures in the overall expansive landscape and would not significantly affect the overall views. Therefore, the treatment plant, storage and booster pumping station facilities would not have the scale or massing to significantly alter or obstruct views of the expansive Cadiz Valley or local mountains and hillsides.

b) As described in the EIR, there are no designated State Scenic Highways in the Project vicinity. The Project as modified would have no impact on scenic resources within designated State Scenic Highways.

c) The Project facilities would be visible from higher elevations in the surrounding mountain ranges. These mountain ranges are largely publicly owned lands managed by BLM, and are visited less frequently than the National Parks located to the north and southwest due to their remote and rugged location and the lack of services. Consistent with design features that would be implemented for Project facilities in the wellfield area, the treatment plant facilities, storage and booster pump station would also be designed to visually blend into the long range views from surrounding areas. Although the treatment facilities would consist of an additional 10 acres of new above-ground structures, these facilities would not be substantially different than existing conditions within the whole of the Project area and surrounding landscape as evaluated in the EIR. In general, Cadiz owns over 25,000 acres of mostly undeveloped land in the area and the Project would utilize approximately less than one percent. The Project facilities and Project modifications would be near the agricultural lands, mining operations, and transportation alignments, but would not significantly alter or obscure the long range views from higher elevations.

d) Night lighting would be required during construction which would, in some cases, occur 24 hours a day. Worker housing areas and nighttime security lighting within staging areas would increase light temporarily in the area during the construction period. Once in operation, the treatment facilities may be equipped with permanent lighting used during infrequent nighttime maintenance activities. The area surrounding the Project site consists of uninhabited open space and night lighting would be noticeable considering there are few light sources in this area.

The treatment facilities may provide a source of glare to visitors in the distant mountains, but considering the small scale of the treatment facilities, glare from distant mountain vistas would be minimal as spreading basins would be covered and design features incorporated for the Project wellfield would also be incorporated for the treatment facilities.

As described in the 2012 EIR, Mitigation Measure **AES-1** and **AES-2** would be implemented to reduce potential impacts from light and glare. Impacts related to modification of the Project during construction and operation are consistent with those described in Section 4.1 of the EIR and no new mitigation would be required. Therefore, Project impacts, as modified, would remain less than significant with mitigation incorporated.

Mitigation Measures in the 2012 EIR

AES-1: Construction lighting shall be shielded or recessed so that light is directed downward and/or away from adjoining properties and public rights-of-way, and towards the construction site, with the goal of minimizing light trespass and glare on adjacent properties and containing light within the construction site.

AES-2: Outdoor lighting shall be minimized and installed for safety and security purposes only. Outdoor lighting of Project facilities and access roads shall be shielded or recessed so that light is directed downward and/or away from adjoining properties and public rights-of-way and towards the Project site, with the goal of minimizing light trespass and glare on adjacent properties and containing light within the Project site.

Significance Determination

Impacts from construction and operation to aesthetic resources from the Project modifications are consistent with those identified in the 2012 EIR. Substantial changes are not proposed in the Project, requiring major revisions of the previous EIR due to the involvement of new significant environmental effects or a substantial increase in the severity of previously identified significant effects to aesthetic resources. No new information of substantial importance indicates the project would have one or more significant effects not discussed in the previous EIR to aesthetic resources nor are significant effects previously examined substantially more severe than described in the previous EIR. No mitigation measures or alternatives previously found not to be feasible would in fact be feasible and would substantially reduce one or more significant effects of the project; and no mitigation measures or alternatives that are considerably different from those analyzed in the previous EIR would substantially reduce one or more significant effects to aesthetic resources.

II. Agriculture and Forestry Resources

Summary of Project Impacts in the 2012 EIR

Table 5 summarizes the Impact and Mitigation Analysis in 2012 EIR for agriculture and forestry resources. The EIR determined that the Project would have a less than significant effect to agricultural zoning and uses, and no mitigation was required.

TABLE 5
AGRICULTURE AND FORESTRY RESOURCES IMPACTS AND MITIGATION SUMMARY

Proposed Project Impact	Mitigation Measure	Significance
Groundwater Conservation and Recovery Component		
Farmland Conversion	None required	No impact
Agricultural Zoning and Williamson Act Contract	None required	Less than significant
Forest Zoning	None required	No impact
Forest Land Conversion	None required	No impact
Agricultural Uses	None required	Less than significant
Imported Water Storage Component		
Farmland Conversion	None required	No impact
Agricultural Zoning and Williamson Act Contract	None required	Less than significant
Forest Zoning	None required	No impact
Forest Land Conversion	None required	No impact
Agricultural Uses	None required	Less than significant

Impact and Mitigation Analysis of Project Modifications

Agricultural and forest land uses in the vicinity of the Project area have not changed since the preparation of the 2012 EIR. The analysis identifies agriculture and forest land use designations and assesses the Project modifications' consistency with those designated land uses.

Issues (and Supporting Information Sources):	*Potentially Significant Impact*	*Less Than Significant with Mitigation Incorporated*	*Less Than Significant Impact*	*No Impact*
AGRICULTURE AND FORESTRY RESOURCES — In determining whether impacts to agricultural resources are significant environmental effects, lead agencies may refer to the California Agricultural Land Evaluation and Site Assessment Model (1997) prepared by the California Department of Conservation as an optional model to use in assessing impacts on agriculture and farmland. In determining whether impacts to forest resources, including timberland, are significant environmental effects, lead agencies may refer to information compiled by the California Department of Forestry and Fire Protection regarding the state's inventory of forest land, including the Forest and Range Assessment Project and the Forest Legacy Assessment project; and forest carbon measurement methodology provided in Forest Protocols adopted by the California Air Resources Board. **Would the project:**				
a) Convert Prime Farmland, Unique Farmland, or Farmland of Statewide Importance (Farmland), as shown on the maps prepared pursuant to the Farmland Mapping and Monitoring Program of the California Resources Agency, to non-agricultural use?	☐	☐	☐	☒
b) Conflict with existing zoning for agricultural use, or a Williamson Act contract?	☐	☐	☐	☒
c) Conflict with existing zoning for, or cause rezoning of, forest land (as defined in Public Resources Code section 12220(g)), timberland (as defined by Public Resources Code section 4526), or timberland zoned Timberland Production (as defined by Government Code section 51104(g))?	☐	☐	☐	☒
d) Result in the loss of forest land or conversion of forest land to non-forest use?	☐	☐	☐	☒
e) Involve other changes in the existing environment which, due to their location or nature, could result in conversion of Farmland, to non-agricultural use or conversion of forest land to non-forest use?	☐	☐	☐	☒

Discussion

a) The Project modifications would not convert any farmland identified by the Farmland Mapping and Monitoring Program of the California Resources Agency to non-agricultural use as there are none mapped in the Project area. The project would have no impact as neither the Project site nor the surrounding areas have been designated as Prime Farmland, Unique Farmland, or Farmland of Statewide Importance.

b) The Project modifications would not conflict with any existing zoning for agricultural uses or affect any property under a Williamson Act contract. Project pipeline modifications would be buried facilities and therefore would not preclude lands zoned as Agriculture (AG) from continuing to support active agricultural operations. The treatment facilities would be permanent structures located on 10 acres of privately owned land zoned for agriculture. The Project modifications occur on lands zoned as AG. The San Bernardino County Development Code (2009) allows Utilities development to occur on lands zoned as AG, subject to a Conditional Use Permit (CUP), unless exempt under Government Code §§ 53091(e). The State of California Government Code establishes an exemption for "the location or construction of facilities for the production, generation, storage, treatment, or transmission of water…." from county or city building and zoning ordinances. (Gov. Code §§ 53091(d), (e)) The implementation of the Project modifications by FVWA would be covered under this exemption for the construction and operation of facilities that are used to produce, store and transmit water. Considering the Project as a whole is exempt from the County's zoning ordinances, no CUP for the Project modifications is required from San Bernardino County, and the Project as modified, would not conflict with the County Land Use designations. Additionally, the Project site and the surrounding areas are not under Williamson Act contracts. Therefore, impacts regarding the confliction with zoning for agriculture and active Williamson Act contracts would not occur with Project implementation.

c) The Project modifications would have no impact to zoning of forested land or timberland zones. There are no designated forest lands in the Project area. No impact would occur.

d) The Project modifications would not result in loss of any forest land or conversion of forest land to non-forest use as there are no forestry resources in the Project site. No impact would occur.

e) The Project modifications would use existing roads to access the Project site and above-ground structures would be located on private land. The Project would not create changes in the existing environment that would convert Farmlands or forest lands to other uses. No impact would occur.

Impacts related to modification of the Project during construction and operation are consistent with those described in Section 4.2 of the EIR and no new mitigation would be required. Therefore, Project impacts, as modified, would remain less than significant.

Significance Determination

Impacts from construction and operation to agricultural and forestry resources from the Project modifications are consistent with those identified in the 2012 EIR. Substantial changes are not proposed in the Project, requiring major revisions of the previous EIR due to the involvement of new significant environmental effects or a substantial increase in the severity of previously identified significant effects to agricultural and forestry resources. No new information of substantial importance indicates the project would have one or more significant effects not discussed in the previous EIR nor are significant effects previously examined substantially more severe than described in the previous EIR. No mitigation measures or alternatives previously found not to be feasible would in fact be feasible and would substantially reduce one or more significant effects of the project; and no mitigation measures or alternatives that are considerably different from those analyzed in the previous EIR would substantially reduce one or more significant effects to agricultural and forestry resources.

III. Air Quality

Summary of Project Impacts in the 2012 EIR

Table 6 summarizes the Impact and Mitigation Analysis in 2012 EIR for air quality. The EIR determined that the Project would have a less than significant effect with implementation of AQ-1 through AQ-5 mitigation measures, with the exception of short-term construction NOx emission impacts, which would be significant and unavoidable.

TABLE 6
AIR QUALITY IMPACTS AND MITIGATION SUMMARY

Proposed Project Impact	Mitigation Measure	Significance Conclusion
Groundwater Conservation and Recovery Component		
Consistency with Air Quality Management Plans	AQ-1 through AQ-5	Less than significant with mitigation
Air Quality Standards	AQ-1 through AQ-5	NOx short-term construction emissions would remain significant and unavoidable. Long-term operational emissions, however, would be less than significant
Sensitive Receptors	None required	Less than significant
Objectionable Odors	None required	Less than significant
Cumulative Impact	AQ-1 through AQ-5	Short term construction emissions would be significant and unavoidable
Imported Water Storage Component		
Consistency with Air Quality Management Plans	AQ-1 through AQ-5	Less than significant with mitigation
Air Quality Standards	AQ-1 through AQ-5	NOx construction emissions would be significant and unavoidable. Operational emissions would be less than significant
Sensitive Receptors	None required	Less than significant
Objectionable Odors	None required	Less than significant
Cumulative Impact	AQ-1 through AQ-5	Short term construction emissions would be significant and unavoidable

Impact and Mitigation Analysis of Project Modifications

Regulation of air pollution is achieved through both national and state ambient air quality standards and through emissions limits on individual sources of air pollutants. Local air quality management districts are responsible for demonstrating attainment with state air quality standards through the adoption and enforcement of Attainment Plans. Since the preparation of the 2012 EIR, national and state ambient air quality standards for criteria air pollutants have changed (Section 4.3 2012 EIR), and as such, the Mojave Desert Air Basin Attainment Status for criteria pollutants was changed (**Table 7**). In 2016, the Mojave Desert Air Quality Management District (MDAQMD) updated their CEQA significant emissions thresholds for construction projects (**Table 8**).

TABLE 7
MOJAVE DESERT AIR BASIN ATTAINMENT STATUS

	Designation/Classification	
Pollutant	**Federal Standards**	**State Standards**
Ozone	Nonattainment	Nonattainment
Ozone – eight hour	Nonattainment	Nonattainment
PM10	Nonattainment	Nonattainment
PM2.5	Attainment/Unclassified	Nonattainment
CO	Attainment/Unclassified	Attainment
Nitrogen Dioxide	Attainment/Unclassified	Attainment
Sulfur Dioxide	Attainment/Unclassified	Attainment
Lead	Attainment/Unclassified	Attainment
Hydrogen Sulfide	No Federal Standard	Nonattainment
Sulfates	No Federal Standard	Attainment
Visibility Reducing Particles	No Federal Standard	Unclassified

SOURCE: Mojave Desert Air Quality Management District. MDAQMD Attainment Status. 2019
http://mdaqmd.ca.gov/home

TABLE 8
MDAQMD AIR EMISSIONS SIGNIFICANCE THRESHOLDS FOR CONSTRUCTION ACTIVITIES

Pollutant	Pounds Per Day	Tons Per Year
NO_x	137	25
VOC (ROG)	137	25
PM10	82	15
PM2.5	65	12
CO	548	100
$CO2_e$	548,000	100,000
SO_x	137	25
H_2S	54	10
Pb	3	0.6

SOURCE: Mojave Desert Air Quality Management District, 2016. *CEQA and Federal Conformity Guidelines,* page 10, http://mdaqmd.ca.gov/home/showdocument?id=192, accessed February 2019.

Impact and Mitigation Analysis of Project Modifications

Construction of the Project modifications would require excavation, trenching and operation of additional pumps to facilitate movement of the water. Assumptions were made as inputs to the emissions model (CalEEMod, version 2016.3.2) that would estimate the potential maximum daily air emissions (worst-case-scenario). The assumptions include the following: a conservative scaling of operation emissions for the additional 2 miles of pipeline, 5 chemical delivery trucks per month, and additional backup emergency power, limited to 200 hours per year during operation (refer to Appendix B, Air Emissions Technical Study, for full list of CalEEMod assumptions and summary outputs for the 2012 EIR and Project modifications). Estimated maximum operational emissions of the Project modifications are provided in **Table 9.**

Table 9
PROJECT MODIFICATIONS ESTIMATED MAXIMUM UNMITIGATED REGIONAL OPERATIONAL EMISSIONS (POUNDS PER DAY)

Source	VOC	NO_X	CO	SO_2	PM10	PM2.5
Operation						
WTP Emissions	0.77	0.56	0.66	<1	0.13	0.05
Pipeline Modification Emissions	5.83	5.49	10.94	<1	1.99	0.36
2012 EIR Project Emissions	125.33	117.99	235.18	<1	42.69	7.68
Maximum Daily Emissions (at Buildout)	**131.9**	**124.0**	**246.8**	**<1**	**44.8**	**8.1**
MDAQMD Significant Emissions Thresholds	137	137	548	137	82	65
Exceeds Thresholds?	**No**	**No**	**No**	**No**	**No**	**No**

Source: ESA 2019

As depicted in **Table 9**, the conservative and over-estimated maximum daily operational emissions of the Project modifications would not exceed MDAQMD thresholds.

Issues (and Supporting Information Sources):	*Potentially Significant Impact*	*Less Than Significant with Mitigation Incorporated*	*Less Than Significant Impact*	*No Impact*
AIR QUALITY — Where available, the significance criteria established by the applicable air quality management district or air pollution control district may be relied upon to make the following determinations. **Would the project:**				
a) Conflict with or obstruct implementation of the applicable air quality plan?	☐	☒	☐	☐
b) Result in a cumulatively considerable net increase of any criteria pollutant for which the project region is non-attainment under an applicable federal or state ambient air quality standard?	☐	☒	☐	☐
c) Expose sensitive receptors to substantial pollutant concentrations?	☐	☐	☐	☒
d) Result in other emissions (such as those leading to odors) adversely affecting a substantial number of people?	☐	☐	☐	☒

Discussion

a) The 2016 MDAQMD CEQA Guidelines state that a project is non-conforming if it conflicts with or delays implementation of any applicable attainment or maintenance plan. A project is conforming if it complies with all applicable MDAQMD rules and regulations, complies with all proposed control measures of the applicable plan, and is consistent with the growth forecasts in the applicable plan. Consistent with the 2012 EIR, the region remains in nonattainment for ozone and particulate matter (PM10 and 2.5). The 2012 EIR included mitigation measures AQ-1 through AQ-5 that would be necessary in order to comply with the MDAQMD's air quality management and attainment plans. The Project would also be required to comply with all rules and regulations established by MDAQMD's to permit construction and operation of the Project. Modifications to the Project would also be required conform to applicable MDAQMD rules and regulations regarding management of the air basin.

b) Project construction activities would generate criteria pollutant emissions from the operation of heavy-duty construction equipment. Mobile source emissions would also be produced from construction worker vehicle trips to and from the Project site. The Project modifications would not require a substantial increase in on-site employees nor an increase in the daily construction activities such as grading and excavation. Construction methods of modified pipeline alignment would be identical to those analyzed in the 2012 EIR, Chapter 3, Section 3.7, *Project Construction*. Construction of the treatment plant would occur within the modified alignment footprint as illustrated in Figure 4 and would not require construction methods substantially different than those assessed in the 2012 EIR. The construction of an additional 2 miles of pipeline would occur at the same daily rate as identified in the emissions assessment conducted for the 2012 EIR (Appendix B). Most of the construction activities would involve erection and installation of treatment facilities within the modified pipeline alignment. Dust suppression mitigation measures would apply to the treatment plant construction area to minimize dust emissions. There would be no increase in the grading and excavation emissions per day activities evaluated in the 2012 EIR thus, pounds per day of construction emissions would not increase. Therefore, construction emissions as a result of the modifications would be negligible.

Operations of the water treatment facilities would require approximately 315 HP that would be offset by a hydroelectric energy facility constructed on site (Figure 4). The addition of 5 trucks per month for chemical deliveries during operation would increase fugitive dust associated with traveling on unpaved roads near the Project site. However, as indicated in Table 9, these emissions would be minimal. To convey the treated water to the CRA, modifications include the installation of two BPS, with a combined HP of 5,828. However, the Project's revised emissions due to energy requirements have been updated since the preparation of the 2012 EIR consistent with availability of newer engine models. With the Project modifications, the Project as a whole would require approximately 15,170 HP to operate facilities. This total power requirement is less than the total power need assumptions of 16,200 HP (12 MW) modeled in the 2012 EIR (Appendix B). As a result of the availability of newer model engines, the estimated installed capacity to drive the Project groundwater pumps is now approximately 8,066 HP. The addition of the BPS would increase operational emissions from approximately 8,066 to 15,170 HP. Therefore, overall Project emissions, with modifications, are expected to be less than emissions estimated in the 2012 EIR.

MDAQMD states that if an individual project results in air emissions of criteria pollutants that exceed MDAQMD's recommended daily thresholds for project-specific impacts, then the project would also result in a cumulatively considerable net increase of these criteria pollutants. The 2012 EIR (Table 4.3-5) concluded that construction emissions of the Project would result in the release of significant levels of NOx (nitrogen oxides). The 2012 EIR concluded that mitigation measures AQ-1 through AQ-5 would be necessary in order to reduce construction and operation emissions. MDAQMD requires permits to operate new internal combustion engines. Therefore, each natural gas engine would require a permit from MDAQMD prior to initiation of the Project. In addition, each piece of construction equipment would be required to comply with MDAQMD's rules and regulations regarding NOx.

Therefore, the emissions from construction and operation of the modifications would not significantly exceed the assumptions estimated in the 2012 EIR and therefore, there would be no new significant impact to air emissions from construction and operation of the water treatment facilities and modified pipeline alignment.

c) The Project area is sparsely populated. The nearest sensitive receptors to the Project facilities are located approximately 3.3 miles north of the Project site near the corner of Cadiz Road and National Trails Highway. The small community of Amboy is located approximately 10 miles to the west on Highway 66, and is populated by less than 20 people. No other sensitive receptor is located in the Project area for over 10 miles. Therefore, odor emissions resulting from the Project modifications would be undetectable.

As described in the 2012 EIR, the maximum daily construction emissions did not exceed MDAQMD thresholds, except for NO_X, and Mitigation Measure AQ-1 and AQ-5 would be implemented to reduce impacts from short-term construction air emissions. Project modifications would not increase daily maximum construction as intensity of construction would not change, thus pounds per day construction emissions estimated in the 2012 EIR (Table 4.3-5) would not go up or down. However, NOx construction emissions remain significant and unavoidable. Operational emissions predicted for the Project and the Project modifications are now less than Project emissions estimated in 2012. No new mitigation could be incorporated to reduce Project NOx emissions.

Mitigation Measures in the 2012 EIR

AQ-1: Construction and operation of the proposed Project shall be conducted in compliance with applicable rules and regulations set forth by the Mojave Desert Air Quality Management District.

AQ-2: The following dust control measures shall be implemented during construction:

- All soil excavated or graded shall be sufficiently watered to prevent excessive dust. Watering shall occur as needed with complete coverage of disturbed soil areas.

- Watering shall take place a minimum of twice daily on unpaved/untreated roads in areas with active operations.
- Areas disturbed by clearing, earth moving, or excavation activities shall be minimized at all times.
- Stockpiles of soil or other fine loose material shall be stabilized by watering or other appropriate method such as non-toxic soil binders to prevent wind-blown fugitive dust.
- On-site vehicle speed on unimproved roads shall be limited to 15 miles per hour.
- Streets adjacent to the Project site shall be kept clean and Project-related accumulated silt shall be removed.

AQ-3: The following measures shall be implemented during construction of the proposed Project:

- All equipment shall be maintained as recommended by manufacturer's manuals.
- Idling engines shall be shut down when not in use for over 30 minutes.
- Electric equipment shall be used whenever possible in lieu of diesel or gasoline powered equipment.
- All construction vehicles shall be equipped with proper emissions control equipment and kept in good and proper running order to substantially reduce NOx emissions.
- On-road and off-road diesel equipment shall use diesel particulate filters if permitted under manufacturer's guidelines.
- The Project shall develop a plan demonstrating that the off-road equipment (more than 50 horsepower) to be used in the construction Project (i.e., owned, leased, and subcontractor vehicles) would achieve a Project-wide fleet-average 20 percent NOx reduction and 45 percent PM reduction compared to the most recent CARB fleet average. Acceptable options for reducing emissions include the use of late model engines, low-emission diesel products, alternative fuels, engine retrofit technology, after-treatment products, add-on devices such as particulate filters, and/or repowering off-road engines/equipment with Tier 2 or Tier 3 engines that operate within allowable emission ranges and as a result, would achieve emission reductions.

AQ-4: All trucks hauling dirt, sand, soil, or other loose materials are to be covered.

AQ-5: Chapter 6.8 of the GMMMP shall be implemented to verify air quality. If changes in air quality occur that exceed baseline conditions over a five-year moving average, the following corrective measures shall be implemented:

- Modification of Project operations to re-establish baseline level air quality levels. Modifications to Project operations would include one or more of the following:

- Reduction in pumping from Project wells;
- Revision of pumping locations within the Project wellfield;

- Stoppage of groundwater extraction for a duration necessary to correct the predicted impact.

Significance Determination

Impacts from construction and operation to air quality from the Project modifications are consistent with those identified in the 2012 EIR. Substantial changes are not proposed in the Project, requiring major revisions of the previous EIR due to the involvement of new significant environmental effects or a substantial increase in the severity of previously identified significant effects to air quality. Although the construction emissions from the Project modifications alone would not exceed thresholds, they would contribute to the overall Project emissions, resulting in significant and unavoidable impacts as described in the previous EIR. No new information of substantial importance indicates the project would have one or more significant effects not discussed in the previous EIR to air quality nor are significant effects previously examined substantially more severe than described in the previous EIR. No mitigation measures or alternatives previously found not to be feasible would in fact be feasible and would substantially reduce one or more significant effects of the project; and no mitigation measures or alternatives that are considerably different from those analyzed in the previous EIR would substantially reduce one or more significant effects to air quality.

IV. Biological Resources

Summary of Project Impacts in the 2012 EIR

Table 10 summarizes the Project's impacts on biological resources and relevant mitigation measures from the 2012 EIR. The EIR determined that the Project would have a less than significant effect to biological resources with implementation of Mitigation Measures AES-1, AES-2, and BIO-1 through BIO-17 mitigation measures.

TABLE 10
BIOLOGICAL RESOURCES IMPACTS AND MITIGATION SUMMARY

Proposed Project Impact	Mitigation Measure	Significance Conclusion
Groundwater Conservation and Recovery Component		
Special-status Wildlife Species	**AES-1**, **AES-2**, and **BIO-1** through **BIO-13**	Less than significant with mitigation
Special-status Plant Species	**BIO-14**	Less than significant with mitigation
Sensitive Habitat	**BIO-5** and **BIO-6**	Less than significant with mitigation
Wetlands	**BIO-15**	Less than significant with mitigation
Wildlife Movement	None required	Less than significant
Local Policy or Ordinance	**BIO-16** and **BIO-17**	Less than significant with mitigation
Habitat Conservation Plan	None required	Less than significant
Imported Water Storage Component		
Special-status Wildlife Species	**AES-1**, **AES-2**, **BIO-1** through **BIO-12**, and **BIO-17**	Less than significant with mitigation
Special-status Plant Species	**BIO-14**	Less than significant with mitigation
Sensitive Habitat	None required	Less than significant
Wetlands	None required	Less than significant
Wildlife Movement	None required	Less than significant
Local Policy or Ordinance	**BIO-16** and **BIO-17**	Less than significant with mitigation
Habitat Conservation Plan	**BIO-7**	Less than significant with mitigation

The water treatment facilities would be constructed along the modified pipeline alignment. The pipeline would be underground once constructed and would transport water. On December 28, 2017, ESA biologists conducted a biological resources survey of the modified water conveyance alignment area. The survey area included the entirety of the modified pipeline segment width of 180 feet and an approximate 50-foot buffer on each side of the alignment, which incorporates the area in which the facilities would be installed. Site walks and aerial imagery was used to verify the vegetation and habitat within the Project area, including the presence of potentially jurisdictional washes. As with the majority of the Project area, the habitat comprising the water conveyance alignment modification and treatment plant, storage, and booster pumping station site consist of Mojave creosote bush scrub. This community is dominated by creosote bush (*Larrea tridentata*) and burrobush (*Ambrosia dumosa*), and is characterized by widely spaced, tall shrubs (ESA, 2019). Several washes cross the revised alignment segment that generally support higher concentrations of Mojave wash scrub, especially creosote. Dominant perennials observed within the washes during the survey include creosote, burrobush, arrowweed (*Pluchea sericea*), wash rabbitbrush (*Chrysothamnus paniculatus*), smoke tree (*Dalea spinosa*) and bladderpod (*Isomerus arborea*) (ESA, 2019). Based on a site walk and review of current aerial photographs, the washes that traverse the water treatment facility site consist of Mojave wash scrub and are consistent with the numerous other washes located within the Project area and described in the 2012 EIR (Chapter 4, Section 4.4).

Impact and Mitigation Analysis of Project Modifications

Issues (and Supporting Information Sources):	*Potentially Significant Impact*	*Less Than Significant with Mitigation Incorporated*	*Less Than Significant Impact*	*No Impact*
4. BIOLOGICAL RESOURCES — Would the project:				
a) Have a substantial adverse effect, either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special-status species in local or regional plans, policies, or regulations, or by the California Department of Fish and Game or U.S. Fish and Wildlife Service?	☐	☒	☐	☐
b) Have a substantial adverse effect on any riparian habitat or other sensitive natural community identified in local or regional plans, policies, regulations, or by the California Department of Fish and Game or U.S. Fish and Wildlife Service?	☐	☒	☐	☐
c) Have a substantial adverse effect on state or federally protected wetlands (including, but not limited to, marsh, vernal pool, coastal, etc.) through direct removal, filling, hydrological interruption, or other means?	☐	☒	☐	☐
d) Interfere substantially with the movement of any native resident or migratory fish or wildlife species or with established native resident or migratory wildlife corridors, or impede the use of native wildlife nursery sites?	☐	☐	☒	☐
e) Conflict with any local policies or ordinances protecting biological resources, such as a tree preservation policy or ordinance?	☐	☒	☐	☐
f) Conflict with the provisions of an adopted Habitat Conservation Plan, Natural Community Conservation Plan, or other approved local, regional, or state habitat conservation plan?	☐	☐	☒	☐

Discussion

a) A records search of the California Department of Fish and Wildlife (CDFW) California Natural Diversity Database (CNDDB) revealed that five species of special-status plants and eight species of special-status wildlife had been documented in the region, which included a search area comprising of 9 USGS 7.5-minute quadrangle (quad) maps, including desert tortoise (*Gopherus agassizii*), burrowing owl (*Athene cunicularia*) and American badger (*Taxidea taxus*). A new query of the CNDDB that included a 9 quad search area revealed one additional special-status plant species, glandular ditaxis (*Ditaxis claryana*), and one additional special-status bird species, hepatic tanager (*Piranga flava*) that have been recorded in the vicinity of the Project area since the 2012 EIR. Both glandular ditaxis and hepatic tanager prefer creosote bush scrub habitat; therefore, these species have the potential to occur in the Project area (CNDDB, 2018).

The 2017 Biological Resources Survey (Appendix C) included an assessment of the potential for special-status wildlife to be present, most notably, any burrows capable of supporting desert tortoise (*Gopherus agassizii*), burrowing owl (*Athene cunicularia*) and American badger (*Taxidea taxus*) along the modified pipeline alignment corridor. Biologists conducted pedestrian transect surveys within the new pipeline alignment, which included a 50-foot buffer on each side, in search of any sign that could indicate that any of these species may be present, such as tracks, scat, bone fragments, feathers, scutes, and other indicators of presence. The overall habitat value within the modified pipeline corridor was examined for its potential to support special-status species that have been historically recorded in the region of the Project, which includes those evaluated in the 2012 EIR.

Based on the results of the 2017 biological resource survey, no sign of desert tortoise, burrowing owl, American badger or any other special-status animal species were observed within the survey area (Appendix C). The new facilities that would be located along the modified pipeline alignment are not within desert tortoise habitat (Figure 4.4-3, 2012 EIR). As concluded in the 2012 EIR, and as verified during the 2017 biological resource survey, the overall habitat in the general area has a low potential to support special-status wildlife species (Appendix C). In particular, the potential for desert tortoise to occur is considered low because the at the Project site is below the known elevation range of the desert tortoise. More importantly, no sign of desert tortoise, including any burrows capable of supporting the species, were observed. Small, approximate 2-to-3-inch reptile burrows were observed within the survey area, none of which could support desert tortoise, burrowing owl or American badgers.

Since the preparation of the 2012 EIR, studies have been published evaluating the connectivity of local natural springs to the underlying aquifer, suggesting that reduction in groundwater levels could adversely affect the springs, which are a vital resource for native wildlife including bighorn sheep (Love and Zdon, 2018; Zdon et al., 2018 [Zdon reports]). Kreamer (2018; 2019) evaluated the Zdon reports and concluded that the purported connection between Bonanza Spring and the Fenner and Cadiz Basins are unsupported by the evidence cited and that the conclusions were seriously flawed (refer to discussion related to Natural Springs in the Hydrology and Water Quality section of this Addendum and Appendix D).

Therefore, subsequent evaluations of studies conducted by Zdon et al. (2018) have concluded there is no connectivity between the groundwater basins and Bonanza Springs, and thus, there is no impact to desert bighorn sheep relying on Bonanza Spring as a water source.

There is no designated critical habitat in the vicinity of the modified pipeline segment or the water treatment facility site; therefore, there would be no impacts to critical habitat.

As described in the 2012 EIR, Section 4.12, the predominant sources of noise include railroad noise, roadway traffic, and equipment noise from existing agricultural operations. Military operations including explosions and low-flying aircraft also generate noise in the valley. Average noise levels in desert environments typically are in the range of 35-55 A-weighted decibels (dBA). In this naturally quiet environment, trains traversing the valley (10 to 20 per day on the BNSF and 2 or 3 on the ARZC) are the primary source of man-made noises. As described in the 2012 EIR, page 4.4-40, construction noise would temporarily affect wildlife species in the near proximity. However, construction of the Project would occur incrementally, and noise would be localized to the area of work. Given the vast open space in the Project area, the construction noise would attenuate to moderate levels within a few hundred feet. Furthermore, the proposed modifications would not result in substantially increased construction noise compared to that analyzed in the 2012 EIR. Impacts of constructing the treatment facilities would be similar to construction noise analyzed in the 2012 EIR.

Noise generated by the water treatment facilities pumps during operation is not expected to exceed 65 dBA outside the facility boundary (**Figure 6**). The facilities would be constructed with sound attenuation features to limit noise generation. The noise would attenuate to below audible levels in close proximity to the facility, which is surrounded by vast desert open space. Wildlife would easily avoid the area that is adjacent to active agricultural operations. Operational noise impacts associated with the proposed modifications would not be substantially greater than that analyzed in the 2012 EIR.

Motion sensing lights installed at the water treatment facilities would increase light sources if sustained motion is detected, however this is unlikely. Night time construction activities would also produce light that could impact nocturnal species. Mitigation Measure **AES-1** and **AES-2** would be implemented to reduce impacts from night time light sources by shielded or recessed lighting so that light is directed toward the construction site. Implementation of Mitigation Measure **BIO-1**, **BIO-9** through **BIO-14** requires preconstruction surveys and avoidance and minimization measures for sensitive biological resources. **BIO-2** through **BIO-4** would ensure protection of desert tortoise through exclusion fencing and development of the Desert Tortoise Avoidance and Protection Plan. Mitigation Measure **BIO-5** would ensure that construction of the revised pipeline segment would minimize disturbance to previously undisturbed areas. Mitigation Measure **BIO-6** would require that temporarily affected areas are restored to pre-construction conditions or better. Mitigation Measure **BIO-7** would require preparation and implementation of a habitat compensation plan for mitigation of permanent and temporary habitat loss. Construction of the proposed modifications would be subject to the same mitigation as the rest of the project.

b) The habitat comprising the water conveyance alignment consists of Mojave creosote bush scrub, which is designated by CDFW as a Sensitive Natural Community. During the 2017 biological resources survey of the revised alignment segment, a total of nine ephemeral washes supporting Mojave creosote bush scrub habitat were delineated that cross the new pipeline alignment segment. As described in the 2012 EIR, the modified water conveyance pipeline would be made of steel and would be buried underground, and would require pipeline appurtenances visible on the surface, including air and vacuum relief valves, blow-off facilities, and access manholes. Appurtenances would be accessed periodically for maintenance. At each ephemeral wash crossing, the pipeline would be either encased in concrete or protected with an underground concrete apron. This reinforcement would protect against future scouring in the washes. Construction and operation of the revised pipeline segment would be installed and operated consistent with the Project as described in Chapter 3 of the 2012 EIR.

c) The nine ephemeral desert washes that cross the revised pipeline alignment do not support wetland habitats (Appendix C). Additionally, the location of the water treatment facilities was selected to avoid ephemeral washes. Construction activities such as vegetation disturbance, grading, trenching, and placement of temporary or permanent structures are regulated within the washes pursuant to Section 1602 of the California Fish and Game Code and Porter Cologne Water Quality Control Act. Therefore, permits would be required from CDFW and the Regional Water Quality Control Board prior to disturbance. Mitigation Measure **BIO-7** would require preparation and implementation of a habitat compensation plan for mitigation of permanent and temporary habitat loss. Site restoration required by Mitigation Measure **BIO-15** would ensure that the washes are returned to pre-construction contours.

d) As described in the 2012 EIR, BLM has designated several regional wildlife movement corridors connecting occupied bighorn sheep habitat in the Project vicinity. Specifically, the wellfield would be located within the bighorn sheep movement corridor connecting the neighboring mountain ranges. However, the pipeline segment and the water treatment facility site are situated in open desert scrub adjacent to existing agricultural activities. The Project modifications are not located within a bighorn sheep movement corridor, nor are they located within occupied bighorn sheep habitat (see Figure 4.4-4, Bighorn Sheep Range and Movement Corridor, 2012 EIR). The pipeline alignment would be constructed in segments and any disturbance would be both temporary and localized to the specific segment under construction, allowing for wildlife movement around the impacted area. Fences would surround the 10-acre water treatment site but would not create a linear barrier across the valley floor that would impede wildlife movement as wildlife is expected to adapt and move around the facilities. Construction of the modifications would not affect the movement corridor of the bighorn sheep.

e) In accordance with San Bernardino County Desert Native Plant Protection Ordinance, certain species are considered locally important or “special-status”: smoke tree (*Dalea spinosa*), all mesquites (*Prosopis spp*.), all species of the family Agavaceae (i.e., yucca, century plant, and nolina), creosote rings (10 feet or greater in diameter), and Joshua trees (*Yucca brevifolia*). As described in the 2012 EIR, the following species are known to occur on or adjacent to the Project area, which are protected in accordance with the San Bernardino County Desert Native Plant Protection Ordinance: Harwood’s milk-vetch, barrel cactus, silver cholla, beavertail cactus, pencil cholla, desert holly, catclaw acacia, palo verde, and smoke tree. These species were not observed during the rare plant survey conducted in April 2017 for the pipeline alignment, nor the 2017 survey of the revised pipeline alignment and treatment plant, storage and booster pumping station area. The water treatment facilities would occupy approximately 10 acres of Mojave creosote bush scrub habitat. It is anticipated that construction of the treatment plant, storage and booster pumping station would require temporary or permanent removal of Mojave creosote bush scrub. The Mojave Desert creosote scrub community that is present within the Project area is not ideal for supporting these species. As described in the 2012 EIR, implementation of Mitigation Measures **BIO-16** and **BIO-17** would reduce any potential impacts to plants protected in accordance with the San Bernardino County Desert Native Plant Protection Ordinance, if determined to be present onsite. Prior to commencement of ground disturbance activities for any component of the proposed Project, a qualified biologist/arborist shall provide an inventory of the number and size of protected species within the proposed Project's impact areas. The qualified biologist/arborist shall mark any smoke tree (Dalea spinosa), mesquites (Prosopis spp.), all species of the family Agavaceae (i.e., yucca, century plant, and nolina), creosote rings (10 feet or greater in diameter), and Joshua trees within the construction zone. Removal of these plants shall be avoided if possible. If avoidance of the species listed in is not possible, these species shall be moved or replanted pursuant to the methods required in the Desert Native Plant Protection Ordinance.

f) With the adoption of the Northern & Eastern Colorado Desert Coordinated Management Plan (NECO) in 2002, all lands that are outside Desert Wildlife Management Areas (DWMA) are characterized as Category 3 Habitat, which includes the Project area. Category 3 Habitat is the lowest priority management area for viable populations of the desert tortoise. However, 41 linear feet of the new pipeline alignment is located on BLM land and is within the Cadiz Valley ACEC (Area of Critical Environmental Concern) and the South Mojave - Amboy NCL (National Conservation Lands).

As part of the Desert Renewable Energy Conservation Plan (DRECP), the BLM has established the Cadiz Valley ACEC (Area of Critical Environmental Concern) and the South Mojave - Amboy NCL (National Conservation Lands) to protect and prevent irreparable damage to important historical, cultural, and scenic values; fish or wildlife resources, or other natural systems or processes; or to protect human life and safety from natural hazards. Areas protected based on their importance for fish and wildlife resources include habitat for endangered, threatened, or sensitive species, or habitat essential for maintaining species diversity. Areas protected based on their importance for natural processes or systems may be habitat for endangered, sensitive, or threatened plant species; rare, endemic, or relic plants or plant communities that are terrestrial, aquatic, or riparian; or rare geological features. The Cadiz Valley ACEC and South Mojave – Amboy NCL have been established to protect high quality habitat for desert tortoise. However, similar to the proposed Project described in the 2012 EIR, impacts to the desert tortoise are not anticipated to occur with the implementation of **BIO-3** Desert Tortoise Avoidance and Protection Plan that would be developed and adopted in consultation with the USFWS and CDFW prior to construction to protect the desert tortoise and other sensitive species in the Project area. The Desert Tortoise Avoidance and Protection Plan would cover the proposed project modifications in the same manner as described in the 2012 EIR. As a result, impacts within the ACEC and/or NCL would be minimal and once constructed the buried pipeline would not impede the objectives of these land use planning efforts. An easement from BLM would be required to cross approximately 41 feet from private land to the ARCZ railroad easement. The FVWA would obtain an easement from BLM for construction and operation of the pipeline on BLM managed lands (Figure 3). As required under the NEPA, impacts as a result of the segment of the modified pipeline alignment that would be installed on BLM managed lands would be determined by the BLM during review of the Project's *SF299 Application for Transportation and Utility Systems and Facilities on Federal Lands.* NEPA requires that federal agencies take their own steps to assess potential environmental impacts. As the managing federal agency, BLM would either grant or deny the easement for the 41-feet of pipeline upon completion of the NEPA process.

The modified pipeline alignment and water treatment plant, storage and booster pumping station are not located within desert tortoise critical habitat, nor are these areas located within a DWMA. The facilities would be located within the corridor surveyed for sensitive biological resources. Therefore, the Project's modifications would not conflict with an adopted habitat conservation plan for San Bernardino County or the Project area.

As described in the 2012 EIR, Mitigation Measure **AES-1**, **AES-2, BIO-1** through **BIO-17** would be implemented to reduce potential impacts from sensitive biological resources. Impacts related to modification of the Project during construction and operation are consistent with those described in Section 4.4 of the EIR and no new mitigation is required. Therefore, Project impacts, as modified, would remain less than significant with mitigation incorporated.

*Mitigation Measures**

AES-1: Construction lighting shall be shielded or recessed so that light is directed downward and/or away from adjoining properties and public rights-of-way, and towards the construction site, with the goal of minimizing light trespass and glare on adjacent properties and containing light within the construction site.

AES-2: Outdoor lighting shall be minimized and installed for safety and security purposes only. Outdoor lighting of Project facilities and access roads shall be shielded or recessed so that light is directed downward and/or away from adjoining properties and public rights-of-way and towards the Project site, with the goal of minimizing light trespass and glare on adjacent properties and containing light within the Project site.

BIO-1: Pre-construction Surveys. Immediately prior to construction activities, pre-construction surveys that comply with USFWS protocol shall be conducted to document any and all locations of burrows and desert tortoise sightings within all proposed disturbance areas that provide potential habitat for the species. If any active burrows are located in facility construction areas, to completely avoid impact on the burrows, construction will be delayed only to be resumed after a qualified biologist has determined that the tortoise has left the area and the burrow is inactive. Following pre-construction surveys, Mitigation Measure BIO-2 shall be implemented to install exclusion fencing around construction areas. Construction areas fenced but inactive for more than 48-hours will be resurveyed to confirm the absence of tortoise prior to resumption of construction activity.

** The California Department of Fish and Game (CDFG) changed their name to the California Department of Fish and Wildlife (CDFW) in 2013. The mitigation measures presented here are unchanged from the 2012 EIR.*

BIO-2: **Exclusion Fencing and Monitoring**. A chain-link or tortoise fence (one-inch by two-inch welded wire mesh attached to the chain-link fence, with approximately two feet above-ground and one foot buried below ground) shall be installed to exclude small wildlife species from entering the active work areas in areas of documented occurrences of special-status ground dwelling wildlife as determined during pre-construction surveys by a qualified biologist or as directed by USFWS. When crossing drainages, these temporary fences must be designed and maintained to allow storm water runoff to flow past the construction site. Fencing / barriers will be erected to completely surround all stationary construction sites (including staging areas) and will be monitored by an Authorized Biologist or Biological Monitor at all times. Along the pipeline construction corridor, temporary fencing may be used as needed and if any tortoises are observed in the surrounding area. Temporary tortoise-proof fencing may be used along the pipeline right-of-way if trenches or pits must be left open. If temporary fencing is used for this purpose it must be installed at the end of each working day. If pits and trenches are left open overnight, then ramps will be placed within them to allow animals, including tortoise to escape in the unlikely event of entrapment. Alternatively, trenches will be filled or covered when construction is not active.

BIO-3: **Desert Tortoise Avoidance and Protection Plan**. A Desert Tortoise Avoidance and Protection Plan shall be developed and adopted in consultation with the USFWS and CDFG prior to construction. Elements of the plan shall include, but are not limited to the following:

- Designated Project personnel will implement the avoidance and protection plan. A Field Contact Representative will be designated to oversee compliance with all tortoise avoidance and protective measures during Project construction, operation and maintenance. The Field Contact Representative will have the authority to halt work if there is non-compliance with any of the plan measures and will do so as needed.
- Facility site preparation activities (specifically vegetation grubbing and clearing) and all construction activity in the northeastern area of the wellfield in Sections 17 and 18 will be prohibited during the species' annual periods of high activity (April through May and September through October).
- A step-by-step protocol to be implemented whenever a desert tortoise is observed by construction or operational personnel. See also Mitigation Measure **BIO-4** Temporary Construction Halt. USFWS and CDFG personnel contacts will be identified for Technical Assistance on take avoidance if needed during construction.
- Flagging and delineation requirements for located burrows and areas with tortoise activity.
- An education program for all construction employees. Program will be conducted onsite prior to the onset of construction and will be provided repeatedly as needed to ensure that all Project contractors (firms) as well as all individuals complete the training. Participation will be recorded and verified. Tortoise protection will be emphasized during all scheduled safety meetings.
- Enforcement of speed limits and checking under vehicles for tortoise prior to leaving Project areas.
- Biological monitoring requirements for all ground disturbance activities. All construction sites and activities will be monitored by Authorized Biological Monitors. An Authorized Biologist (approved by USFWS and CDFG) will plan and

oversee all construction monitoring activities in the field. The authorized biologist will identify, train, and oversee biological monitors for day-to-day monitoring and reporting activities.

- To prevent increased use of the Project areas by common ravens and coyotes, implementation of measures such as trash management, removal of unnatural sources of standing water, and other means. Drilling mud pits and water discharges will be controlled to minimize the duration of standing water at any drilling site. A clean workplace will be maintained in all areas. No trash is to be thrown on the ground or left in open containers, equipment, or truck beds. Refuse receptacles with lids will be provided for all construction personnel and are to be maintained and emptied on a regular basis and at least weekly. Trash collection will be conducted in all construction areas as needed to keep all areas clean on a daily basis. Portable toilets will be provided and used by all construction personnel.
- At the end of construction all equipment removal will monitored by Authorized Biologists or Biological Monitors.

BIO-4: **Temporary Construction Halt.** If a desert tortoise is observed within 300 feet of the construction activities or is determined by the Authorized Biologist to be in harm's way, then construction activities shall be halted in the vicinity as directed by the Authorized Biologist. Work shall only continue once the Authorized Biologist determines there is no risk to the desert tortoise.

BIO-5: **Pipeline Siting to Minimize Vegetation Disruption.** The pipeline shall be installed within previously disturbed areas of the easement to the extent feasible. During construction, previously undisturbed areas within the pipeline alignment that are not needed for construction shall be staked and flagged to prevent construction equipment access or disturbance in these areas. The cordoned off areas shall be flagged and monitored by a qualified biologist during construction activities.

BIO-6: **Site Restoration Plan.** A special-status species and sensitive habitat restoration plan shall be prepared prior to construction for unavoidable temporary impacts on special-status plants and sensitive habitats. The plan would include, at a minimum, the following measures:

- A salvage and replacement program for the top 12 inches of surface material and topsoil. The program shall identify soil preparation requirements, including grain size specifications that shall need to be engineered or amended on site to match to the greatest extent feasible the existing surface soil conditions.
- A salvage and replanting program for perennial special-status species.
- An invasive plant species maintenance, monitoring, and removal program.
- Success criteria that establishes yearly thresholds for growth and reestablishment of habitat.
- A five-year maintenance and monitoring plan to ensure successful implementation of the restoration plan.

BIO-7: **Habitat Compensation.** A habitat compensation plan would be prepared and implemented that includes at a minimum the following measure:

- Purchase of compensatory mitigation lands or credits at a USFWS and CDFG approved conservation bank at a minimum 1:1 ratio for permanent habitat loss and

0.5:1 for temporary habitat loss (or that required by the USFWS and CDFG permit conditions) for preservation in perpetuity.

BIO-8: Prior to construction, surveys for Mojave fringe-toed lizard shall be conducted by a qualified biologist within the sand dunes and sand fields habitats within the ARZC ROW. If Mojave fringe-toed lizards are identified in the construction zone, the area shall be fenced during construction as described in BIO-2 to prevent lizards from entering the construction site. Once fenced, a qualified biologist shall trap the area for lizards and release captured lizards into adjacent suitable habitat as determined by the qualified biologist.

BIO-9: If construction and vegetation removal is proposed for the bird nesting period of February 1 through August 31, then pre-construction surveys for nesting bird species shall begin 30 days prior to construction disturbance with subsequent weekly surveys, the last one being no more than three days prior to work initiation. The surveys shall include habitat within 300 feet (500 feet for raptors) of the construction limits. Active nest sites located during the pre-construction surveys shall be avoided and a non-disturbance buffer zone established dependent on the species and in consultation with USFWS and CDFG. This buffer zone shall be delineated in the field with flagging, stakes, or construction fencing. Nest sites shall be avoided with approved non-disturbance buffer zones until the adults and young are no longer reliant on the nest site for survival as determined by a qualified biologist.

BIO-10: A burrowing owl survey shall be conducted pursuant to the Burrowing Owl Survey Protocol and Mitigation Guidelines of the California Burrowing Owl Consortium (1993) or per the Staff Report on Burrowing Owl Mitigation prepared by CDFG (1995). At a minimum, this survey shall include the following:

- A pre-construction survey conducted by a qualified biologist within 30 days of the start of construction. This survey shall include two early morning surveys and two evening surveys to ensure that all owl pairs have been located.
- If pre-construction surveys are undertaken during the breeding season (February 1st through July 31st) active nest burrows should be located within 250 feet of construction zones and an appropriate buffer around them (as determined by the Project biologist) shall remain excluded from construction activities until the breeding season is over.
- During the non-breeding season (August 15th through January 31st), resident owls may be relocated to alternative habitat. Owls shall be encouraged to relocate from the construction disturbance area to off-site habitat areas and undisturbed areas of the Project site through the use of one-way doors on burrows. If ground squirrel burrows, stand pipes, and other structures that have been documented during pre-construction surveys as supporting either a nesting burrowing owl pair or resident owl are removed to accommodate the proposed Project, these structures and burrows shall be relocated or replaced on or adjacent to the Project site. Relocated and replacement structures and burrows shall be sited within suitable foraging habitat within one-half mile of the Project area as determined by the qualified biologist. Suitable development-free buffers shall be maintained between replacement nest burrows and the nearest building, pathway, parking lot, or landscaping. The relocation of resident owls shall be in conformance with all necessary State and federal permits.

BIO-11: A qualified biologist shall conduct focused pre-construction surveys no more than two weeks prior to construction for potential American badger dens. If no potential American badger dens are present, no further mitigation is required. If potential dens are observed, the following measures are required to avoid potential adverse effects to the American badger:

- If the qualified biologist determines that potential dens are inactive, the biologist shall excavate these dens by hand with a shovel to prevent badgers from re-using them during construction.
- If the qualified biologist determines that potential dens may be active, the entrances of the dens shall be blocked with soil, sticks, and debris for three to five days to discourage use of these dens prior to Project disturbance. The den entrances shall be blocked to an incrementally greater degree over the three- to five-day period. After the qualified biologist determines that badgers have stopped using active dens within the Project boundary, the dens shall be hand-excavated with a shovel to prevent re-use during construction.
- Construction activities shall not occur within 30 feet of active badger dens.

BIO-12: Prior to construction activities, winter and spring surveys shall be conducted to determine the nature of trestle use by pallid bats. Surveys shall follow the appropriate site-specific protocol as determined in coordination with CDFG.

BIO-13: If a special-status natal bat roost site is found within the limits of construction during pre-construction surveys, the roosts shall be staked, flagged, fenced, or otherwise clearly delineated. Roosts shall be avoided with non-disturbance buffer zones established by a qualified biologist in consultation with the USFWS and CDFG until the site is no longer in active use as a natal roost.

BIO-14: Prior to construction, construction zone limits shall be marked by a qualified biologist and shall be staked, flagged, fenced, or otherwise clearly delineated to ensure that the construction zone is limited to minimize impacts on special-status plant species. These limits shall be identified on the construction drawings. No earth-moving equipment shall be allowed outside demarcated construction zones unless pre-approval is obtained from a qualified biologist.

BIO-15: A Waters of the State Mitigation Plan shall be prepared to include with RWQCB and CDFG permit applications. Conditions of the Mitigation Plan shall include at a minimum the following measures:

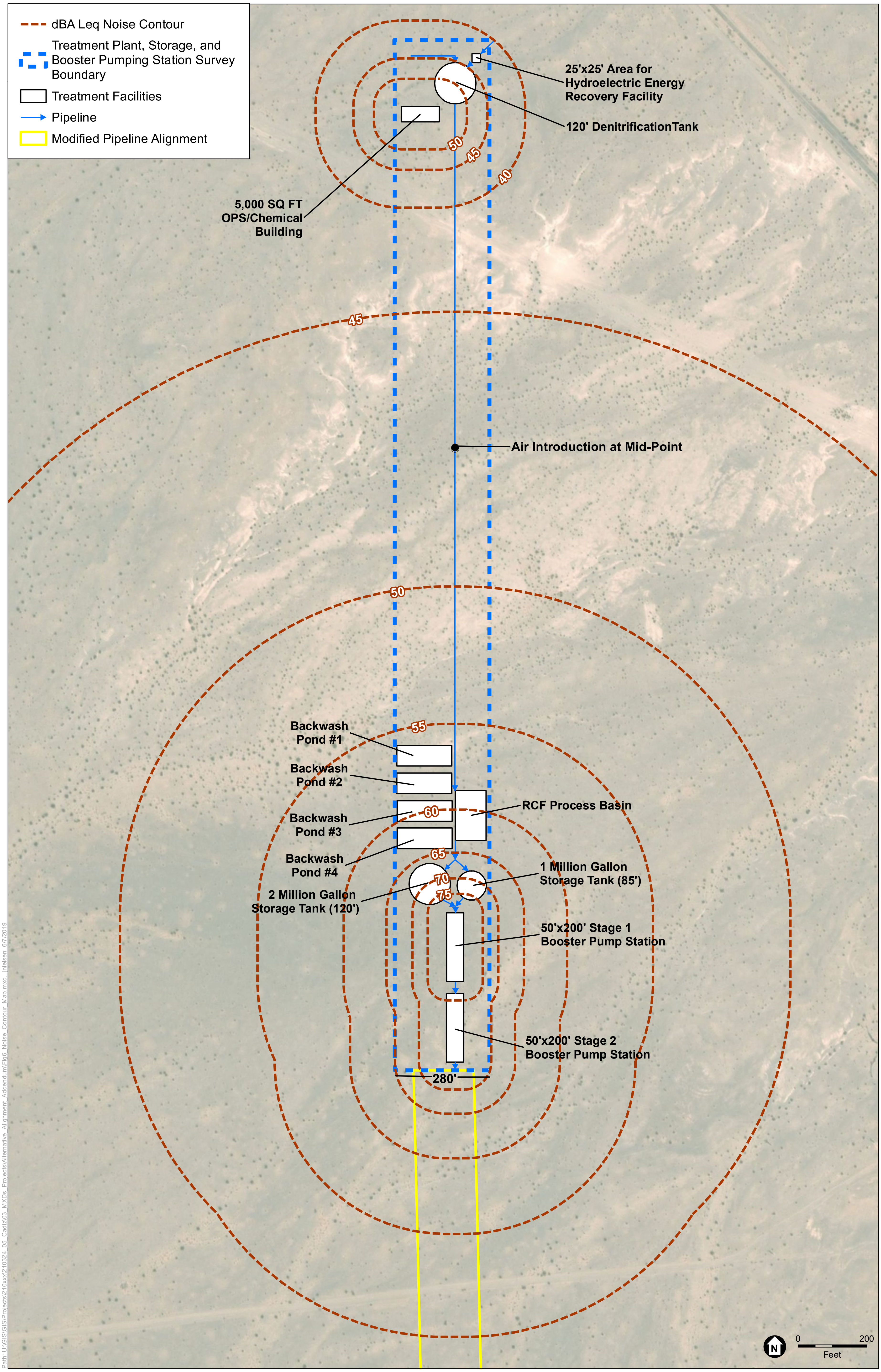
- measures to divert flows during construction,
- measures to minimize construction footprint within washes,
- measures to minimize erosion,
- measures to minimize discharge of contaminants through proper storage of chemicals and vehicle maintenance, and
- post-construction site restoration performance standards.

BIO-16: Prior to commencement of ground disturbance activities for any component of the proposed Project, a qualified biologist/arborist shall provide an inventory of the number and size of protected species within the proposed Project's impact areas. The qualified biologist/arborist shall mark any smoke tree (Dalea spinosa), mesquites (Prosopis spp.), all species of the family Agavaceae (i.e., yucca, century plant, and nolina), creosote rings (10 feet or greater in diameter), and Joshua trees within the construction zone. Removal of these plants shall be avoided if possible.

BIO-17: If avoidance of the species listed in BIO-16 is not possible, these species shall be moved or replanted pursuant to the methods required in the Desert Native Plant Protection Ordinance.

Significance Determination

Impacts to biological resources that may result from the Project's modified design are consistent with those identified in the 2012 EIR. Construction and operation of the modified conveyance pipeline alignment and water treatment facility would not result in any new significant environmental effects or a substantial increase in the severity of previously identified significant effects to biological resources. No new information of substantial importance indicates the Project would have one or more significant effects that were not discussed in the 2012 EIR nor are there any new significant effects that were not previously examined substantially or that would be more severe than described in the 2012 EIR. No new mitigation measures or alternatives are warranted and those already certified in the 2012 EIR would in fact be feasible and would substantially reduce any significant effects of the revised Project on biological resources. Moreover, there are no new mitigation measures or alternatives that are considerably different from those analyzed in the 2012 EIR, and the proposed mitigation measures are designed to minimize impacts to biological resources to a level of less than significant.



SOURCE: ESRI, 2019; ESA, 2019.

Cadiz Groundwater Project

Figure 6
Noise Contour Map

ESA

V. Cultural Resources

Summary of Project Impacts in the 2012 EIR

Table 11 summarizes the Project's impacts on cultural resources and relevant mitigation measures from the 2012 EIR. The EIR determined that the Project would have a less than significant effect to cultural resources with implementation of Mitigation Measures CUL-1 through CUL-7, and CUL-11.

TABLE 11
CULTURAL RESOURCES IMPACTS AND MITIGATION SUMMARY

Proposed Project Impact	Mitigation Measure	Significance Conclusion
Groundwater Conservation and Recovery Component		
Historical Resources	**CUL-1 through CUL-6**	Less than significant with mitigation
Archaeological Resources	**CUL-1 through CUL-7**	Less than significant with mitigation
Paleontological Resources	**CUL-8 through CUL-10**	Less than significant with mitigation
Human Remains	**CUL-2, CUL-3, CUL-6,** and **CUL-11**	Less than significant with mitigation
Indian Trust Assets	None required	No impact
Imported Water Storage Component		
Historical Resources	**CUL-1 through CUL-6**	Less than significant with mitigation
Archaeological Resources	**CUL-1 through CUL-7**	Less than significant with mitigation
Paleontological Resources	**CUL-8 through CUL-10**	Less than significant with mitigation
Human Remains	**CUL-11**	Less than significant with mitigation
Indian Trust Assets	None required	No impact

Construction and operation activities for the Project modifications are consistent with those activities described in the 2012 EIR. A Phase I Cultural Resources Assessment was conducted for the modified pipeline segment and treatment facilities sites on January 28 and February 20, 2019.

Impact and Mitigation Analysis of Project Modifications

Issues (and Supporting Information Sources):	*Potentially Significant Impact*	*Less Than Significant with Mitigation Incorporated*	*Less Than Significant Impact*	*No Impact*
V. CULTURAL RESOURCES — Would the project:				
a) Cause a substantial adverse change in the significance of a historical resource pursuant to §15064.5?	☐	☒	☐	☐
b) Cause a substantial adverse change in the significance of an archaeological resource pursuant to §15064.5?	☐	☒	☐	☐
c) Disturb any human remains, including those interred outside of formal cemeteries?	☐	☒	☐	☐

Discussion

a) Two historical resources, the Old Cadiz-Parker Road (P-36-011583) and the Atchison Topeka and Santa Fe (ATSF) Parker Cutoff railroad line (P-36-009853), were identified within and adjacent to (within 100 feet of) the modified pipeline alignment, respectively. The Old Cadiz-Parker Road has been previously recommended eligible for the National Register of Historic Places (NRHP) and California Register of Historical Resources (CRHR) under Criterion A/1 due to its association with the ATSF Parker Cutoff railroad line, and qualifies as a historical resource pursuant to CEQA. An approximately 40-foot east-west trending segment of the modified pipeline alignment would be installed beneath and perpendicular to the Old Cadiz-Parker Road bed via trenching (Phase I Cultural Resources Assessment, ESA, 2019). After installation of the conveyance pipeline segment, the road bed would be restored to its original condition and no permanent significant impacts to the resource's integrity of location, design, setting, materials, workmanship, feeling, and association would occur.

The ATSF Parker Cutoff railroad line (P-36-009853) has been determined eligible for listing in the NRHP under Criteria A and C, and therefore qualifies as a historical resource pursuant to CEQA (Phase I Cultural Resources Assessment, ESA, 2019). The railroad is located approximately 100 feet east of the modified pipeline alignment and would not be subject to direct impacts associated with the installation of the pipeline. The pipeline would be subsurface, no indirect visual impacts to the resource would occur.

A small portion, approximately 41 linear feet, of the new alignment would be installed within BLM lands The SMWD would obtain an easement from BLM for construction and operation of the pipeline on approximately 4,200 square feet of NCL designated lands (Figure 3).

Four archaeological resources (CAD-VNO-002-H, -003-H, -004-H, and -005-H) were identified within the modified pipeline alignment and one archaeological resource (CAD-VNO-001-H) was identified within 100 feet of the modified pipeline alignment (Phase I Cultural Resources Assessment, ESA, 2019). These five resources all consist of discrete historic-period refuse scatters containing sanitary cans and pull-tab beverage cans dating to the 1960s. Although artifacts date to the 1960s and are contemporary with use of the area during Joint Exercise Desert Strike, which occurred in May of 1964, and with the period of historic use of the ATSF Parker Cutoff, the sites do not contain evidence of a direct association with Desert Strike military training exercises and/or with maintenance of the ATSF Parker Cutoff. The five resources were evaluated and found not eligible for listing in the CRHR, and therefor do not qualify as historical resources pursuant to CEQA. No resources were identified within the water treatment plant component for the Project as a result of the survey.

Although no known historical resources would be significantly impacted by Project-related ground disturbance, there exists the possibility that previously unidentified archaeological deposits underlie the modified pipeline alignment. Should unknown subsurface archeological deposits underlie the Project alignment, they may qualify as historical resources pursuant to CEQA, and could be significantly impacted by Project-related ground disturbance.

b) As noted above, five historic-period archaeological sites were identified within the modified pipeline alignment. These five sites are comprised of refuse scatter dating to the 1960s, making them contemporary with use of the area during Joint Exercise Desert Strike, which occurred in May of 1964, and with the period of historic use of the ATSF Parker Cutoff (Phase I Cultural Resources Assessment, ESA, 2019). However, the five sites contain no data linking them with the Joint Exercise Desert Strike or the ATSF Parker Cutoff. These five resources do not contain information needed to answer important scientific research questions, they do not have special or particular qualities such as being the oldest of its type or the best available example of its type, nor are they directly associated with a scientifically recognized important prehistoric or historic event or person. Therefore, these five resources do not qualify as unique archaeological resources pursuant to CEQA.

Although no known unique archaeological resources were identified, there exists the possibility that previously unidentified archaeological deposits underlie the modified pipeline alignment. Should unknown subsurface archeological deposits underlie the Project alignment, they may qualify as unique archeological resources pursuant to CEQA, and could be significantly impacted by Project-related ground disturbance.

c) No human remains were identified within the modified pipeline alignment. However, this does not preclude the possibility of inadvertently uncovering human remains, including those interred outside of formal cemeteries, during Project implementation.

As described in the 2012 EIR, Mitigation Measure **CUL-1**, **CUL-6**, **CUL-7**, and **CUL-11** would be implemented to reduce potential impacts to cultural resources. Impacts related to modification of the Project during construction and operation are consistent with those described in Section 4.5 of the EIR and no new mitigation is required. Therefore, Project impacts, as modified, would remain less than significant with mitigation incorporated.

Mitigation Measures

CUL-1: A qualified archaeologist, defined as an archaeologist meeting the Secretary of the Interior's Standards for professional archaeology, shall be retained to carry out all mitigation measures related to archaeological resources.

CUL-6: Prior to construction, an archaeological monitor shall be retained to monitor all ground-disturbing activities, including brush clearance and grubbing, within the following areas: the proposed wellfield area; staging areas; CRA tie-in areas; and within 100 feet of all significant historical resources. The monitor shall work under the supervision of the qualified archaeologist. If ground-disturbing activities are occurring simultaneously in areas located more than 500 feet apart, additional monitors shall be retained. If so requested by the Native American community, a Native American monitor shall also monitor all ground-disturbing activities. The qualified archaeologist, in consultation with the lead agency, shall have the discretion to modify the monitoring requirements based on in-field observations of subsurface conditions. The duration and timing of monitoring shall be determined by the qualified archaeologist in consultation with the lead agency and based on the grading plans. In the event that cultural resources are unearthed during ground-disturbing activities, the archaeological monitor and/or Native American monitor shall be empowered to halt or redirect ground-disturbing activities away from the vicinity of the find so that the find can be evaluated and appropriate treatment determined.

CUL-7: If archaeological resources are encountered, all activity in the vicinity of the find shall cease until it can be evaluated by a qualified archaeologist. If the qualified archaeologist determines that the resources may be significant, he or she would develop an appropriate treatment plan for the resources. Appropriate Native American representatives shall be consulted in determining appropriate treatment for unearthed cultural resources if the resources are prehistoric or Native American in nature.

Work may proceed on other parts of the Project site while mitigation for cultural resources is being carried out.

CUL-11: If human remains are uncovered during Project construction, all work in the vicinity of the find shall be halted and the County Coroner would be contacted to evaluate the remains and follow the procedures and protocols set forth in Section 15064.5 (e)(1) of the CEQA Guidelines. If the County Coroner determines that the remains are Native American, the NAHC shall be contacted, in accordance with Health and Safety Code Section 7050.5, subdivision (c) and Public Resources Code 5097.98 (as amended by AB 2641). Per Public Resources Code 5097.98, the landowner shall ensure that the immediate vicinity, according to generally accepted cultural or archaeological standards or practices, where the Native American human remains are located, is not damaged or disturbed by further development activity until the landowner has discussed and conferred, as prescribed in this Section (PRC 5097.98) with the most likely descendants taking into consideration their recommendations, and developing a treatment plan, taking into account the possibility of multiple human remains.

Significance Determination

Impacts to cultural resources that may result from the Project's modified design are consistent with those identified in the 2012 EIR. Construction and operation of the modified conveyance pipeline alignment and water treatment facility would not result in any new significant environmental effects or a substantial increase in the severity of previously identified significant effects to cultural resources. The Project would not result in effects beyond those discussed in the 2012 EIR nor are there any new significant effects not previously examined that would be more severe than described in the 2012 EIR. No new mitigation measures or alternatives are warranted and those already certified in the 2012 EIR would in fact be feasible and would substantially reduce any significant effects of the revised Project on cultural resources. Moreover, there are no new mitigation measures or alternatives that are considerably different from those analyzed in the 2012 EIR, and the proposed mitigation measures are designed to minimize impacts to cultural resources to a level of less than significant.

VI. Geology, Soils and Seismicity

Summary of Project Impacts in the 2012 EIR

Table 12 summarizes the Impact and Mitigation Analysis in 2012 EIR for geology, soils and seismicity. The EIR determined that the Project would have a less than significant effect to erosion of soils and geological resources with implementation of HYDRO-1, HYDRO-4, BIO-6, GEO-1 and GEO-2 mitigation measures.

TABLE 12
GEOLOGY, SOILS, AND SEISMICITY IMPACTS AND MITIGATION SUMMARY

Proposed Project Impact	Mitigation Measure	Significance Conclusion
Groundwater Conservation and Recovery Component		
Seismic Impacts from Surface Fault Rupture, Ground Shaking, Landslides, or Liquefaction	None required	Less than significant
Soil Erosion and Loss of Topsoil	HYDRO-1 and BIO-6	Less than significant with mitigation
Geologically Unstable Area	GEO-1	Less than significant with mitigation
Expansive or Corrosive Soils	None required	Less than significant
Soil Suitability for Septic System	None required	No impact
Imported Water Storage Component		
Seismic Impacts from Surface Fault Rupture, Ground Shaking, Landslides, or Liquefaction	GEO-2	Less than significant with mitigation
Soil Erosion and Loss of Topsoil	HYDRO-1 and HYDRO-4	Less than significant with mitigation
Geologically Unstable Area	None required	Less than significant
Expansive or Corrosive Soils	None required	Less than significant
Soil Suitability for Septic System	None required	No impact

Construction and operation activities for the Project modifications are consistent with those activities described in the 2012 EIR. The geological and soil characteristics in the vicinity of the Project have not changed since the preparation of the 2012 EIR. The analysis evaluates impacts to geological, soil and seismicity as a result of the Project modifications.

Impact and Mitigation Analysis of Project Modifications

Issues (and Supporting Information Sources):	*Potentially Significant Impact*	*Less Than Significant with Mitigation Incorporated*	*Less Than Significant Impact*	*No Impact*
GEOLOGY AND SOILS — Would the project:				
a) Directly or indirectly cause potential substantial adverse effects, including the risk of loss, injury, or death involving:				
i) Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault? (Refer to Division of Mines and Geology Special Publication 42.)	☐	☐	☒	☐
ii) Strong seismic ground shaking?	☐	☐	☒	☐
iii) Seismic-related ground failure, including liquefaction?	☐	☐	☒	☐
iv) Landslides?	☐	☐	☒	☐
b) Result in substantial soil erosion or the loss of topsoil?	☐	☒	☐	☐
c) Be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the project, and potentially result in on- or off-site landslide, lateral spreading, subsidence, liquefaction, or collapse?	☐	☒	☐	☐
d) Be located on expansive soil, as defined in Table 18-1-B of the Uniform Building Code (1994), creating substantial direct or indirect risks to life or property?	☐	☐	☒	☐
e) Have soils incapable of adequately supporting the use of septic tanks or alternative waste water disposal systems where sewers are not available for the disposal of waste water?	☐	☐	☐	☒
f) Directly or indirectly destroy a unique paleontological resource or site or unique geologic feature?	☐	☒	☐	☐

Discussion

a) The Project site is not located along the trace of an active or potentially active fault or fault system. As evaluated in the 2012 EIR, with the nearest mapped active faults are located approximately 45 miles west of the Project site. Major seismic activity along the nearby and active San Andreas or Garlock fault systems, or other associated faults, could affect the Project modifications through strong seismic ground shaking. Strong seismic ground shaking could potentially cause structural damage to the Project facilities, possibly resulting in damage to facilities and interruption of service.

In the event that shallow groundwater is present, strong ground shaking could enable liquefaction of sediments. Liquefaction in such areas could cause differential settlement or other damage to pipelines, wells, and other facilities. Project treatment facilities as modified would be located upon relatively flat topography. A review of geologic maps of the area did not reveal any existing landslides within or adjacent to the Project site, and the soils associations identified for sloped areas are not anticipated to have a high propensity for landslides. The Project facilities would be designed to withstand strong ground shaking as required to comply with the California Building Code (CBC) to minimize the potential effects of liquefaction, ground shaking, landslides, and other seismic activity to Project facilities.

b) During the construction phase of the Project modifications, the use of heavy machinery for grading, trenching, facilities installation, and other activities would disturb surface topsoil layers. Existing desert vegetation in those locations would be removed from the facilities' installation sites, which would also disturb soils. These factors could expose construction areas to erosive forces including wind and storm-water runoff. Increases in erosion could result in changes to nearby topography, drainage patterns, and vegetation patterns in affected areas.

Upon completion of the Project modifications, a surface restoration crew would perform re-vegetation and erosion control. Excavated topsoil would be returned to the trenches and compacted, and or spread evenly at the site. Washes that are impacted by construction would be returned to their pre-construction condition. As described in the 2012 EIR, implementation of Mitigation Measures **HYDRO-1, HYDRO-4** and **BIO-6**, would reduce impacts to soil in the form of erosion from construction activities.

c) The Project facilities as modified would be within the area that could be affected by subsidence. As described in the EIR on Page 4.6-35 through 4.6-38, the maximum model-predicted subsidence in the vicinity of the Project modifications would not exceed railroad tolerance levels. Cadiz monitors subsidence in the Project area as part of its agricultural development monitoring program, and no subsidence has been observed in the area as a result of Cadiz' use of groundwater for irrigation since its agricultural operation began in 1993.

Section 6.3 of the Project's GMMMP (Appendix A) includes measures to verify model-predicted effects and confirm protection of critical resources from subsidence. As described in the 2012 EIR, implementation of Chapter 6.3 of the GMMMP as Mitigation Measure **GEO-1** would ensure that the potential impacts from subsidence are reduced to less than significant levels. If the subsidence is determined to be attributable to Project operations, then an assessment will be made to update trends and projections in subsidence over the remaining Project life and to determine whether the subsidence constitutes a potential adverse impact to aquifer health or surface uses.

d) There are no expansive soils within the area of the Project modifications (2012 EIR Section 4.6, page 4.6-39). Expansive soils generally occur in regions with moderate to high clay content. Mapped soil associations within the Project area contain very low to negligible amounts of clay material. No impact from expansive soils would occur.

As described in the 2012 EIR, the Project site is located in areas where the soils are known to have lower pH levels and higher salt contents. The corrosive effects of such soil conditions could reduce the integrity of steel or concrete materials. Failure of the water pipeline would result in damage to the conveyance facilities and the erosion of soil at the break location. A sudden failure of the water or natural gas pipe integrity could cause the release of water or natural gas at pressures that could cause injury to nearby workers.

The design of the modified pipeline alignment and associated subsurface infrastructure would be required to meet the minimum standards of the CBC for areas with potential corrosive soils. Buried metal pipes typically have cathodic protection installed that reduces corrosive effects. Compliance with the CBC would ensure that the facilities would be constructed to minimize the potential effects of corrosion. Therefore, impacts related to corrosion are less than significant.

e) The development of the Project modifications would not include the addition or removal of septic tanks or alternative wastewater disposal systems. Current worker accommodations in the vicinity are designed to accommodate septic demands for periodic work forces. Therefore, the issue of support for septic or alternate wastewater disposal systems would have no impact.

f) An updated paleontological resources records search prepared by the Natural History Museum of Los Angeles County (LACM) (McLeod, 2019) indicates the modified pipeline alignment and groundwater treatment facility are located on surficial deposits of Quaternary young alluvium (Qya). These deposits date to the Holocene and are younger than 10,000 years. Given the young age of these deposits, they are unlikely to contain in-situ fossil remains and have been assigned a Potential Fossil Yield Classification System (PFYC) rating of Class 2, low likelihood to contain vertebrate fossils or scientifically significant fossils. However, it should be noted that although PFYC Class 2 units have low paleontological sensitivity at the surface, they are often underlain at varying depths by older Pleistocene surficial deposits that may contain scientifically significant fossil remains. As such, Project-related ground disturbing activities associated the construction of the modified pipeline alignment and groundwater treatment facility can penetrate through the overlying low sensitivity Holocene age deposits into paleontologically sensitive Pleistocene-age deposits. As described in the 2012 EIR, implementation of Mitigation Measures **CUL-8** through **CUL-10** would ensure potential impacts to paleontological resources would be less than significant.

As described in the 2012 EIR, Mitigation Measure **HYDRO-1**, **HYDRO-4**, **BIO-6**, **CUL-8** through **CUL-10** and **GEO-1** and would be implemented to reduce potential impacts from soil erosion and land subsidence, and potential impacts to paleontological resources. Impacts related to modification of the Project during construction and operation are consistent with those described in Section 4.5 and 4.6 of the EIR and no new mitigation is required. Therefore, Project impacts, as modified, would remain less than significant with mitigation incorporated.

Mitigation Measures in the 2012 EIR

GEO-1: Chapter 6.3 of the GMMMP shall be implemented to address the potential impact for land subsidence. If land subsidence is observed at rates that are greater than projected by the groundwater flow simulation model for an equivalent elapsed time, or if a change in the ground surface elevation of more than 0.5 feet within the Project area occurs, or if subsidence of more than one inch vertically over 62 feet horizontally within the vicinity of railroad tracks occurs, the following shall occur:

Implement the corrective measures that involve modification of Project operations to actively arrest subsidence through one or more of the following:

– Reduction in pumping from Project wells;

– Revision of pumping locations within the Project wellfield;

– Stoppage of groundwater extraction for a duration necessary to correct the predicted impact; or

– Repair of any structures damaged as a result of subsidence attributable to Project operations.

HYDRO-1: A construction Storm Water Pollution Prevention Plan shall be prepared and included in construction specifications for the Project. At a minimum, the plan shall include the following required Best Management Practices or equivalent measures:

- Install temporary sediment fences or straw waddles at stream crossings or washes to prevent erosion and sedimentation during construction, including at each ARZC railroad trestle along the pipeline alignment.
- Establish designated fueling areas equipped with secondary containment,
- Require drip-pans under all idle equipment on the construction sites,
- Ensure that spill prevention kits are present at all construction sites.

HYDRO-4 ensures that above ground structures are not placed within any visible stream drainage or wash in a manner that could result in the restriction of surface water flow. In addition, because the drainage patterns of the intermittent streams in desert areas can change annually, if not with each individual rain event, the infrastructure elements shall be constructed to be protected from future changes to drainage patterns by routing water away and around the structures in such a manner so as to not concentrate the flow and increase the potential for erosion.

BIO-6: A special-status species and sensitive habitat restoration plan shall be prepared and approved by the USFWS and CDFG prior to construction for unavoidable temporary impacts on special-status plants and sensitive habitats. The plan would include, at a minimum, the following measures:

- A salvage and replacement program for the top 12 inches of surface material and topsoil. The program shall identify soil preparation requirements, including grain size specifications that shall need to be engineered or amended on site to match to the greatest extent feasible the existing surface soil conditions.
- A salvage and replanting program for perennial special-status species.
- An invasive plant species maintenance, monitoring, and removal program.
- Success criteria that establishes yearly thresholds for growth and reestablishment of habitat.
- A five-year maintenance and monitoring plan to ensure successful implementation of the restoration plan.

CUL-8: Prior to construction, those portions of the Project area (including the wellfield, CRA tie-in Options 2a and 2b, access roads, staging areas, and borrow areas) not previously surveyed within the past 5 years, shall be surveyed by a qualified vertebrate paleontologist, defined as one holding an advanced degree in paleontology, biology, or a related discipline, and having at least five years of professional experience. If paleontological resources are encountered, they shall be documented or recovered, and curated, as appropriate, prior to the start of construction. The evaluation will be documented in a report to be submitted for review and approval by the lead agency prior to the start of construction. The report shall also be submitted to the San Bernardino County Museum.

CUL-9: Prior to the start of any earth moving activity, a qualified vertebrate paleontologist shall be retained. The paleontologist shall prepare a Paleontological Mitigation and Monitoring Plan (PMMP) that shall be based on prior paleontological evaluations, including the results of the paleontological survey as described in Mitigation Measure CUL-8 in the 2012 EIR, and shall address pre-construction salvage and reporting; pre-construction contractor sensitivity training; procedures for paleontological resources monitoring including the identification of specific paleontological monitoring locations as defined by areas where Pleistocene age sediments may be impacted during construction; microscopic examination of samples where applicable; the evaluation, recovery, identification, and curation of fossils; and the preparation of a final mitigation report.

CUL-10: All earth-moving activities within those formations identified as sensitive within the PMMP shall be monitored on a full-time basis, unless the paleontologist determines that sediments are previously disturbed or there is no reason to continue monitoring in a particular area due to other depositional factors which would make fossil preservation unlikely or deemed scientifically insignificant. In the event fossils are exposed during earth moving, construction activities shall be redirected to other work areas until the procedures outlined in the PMMP have been implemented or the paleontologist determines work can resume in the vicinity of the find.

When fossils are discovered, they and associated data shall be collected quickly and professionally. Fossil salvage procedures shall include the collection of bulk matrix samples if scientifically significant microfossils are believed to be present based on field evidence. All fossils collected during monitoring shall be transferred to a secure facility for laboratory preparation and identification. Laboratory preparation shall include stabilization, matrix removal, and conservation of individual fossil specimens, as well as screenwashing and picking of bulk matrix samples. Fossils shall be prepared to the point of curation and identified by technical specialists, as needed, to the lowest possible taxonomic level. At the end of the Project, the paleontologist shall prepare a report that includes a description and inventory list of recovered fossil materials; a map showing the location of paleontological resources found in the field; determinations of sensitivity and significance; and a statement that Project impacts to paleontological resources have been mitigated. The results of the paleontological surveys, construction monitoring, and subsequent laboratory work shall be compiled in a final paleontological mitigation report authored by the qualified paleontologist for the Project. The final report shall include all Project data and a copy of the receipt of specimens from the paleontological repository. Following preparation, the fossils and associated data and a copy of the final paleontological mitigation report shall be transferred to a public museum (paleontological

Significance Determination

Impacts from construction and operation to geology and soil resources from the Project modifications are consistent with those identified in the 2012 EIR. Substantial changes are not proposed in the Project, requiring major revisions of the previous EIR due to the involvement of new significant environmental effects or a substantial increase in the severity of previously identified significant effects to geology and soil resources. No new information of substantial importance indicates the project would have one or more significant effects not discussed in the previous EIR nor are significant effects previously examined substantially more severe than described in the previous EIR. No mitigation measures or alternatives previously found not to be feasible would in fact be feasible and would substantially reduce one or more significant effects of the project; and no mitigation measures or alternatives that are considerably different from those analyzed in the previous EIR would substantially reduce one or more significant effects to geology and soil resources.

VII. Greenhouse Gas Emissions

Summary of Project Impacts in the 2012 EIR

Table 13 summarizes the Impact and Mitigation Analysis in 2012 EIR for greenhouse gas (GHG) emissions. The EIR determined that the Project would have a less than significant effect to GHG emissions with implementation of GHG-1 and GHG-2 mitigation measures.

TABLE 13
GREENHOUSE GAS IMPACTS AND MITIGATION SUMMARY

Proposed Project Impact	Mitigation Measure	Significance Conclusion
Groundwater Conservation and Recovery Component		
Greenhouse Gas Emissions	**GHG-1**	Less than significant with mitigation
Imported Water Storage Component		
Greenhouse Gas Emissions	**GHG-2**	Less than significant with mitigation

The Project modifications include the addition of 2-miles of pipeline and water treatment facilities. Operation of the treatment facilities would require 5 truck deliveries of chemicals per month and operations of pumps to convey the treated water to the CRA.

TABLE 14
ANNUAL CONSTRUCTION GREENHOUSE GAS EMISSIONS

Emission Source	CO_2e (Metric Tons) [a]
Water Treatment Plant Emissions	223
Pipeline Extension Emissions	571
2012 EIR Emissions [b]	13,448
Total Project Construction Emissions	**14,242**
Annual Construction Emissions (Amortized over 30 years)	**448**

a Totals may not add up exactly due to rounding in the modeling calculations
b Existing project emissions are “with natural gas” from Table 4.7-4 of the 2012 EIR

TABLE 15
ANNUAL PROJECT OPERATION GREENHOUSE GAS EMISSIONS

Emissions Source	CO_2e (Metric Tons per Year) [a]
Water Treatment Plant Emissions	221
Pipeline Extension Emissions	1,290
Final EIR Emissions	27,731
Total Annual Project Operational	**29,242**
Annual Project Construction (Amortized)	436
Total Annual Project GHG Emissions	**29,678**
Significance Threshold	100,000
Exceeds Threshold?	

[a] Totals may not add up exactly due to rounding in the modeling calculations
Source: ESA, 2011 & 2019.

Impact and Mitigation Analysis of Project Modifications

MDAQMD has jurisdiction over the desert portion of San Bernardino County and the far eastern end of Riverside County, and thus it has jurisdiction over the Project area. During preparation of the 2012 EIR, the MDAQMD had not adopted significance thresholds for the purposes of evaluating project construction emissions under CEQA for GHG emissions. Given the Project's proximity to the South Coast Air Quality Management District (SCAQMD), the 2012 EIR utilized, but did not adopt, the SCAQMD's significance threshold of 10,000 metric tons of carbon dioxide equivalent (MTCO2e) per year as a benchmark in evaluating the Project's contribution to GHG emissions. Since the preparation of the 2012 EIR, MDAQMD has established an annual GHG threshold of significance for evaluation of construction projects under CEQA of 100,000 MTCO2e, thus this evaluation uses the MDAQMD established threshold of significance.

Issues (and Supporting Information Sources):	*Potentially Significant Impact*	*Less Than Significant with Mitigation Incorporated*	*Less Than Significant Impact*	*No Impact*
VIII. GREENHOUSE GAS EMISSIONS — Would the project:				
a) Generate greenhouse gas emissions, either directly or indirectly, that may have a significant impact on the environment?	☐	☐	☒	☐
b) Conflict with an applicable plan, policy, or regulation adopted for the purpose of reducing the emissions of greenhouse gases?	☐	☐	☒	☐

Discussion

a) GHG emissions are considered to be exclusively cumulative impacts; there are no non-cumulative GHG emission impacts from a climate change perspective. However, estimated GHG emissions as a result of construction and operation of the Project modifications are below the MDAQMD established thresholds of significance for annual

GHG emissions of 100,000 MTCO2e per year. The Project modifications would not substantially increase GHG emissions compared with the 2012 EIR assumptions.

b) The Project is exempt from the County's zoning and development pursuant to Government Code section 53091. Emissions from construction and operation of the Project modifications are less than the MDAQMD established thresholds of significance for annual GHG emissions of 100,000 MTCO2e per year. Therefore, Project modifications would not conflict with plans, policies or regulations for the purpose of reducing GHG emissions. The Project modifications would not substantially increase GHG emissions compared with the 2012 EIR assumptions (refer to Appendix B).

The Project with or without the modifications would not exceed daily or annual GHG emissions thresholds of significance established by the MDAQMD. However, the 2012 EIR imposed a lower threshold of significance, requiring purchase of GHG offset credits to reduce total first year emissions to below 10,000 $MTCO_2e$. The total project emissions including the increment of emissions associated the proposed modifications would be validated by an accredited third-party verification body and reported to the Climate Registry as required in Mitigation Measure **GHG-1**. No new mitigation is required.

Mitigation Measures in the 2012 EIR

GHG-1: Within 90 days of completion of construction of the Groundwater Conservation and Recovery Component of the Project, carbon offset credits shall be purchased from the Climate Registry, or other source that is approved by CARB as being consistent with the policies and guidelines of the California Global Warming Solution Act of 2006 (AB 32), or that is approved by a local or regional agency with jurisdiction over or within San Bernardino County as local emissions credits under a GHG reduction plan or similar program, in sufficient quantity to reduce the Project's first year total (direct plus indirect) GHG emissions below 10,000 $MTCO_2e$ per year. The first year offsets identified in the binding agreement shall be purchased and retired no later than 12 calendar months from completion of the first full year of operation. The estimated amount of offsets required is 18,153 $MTCO_2e$ per year (i.e., 28,153 – 10,000 $MTCO_2e$ per year) if the wellfield and intermediate pump station are powered by natural gas. This volume may be reduced if less power is needed, solar power is provided, or diesel powered wells are retired at the Cadiz Ranch that would count as an offset.

If electricity from the grid is used, the required offsets are estimated to be 5,810 $MTCO_2e$ per year (i.e., 15,810 – 10,000 $MTCO_2e$ per year). Since offsets for off-site electricity generation is the responsibility of the energy generators, the Project may obtain verification of these offsets or purchase additional offsets as needed.

A GHG inventory shall be completed which will be verified by an accredited third-party verification body and reported to the Climate Registry. The Applicant shall purchase and retire such additional carbon offset credits (due to a net increase in emissions from the first full year of operations) as may be needed each year to ensure that the Project's total (direct plus indirect) GHG emissions are offset below the benchmark of 10,000 $MTCO_2e$ above existing 2011 conditions.

Significance Determination

Impacts to atmospheric levels of GHG from the Project are less than previously determined based on current thresholds of significance. No substantial changes are not proposed in the Project, requiring major revisions of the previous EIR due to the involvement of new significant environmental effects or a substantial increase in the severity of previously identified significant effects to atmospheric levels of GHG. No new information of substantial importance indicates the project would have one or more significant effects not discussed in the previous EIR nor are significant effects previously examined substantially more severe than described in the previous EIR. No mitigation measures or alternatives previously found not to be feasible would in fact be feasible and would substantially reduce one or more significant effects of the project; and no mitigation measures or alternatives that are considerably different from those analyzed in the previous EIR would substantially reduce one or more significant effects to atmospheric levels of GHGs.

VIII. Hazards and Hazardous Materials

Summary of Project Impacts in 2012 EIR

Table 16 summarizes the Impact and Mitigation Analysis in 2012 EIR. The EIR determined that the Project would have a less than significant effect from hazards and hazardous materials with implementation of HAZ-1, HAZ-2, and HAZ-3.

TABLE 16
HAZARDS AND HAZARDOUS MATERIALS IMPACTS AND MITIGATION SUMMARY

Proposed Project Impact	Mitigation Measure	Significance
Groundwater Conservation and Recovery Component		
Routine Transportation, Use, Disposal or Release of Hazardous Materials	HAZ-1	Less than significant with mitigation
Hazardous Materials Use Near Schools	None required	No impact
Hazardous Material Sites	HAZ-2 and HAZ-3	Less than significant with mitigation
Airport Hazards	None required	Less than significant
Emergency Response Plans	None required	No impact
Grassland and Wildland Fires	None required	Less than significant
Imported Water Storage Component		
Routine Transportation, Use, Disposal or Release of Hazardous Materials	HAZ-1	Less than significant with mitigation
Hazardous Materials Use Near Schools	None required	No impact
Hazardous Material Sites	HAZ-3	Less than significant with mitigation
Airport Hazards	None required	Less than significant
Emergency Response Plans	None required	No impact
Grassland and Wildland Fires	None required	Less than significant

Impact and Mitigation Analysis of Project Modifications

This evaluation focuses on potential public safety and hazards impacts, including the use, disposal, transport, or management of hazardous or potentially hazardous materials resulting from the construction and operation of the Project modifications.

Issues (and Supporting Information Sources):	*Potentially Significant Impact*	*Less Than Significant with Mitigation Incorporated*	*Less Than Significant Impact*	*No Impact*
HAZARDS AND HAZARDOUS MATERIALS — Would the project:				
a) Create a significant hazard to the public or the environment through the routine transport, use, or disposal of hazardous materials?	☐	☒	☐	☐
b) Create a significant hazard to the public or the environment through reasonably foreseeable upset and accident conditions involving the release of hazardous materials into the environment?	☐	☒	☐	☐
c) Emit hazardous emissions or handle hazardous or acutely hazardous materials, substances, or waste within one-quarter mile of an existing or proposed school?	☐	☐	☐	☒
d) Be located on a site which is included on a list of hazardous materials sites compiled pursuant to Government Code Section 65962.5 and, as a result, would it create a significant hazard to the public or the environment?	☐	☒	☐	☐
e) For a project located within an airport land use plan or, where such a plan has not been adopted, within two miles of a public airport or public use airport, would the project result in a safety hazard or excessive noise for people residing or working in the project area?	☐	☐	☐	☒
f) Impair implementation of or physically interfere with an adopted emergency response plan or emergency evacuation plan?	☐	☐	☐	☒
g) Expose people or structures, either directly or indirectly, to a significant risk of loss, injury, or death involving wildland fires?	☐	☐	☒	☐

Discussion

Approximately five percent of the water entering the treatment plant would be discharged as filter waste to the four backwash basins. After drying by evaporation, and recycling of supernatant back to the head of the RCF process, backwash solid waste would be disposed of in accordance with state and federal regulations. Residuals tests were conducted on backwash sludge obtained after backwashing on August 28, 2018 and September 12, 2018. As depicted in **Table 17**, backwash residuals levels of continuants do not exceed California Soluble Threshold Limit Concentrations (STLC).

TABLE 17
SUMMARY OF WATER TREATMENT FACILITIES RESIDUALS FROM PILOT TESTING

Parameter/Date	TCLP Result (toxicity characteristics leaching procedure	TCLP Regulatory Limit[a]	TTLC Result) (total threshold limit concentration)	TTLC Regulatory Limit[b]	STLC Result (soluble threshold limit concentration)	STLC Regulatory Limit[b]
Arsenic/8-22-18	<0.1 mg/L	5.0 mg/L	541 mg/kg	2,500 mg/kg	0.662 mg/L	5.0 mg/L
Arsenic/9-12-18	0.487 mg/L		623 mg/L		4.15 mg/L	
Chromium/8-22-18	<0.1 mg/L	5.0 mg/L	1,869 mg/kg	2,500 mg/kg	13.1 mg/L	560 mg/L if TCLP is passed
Chromium/9-12-18	<0.1 mg/L		2,262 mg/kg		13.6 mg/L	
Selenium/8-22-18						
Selenium/8-12-18						

[a] 40 CFR 261.24
[b] CA 22 CCR 66261.24 Table II

a) The routine transport, use, and disposal of hazardous materials could result in hazards to people and the environment due to the potential for accidental release. As part of Project modification construction, potentially hazardous materials, including equipment fuel, paints, lubricants, antifreeze, solvents, and other potentially hazardous materials would be transported to, stored, and used in the Project area. It is anticipated that one or more temporary, above-ground fuel storage tanks would be used during construction to service construction equipment. Due to the remote Project location, servicing and emergency repair of construction equipment may occur in the Project area. Potentially hazardous materials may also be required for operation of the Project, including natural gas that would power the pumps and chemicals required for the treatment processes.

The safe handling, storage and use of hazardous chemicals would be regulated through state hazardous materials regulations as outlined in the EIR. The use of additional chemicals required for the treatment plant would not increase the risk of a release of hazardous materials substantially. The treatment process would use ferrous chloride to reduce hexavalent chromium to trivalent chromium. The net result of regulatory compliance would be the reduction of risks and hazards to workers, the public, and the environment, to levels that are considered acceptable for all hazardous materials proposed for use. Implementation of Mitigation Measure **HAZ-1** would ensure that transportation, storage, and handling of hazardous materials would not result in accidental releases that could significantly impact neighboring land uses.

b) Mishandling of these fuel materials could result in their accidental release to the environment, which could in turn result in a hazardous condition to workers, the public, or the environment. However, by following applicable laws and regulations, the safe handling and use of hazardous materials and the safe disposal of the resulting hazardous wastes could be managed and achieved. More specifically, federal and State agencies would determine driver-training requirements, load labeling procedure and container specifications to minimize the risk of accidental release. Implementation of Mitigation Measure **HAZ-1** would ensure that transportation, storage, and handling of hazardous materials would not result in accidental releases that could significantly impact neighboring land uses.

c) There are no schools located within a quarter mile of the Project. Therefore, there would be no impacts to schools.

d) The Project is not located on a site listed on a hazardous material site list pursuant to Government Code Section 65962.5. However, the area has a known history of military use and Unexploded Ordinances has been found in the vicinity. Construction of the Project facilities as modified would involve grading and excavation, with the potential of encountering previously unidentified hazardous materials. Encountering contaminated soil, surface water, and groundwater without taking proper precautions could result in the exposure of construction workers and the environment to hazardous conditions. Implementation of Mitigation Measures **HAZ 2** and **HAZ-3** would reduce impacts from contaminated soils and Unexploded Ordinances to workers and surrounding land uses.

e) The Project is not located within an airport land use plan or within two miles of a public or public-use airport where no plan has been adopted. The nearest public airport is located approximately 35 miles from the Project area.

f) The Project would not be located on any roads and would not interfere with adopted emergency response plans or evacuation routes defined by any local jurisdictions. The Project area is not located in the immediate vicinity or flight path of a major airport. Emergency responses to remote parts of eastern San Bernardino County typically involve helicopter transport, which would not be hindered by Project construction or operation. Therefore, no impact would occur.

g) The Project would be located within a sparsely-vegetated desert area. As indicated in the 2012 EIR, the CAL FIRE hazard severity zone map identifies the Project area as within its lowest fire hazard severity zone, the lowest possible risk category. The nearest residences are located in Chambless, approximately 5 miles from the Project site.

As described in the 2012 EIR, Mitigation Measure **HAZ-1, HAZ-2** and **HAZ-3** would be implemented to reduce potential impacts from hazards and hazardous materials. Impacts related to modification of the Project during construction and operation are consistent with those described in Section 4.8 of the EIR and no new mitigation is required. Therefore, Project impacts, as modified, would remain less than significant with mitigation incorporated.

Mitigation Measures in the 2012 EIR

HAZ-1: On-site materials storage, fueling, and vehicle maintenance areas shall be equipped with secondary containment and spill containment equipment. Storage, handling, and disposal of hazardous materials shall comply with applicable regulations including submittal of a Business Plan to the County Fire Department.

HAZ-2: If excavation uncovers contaminated materials, excavation activities shall cease in the contaminated area. Soil samples shall be collected to characterize the soils and contamination. The CUPA shall be notified of the sample results. The construction contractor shall stockpile contaminated soils on plastic sheeting as necessary to prevent releasing contamination into the ground and shall ultimately dispose of the materials in coordination with the CUPA in compliance with hazardous material regulations.

HAZ-3: No construction or other Project activities shall occur at the Cadiz Sonic Lake Target Targe No. 5 and No. 9 areas, until the USACE clears the proposed locations for the potential presence of unexploded ordnance from historical military uses. In the event that the USACE encounters unexploded ordnance, the USACE is obligated to remove the unexploded ordnance under their ongoing investigations.

Significance Determination

Impacts from construction and operation related to transportation, handling and storage of hazardous substances from the Project modifications are consistent with those identified in the 2012 EIR. Substantial changes are not proposed in the Project, requiring major revisions of the previous EIR due to the involvement of new significant environmental effects or a substantial increase in the severity of previously identified significant effects from transportation, handling and storage of hazardous substances. No new information of substantial importance indicates the project would have one or more significant effects not discussed in the previous EIR nor are significant effects previously examined substantially more severe than described in the previous EIR. No mitigation measures or alternatives previously found not to be feasible would in fact be feasible and would substantially reduce one or more significant effects of the project; and no mitigation measures or alternatives that are considerably different from those analyzed in the previous EIR would substantially reduce one or more significant effects to transportation, handling and storage of hazardous substances.

IX. Hydrology and Water Quality

Summary of Project Impacts in the 2012 EIR

Table 18 summarizes the Impact and Mitigation Analysis in 2012 EIR for hydrological resources and water quality. The EIR determined that the Project would have a less than significant effect to hydrological resources with implementation of Mitigation Measures HYDRO-1 through HYDRO-5.

TABLE 18
HYDROLOGY AND WATER QUALITY IMPACTS AND MITIGATION SUMMARY

Proposed Project Impact	Mitigation Measure	Significance Conclusion
Groundwater Conservation and Recovery Component		
Impacts to Water Quality Standards or Waste Discharge Requirements	**HYDRO-1**, **HYDRO-2**, and **HYDRO-3**	Less than significant with mitigation
Impacts to Groundwater Supplies or Groundwater Recharge	**HYDRO-3**	Less than significant with mitigation
Impacts to Drainage Patterns	**HYDRO-4**	Less than significant with mitigation
Impacts to Housing or Structures Relative to Flooding, Seiche, Tsunami, or Mudflow	**HYDRO-4**	Less than significant with mitigation
Imported Water Storage Component		
Impacts to Water Quality Standards or Waste Discharge Requirements	None required	Less than significant
Impacts to Groundwater Supplies or Groundwater Recharge	None required	No impact
Impacts to Drainage Patterns	**HYDRO-5**	Less than significant with mitigation
Impacts to Housing or Structures Relative to Flooding, Seiche, Tsunami, or Mudflow	**HYDRO-4**	Less than significant with mitigation

Impact and Mitigation Analysis of Project Modifications

The watershed in the Project area has not changed since the preparation of the 2012 EIR. Various site-specific and regional reports and maps were reviewed in the 2012 EIR to evaluate the potential impacts of the Project to hydrology and water quality (Section 4.9, Hydrology and Water Quality). The 2012 EIR evaluated hydrologic data from regional investigations, as well as site-specific hydrologic data collected from wells on the Project site and generated from models of the aquifer behavior.

Issues (and Supporting Information Sources):	*Potentially Significant Impact*	*Less Than Significant with Mitigation Incorporated*	*Less Than Significant Impact*	*No Impact*
HYDROLOGY AND WATER QUALITY — Would the project:				
a) Violate any water quality standards or waste discharge requirements or otherwise substantially degrade surface or ground water quality?	☐	☒	☐	☐
b) Substantially decrease groundwater supplies or interfere substantially with groundwater recharge such that the project may impede sustainable groundwater management of the basin?	☐	☒	☐	☐
c) Substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river or through the addition of imperious surfaces, in a manner which would:	☐	☒	☐	☐
i) result in substantial erosion or siltation on- or off-site;	☐	☒	☐	☐
ii) substantially increase the rate or amount of surface runoff in a manner which would result in flooding on- or offsite;	☐	☒	☐	☐
iii) create or contribute runoff water that would exceed the capacity of existing or planned stormwater drainage systems or provide substantial additional sources of polluted runoff; or	☐	☒	☐	☐
iv) impede or redirect flood flows?	☐	☒	☐	☐
d) In flood hazard, tsunami, or seiche zones, risk or release of pollutants due to project inundation?	☐	☒	☐	☐
e) Conflict with or obstruct implementation of a water quality control plan or sustainable groundwater management plan?	☐	☐	☒	☐

Discussion

a) Construction of the Project modifications would disturb soils that could result in erosion and/or siltation. In addition, construction equipment and the associated chemical usage could result in spills that could impact surface water quality. Construction of the Project treatment facilities and modified pipeline would not be subject to the NPDES Construction General Permit for Discharges of Stormwater since there are no Waters of the U.S. in the facility construction footprint that would be affected. The Project would be required to comply with Waste Discharge Requirements (WDR) from the RWQCB for impacts to waters of the state.

Since, construction activities from the Project modifications may result in surface runoff quality impacts, as described in the 2012 EIR, Mitigation Measure **HYDRO-1** has been developed to ensure that construction-related BMPs are implemented to prevent soil erosion and to control hazardous materials used during construction from adversely affecting surface water runoff.

b) As described in the 2012 EIR (Section 4.9, page 4.9-61), the Project would capture groundwater that is comprised of natural recharge and groundwater already held in storage that would be retrieved before it flows to the Dry Lakes where it is lost to evaporation. To capture the water, groundwater would be extracted from the wellfield to intentionally lower the water table. The water table would be lowered to a level at or below the water levels at the Dry Lakes to gain control of the flow and to prevent the water from flowing to the Dry Lakes. Complete recovery of water levels to pre-Project levels is estimated to occur at 67 years after the Project pumping stops. Hydrological studies conducted during and after the preparation of the 2012 EIR indicate that an average annual pumping rate of 50,000 AFY would be an efficient pumping volume to reverse the groundwater flow south of the Fenner Gap, thus creating an effective groundwater hydraulic control mechanism that alters the gradient so that the flow of groundwater changes direction from flowing toward the Dry Lakes to flowing toward the wellfield and allows for the conservation of fresh groundwater (2012 EIR Section 4.9.3 Hydrology and Water Quality, p. 4.9-5). Table 4.9-11, tabulates the volumes of groundwater that would be recovered under the three scenarios; 2012 EIR Figures 4.9-11a and 4.9-11b illustrate this concept. Based on the Project scenario modeling results, within 67 years after pumping ceases, the groundwater storage levels are anticipated to fully recover to pre-Project conditions.

Supplemental groundwater modeling also showed that pumping at higher rates during the initial period of Project operations would save even larger amounts of water for beneficial use and would allow for hydraulic control earlier in the life of the Project (2012 EIR, Section 4.9.3 Hydrology and Water Quality, pp. 4.9-72 to 4.9-73 and Appendix H2 Supplemental Assessment of Pumping Required, pp. 7-11). Pumping at a rate of 75,000 AFY during the first 25 years and 25,000 AFY during the second 25 years would reduce evaporative losses by approximately an additional 130,000 AF over the 50-year term of the Project (2012 EIR, Appendix H2 Supplemental Assessment of Pumping Required). This analysis shows that pumping above natural recharge rates increases the conservation of water that would otherwise evaporate, resulting in reduced overall losses from the groundwater basin compared to a natural recharge only scenario. Pumping at higher rates early in the Project captures more water in transit to the Dry Lakes and reduces evaporative losses.

The modifications to the Project would not increase groundwater pumping rates. The water treatment facilities would treat the stored groundwater to meet quality standards anticipated to be required to pump into the CRA. The modifications to the Project would not change the Project's effects on groundwater.

Natural Springs

Since the certification of the 2012 EIR, studies have been published evaluating the potential that local natural springs may be hydrologically connected to the underlying aquifer, suggesting that reduction in groundwater levels could adversely affect the springs, which are a vital resource for native wildlife including bighorn sheep. In 2018, the Mojave Desert Land Trust requested a report prepared by Andy Zdon et. al., (*Understanding the source of water for selected springs within Mojave Trails National Monument, California*; 2018 hereafter referred to as the Zdon report). The Zdon report addressed the topic of Bonanza Spring, the largest spring in the southeastern Mojave Desert, characterized in the 2012 EIR as a perched spring disconnected from the basin-fill aquifer system. The report evaluated the source of spring flow at Bonanza Spring, based upon published geologic maps, measured groundwater levels, water quality chemistry, and isotope data compiled from both published sources and new samples collected for water chemistry and isotopic composition.

Zdon's evaluation suggested a different conclusion from the analyses summarized in the SMWD 2012 EIR; specifically concluding that Bonanza Spring has a regional water source, in hydraulic communication with basin fill aquifer systems and deriving its water from recharge north of the Clipper Mountains, and could be impacted if groundwater levels decrease at, or near, the spring. Zdon suggested that neighboring Lower Bonanza Spring appears to primarily be a downstream manifestation of surfacing water originally discharged from the Bonanza Spring source, whereas other springs in the area – Hummingbird, Chuckwalla, and Teresa Springs – each appear to be locally sourced as "perched" springs. The Zdon report recommended that future groundwater development in the region, should it occur, be cognizant of the likelihood of a hydraulic connection between the recharge area for Fenner Valley, and Fenner Valley itself with Bonanza Spring. Based on the existing source characterization of Bonanza Spring, Zdon suggested that a reduction in groundwater level could result in an uncertain, but potentially substantial decrease in free-flowing water from the spring source. Zdon recommended that future groundwater-level monitoring be designed and installed, including additional monitoring wells between a proposed well field in Fenner Valley and the spring.

In June 2018, Dr. David Kreamer, a UNLV Hydrology Professor, prepared an external peer review and evaluation of the Zdon report. The review encompassed selected references cited from Zdon and other sources, as well as a field study of Upper and Lower Bonanza Spring, its watershed, and surrounding area. Dr. Kreamer's evaluation concluded that the Zdon report's information pertaining to water quality and isotopic relationships for springs, wells and groundwater in the southeast Mojave Desert is poorly referenced, and that Zdon's conclusions – particularly with respect to the purported connection between Bonanza Spring and the Fenner and Cadiz Basins – are unsupported by the evidence cited. Overall, Dr. Kreamer noted that there is disagreement between the data presented in the Zdon report and data published elsewhere, and he concluded that a complete interpretation of all available data supports completely different and sometimes opposite conclusions reached by Zdon.

In January 2019, Dr. David Kreamer prepared an external peer review and evaluation of a second Zdon report, *Use of Radiocarbon Ages to Narrow Groundwater Recharge Estimates in the Southeastern Mojave Desert* (Love and Zdon 2018; hereafter referred to as the Love and Zdon report). The Love and Zdon report attempt to critically review and constrain estimates of groundwater recharge in the Southeastern Mojave Desert by use of radiocarbon dating. The conclusions reached in this paper rely on previous published work in non-journal publications, and one round of radiochemical measurements made at five (5) selected springs. Dr. Kreamer concluded that while the Love and Zdon report adds data to study of springs in the Mojave Desert, the conclusions were seriously flawed, contain both citations and self-citations from non-referenced work, do not adequately describe limitations or uncertainties in their work, fail in some cases to consider the possibility of local spring recharge beyond surface catchments, use different areas and basins for their comparison of annual recharge volumes, and neglect the incorporation of standard methodologies to collect and interpret their data. In sum, Dr. Kreamer suggested that the Love and Zdon report was found to suffer from critical weaknesses which undercut and invalidate some of its conclusions, and contains serious methodological omissions in interpretation of recharge and average groundwater residence time, which ultimately influence the interpretation for the hydrogeology of the study area.

In February 2019, a peer review was conducted for the 2012 EIR conclusions and effectiveness of the GMMMP (Appendix A). The report, by Three Valley Municipal Water District, addressed concerns presented in the Zdon report. The peer review study concluded that the evidence presented in 2012 EIR accurately reflected the best available science, and that the GMMMP provided substantial mitigation values. The study recommended additional monitoring to augment the data collection, but was clear to conclude that the new recommendations did not present new information or contradict the conclusions of the 2012 EIR.

In summary, the Zdon report and the Love and Zdon report prepared since the certification of the 2012 EIR do not contain any new information that changes the conclusions of the analysis in the 2012 EIR with respect to potential adverse effects on natural springs. The referenced reports are provided in Appendix D of this Addendum.

c) The placement of the constructed infrastructure, specifically the water treatment plant, could result in changing the existing drainage patterns by blocking or re-routing existing flow patterns within the modified pipeline alignment. The changed flow path of water could result in erosion or siltation that could result in damage to structures or the environment from erosion or flooding. However, the treatment facilities would be installed outside of defined washes.

As described in the 2012 EIR, Mitigation Measure **HYDRO-4** ensures that above ground structures are not placed within any visible stream drainage or wash in a manner that could result in the restriction of surface water flow. In addition, because the drainage patterns of the intermittent streams in desert areas can change annually, if not with each individual rain event, the infrastructure elements shall be constructed to be protected from future changes to drainage patterns by routing water away and around the structures in such a manner so as to not concentrate the flow and increase the potential for erosion. Project operators shall prepare a drainage analysis to ensure that diverted stormwater runoff does not affect downstream railroad crossings, roads, or other infrastructure.

d) The Project area is not located within the 100-year flood zone maps prepared by FEMA. The area is not subject to seiches, tsunamis, or mudflows. Although not identified as being within 100-year flood maps, the general area is known to experience occasional seasonal short-term flooding. The seasonal flooding could damage above-ground structures such as well heads and supporting power equipment. Implementation of Mitigation Measure **HYDRO-4** would ensure that the Project would not adversely affect the floodplain.

e) As described in the 2012 EIR, Section 4.9, and associated groundwater studies conducted for the Project, intentional lowering of groundwater levels (1) is necessary to conserve water that would otherwise be lost to evaporation, (2) is part of the Project's comprehensive groundwater management program that is subject to continuous monitoring and adaptive management, if necessary, and (3) would not cause any long-term material impacts to the aquifer system or surface uses within the Project area. As described in the 2012 EIR, Appendix B2, *Groundwater Stewardship Committee October 2011 Summary of Findings and Recommendations*, and Appendix H1, *Cadiz Groundwater Modeling and Impact Analysis*, the Project is consistent with legal principles applicable to groundwater management in California.

There is no Groundwater Sustainability Agency required under the Sustainable Groundwater Management Act for the groundwater basin. Furthermore, the project would be consistent with the San Bernardino County Groundwater Management Ordinance as managed and documented within the GMMMP. As described in the 2012 EIR, Mitigation Measure **HYDRO-1** through **HYDRO-4** would be implemented to reduce potential impacts to hydrological resources. Impacts related to modification of the Project during construction and operation are consistent with those described in Section 4.9 of the EIR and no new mitigation is required. Therefore, Project impacts, as modified, would remain less than significant with mitigation incorporated.

Mitigation Measures in the 2012 EIR

HYDRO-1: A construction and maintenance Storm Water Pollution Prevention Plan shall be prepared and included in construction specifications and Operations and Maintenance Manual (OMM) for the Project. At a minimum, the plan shall include the following required Best Management Practices or equivalent measures:

- Install temporary sediment fences or straw waddles at stream crossings or washes to prevent erosion and sedimentation during construction, including at each ARZC railroad trestle along the pipeline alignment.
- Establish designated fueling areas equipped with secondary containment,
- Require drip-pans under all idle equipment on the construction sites,

- Ensure that spill prevention kits are present at all construction sites.

HYDRO-2: Chapter 6.4 of the GMMMP shall be implemented to address the potential impacts for the migration of the saline/freshwater water interface to adversely affect groundwater quality. If monitored increases in TDS result in impairment to beneficial uses of groundwater by overlying land owners, one or more of the following corrective measures shall be implemented:

- Deepen or otherwise improve the efficiency of the impacted well(s); or
- Blend impacted well water with another local source; or
- Construct replacement well(s); or
- Pay the impacted well owner for any increased material pumping costs incurred by the well owner; or
- Modify Project operations until adverse effects are no longer present at the affected well(s). Modification to Project operations would include one or more of the following:
  - Reduction in pumping from Project wells; or
  - Revision of pumping locations within the Project wellfield; or
  - Stoppage of groundwater extraction for a duration necessary to correct the predicted adverse effect on existing wells; or
- Installation of an injection or extraction well(s) in conjunction with appropriate injection of lower-TDS water or extraction of higher-TDS water to manage the migration of high-TDS water from the Dry Lakes.

HYDRO-3: Chapter 6.2 of the GMMMP shall be implemented to address potential impacts to Third Party wells. If a written complaint by a well owner is received regarding decreased groundwater production yield, degraded water quality, or increased pumping costs submitted by neighboring landowners or the salt mining operators on the Bristol and Cadiz Dry Lakes, the following corrective measures shall be implemented:

- Arrange for an interim water supply to the affected party as necessary.
- Implement additional corrective measures that include one or more of the following actions:
  - Deepen or otherwise improve the efficiency of the impacted well(s); or
  - Blend impacted well water with another local source; or
  - Construct replacement well(s); or
  - Pay the impacted well owner for any increased material pumping costs incurred by the well owner; or
  - Modify Project operations until adverse effects are no longer present at the affected well(s). Modification to Project operations would include one or more of the following:
    - Reduction in pumping from Project wells; or
    - Revision of pumping locations within the Project wellfield; or

- Stoppage of groundwater extraction for a duration necessary to correct the predicted adverse effect on existing wells.

HYDRO-4: All construction and operation plans shall be prepared that identify standard best management practices (BMPs) to control drainage around the Project infrastructure including but not limited to wellpads, pump stations, an energy generation facility, air relief valves, forebay and equalization storage facilities, spreading basins, and railcar wash areas. The BMPs shall include placing facility and well pads and above-ground appurtenant facilities outside of visible drainages; and grading well pads to disperse runoff from the site in a manner that minimizes scour potential of storm water. BMPs include the use of physical barriers to prevent or manage seepage, detain runoff and prevent erosion during construction and operation and may include the use of siltation straw wattles, hay bales, setbacks and buffers, and other similar methods that reduce the energy in surface water flow.

Significance Determination

Impacts from construction and operation to hydrology and water quality resources from the Project modifications are consistent with those identified in the 2012 EIR. Substantial changes are not proposed in the Project, requiring major revisions of the previous EIR due to the involvement of new significant environmental effects or a substantial increase in the severity of previously identified significant effects to hydrology and water quality resources. No new information of substantial importance indicates the project would have one or more significant effects not discussed in the previous EIR nor are significant effects previously examined substantially more severe than described in the previous EIR. No mitigation measures or alternatives previously found not to be feasible would in fact be feasible and would substantially reduce one or more significant effects of the project; and no mitigation measures or alternatives that are considerably different from those analyzed in the previous EIR would substantially reduce one or more significant effects to hydrology and water quality resources.

X. Land Use and Planning

Summary of Project Impact and Mitigation Analysis in 2012 EIR

Table 19 summarizes the Impact and Mitigation Analysis in 2012 EIR for land uses in the Project area. The EIR determined that the Project would have a less than significant effect to existing land uses and no mitigation was required.

TABLE 19
LAND USE AND PLANNING IMPACTS AND MITIGATION SUMMARY

Proposed Project Impact	Mitigation Measure	Significance Conclusion
Groundwater Conservation and Recovery Component		
Divide an Established Community	None required	Less than significant
Consistency with Land Use Plans	None required	Less than significant
Habitat Conservation Plans or Natural Community Conservation Plans	None required	No impact
Socioeconomics	None required	Beneficial
Environmental Justice	None required	No impact
Imported Water Storage Component		
Divide an Established Community	None required	No impact
Consistency with Land Use Plans	None required	Less than significant
Habitat Conservation Plans or Natural Community Conservation Plans	None required	No impact
Socioeconomics	None required	Beneficial
Environmental Justice	None required	No impact

Impact and Mitigation Analysis of Project Modifications

Land uses in the Project area have not changed since the preparation of the 2012 EIR. Land uses in the Project area consist largely of open space, mining, utility corridors, water conveyance, and military installations Modifications to the Project are evaluated for consistency with surrounding land uses.

Issues (and Supporting Information Sources):	*Potentially Significant Impact*	*Less Than Significant with Mitigation Incorporated*	*Less Than Significant Impact*	*No Impact*
LAND USE AND PLANNING — Would the project:				
a) Physically divide an established community?	☐	☐	☐	☒
b) Cause a significant environmental impact due to a conflict with any land use plan, policy, or regulation adopted for the purpose of avoiding or mitigating an environmental effect?	☐	☐	☒	☐

Discussion

a) The nearest residential and commercial communities to the Project area are in Chambless, 5 miles to the north of the Project area, Amboy, 15 miles to the west of the Project area and Twentynine Palms, 40 miles to the southwest. The pipeline alignment modification adds approximately 2 miles of pipeline to the 43-mile original alignment evaluated in the EIR. The new alignment would turn west 90 degrees from the ARZC ROW for approximately 1.9 miles, then turn north for an additional 1.9 miles to extend into the Cadiz Project site (Figure 2). Construction and operation of the Project modifications would occur within private lands, with the exception of 41 feet of pipeline that would be installed on BLM NCL lands. There are no communities within the vicinity of the Project modifications. Therefore, no impact would occur.

b) The Project modifications occur on lands zoned as AG. The San Bernardino County Development Code (2009) allows Utilities development to occur on lands zoned as AG, subject to a Conditional Use Permit (CUP), unless exempt under Government Code §§ 53091(e). The State of California Government Code establishes an exemption for "the location or construction of facilities for the production, generation, storage, treatment, or transmission of water…." from county or city building and zoning ordinances. (Gov. Code §§ 53091(d), (e)) The implementation of the Project modifications by FVWA would be covered under this exemption for the construction and operation of facilities that are used to produce, store and transmit water. Considering the Project as a whole is exempt from the County's zoning ordinances, no CUP for the Project modifications is required from San Bernardino County, and the Project as modified, would not conflict with the County Land Use designations.

The modified pipeline alignment, 41 linear feet, occurs on lands designated by BLM as the Cadiz Valley ACEC and the South Mojave - Amboy NCL lands (Figure 3). These designations have been established to protect high quality habitat for desert tortoise. The Project as modified would be required to comply with BLM's criteria for development within these designated areas. However, as described in the 2012 EIR, impacts to the desert tortoise are not anticipated to occur with mitigation measures adopted to protect sensitive biological species in the Project area (ESA, 2012). As required under the National Environmental Policy Act (NEPA), impacts to the ACEC and/or NCL as a result of the segment of the modified pipeline alignment that would be installed on BLM managed lands would be determined by the BLM during review of the Project's SF299 *Application for Transportation and Utility Systems and Facilities on Federal Lands*.

> NEPA requires that federal agencies take their own steps to assess potential environmental impacts. As the managing federal agency, BLM would either grant or deny the easement for the 41-feet of pipeline upon completion of the NEPA process.

Impacts related to modification of the Project during construction and operation are consistent with those described in Section 4.10 of the EIR. No new mitigation is required, therefore, Project impacts, as modified, would remain less than significant.

Significance Determination

Impacts from construction and operation to land uses from the Project modifications are consistent with those identified in the 2012 EIR. Substantial changes are not proposed in the Project, requiring major revisions of the previous EIR due to the involvement of new significant environmental effects or a substantial increase in the severity of previously identified significant effects to land uses and planning. No new information of substantial importance indicates the project would have one or more significant effects not discussed in the previous EIR nor are significant effects previously examined substantially more severe than described in the previous EIR. No mitigation measures or alternatives previously found not to be feasible would in fact be feasible and would substantially reduce one or more significant effects of the project; and no mitigation measures or alternatives that are considerably different from those analyzed in the previous EIR would substantially reduce one or more significant effects to land uses and planning.

XI. Mineral Resources

Summary of Project Impacts and Mitigation Analysis in 2012 EIR

Table 20 summarizes the Impact and Mitigation Analysis in 2012 EIR for mineral resources in the Project area. The EIR determined that the Project would have a less than significant effect to mineral resources with implementation of MIN-1 mitigation measure.

TABLE 20
MINERAL RESOURCES IMPACTS AND MITIGATION SUMMARY

Proposed Project Impact	Mitigation Measure	Significance Conclusion
Groundwater Conservation and Recovery Component		
Loss of Availability of Known Mineral Resources	MIN-1	Less than significant with mitigation
Loss of Availability of Locally Important Mineral Resources	None required	No impact
Imported Water Storage Component		
Loss of Availability of Known Mineral Resources	None required	No impact
Loss of Availability of Locally Important Mineral Resources	None required	No impact

Impact and Mitigation Analysis of Project Modifications

Mineral excavation and locations of known mineral resources within the vicinity of the Project as a whole have not changed since the preparation of the 2012 EIR. Mineral resource impacts are based upon the Project modifications' proximity to nearby mineral resources that are identified as being of importance on a local, regional, state, or federal level.

Issues (and Supporting Information Sources):	*Potentially Significant Impact*	*Less Than Significant with Mitigation Incorporated*	*Less Than Significant Impact*	*No Impact*
MINERAL RESOURCES — Would the project:				
a) Result in the loss of availability of a known mineral resource that would be of value to the region and the residents of the state?	☐	☒	☐	☐
b) Result in the loss of availability of a locally-important mineral resource recovery site delineated on a local general plan, specific plan, or other land use plan?	☐	☐	☐	☒

Discussion

a) Playas in the local area have historically and are currently producing evaporite minerals: Tetra Technologies produces salts at Bristol and Cadiz Dry Lakes; National Chloride produces salts at Bristol Dry Lake and the Salt Products Company produces salt at Danby Dry Lake. The salt producing operations at Bristol and Cadiz Dry Lakes recover sodium chloride by pumping saline water from wells into trenches, where evaporation removes more water from the solution. As described in the 2012 EIR, if the Project drawdown results in water levels too deep to initiate the salt concentration process by simple excavation, this impact would be considered significant since the salt production operators would have to initially fill the trenches with pumped saline groundwater, thus incurring an added operational cost (page 4.11-8). Implementation of measures identified in Chapter 6.5 of the GMMMP as mitigation measure **MIN-1** would reduce potential impacts to brines resources. If changes in groundwater levels occur that are larger than projected by the groundwater model simulations or if changes occur in groundwater or brine water levels that are greater than 50 percent of the water column above the intake of any of salt mining companies' wells in comparison to pre-operational static levels in wells at the margins of the dry lakes, corrective measures would be implemented.

b) Some portions of the 43-mile water conveyance pipeline cross areas of potential mineral resources that are on public lands managed by the BLM. No impact to availability of mineral resources from the Project modifications would occur on BLM land considering the area is small, adjacent to the ARZC ROW, and the 41 feet of pipeline would be buried but not exclude availability. The remaining modified pipeline as well as the treatment facilities would be located on private lands.

As described in the 2012 EIR, Mitigation Measure **MIN-1** would be implemented to reduce potential impacts to brine resources due to operation. Impacts related to modification of the Project during construction and operation are consistent with those described in Section 4.11 of the EIR and no new mitigation is required. Therefore, Project impacts, as modified, would remain less than significant with mitigation incorporated.

Mitigation Measures

MIN-1: Chapter 6.5 shall be implemented to address the potential impact for groundwater level drawdown on existing salt production operations. If changes in groundwater levels occur that are larger than projected by the groundwater model simulations or if changes occur in groundwater or brine water levels that are greater than 50 percent of the water column above the intake of any of salt mining companies' wells in comparison to pre-operational static levels in wells at the margins of the dry lakes, one or more of the following actions shall be implemented:

- Reduction in pumping from Project wells; or
- Revision of pumping locations within the Project wellfield; or
- Stoppage of groundwater extraction for a duration necessary to correct the predicted impact; or

- Installation of injection wells to mitigate the impact, or
- Compensation to mining operators for the additional costs of pumping.

Significance Determination

Impacts from construction and operation to mineral resources from the Project modifications are consistent with those identified in the 2012 EIR. Substantial changes are not proposed in the Project, requiring major revisions of the previous EIR due to the involvement of new significant environmental effects or a substantial increase in the severity of previously identified significant effects to mineral resources. No new information of substantial importance indicates the project would have one or more significant effects not discussed in the previous EIR to resources nor are significant effects previously examined substantially more severe than described in the previous EIR. No mitigation measures or alternatives previously found not to be feasible would in fact be feasible and would substantially reduce one or more significant effects of the project; and no mitigation measures or alternatives that are considerably different from those analyzed in the previous EIR would substantially reduce one or more significant effects to mineral resources.

XII. Noise

Summary of Project Impacts in the 2012 EIR

Table 21 summarizes the Impact and Mitigation Analysis in the 2012 EIR. The EIR determined that the Project would not have a significant effect due to noise during construction and operation of the Project and no mitigation was required.

TABLE 21
NOISE IMPACTS AND MITIGATION SUMMARY

Proposed Project Impact	Mitigation Measure	Significance Conclusion
Groundwater Conservation and Recovery Component		
Sensitive Receptors	None required	Less than significant
Ground-borne Vibrations and Ground-borne Noise	None required	Less than significant
Ambient Noise Levels	None required	Less than significant
Exposure to Excessive Noise Levels	None required	Less than significant
Imported Water Storage Component		
Sensitive Receptors	None required	Less than significant
Ground-borne Vibrations and Ground-borne Noise	None required	Less than significant
Ambient Noise Levels	None required	Less than significant
Exposure to Excessive Noise Levels	None required	Less than significant

Impact and Mitigation Analysis of Project Modifications

The predominant sources of noise in the vicinity of the Project area have not changed since the preparation of the 2012 EIR which include railroad noise, roadway traffic, and equipment noise from existing agricultural operations. The noise surrounding the Project site would be expected to be typical of open space and agricultural areas.

Issues (and Supporting Information Sources):	*Potentially Significant Impact*	*Less Than Significant with Mitigation Incorporated*	*Less Than Significant Impact*	*No Impact*
NOISE — Would the project result in:				
a) Generation of a substantial temporary or permanent increase in ambient noise levels in the vicinity of the project in excess of standards established in the local general plan or noise ordinance, or applicable standards of other agencies?	☐	☐	☒	☐
b) Generation of excessive groundborne vibration or groundborne noise levels?	☐	☐	☒	☐

Issues (and Supporting Information Sources):	*Potentially Significant Impact*	*Less Than Significant with Mitigation Incorporated*	*Less Than Significant Impact*	*No Impact*
c) For a project located within the vicinity of a private airstrip or an airport land use plan or, where such a plan has not been adopted, within two miles of a public airport or public use airport, would the project expose people residing or working in the project area to excessive noise levels?	☐	☐	☒	☐

Discussion

a) Noise levels associated with the construction and operation of the Project are described in Tables 4.12-2 and 4.12-3 of the 2012 EIR. The loudest portion of typical construction would be during excavation of the pipeline trenches and when blasting or drilling through rock if needed. The nearest sensitive receptors to construction activities are approximately 3.3 miles to the north of the Project wellfield. The location of the treatment facilities is approximately 4 miles southwest from the Project wellfield (Figure 2)

Construction methods within the new pipeline alignment would be similar to those assessed in the EIR. Construction of the treatment plant would generate noise temporarily during installation, but once constructed the facility would result in minimal noise impacts. Considering construction noise from the treatment plant would be approximately 7 to 8 miles from the nearest sensitive receptors, noise would attenuate to imperceptible levels. The construction zone is in a remote area and the temporary noise would not be audible to sensitive receptors. No new impacts to wildlife would occur, since the EIR considered construction and operational noise on wildlife. The proposed modifications may extend construction slightly, but would not substantially increase noise impacts.

As described in the 2012 EIR, Section 4.12, the predominant sources of noise include railroad noise, roadway traffic, and equipment noise from existing agricultural operations. Military operations including explosions and low-flying aircraft also generate noise in the valley. Average noise levels in desert environments typically are in the range of 35-55 A-weighted decibels (dBA). In this naturally quiet environment, trains traversing the valley (10 to 20 per day on the BNSF and 2 or 3 on the ARZC) are the primary source of man-made noises. As described in the 2012 EIR, page 4.4-40, construction noise would temporarily affect wildlife species in the near proximity. However, construction of the Project would occur incrementally, and noise would be localized to the area of work. Given the vast open space in the Project area, the construction noise would attenuate to moderate levels within a few hundred feet. Furthermore, the proposed modifications would not result in substantially increased construction noise compared to that analyzed in the 2012 EIR.

Noise generated by the water treatment facilities pumps during operation is not expected to exceed 65 dBA outside the facility boundary (**Figure 6**). As with the facilities described in the 2012 EIR, page 4.12-10, water treatment facilities would be constructed with sound attenuation features to limit noise generation. Operational noise impacts associated with the proposed modifications would be similar to that analyzed in the 2012 EIR.

b) Ground borne vibration (GBV) created by construction activity, notably grading and excavation utilizing large bulldozers, would fall within the range of readily perceivable vibration at 25 feet from source but would not exceed the threshold at which continuous vibration would begin to annoy people. Ground borne vibration would attenuate at a rate of approximately 6 VdB per doubling of distance. Considering the nearest sensitive receptors are approximately 7 to 8 miles from the treatment facilities and new pipeline alignment, the nearest sensitive receptor would be exposed to minimal GBV if any.

c) The Project site is located in close proximity to the private airstrip owned and maintained by Cadiz Inc. This airstrip is used approximately five times a month and is not available to the public. During construction, there may be a minor increase in the number of flights into and out of the airstrip associated with various contractor personnel visiting the Project area as but it is expected that the increase would amount to less than five visits per week and would be temporary, only lasting throughout construction. Ongoing travel to and from the Project site for ongoing maintenance of the facilities and pump stations would occur infrequently and should be on par with current airstrip operations. Therefore, future employees on the Project site would not be subjected to excessive noise levels from airstrip activity.

Impacts related to modification of the Project during construction and operation are consistent with those described in Section 4.12 of the EIR. No new mitigation is required, therefore, Project impacts, as modified, would remain less than significant.

Significance Determination

Impacts from noise to sensitive receptors from construction and operation of the Project modifications are consistent with those identified in the 2012 EIR. Substantial changes are not proposed in the Project, requiring major revisions of the previous EIR due to the involvement of new significant environmental effects or a substantial increase in the severity of previously identified significant effects. No new information of substantial importance indicates the project would have one or more significant effects not discussed in the previous EIR nor are significant effects previously examined substantially more severe than described in the previous EIR. No mitigation measures or alternatives previously found not to be feasible would in fact be feasible and would substantially reduce one or more significant effects of the project; and no mitigation measures or alternatives that are considerably different from those analyzed in the previous EIR would substantially reduce one or more significant effects from noise to sensitive receptors.

XIII. Public Services

Summary of Project Impacts in the 2012 EIR

Table 22 summarizes the Impact and Mitigation Analysis in 2012 EIR to public services. The EIR determined that the Project would have a less than significant effect to public services. Impacts and mitigation to energy usage described in the table below are addressed separately.

TABLE 22
PUBLIC SERVICES AND UTILITIES IMPACTS AND MITIGATION SUMMARY

Proposed Project Impact	Mitigation Measure	Significance Conclusion
Groundwater Conservation and Recovery Component		
Public Services	None required	Less than significant
Expansion of New Wastewater Facilities and Compliance with Wastewater Requirements	None required	Less than significant
Storm Water Drainage Facilities	HYDRO-1, HYDRO-5, and UTIL-1	Less than significant with mitigation
Expansion of New Water Supply Facilities	None required	Less than significant
Solid Waste	None required	Less than significant
Disruption of Local and Regional Utilities	UTIL-2	Less than significant with mitigation
Energy Usage	UTIL-3	Less than significant with mitigation
Imported Water Storage Component		
Public Services	None required	Less than significant
Expansion of New Wastewater Facilities and Compliance with Wastewater Requirements	None required	No impact
Storm Water Drainage Facilities	HYDRO-1, HYDRO-5, and UTIL-4	Less than significant with mitigation
Expansion of New Water Supply Facilities	None required	Less than significant
Solid Waste	None required	Less than significant
Disruption of Local and Regional Utilities	UTIL-2	Less than significant with mitigation
Energy Usage	None required	Less than significant

Impact and Mitigation Analysis of Project Modifications

Public services in the vicinity of the Project have not changed since the preparation of the 2012 EIR.

Issues (and Supporting Information Sources):	Potentially Significant Impact	Less Than Significant with Mitigation Incorporated	Less Than Significant Impact	No Impact
PUBLIC SERVICES — Would the project:				
a) Result in substantial adverse physical impacts associated with the provision of new or physically altered governmental facilities, need for new or physically altered government facilities, the construction of which could cause significant environmental impacts, in order to maintain acceptable service ratios, response times, or other performance objectives for any of the following public services:				
i) Fire protection?	☐	☐	☒	☐
ii) Police protection?	☐	☐	☒	☐
iii) Schools?	☐	☐	☐	☒
iv) Parks?	☐	☐	☐	☒
v) Other public facilities?	☐	☐	☐	☒

Discussion

a. The Project modifications would include treatment facilities and pipeline realignment located on privately owned land. During construction of the Project and Project modifications, approximately 240 workers would be on-site at any given time, for a period of up to two years. The Project would maintain fire suppression equipment, trained personnel, and an emergency evacuation plan. The existing Cadiz wells would provide water for the fire suppression systems.

Emergency medical service demand could increase during the summer months, due to the potential for workers to experience heat exhaustion and/or sunstroke during periods of extreme heat. In addition, accidents can occur during construction, necessitating emergency response to the Project site. The construction contractor would provide safety training to all construction workers and would have sufficient on-site medical supplies to address heat-related illness and minor injuries. The Cadiz agricultural operations have first aid materials onsite and the site manager has been trained as a first responder. In addition, the existing Wonder Valley Fire Station has confirmed that it has the capacity to meet the minor increase in demand for fire and emergency services that could occur during construction and operation of the Project. As described in the 2012 EIR, the Morongo Basin Police Station has the capacity to meet the minor increase in law enforcement service calls that could result during construction of the Project. Additionally, the minor increase in emergency medical, police, and fire protection service calls during construction and operation would be short-term and would not require the provision of new or the expansion of existing governmental facilities in order to maintain acceptable services to the Project area.

> The Project would not construct or require the construction of permanent residential development and operation of the Project would not require a substantial number of new, full-time employees. The Project would not result in the need to expand existing or construct new school or library facilities or affect school related services. Similarly, because the proposed Project does not include residential development and would not bring a substantial number of new, full-time employees to the Project area, it would not result in substantial adverse physical impacts associated with the expansion of hospitals or other public facilities.

Impacts related to modification of the Project during construction and operation are consistent with those described in Section 4.13 of the EIR. No new mitigation is required, therefore, Project impacts, as modified, would remain less than significant.

Significance Determination

Impacts from construction and operation to public services from the Project modifications are consistent with those identified in the 2012 EIR. Substantial changes are not proposed in the Project, requiring major revisions of the previous EIR due to the involvement of new significant environmental effects or a substantial increase in the severity of previously identified significant effects to public services. No new information of substantial importance indicates the project would have one or more significant effects not discussed in the previous EIR resources nor are significant effects previously examined substantially more severe than described in the previous EIR. No mitigation measures or alternatives previously found not to be feasible would in fact be feasible and would substantially reduce one or more significant effects of the project; and no mitigation measures or alternatives that are considerably different from those analyzed in the previous EIR would substantially reduce one or more significant effects to public services.

XIV. Transportation and Traffic

Summary of Project Impacts in the 2012 EIR

Table 23 summarizes the Impact and Mitigation Analysis in 2012 EIR for transportation and traffic. The EIR determined that the Project would have a less than significant effect with implementation of TR-1 through TR-4 mitigation measures.

TABLE 23
TRAFFIC AND TRANSPORTATION IMPACTS AND MITIGATION SUMMARY

Proposed Project Impact	Mitigation Measure	Significance Conclusion
Groundwater Conservation and Recovery Component		
Consistency with Regulations for Circulation System Performance	TR-1 through TR-4	Less than significant with mitigation
Congestion Management Program/ LOS Standard	TR-1 through TR-4	Less than significant with mitigation
Air Traffic	None required	Less than significant
Traffic Hazards	TR-1 through TR-4	Less than significant with mitigation
Emergency Access	TR-1	Less than significant with mitigation
Public Transit, Bicycle, or Pedestrian Facilities	None required	No impact
Imported Water Storage Component		
Consistency with Regulations for Circulation System Performance	TR-1 through TR-4	Less than significant with mitigation
Congestion Management Program/ LOS Standard	TR-1 through TR-4	Less than significant with mitigation
Air Traffic	None required	Less than significant
Traffic Hazards	TR-1 through TR-4	Less than significant with mitigation
Emergency Access	TR-1	Less than significant with mitigation
Public Transit, Bicycle, or Pedestrian Facilities	None required	No impact

Impact and Mitigation Analysis of Project Modifications

The transportation and traffic conditions in the vicinity of the Project have not changed since the preparation of the 2012 EIR. Increased traffic volumes estimated for project construction and operation were compared with existing roadway conditions and State and County thresholds.

Issues (and Supporting Information Sources):	*Potentially Significant Impact*	*Less Than Significant with Mitigation Incorporated*	*Less Than Significant Impact*	*No Impact*
XVII. TRANSPORTATION — Would the project:				
a) Conflict with a program plan, ordinance or policy addressing the circulation system, including transit, roadway, bicycle and pedestrian facilities?	☐	☒	☐	☐

Issues (and Supporting Information Sources):	*Potentially Significant Impact*	*Less Than Significant with Mitigation Incorporated*	*Less Than Significant Impact*	*No Impact*
b) Would the project conflict or be inconsistent with CEQA Guidelines section 15064.3, subdivision (b)?	☐	☒	☐	☐
c) Substantially increase hazards due to a geometric design feature (e.g., sharp curves or dangerous intersections) or incompatible uses (e.g., farm equipment)?	☐	☐	☒	☐
d) Result in inadequate emergency access?	☐	☐	☒	☐

Discussion

a) The Project would not result in significant increases of traffic once construction is completed since the Project and Project modifications would not require a substantial number of on-site workers and only minimal maintenance trips on local roadways including the Cadiz-Rice road. Therefore, the Project would not conflict with the San Bernardino County CMP, the Circulation Element of the San Bernardino County General Plan, or SCAG's Regional Transportation Plan.

The pipeline construction would occur adjacent to the ARZC rail system. Construction at rail line crossings would be either by jack and bore or conventional tunnel with ribs and lagging or lineal plate. All construction operations at rail line crossings would be coordinated with the affected railroad companies to ensure that normal operations would not be affected. Additionally, construction materials and equipment, particularly oversized loads may be delivered to the construction site via the BNSF Railroad and dropped off at the intersection with the ARZC rail line. Equipment and materials would then be delivered to construction sites using either the existing ARZC rail system or by truck. Coordination with the ARZC and BNSF Railroad would be required. Currently, the BNSF rail line is used frequently during the day. The ARZC rail line is used a few times per day. Shipments on the BNSF and the ARZC rail lines would not substantially increase the overall number of trains running on the BNSF or ARZC rail lines, but may add a few trains per day during peak delivery periods. As described in the 2012 EIR, Mitigation Measures **TR-2** through **TR-4** would be implemented to reduce potential impacts to railway transit.

b) The Project would increase traffic on local roadways during construction, though the local roadways currently have very little traffic as the greater Project area is sparsely populated. Construction of the Project is expected to last up to 2 years. The primary impacts from the movement of construction trucks would include short-term and intermittent impacts on roadway capacities due to slower moving vehicles. Traffic-generating construction activities would consist of the arrival and departure of constructions workers, trucks hauling equipment and materials to the construction site, the hauling of excavated soils, and importing of new fill. Trucks leaving roadways onto construction sites would slow any traffic and could result in hazards to fast moving traffic on the sparsely used roads. If lane closures or flagmen are required to manage traffic during delivery of construction equipment, an encroachment permit from Caltrans would be necessary.

The Project would not increase average daily trips on local highways considerably or cause delays on local county roads such as the Cadiz-Rice road. Construction related traffic would slow to exit SR-62 near the Cadiz-Rice road exit and at the Amboy exit on US-66 and may briefly affect through-traffic speeds. Traffic control measures, including turn-off lanes may be necessary to avoid impacts to high speed traffic. Implementation of a traffic control plan as described in Mitigation Measures **TR-1** would reduce construction-related traffic impacts.

The Project would not conflict with CEQA Guidelines section 15064.3, subdivision (b).

c) The Project would not construct or modify roadways or alter the existing regional circulation system. Therefore, it would not introduce hazardous design features into the existing environment.

d) The Project would not impede traffic in the Project area and would not create obstacles to emergency service providers since no road or lane closures would be necessary. The nearest fire station is the Wonder Valley fire station, located approximately 33 miles west of the Project site. The average fire response time to the Project site is 35 minutes to one hour depending on where the emergency is located on the Cadiz-Rice road. Police protection services are provided by SBCSD's Morongo Basin Station, located 78 miles west of the Project site. The average police response time is one hour. Mitigation Measure **TR-1** also requires coordination with emergency service providers at least one month prior to construction within roadways that might affect emergency response times.

As described in the 2012 EIR, Mitigation Measure **TR-1** through **TR-4** would be implemented to reduce potential impacts. Impacts related to modification of the Project during construction and operation are consistent with those described in Section 4.15 of the EIR and no additional mitigation is required. Therefore, impacts due to construction and operation of the Project as modified would remain less than significant with mitigation incorporated.

Mitigation Measures in the 2012 EIR

TR-1: A Traffic Control Plan shall be implemented that includes the following elements:

- Identify hours of construction and hours for deliveries and include a discussion of haul routes;
- Identify all access restrictions, parking restrictions, and signage requirements on major roads (e.g., speed limit);
- Identify signage and flag men necessary at turn-off lanes on SR-62 and US-66 to avoid traffic hazards on fast moving roads;
- Include a plan to coordinate all construction activities with emergency service providers in the area at least one month in advance. Emergency service providers shall be notified of the timing, location, and duration of construction activities. All roads shall remain passable to emergency service vehicles at all times; and
- Arrange for a telephone resource to address public questions and complaints during Project construction.

TR-2: The construction contractor shall submit construction plans for construction within the railroad easement to the railroad owner and operator for their review and approval. Any plans to deliver materials on the rail lines shall be reviewed and approved by the railroad owner and operator. The construction contractor shall obtain approval from the railroad operator for material delivery and staging activities within the railroad right-of-way.

TR-3: During construction, all at-grade railroad crossings shall be clearly flagged and barricaded to ensure that all vehicular traffic comes to a full stop prior to crossing railroad tracks.

TR-4: The construction contractor shall implement mandatory railroad safety training and implement railroad safety measures requested by the railroad operator.

Significance Determination

Impacts from construction and operation from the Project modifications are consistent with those identified in the 2012 EIR. Substantial changes are not proposed in the Project, requiring major revisions of the previous EIR due to the involvement of new significant environmental effects or a substantial increase in the severity of previously identified significant effects to transportation and traffic resources. No new information of substantial importance indicates the project would have one or more significant effects not discussed in the previous EIR nor are significant effects previously examined substantially more severe than described in the previous EIR. No mitigation measures or alternatives previously found not to be feasible would in fact be feasible and would substantially reduce one or more significant effects of the project; and no mitigation measures or alternatives that are considerably different from those analyzed in the previous EIR would substantially reduce one or more significant effects to transportation and traffic resources.

XV. Energy

Summary of Project Impacts in the 2012 EIR

Table 24 summarizes the Impact and Mitigation Analysis in 2012 EIR for public services including energy usage. The EIR determined that the Project would have a less than significant effect to energy usage with implementation of UTIL-3 mitigation measure.

TABLE 24
ENERGY IMPACTS AND MITIGATION SUMMARY

Proposed Project Impact	Mitigation Measure	Significance Conclusion
Groundwater Conservation and Recovery Component		
Public Services	None required	Less than significant
Expansion of New Wastewater Facilities and Compliance with Wastewater Requirements	None required	Less than significant
Storm Water Drainage Facilities	**HYDRO-1, HYDRO-6, and UTIL-1**	Less than significant with mitigation
Expansion of New Water Supply Facilities	None required	Less than significant
Solid Waste	None required	Less than significant
Disruption of Local and Regional Utilities	UTIL-2	Less than significant with mitigation
Energy Usage	UTIL-3	Less than significant with mitigation
Imported Water Storage Component		
Public Services	None required	Less than significant
Expansion of New Wastewater Facilities and Compliance with Wastewater Requirements	None required	No impact
Storm Water Drainage Facilities	**HYDRO-1, HYDRO-6, and UTIL-4**	Less than significant with mitigation
Expansion of New Water Supply Facilities	None required	Less than significant
Solid Waste	None required	Less than significant
Disruption of Local and Regional Utilities	UTIL-2	Less than significant with mitigation
Energy Usage	None required	Less than significant

Impact and Mitigation Analysis of Project Modifications

To convey the treated water to the CRA, modifications include the installation of two BPS, with a combined HP of 5,828. The Project's energy requirements have been updated since the preparation of the 2012 EIR consistent with availability of newer engine models. With the Project modifications, the Project as a whole would require approximately 15,170 HP. While there will be a net increase in power needs, the 2012 EIR conservatively estimated the total HP of 16,200. With the Project modifications, the Project as a whole would require approximately 15,170 HP to operate facilities. This total power requirement is less than the total power need assumptions of 16,200 HP (12 MW), modeled in the 2012 EIR (Appendix B) which included a standby power source. As a result of the availability of newer model engines, the estimated installed capacity to drive the Project groundwater pumps is now approximately 8,066 HP. The addition of the BPS would increase operational energy needs from approximately 8,066 to 15,170 HP. Therefore, overall Project energy usage with modifications, is expected to be less than the initial Project design evaluated in the 2012 EIR.

Issues (and Supporting Information Sources):	*Potentially Significant Impact*	*Less Than Significant with Mitigation Incorporation*	*Less Than Significant Impact*	*No Impact*
ENERGY — Would the project:				
a) Result in a substantial increase in overall or per capita energy consumption?	☐	☒	☐	☐
b) Result in wasteful or unnecessary consumption of energy?	☐	☐	☒	☐
c) Require or result in the construction of new sources of energy supplies or additional energy infrastructure capacity the construction of which could cause significant environmental effects?	☐	☐	☒	☐
d) Conflict with applicable energy efficiency policies or standards?	☐	☐	☐	☒

Discussion

a) The Project modifications would include a number of water pumps powered by natural gas to convey water to and from the treatment facilities as described in **Table 4**. However, the total energy consumption of the Project would remain below the total 12 MW (16,200 HP) capacity assumed in the 2012 EIR (Appendix B). Therefore, the amount of energy needed to operate the Project, including the modifications, would be less than the assumptions in the 2012 EIR.

b) As described in the EIR, overall net energy use for water delivery to Project Participants would be less than a comparable delivery from the SWP since energy usage for the SWP is greater than for the proposed Project. The Project would result in slightly smaller energy demand than from other potential water supply sources available to the Project The CEC estimates that delivery of water via the SWP West Branch to northern Los Angeles County requires approximately 7,672 kWh/MG. The Project would require approximately 6,998 kWh/MG, which is less than energy required to convey the same amount of water through the SWP. The water treatment facilities would require 5,304 kWh per day that would be offset by hydroelectric power installed onsite. The Project would not result in wasteful use of electricity or substantially increase energy use compared to existing energy demands for importing water to Southern California.

c) The Project modifications do not require the construction of new sources of energy supplies to supply energy to the Project however, a small hydroelectric facility would be installed onsite to offset the energy used to treat the water. Power to operate the BPS would be provided by existing underground natural gas pipelines. Overall Project energy usage with modifications, is expected to be less than the initial Project design evaluated in the 2012 EIR.

d) To support the California Energy Action Plan II to reduce the State's overall energy usage, the Project would incorporate energy efficient pumps, solar and hydroelectric power, lighting, and other equipment to minimize energy impacts. The Project as modified would be consistent with County goals of reducing GHG emissions.

As described in the 2012 EIR, Mitigation Measure **UTIL-3** would be implemented to reduce energy usage. Impacts related to modification of the Project are less than previously estimated in Section 4.13 of the EIR and no new mitigation would be required. Therefore, Project impacts, as modified, would remain less than significant with mitigation incorporated.

Mitigation Measures in the 2012 EIR

UTIL-3: Pumps installed as part of the Project shall be rated for high efficiency to minimize energy consumption.

Significance Determination

Impacts from construction and operation to energy resources from the Project modifications are consistent with those identified in the 2012 EIR. Substantial changes are not proposed in the Project, requiring major revisions of the previous EIR due to the involvement of new significant environmental effects or a substantial increase in the severity of previously identified significant effects to energy resources. No new information of substantial importance indicates the project would have one or more significant effects not discussed in the previous EIR nor are significant effects previously examined substantially more severe than described in the previous EIR. No mitigation measures or alternatives previously found not to be feasible would in fact be feasible and would substantially reduce one or more significant effects of the project; and no mitigation measures or alternatives that are considerably different from those analyzed in the previous EIR would substantially reduce one or more significant effects to energy usage.

XVI. Wildfire

Issues (and Supporting Information Sources):	*Potentially Significant Impact*	*Less Than Significant with Mitigation Incorporated*	*Less Than Significant Impact*	*No Impact*
20. Wildfire—If located in or near state responsibility areas or lands classified as very high fire hazard severity zones, would the project:				
a) Substantially impair an adopted emergency response plan or emergency evacuation plan?	☐	☐	☐	☒
b) Due to slope, prevailing winds, and other factors, exacerbate wildfire risk, and thereby expose project occupants to, pollutant concentrations from a wildfire or the uncontrolled spread of a wildfire?	☐	☐	☒	☐
c) Require the installation or maintenance of associated infrastructure (such as roads, fuel breaks, emergency water sources, power lines or other utilities) that may exacerbate fire risk or that may result in temporary or ongoing impacts to the environment?	☐	☐	☒	☐
d) Expose people or structures to significant risks, including downslope or downstream flooding or landslides, as a result of runoff, post-fire slope instability, or drainage changes?	☐	☐	☒	☐

Summary of Project Impacts in the 2012 EIR

While the 2012 EIR included existing information on vegetation and wildfire hazards in the Project area, the 2012 EIR did not address Wildfire as a CEQA significance threshold (ESA, 2012) as Wildfire was not included in the *Appendix G Checklist* thresholds at the time of publication. Therefore, no analysis of the above thresholds or mitigation measures were identified in the 2012 EIR. Consistent with the 2019 *CEQA Guidelines,* the potential impact of Wildfire due to implementation of the Project is discussed below.

Impact and Mitigation Analysis of Project Modifications

This evaluation focuses on potential public safety and structural hazards impacts regarding wildfire resulting from the construction and operation of the Project modifications.

Discussion

a) As discussed above in VIII, *Hazards and Hazardous Materials* of this Addendum, *t*he Project would not be located on any roads and would not interfere with adopted emergency response plans or evacuation routes defined by any local jurisdictions. The Project area is not located in the immediate vicinity or flight path of a major airport. Emergency responses to remote parts of eastern San Bernardino County typically involve helicopter transport, which would not be hindered by Project construction or operation. Therefore, no impact would occur.

b) As discussed in above in VIII, *Hazards and Hazardous Materials* of this Addendum, the Project would be located within a sparsely-vegetated desert area. As indicated in the 2012 EIR, the CAL FIRE hazard severity zone map identifies the Project area as within its lowest fire hazard severity zone, the lowest possible risk category. The nearest residences are located in Chambless, approximately 5 miles from the Project site. The Project area is relatively flat and does not contain steep slopes. The Project area is susceptible to winds; however, as the area is not within a fire hazard severity zone and does not contain vegetation that increases risk of wildfire, implementation of the Project would not exacerbate the potential for wildfire to start or spread in the Project area. Potential impacts regarding the exposure of Project occupants to pollutant concentrations from wildfire or uncontrolled spread of wildfire would be considered less than significant.

c) The Project would not result in the installation of permanent roads, fuel breaks, emergency water sources or new power lines and other utilities. All construction must comply with fire protection and prevention requirements specified by the California Code of Regulations (CCR) and California Division of Occupational Safety and Health (Cal/OSHA). This includes various measures such as easy accessibility of firefighting equipment, proper storage of combustible liquids, no smoking in service and refueling areas, and worker training for firefighter extinguisher use. With adherence to applicable laws and regulations, impacts would be reduced to a less than significant level.

d) As discussed in VI, *Geology and Soils* and IX, *Hydrology and Water Quality*, the Project area is not located within the 100-year flood zone maps prepared by FEMA. Although not identified as being within 100-year flood maps, the general area is known to experience occasional seasonal short-term flooding. As described above, it is highly unlikely the Project area would experience a wildfire. Nonetheless, the seasonal flooding could damage above-ground structures such as well heads and supporting power equipment after a wildfire, if one were to occur. The facilities would be constructed to accommodate potential flooding, directing flows around improvements. Buried pipelines would be armored under washes with concrete as appropriate to ensure protection during large flood events. Project features would be designed to avoid or minimize potential impacts.

Mitigation Measures in the 2012 EIR

No mitigation measures were included in the 2012 EIR pertaining to wildfire. No additional mitigation would be required as a result of the proposed modifications.

Significance Determination

Not applicable.

Cumulative Impacts

This Addendum evaluates the potential for the modified project to result in new or substantially more severe significant cumulative impacts compared to the cumulative impacts disclosed in the 2012 EIR. The information used in this evaluation includes analysis from the certified Cadiz Valley Water Conservation, Recovery, and Storage Project EIR, the modified project description, new technical studies, and an updated cumulative projects list **(Table 5-1)**. The analysis provides conclusions on whether the project modifications result in new impacts that could be cumulatively considerable, or substantially increases previously identified cumulative impacts.

TABLE 25
PLANS, PROGRAMS, AND PROJECTS EVALUATED IN THE CUMULATIVE EFFECTS ANALYSIS

Project Name	Nature of Project /Description	Relationship to and Distance from Project Area	Status	Areas of Potential Cumulative Effect
General Plans				
County of San Bernardino General Plan	Guides land use and planning in the County and future development; facilitates economic development; enhances neighborhoods and commercial areas; and ensures adequate infrastructure, services and facilities are present to support projected growth. The Project is exempt from County zoning ordinances and no CUP is required because facilities "related" to water receive qualified immunity, subject to confirmation by SMWD at a public hearing (Gov. Code § 53096(b)). The General Plan EIR[1] requires projects in the Desert Region to mitigate impacts on biological resources to less than significant in order to obtain permits. The General Plan policies are considered provisionally to assess Project consistency.	The Project area is in the Desert Region within unincorporated portions of San Bernardino County zoned for resource conservation (RC) and agriculture (AG).	The General Plan was adopted March 13, 2007. A draft supplement amendment, the Greenhouse Gas Reduction Plan[2]was adopted in September 2011.	Aesthetics, Agriculture, Air Quality, Biological Resources, Fire Hazard, and Traffic. Project would not conflict with General Plan goals or policies, preclude continued agricultural use, or prevent agricultural expansion into adjacent AG-zoned lands to the west. Regional development would have construction and operational impacts on scenic resources, AG conversion, air quality, biological resources, fire hazards, and traffic.
Yucca Valley General Plan Update / SR-62 Realignment	The Town of Yucca Valley has updated their General Plan,[3] which among other things, evaluates traffic and circulation alternatives for re-routing SR-62 around the Old Town planning area. The General Plan Update process was coordinated with other agencies, including Riverside County and Caltrans.	The Town of Yucca Valley is approximately 50 miles west of the Project area. Vehicles would use SR-62 to access Project site.	The General Plan Update was adopted by the Town Council on February 4, 2014..	Traffic. SR-62 is the primary transportation corridor in the region, connecting the Morongo Basin, Town of Yucca Valley, community of Joshua Tree, and Twentynine Palms to the I-10 and Riverside County.

1 County of San Bernardino, *San Bernardino County 2006 General Plan Program Draft Program Environmental Impact Report*, September 2006, pages I-3 through I-26.

2 Pacific Municipal Consultants, 2011. General Plan Amendment and Greenhouse Gas Reduction Plan, Final Supplemental Program Environmental Impact Report. Available online at: http://www.sbcounty.gov/Uploads/lus/Countywide/GreenhouseGas/Full-Vol-1.pdf, accessed May 2019.

3 Town of Yucca Valley, 2014. General Plan Update. Available online at: http://www.yucca-valley.org/departments/gpu.html, accessed May 2019.

Project Name	Nature of Project /Description	Relationship to and Distance from Project Area	Status	Areas of Potential Cumulative Effect
Energy Projects, Plans, and Programs				
Renewable Energy Transmission Initiative (RETI) / Competitive Renewable Energy Zones (CREZs)	Statewide initiative to identify, designate, and facilitate the permitting and development of renewable energy and associated transmission projects. 32 Competitive Renewable Energy Zones (CREZs) have been identified in California: areas that can be developed in a cost effective and environmentally benign, responsible manner. There are 2 CREZs in the Project vicinity: the Twentynine Palms CREZ and Iron Mountain CREZ.). Iron Mountain ranks last and Twentynine Palms ranks 17 of 32 in affordability.	The Iron Mountain CREZ (~40,000 acres) lies parallel to and overlaps slightly with the Project area along the ARZC ROW, near the CRA tie-in. The Twentynine Palms CREZ (~18,256 acres) is 25 miles west.	Transmission segments and CREZs have been identified and detailed environmental and cost assessments have been conducted[4]. There are four solar projects in the Twentynine Palms CREZ and seven solar projects and one wind project in the Iron Mountain CREZ.	Aesthetics, Air Quality, Biological and Cultural Resources, GHG, Noise, Transportation, Utilities. Typical construction and operation impacts associated with implementation of solar thermal and wind facilities.
California Desert Renewable Energy Conservation Plan (DRECP)	DRECP[5] will be an NCCP that facilitates and streamlines the approval and permitting of renewable energy projects in the Desert Region and serves as the basis for one or more HCPs under FESA. Projects have and will include large-scale solar thermal, solar PV, wind, and associated infrastructure / transmission. The BLM signed the Record of Decision approving its Land Use Plan Amendment on September 14, 2016, completing Phase I of the DRECP. The BLM Plan Amendment covers the 10 million acres of BLM-managed lands in the DRECP plan area and supports	Covers the Project area; will apply to renewable energy projects in the Planning Area.[7]	The Best Management Practices and Guidance Manual and the DRECP Framework Conservation Strategy and starting point maps are complete. The Renewable Energy Action Team (REAT) [8] prepared the DRECP Joint EIR/EIS in September 2014.[9]	Biological Resources. The DRECP provides binding, long-term endangered species permit assurances and facilitate the project approval process for renewable energy projects in the Planning Area, including projects within the nearby CREZs and Solar Energy Program (SEZ) and associated transmission corridors.

4 California Energy Commission, 2015. Renewable Energy Projects in Development with Existing and Approved Transmission Lines Including Desert Renewable Energy Conservation Plan Boundaries and Preferred Development Focus Areas. Available online at: https://www.energy.ca.gov/maps/renewable/renewable_development_drecp.pdf, accessed May 2019.

5 Desert Renewable Energy Conservation Plan, 2019a. Available online at: http://www.drecp.org/, accessed May 2019.

7 Desert Renewable Energy Conservation Plan, 2019b. DRECP Gateway. Available online at: https://drecp.databasin.org/maps/4a5c4f9527f14b7198053bd467f315e7/active, accessed May 2019.

8 Desert Renewable Energy Conservation Plan, 2019c. REAT. Available online at: https://www.drecp.org/participants/, accessed May 2019.

9 Desert Renewable Energy Conservation Plan, 2014. Draft DRECP and EIR/EIS. Available online at: https://www.drecp.org/draftdrecp/, accessed May 2019.

Project Name	Nature of Project /Description	Relationship to and Distance from Project Area	Status	Areas of Potential Cumulative Effect
	the overall renewable energy and conservation goals of the DRECP[6]. Phase II of the DRECP focuses on better aligning local, state, and federal renewable energy development and conservation plans, policies, and goals. It includes building off of the Renewable Energy Conservation Planning Grants (RECPG) that were awarded by the California Energy Commission to counties in the plan area.			
West-wide Energy Corridor Program	Federal directive to designate corridors[10] on federal land for oil, gas and hydrogen pipelines and electricity transmission and distribution facilities (energy corridors). Of the 5,000 miles of Federal 368 Energy Corridors designated across 11 States, two 368 Energy Corridors are located in the Project vicinity, along Old US 66 and I-10, respectively. The Corridor nearest the Project site extends from Barstow to the Nevada border, following I-40 and Old US 66 northwest of the Project site. Northeast of the Project site, the alignment veers directly north and travels along / adjacent to (but outside of) the Mojave National Preserve before heading east into Nevada[11].	One 368 Federal Energy Corridor traverses the northernmost portion of the Project area, intersecting the proposed wellfield and spreading basin areas along Old US 66. A second corridor is located 30 miles south of the Project site along the I-10.	Agency-specific EIS and RODs were issued by both the BLM and the U.S. Forest Service on January 14, 2009.[12] An evaluation of site-specific impacts at the local project level will occur in the event that a project proposal is submitted for consideration.[13]	Aesthetics, Air Quality, Biological and Cultural Resources, GHG, Noise, Transportation, Utilities. Typical construction and operation impacts associated with new or extended transmission corridor projects north and south of the Project site.

6 Desert Renewable Energy Conservation Plan, 2016. BLM Record of Decision, Land Use Amendment, and Environmental Impact Statement. Available online at: https://www.drecp.org/finaldrecp/, accessed May 2019.

10 U.S. Department of the Interior, Bureau of Land Management (BLM), 2019a. West-wide Energy Corridors. Available online at: https://www.blm.gov/programs/lands-and-realty/right-of-way/west-wide-energy-corridors, accessed May 2019.

11 West-wide Energy Corridor, 2019. Information Center. Available online at: http://corridoreis.anl.gov/, accessed May 2019.

12 BLM, 2009. Approved Resource Management Plan Amendments/ Record of Decision (ROD) for Designation of Energy Corridors on Bureau of Land Management-Administered Lands in the 11 Western States. Available online at: http://corridoreis.anl.gov/documents/docs/Energy_Corridors_final_signed_ROD_1_14_2009.pdf, accessed May 2019.

13 West-side Energy Corridor, 2008. Programmatic Environmental Impact Statement, Designation of Energy Corridors on Federal Land in the 11 Western States (DOE/EIS-0368). Available online at: http://www.corridoreis.anl.gov/eis/guide/index.cfm#vol1, accessed May 2019.

Project Name	Nature of Project /Description	Relationship to and Distance from Project Area	Status	Areas of Potential Cumulative Effect
BLM Solar Energy Development Program	BLM is evaluating utility-scale solar energy development in Arizona, California, Colorado, Nevada, New Mexico, and Utah. The Draft Solar PEIS[14] analyzes a no action alternative, the Solar Energy Development Program Alternative under which 22 million acres of BLM land would be opened to solar development, and the SEZ Program Alternative that would focus solar development on 676,000 acres of SEZs. The BLM identified 24 SEZs, four in California. The proposed Iron Mountain SEZ, located on BLM-administered land in Ward Valley, was the closest SEZ to the project area and would have overlapped with the area proposed for the Project conveyance pipeline and the CRA tie-in facility. However, the Iron Mountain Sez was eliminated from further consideration as part of a revised program proposal released by the DOE and BLM in October 2011. As a result, no cumulative effects associated with the BLM program would occur.	The Iron Mountain SEZ (106,522 acres) was located immediately adjacent to and overlapping the proposed Project area along the ARZC ROW and near the CRA tie-in. The proposed SEZ surrounded several Cadiz parcels. This SEZ has been eliminated from further consideration	On October 27, 2011, BLM issued a Supplement to the Draft Solar PEIS to update the proposed program. As part of the update, the Iron Mountain SEZ (among others) was eliminated from further consideration.	Because the Iron Mountain SEZ has been eliminated from further consideration, energy development previously anticipated and described in the BLM Solar PEIS is no longer anticipated. Therefore, no cumulative effects are analyzed for this program.
Rice Solar Energy Project (RSEP)	RSEPproposes a 150 MW power tower facility in eastern Riverside County. The facility would use concentrating solar power (CSP) technology, with a central receiver tower and an integrated thermal storage system. The proposed technology generates power from sunlight by focusing energy from a field of sun-tracking mirrors called heliostats onto a central receiver. The proposed 2011 to 2013 (30-month) construction period would require 780 AFY of water. Process water requirements for facility operations, commencing by the end of 2013, would be up to 180 AFY, assuming an operating capacity factor of 37 percent.	1,410 acres of a privately-owned 2,560-acre parcel in eastern Riverside County, 6 miles southeast of the Project area, south of SR-62.	RSEP was approved on 12/15/2010.[15]The project is currently in the compliance phase and on hold before construction.	Aesthetics, Air Quality, Biological and Cultural Resources, GHG, Noise, Transportation, Utilities. Typical construction and operation impacts associated with 150 MW facility. Site access would be via SR-62. Propane would be used for auxiliary heating. The workforce would average 280 construction workers and 47 full-time staff, mostly locals.

14 BLM, 2012. Approved Resource Management Plan Amendments/Record of Decision (ROD) for Solar Energy Development in Six Southwestern States. Available online at: http://blmsolar.anl.gov/documents/, accessed May 2019.

15 California Energy Commission (CEC), 2019. Rice Solar Energy Project. Available online at: https://www.energy.ca.gov/sitingcases/ricesolar/index.html, accessed May 2019.

Project Name	Nature of Project /Description	Relationship to and Distance from Project Area	Status	Areas of Potential Cumulative Effect
California Desert Protection and Recreation Act (CDPRA) of 2018	The CDPRA[16] would: designate 328,000 acres of public land as wilderness, which means they can never be developed, mined, or otherwise disturbed and add key wild areas to Death Valley and Joshua Tree National Parks; protect 73 miles of waterways as Wild and Scenic; and promote other protections of special land such as BLM off-road lands.[17] The Act created two new National Monuments, expanded Joshua Tree and Death Valley National Parks and the Mojave National Preserve, and establish new wilderness areas throughout Southern California. The Act preserves about 1.6 million acres of public lands, including historic trails, Native American cultural areas, and portions of Old US 66. The Mojave Trails National Monument [18] would link Mojave National Preserve and 13 wilderness areas with the 941,413 acre monument and direct renewable energy development away from pristine public lands and towards federal Solar Energy Program Areas.	The Project spreading basin area for the Phase 2 Imported Water Storage Component would overlap slightly with the southernmost portion of the proposed Mojave Trails National Monument.	Senator Feinstein and local congressional delegation have enacted the CDPRA of 2018 to add protections to publicly owned land to provide wildlife corridors, protect watershed and waterways, and preserve desert heritage.	Aesthetics, Air Quality, GHG, Biological and Cultural Resources, Land Use. Protections placed on large swaths of land in the Project area would render them undevelopable and thereby protect aesthetic, biological, and cultural resources in these areas.

[16] Congress.Gov, 2018. S. Rept. 115-421 – California Desert Protection and Recreation Act of 2018. Available online at: https://www.congress.gov/congressional-report/115th-congress/senate-report/421/1, accessed May 2019.

[17] Campaign for the California Desert, 2019. Legislation. Available online at: http://californiadesert.org/legislation/, accessed May 2019.

[18] BLM, 2019b. Mojave Trails National Monument. Available online at: https://www.blm.gov/programs/national-conservation-lands/california/mojave-trails-national-monument, accessed May 2019.

Project Name	Nature of Project /Description	Relationship to and Distance from Project Area	Status	Areas of Potential Cumulative Effect
Marine Corps Base Expansion[19]: Land Acquisition and Airspace Establishment to Support Large-Scale Marine Air Ground Task Force Live Fire and Maneuver Training	The Marine Corps is studying alternatives for a large-scale training facility that would accommodate a new program of sustained, combined-arms, live-fire, and maneuver training for a Marine Expeditionary Brigade-sized Marine Air Ground Task Force. The project would expand the existing air and ground operating areas at the Combat Center to establish the required sized facility for the training. Three major components include acquisition of land next to the existing Combat Center, modification and establishment of special use airspace, and expanded training. Nearly 20,000 public comments have helped to develop a range of reasonable alternatives to meet MEB training requirements, including an “Alternative 6”, the DEIS preferred alternative. Alternative 6 would accommodate continued public access to 40,000 acres in the West Study Area. Alternative 3 proposes to add approximately 22,000 acres of land to the South and approximately 177,000 acres to the East of the 29 Palms Base.	Current Base boundary is 12 miles west of Project area. One of the land acquisition alternatives (Alternative 3) overlaps substantially with the Project area and, if chosen, would render the Project infeasible (this Alternative has not been selected as the preferred alternative in the PEIS). The proposed land acquisition areas total 380,000 acres.	The SEIS was prepared during the fall of 2016. As part of this analysis, a revised Biological Opinion was released on January 31, 2017. A ROD for the BLM, a cooperating agency on this project, was signed on February 9, 2017. The Department of the Navy’s ROD was signed on February 10, 2017, documenting the Marine Corps selection of a tortoise translocation alternative. [20]	Air Quality, Biological Resources, GHG, Land Use, Transportation. Depending on the alternative, potential take of 19 to 725 desert tortoise and impacts on up to 130,000 acres of desert tortoise habitat. Acquisition of up to 200,000 acres would close two active mines and conflict with AG zoning on the Project site. From 6, 000-10,000 Marines (up to 12,000) would arrive via bus (~200 buses) over ~10 days via SR-62, with up to 200 buses arriving same day. In addition, up to 40 instructor vehicles would travel on SR-62 up to 30 days annually.
Desert Xpress High-speed Passenger Train Project	DesertXpress proposes a fully grade-separated, double-track passenger-only railroad along an approximately 200-mile corridor between Victorville, California and Las Vegas, Nevada. The project would bring 35,000 jobs to Clark County and several thousand more jobs to southern California once the project begins.	At its nearest point, the project is located 57 miles northwest of the Project area.[21]	The FRA issued the ROD on July 8, 2011.[22]	Air Quality, Biological Resources, GHG, Transportation. Trucks would utilize I-40, Old US 66, I-95, and SR-62. Cumulative impacts to desert tortoise.

[19] U.S. Marine Corps, Twentynine Palms Marine Corps, *Land Acquisition and Air Space Establishment Study Updates,* http://www.marines.mil/unit/29palms/LAS/pages/updates.aspx, accessed July 2011.

[20] U.S Marine Corps, 2019. SIES for Land Acquisition and Airspace Establishment. Available online at: https://www.29palms.marines.mil/Staff-Offices/Government-and-External-Affairs/SEISforLAA/, accessed May 2019.

[21] XpressWest, 2016, the Project. Available online at: http://www.xpresswest.com/project.html, accessed May 2019.

[22] Federal Railroad Administration, 2011. *Record of Decision, DesertXpress High-Speed Passenger Train*. July 2011.

Project Name	Nature of Project /Description	Relationship to and Distance from Project Area	Status	Areas of Potential Cumulative Effect
Other BLM Projects[23]				
Tetra Tech ROW Re-Issuance	The purpose and need for the proposed project is to respond to a Federal Land Policy and Management Act (FLPMA) right-of-way application submitted by Tetra Technologies, Inc. to re-issue previously authorized ROW grants on public lands administered by the BLM in compliance with FLPMA, BLM right-of-way regulations, and other applicable Federal laws and policies.[24]	The Project is located north of the site within a 25-mile buffer of the Project area.	Preparation and Planning No environmental documentation has been published for this project as of April 15, 2019.	Air Quality, Biological Resources, GHG, Transportation. Vehicles may utilize local ROWs. Cumulative impacts to desert tortoise.
Desert Bighorn Sheep Capture – Respiratory Disease Study	The project includes the surveying and capturing of Desert Bighorn Sheep (DBS), subspecies Ovis Canadensis nelson, using a small helicopter with a contractor- supplied pilot through Leading Edge Aviation, mugger and net gunner (capture crew). The targets of this capture are pre-determined rams that are suspected of having GPS/VHF collars that are fitting overly tight and/or are malfunctioning. The project is proposed for the Spring 2017 season, between March 26th and April 4th. Survey and capture activities are anticipated to last approximately 4 days however, scheduling may vary slightly due to unforeseen weather or equipment problems.[25]	The Project is located north of the site within a 25-mile buffer of the Project area.	Preparation and Planning No environmental documentation has been published for this project as of April 4, 2017.	Air Quality, Biological Resources, Noise. Dust and overflight noise from helicopter use. Biological impacts to DBS in the Project area. No significant cumulative impacts anticipated or analyzed.

[23] BLM, 2019c. ePlanning Project Search. Available online at: https://eplanning.blm.gov/epl-front-office/eplanning/nepa/nepa_register.do, accessed May 2019.

[24] BLM, 2019d. DOI-BLM-CA-D090-2018-0041-CX (Tetra Tech ROW Re-Issuance). Available online at: https://eplanning.blm.gov/epl-front-office/eplanning/projectSummary.do?methodName=renderDefaultProjectSummary&projectId=121224, accessed May 2019.

[25] BLM, 2017a. DOI-BLM-CA-D090-2017-0007-CX (Desert Bighorn Sheep Capture). Available online at: https://eplanning.blm.gov/epl-front-office/eplanning/projectSummary.do?methodName=renderDefaultProjectSummary&projectId=75399, accessed May 2019.

Project Name	Nature of Project /Description	Relationship to and Distance from Project Area	Status	Areas of Potential Cumulative Effect
Deep Well Anode Installment	The project would respond to an MLA right-of-way application submitted by Southern California Gas Company to install a mainline valve on public lands administered by the BLM in compliance with MLA, BLM right-of-way regulations, and other applicable Federal laws and policies.[26]	The Project is located north of the site within a 25-mile buffer of the Project area.	Preparation and Planning No environmental documentation has been published for this project as of August 26, 2018.	Aesthetics, Air Quality, Biological and Cultural Resources, GHG, Noise, Transportation, Utilities. Typical construction and operation impacts associated with new or extended pipeline/valve gas facility projects transmission corridor projects north of the Project site and along local ROWs.
Cathodic Protection Station Installations	The purpose and need for the proposed action is to respond to an MLA right-of-way application submitted by PG&E to install seven (7) cathodic protection stations on public lands administered by the BLM in compliance with MLA, BLM right-of-way regulations, and other applicable Federal laws and policies. In accordance with BLM Manual 6220, the BLM shall consider whether ROW proposals are consistent with the authority that designated the component.[27]	The Project is located northeast of the site within a 25-mile buffer of the Project area.	Preparation and Planning No environmental documentation has been published for this project as of June 26, 2018.	Aesthetics, Air Quality, Biological and Cultural Resources, GHG, Noise, Transportation, Utilities. Typical construction and operation impacts associated with facility rehabilitation projects north of the Project site and along local ROWs.
Piute Mountain Burro Gather	The project would conduct gathers and bait trapping. Captures would be conducted by BLM in-house or by a BLM contracted vendor which will operate within the parameters set forth in the contract. A temporary capture corral site would be located on the existing roadway/designated route of travel. The temporary corral would be assembled using interconnected 10-foot long metal panels. The project would include up to 8 people for ground support at the capture site, three horse trailers and associated pickup trucks.[28]	The Project is located northeast of the site within a 25-mile buffer of the Project area.	Preparation and Planning No environmental documentation has been published for this project as of June 19, 2018.	Air Quality, Biological Resources, Noise. Dust from trucks traveling along local roads. No significant cumulative impacts anticipated or analyzed.

[26] BLM, 2018a. DOI-BLM-CA-D090-2018-0033-CX (Deep Well Anode Installment).Available online at: https://eplanning.blm.gov/epl-front-office/eplanning/projectSummary.do?methodName=renderDefaultProjectSummary&projectId=112628, accessed May 2019.

[27] BLM, 2018b. DOI-BLM-CA-D090-2018-0029-CX (Cathodic Protection Station Installations).Available online at: https://eplanning.blm.gov/epl-front-office/eplanning/projectSummary.do?methodName=renderDefaultProjectSummary&projectId=109394, accessed May 2019.

[28] BLM, 2018c. DOI-BLM-CA-D090-2018-0027-DNA (Piute Mountain Burro Gather). Available online at: https://eplanning.blm.gov/epl-front-office/eplanning/projectSummary.do?methodName=renderDefaultProjectSummary&projectId=108698, accessed May 2019.

Project Name	Nature of Project /Description	Relationship to and Distance from Project Area	Status	Areas of Potential Cumulative Effect
Airways 12kv Distribution Line ROW Reissuance	Reissue Southern California Edison's ROW grant CACA-019094, which authorized the operation and maintenance of a 12kv distribution line.[29]	The Project is located southeast of the site within a 25-mile buffer of the Project area.	Analysis and Document Preparation No environmental documentation has been published for this project as of February 21, 2019.	Aesthetics, Air Quality, Biological and Cultural Resources, GHG, Noise, Transportation, Utilities. Typical construction and operation impacts associated with energy distribution line projects south of the Project site and along local ROWs.
Fiber Optic Cable Re-issuance	The purpose and need for the proposed action is to respond to a FLPMA right-of-way application submitted by Frontier Communications of the Southwest, Inc. to re-issue an existing ROW grant on public lands administered by the BLM in compliance with FLPMA, BLM right-of-way regulations, and other applicable Federal laws and policies. The BLM will decide whether to deny the proposed right-of-way, grant the right-of way, or grant the right-of-way with modifications. Modifications may include modifying the proposed use or changing the route or location of the proposed facilities (43 CFR 2805.10(a)(1)).[30]	The Project is located southeast of the site within a 25-mile buffer of the Project area.	Preparation and Planning No environmental documentation has been published for this project as of July 18, 2018.	No significant cumulative impacts anticipated or analyzed.
USGS Earthquake Warning Station	In accordance with FLPMA (Section 103(c)), public lands are to be managed for multiple use that takes into account the long-term needs of future generations for renewable and non-renewable resources, including but not limited to scientific values. The Secretary of the Interior is authorized to grant rights-of-way on public lands for systems of other electronic signals and other means of communication. (Section 501(a)(5)). Taking into account the BLM's multiple use mandate, the purpose and need for the project is to respond to a FLPMA right-of-way application submitted by USGS to construct, operate, maintain, and decommission an earthquake early warning	The Project is located southeast of the site within a 25-mile buffer of the Project area.	Preparation and Planning No environmental documentation has been published for this project as of May 14, 2018.	Aesthetics, Air Quality, Biological and Cultural Resources, GHG, Noise, Transportation, Utilities. Typical construction and operation impacts associated with aboveground utility facility projects south of the Project site and along local ROWs.

[29] BLM, 2019e. DOI-BLM-CA-D090-2019-0007-CX (Airways 12kv Distribution Line ROW Reissuance). Available online at: https://eplanning.blm.gov/epl-front-office/eplanning/projectSummary.do?methodName=renderDefaultProjectSummary&projectId=119681, accessed May 2019.

[30] BLM, 2018d. DOI-BLM-CA-D090-2018-0030-CX (Fiber Optic Cable Re-issuance). Available online at: https://eplanning.blm.gov/epl-front-office/eplanning/projectSummary.do?methodName=renderDefaultProjectSummary&projectId=109937, accessed May 2019.

Project Name	Nature of Project /Description	Relationship to and Distance from Project Area	Status	Areas of Potential Cumulative Effect
	system facility and associated infrastructure on public lands administered by the BLM in compliance with FLPMA, BLM right-of-way regulations, and other applicable Federal laws and policies. [31]			
Earp Hill Accelerated Restoration	The project would restore a rock extraction and processing site and conduct restoration actions on the accompanying roads on BLM public lands on Earp Hill near Vidal Junction, California. This action would also serve to eliminate unauthorized motor vehicle use, trash dumping and set an accelerated trajectory for sites to return to natural conditions. Restoration will consist of treatments that manipulate surface conditions and planting with native shrubs and cacti on the existing linear disturbances across the range of elevation and exposures on Earp Hill.[32]	The Project is located southeast of the site within a 25-mile buffer of the Project area.	Preparation and Planning No environmental documentation has been published for this project as of December 20, 2017.	Aesthetics, Air Quality, Biological and Cultural Resources, GHG, Noise, Transportation, Utilities. Typical construction and operation impacts associated with restoration activities south of the Project area.
South Whipple Mountains 2018 Abandoned Mine Land Closures	The BLM Needles Field Office (NFO) proposes to close 15 Abandoned Mine Land (AML) features, consisting of a total of nine open abandoned mine shafts, and seven admits (sixteen total features), located on public lands northeast of Vidal Junction, California. All actions will occur in the southern Whipple Mountains outside of wilderness.[33]	The Project is located east of the site within a 25-mile buffer of the Project area.	Preparation and Planning No environmental documentation has been published for this project as of December 19, 2018.	Air Quality, Biological Resources, Cultural Resources, GHG, Land Use, Transportation. Typical construction and operation impacts associated with the closing of mines, including dynamite blasting and restoration activities east of the Project area.

[31] BLM, 2018e. DOI-BLM-CA-D090-2018-0022-CX (USGS Earthquake Warning Station). Available online at: https://eplanning.blm.gov/epl-front-office/eplanning/projectSummary.do?methodName=renderDefaultProjectSummary&projectId=106177, accessed May 2019.

[32] BLM, 2017B. DOI-BLM-CA-D090-2018-0006-CX (Earp Hill Accelerated Restoration). Available online at: https://eplanning.blm.gov/epl-front-office/eplanning/projectSummary.do?methodName=renderDefaultProjectSummary&projectId=95160, accessed May 2019.

[33] BLM, 2018f. DOI-BLM-CA-D090-2018-0032-CX (South Whipple Mountains 2018 Abandoned Mine Land Closures). Available online at: https://eplanning.blm.gov/epl-front-office/eplanning/projectSummary.do?methodName=renderDefaultProjectSummary&projectId=112077, accessed May 2019.

Aesthetics

Construction activities associated with renewable energy projects would require the use and storage of heavy equipment in the Project vicinity. During construction, excavated trenches, stockpiled soils, equipment storage, and staging areas/activities would alter the quality of the visual environment along Old US 66 and SR-62. Because construction activities would be short-term and the majority of viewers would be driving, viewers would experience degraded views for a very short period of time, and construction-related visual impacts are considered less than significant.

Development of the proposed energy projects in the Project region could result in significant cumulative effects on aesthetics resources. However, the incremental effects associated with the permanent aboveground Project facilities would not be cumulatively considerable. The Project would have less than significant effects on aesthetic resources. These Project facilities would not result in cumulatively considerable aesthetic impacts as they would have little effect on the overall view. Implementation of Mitigation Measure **AES-1** would reduce light- and glare-related impacts to a less than significant level by requiring all lighting to be shielded and directed onto the Project site and away from adjoining property and public ROWs. Based on the limited footprint of the aboveground Project facilities and the implementation of Mitigation Measure AES-1, and the magnitude and type of development proposed along the energy corridors, the Project's incremental effect on aesthetic resources would not be cumulatively considerable.

Cumulative Analysis of Project Modifications

Development of the cumulative projects in the project region could result in cumulative effects on aesthetic resources. The project modifications include a modified pipeline alignment and new water treatment plant. The water treatment plant and modified pipeline alignment would still remain within the vicinity of the original area. The revised pipeline alignment would not obstruct long-range views of the desert and mountains and would not adversely affect the visual character of the rail corridor. The new treatment plant, storage and booster pumping station facilities would have low profiles, and would not have the scale or massing to obstruct scenic views of the desert and mountains, and would not affect the visual character of the area.

The project modifications would introduce nighttime lighting similar to the original project which could impact the nighttime character of the valley, however, as described, mitigation measures to reduce nighttime lighting impacts would be implemented. Therefore, the incremental effects associated with the permanent aboveground facilities would not be cumulatively considerable.

Applicable Mitigation Measures

Implementation of mitigation measures **AES-1** and **AES-2** is required.

Conclusion

The Project modifications would result in similar impacts compared to the 2012 EIR; therefore, the modifications to the project would not result in a new significant impact, or substantially increase the severity of an impact identified in the 2012 EIR. No mitigation is required beyond the existing commitments contained within the 2012 EIR.

Agriculture and Forestry Resources

The Project would convert some agricultural land uses to other uses but would not preclude ongoing agricultural use of the Project site. The Project would avoid active agricultural areas to the maximum extent feasible in order to avoid direct impacts to agricultural lands. Construction and operation of the Project would not result in significant effects on agricultural resources.

Beyond the irrigated agriculture on the Cadiz Inc. Property, there is little agriculture activity in the Project vicinity and none of the other projects identified in eastern San Bernardino County (within the geographic scope for cumulative analysis of agricultural resources) would result in significant effects on agricultural uses or convert significant proportions of agricultural lands to non-agricultural uses. Therefore, the incremental effects of the Project, when considered together with cumulative projects, would not result in a cumulatively considerable impact on agricultural resources.

Cumulative Analysis of Project Modifications

The Project modifications would not convert any farmland to non-agricultural uses. The Project modifications would have no impact. Therefore, the incremental effects of the Project modifications, when considered together with cumulative projects, would not result in a cumulatively considerable impact on agricultural resources.

Applicable Mitigation Measures

No mitigation measures are required.

Conclusion

The Project modifications would result in similar impacts compared to the 2012 EIR; therefore, the Project would not result in a new significant impact, or substantially increase the severity of an impact identified in the 2012 EIR. No new mitigation is required.

Air Quality

The geographic scope of cumulative air quality impacts is the MDAQMD. Notably, any project that would individually have a significant air quality impact would also be considered to have a significant cumulative air quality impact.

As discussed in Section 4.3 Air Quality, with implementation of Mitigation Measures **AQ-1** through **AQ-5**, Project emissions would meet MDAQMD significance thresholds for criteria air pollutants and be less than significant except for NOx emissions. NOx emissions during construction would exceed MDAQMD thresholds and remain a significant and unavoidable effect of Project construction. As shown in Table 4.3-6, the projected long-term operational emissions associated with the Project, however, would be less than significant.

Other projects that would contribute to cumulative impacts on air quality are shown in Table 25. (Please note that Table 25 only includes projects in the general vicinity of the Project and does not purport to list all construction projects within the MDAQMD). Concurrent construction of the

Project, together with other projects in the air basin, would generate emissions of criteria pollutants and toxic air contaminants, including suspended and inhalable particulate matter and equipment exhaust emissions. Because the Project construction alone would exceed significance thresholds established by the MDAQMD for activities and operations within the high desert portion of the Mojave Desert Air Basin, when considered in conjunction with overlapping construction projects in the MDAQMD, its contribution to cumulative air quality impacts are cumulatively considerable.

Project operations would not create emissions that would exceed the MDAQMD thresholds due to minimal daily operational trips and low emissions from engine operations (see Table 4.3-6 of the 2012 EIR). Long-term Project operations would not result in significant cumulative impact.

Cumulative Analysis of Project Modifications

MDAQMD states that if an individual project results in air emissions of criteria pollutants that exceed MDAQMD's recommended daily thresholds for project-specific impacts, then the project would also result in a cumulatively considerable net increase of these criteria pollutants. Although the Project modifications would result in air pollutant emission levels not exceeding thresholds during operation and construction, the Project as a whole would result in construction emissions of NOx that exceed daily thresholds of significance

The 2012 EIR concluded that construction emissions of the Project would result in significant levels of nitrogen oxides. The 2012 EIR included mitigation measures that would be necessary in order to reduce construction and operation emissions.

Applicable Mitigation Measures

Implementation of mitigation measures **AQ-1** and **AQ-5** is required

Conclusion

The Project modifications would result in similar impacts compared to the 2012 EIR; therefore, the modifications to the project would not result in a new significant impact, or substantially increase the severity of an impact identified in the 2012 EIR. No mitigation is required beyond the existing commitments contained within the 2012 EIR

Biological Resources

Though development and growth in the Project vicinity has been infrequent and sporadic over the last 50 years, regionally, renewable energy development in the Mojave and Sonoran Deserts has recently increased and with it, impacts to biological resources have and would continue to increase. The cumulative projects listed in Table 25 and demonstrate that development pressure is increasing in the Project area due to (1) identification of renewable energy development zones (i.e., CREZs) in the Project vicinity for which streamlined project approval and permitting is anticipated; (2) the number, magnitude, and concentration of proposed projects; and (3) the number of acres/areas set aside and/or proposed to be set aside for conservation and resource protection (by preserving 1.6 million acres of public lands throughout California and hundreds of thousands of acres in the Project vicinity, the CDPA of 2011 would also direct development towards designated areas such as CREZs). For these reasons, the DRECP establishes a framework for efficient renewable energy project permitting within the Planning Area, resulting in greater conservation than would occur from a project-by-project, species-by-species review. The Project site is located within the DRECP Planning Area, but it would not be covered by the DRECP because it is not a renewable energy proposal.

The proposed modifications would not increase impacts to biological resources. Project footprint impacts on plant species, habitats, and species with limited distribution are evaluated at a site-specific, local level, while the direct and indirect impacts of Project activities (construction and operation) on regionally-distributed and important species such as desert tortoise are evaluated more broadly.

The geographic scope of the cumulative effects analysis for biological resources varies based on the biological resource being evaluated. As described in Table 25, the overall geographic scope for the cumulative analysis of impacts to biological resources includes the portion of the Mojave Desert bounded by I-40 and Old US 66 to the north, I-95 to the east, SR-62 to the west, and SR 247 to the west. However, Project footprint impacts on plant species, habitats, and species with limited distribution are evaluated at a site-specific, local level, while the direct and indirect impacts of Project activities (construction and operation) on regionally-distributed and important species such as desert tortoise are evaluated more broadly.

Of the cumulative projects, in Table 25, those that would affect large geographic areas and similar environmental resource areas and that would occur in close proximity to the Project would be most likely to contribute to cumulative impacts on biological resources. These include the following: RETI development within the Iron Mountain CREZ (~ 40,000 acres), which intersects and overlaps with the Project site along the southern portion of the ARZC ROW and CRA-tie-in; implementation of the RSEP on BLM lands south of SR-62; the Marine Corps Base Expansion on up to 380,000 acres of land west of the Project site; RETI development within the Twentynine Palms CREZ to the west (~18,256 acres); implementation of the High-Speed Passenger Train Project to the northwest and the West-Wide transmission corridor to the north; construction and operation of the James W Wilson RV Park located just north of the Project site; and implementation of the DRECP (which includes the Project site in its Planning Area), and potential adoption of the CDPA of 2011. Together with the Project, all of these projects and activities, with the exception of the DRECP and CDPA, would result in direct losses and degradation of habitat (either through removal or temporary disturbance) and soils (i.e., through dust deposition), habitat fragmentation and disruption of wildlife corridors / wildlife movement in the Project vicinity; construction noise impacts on wildlife species (i.e., impacts to nesting birds and bats); attraction of predators to the area; introduction and spread of exotic weed species; and loss, disruption, or degradation of sensitive communities, including desert washes and drainages.

The DRECP, a planning document and NCCP, and the CDPA, an open space/conservation plan, are both intended to help avoid, minimize, and/or mitigate the cumulative effects of planned renewable energy development across the region; target substantial acreage of land for open space and habitat conservation; and have the potential to contribute to meaningful resource conservation in the region. Implementation of these plans would have a beneficial impact on biological resources that would, in part, mitigate the effects of the development described herein.

If the projects and plan areas listed above are constructed and/or reach full build-out conditions, permanent and temporary losses of desert habitats / vegetation communities would occur. In addition to direct impacts (removal and disturbance) on up to 250 acres of Mojave creosote bush scrub, Mojave wash scrub, and stabilized desert dunes/desert sand fields associated with implementation of the Project, other projects with cumulative impacts on biological resources would result in direct impacts including up to 40,000 acres of development within the Iron Mountain CREZ; 1,410 acres of RSEP development; up to 380,000 acres associated with the Marine Corps Base Expansion; and up to 18,256 acres of development within the Twentynine Palms CREZ, for an estimated cumulative disturbance of up to 524,000 acres and temporary losses of desert habitats. The federal 368 corridor would also disturb the existing habitats along the Old US 66 and I-40 corridors.

The EIS for the Marine Corps Base Expansion concluded that impacts to creosote bush scrub would be cumulatively considerable but that other habitat disturbance – based on the nature of military maneuvers – would not be significant. That is, of the 524,000 acres of potential disturbance associated with cumulative development in the Project area, up to 380,000 acres would be subject to periodic disturbance from military maneuvers over the long-term, but the Base Expansion Project would not denude large areas of habitat.

For the remaining 144,000 acres of impacts associated with renewable energy development projects and programs in the Project area and vicinity, it is assumed that full-build-out of designated renewable energy development zones (CREZs) would remove habitats. There are several factors that make the Project's contribution to effects on habitats and associated species less than cumulative considerable. First, Project effects would be mitigated through avoidance and minimization measures coupled with compensatory habitat acquisition and management. Second, renewable energy development within designated CREZ areas is to be sited to avoid and minimize effects and to also be fully mitigated through the DRECP effort. In addition, there is substantial acreage in the project region that is protected from use directly or indirectly for habitat conservation including the existing Joshua Tree National Park (1,017,750 protected acres) and Mojave National Preserve (1,419,800 protected acres), numerous BLM Wilderness areas and ACECs in the Project area (there are 3.6 million acres within BLM Wilderness Areas in California); and the proposed protection of an additional 1.6 million acres of desert lands proposed under the CDPA of 2011, including 941,413 acres for the proposed Mojave Trails National Monument located immediate north of the Project site, 133,524 acres for the proposed Sand to Snow National Monument near the intersection of SR-62 and the I-10 and the addition of 2,900 acres to Joshua Tree National Park, 40,740 acres to Death Valley National Park, and 7,141 acres to the San Gorgonio Wilderness.

Approximately 250 acres of desert habitats would be affected from implementation of the Project analyzed in the 2012 EIR. The proposed modifications would add approximately 20 acres to the total. None of the Project area would affect high quality habitat that is within an area proposed for conservation. Wildlife and vegetation potentially using the affected habitats have been described in Section 4.4 Biological Resources in detail. The only species listed within either the State or federal ESA is the desert tortoise. The Project facilities would not be located in any Wilderness Area or critical habitat except a portion of the area identified for the spreading basins for the Imported Water Storage Component extend into the designated critical habitat for the desert tortoise. Given the comparative impacts of other projects in the region that could affect up to 524,000 acres, and the size of the National Parks, National Preserves, DMWAs, and ACECs that have been developed to protect the desert ecosystem resources including the desert tortoise, the Project's contributions would not be significant or cumulatively considerable.

The proposed modifications would add a new road for two miles near the Cadiz agricultural operations. Mitigation Measures BIO-1 through BIO-18 identified in the 2012 EIR would mitigate for direct impacts of the Project, such that no impact would remain significant and unavoidable. Effects to all species including special status species such as the desert tortoise and County-protected plants would be avoided where possible. Where impact to species is unavoidable, compensation and restoration is proposed as mitigation. Implementation of these mitigation measures listed in Section 4.4 including compensating Project effects with conserved lands in perpetuity as approved by resource agencies would lessen the Project's direct effects on biological resources in the region.

These mitigation measures to preserve habitat in perpetuity to compensate direct Project effects also assist in diminishing contributions to the cumulative effect. In addition, federal, State and local plans have been established to preserve desert ecosystems including the CDPA and local ordinances. Compatibility and consistency with the CDPA, federal ESA, federal CWA, and local ordinances would ensure that the impacts of the Project would not contribute considerably to a cumulatively significant impact to biological resources in the eastern California deserts.

Approximately 250 acres of desert habitats would be affected from implementation of the Project analyzed in the 2012 EIR. The proposed modifications would add approximately 20 acres to the total. The proposed modifications would add a new road for two miles near the Cadiz agricultural operations and a 10-acre treatment plant. Mitigation Measures BIO-1 through BIO-18 identified in the 2012 EIR would mitigate for direct impacts of the Project, such that no impact would remain significant and unavoidable. Effects to all species including special status species such as the desert tortoise and County-protected plants would be avoided where possible. Compatibility and consistency with the CDPA, federal ESA, federal CWA, and local ordinances would ensure that the impacts of the Project would not contribute considerably to a cumulatively significant impact to biological resources in the eastern California deserts.

Cumulative Analysis of Project Modifications

Impacts related to modification of the Project during construction and operation are consistent with those described in the 2012 EIR and no new mitigation is required. Therefore, Project impacts, as modified, would remain less than significant with mitigation incorporated. The Project modifications would not result in cumulatively considerable impacts.

Applicable Mitigation Measures

Implementation of mitigation measures **AES-1, AES-2, BIO-1** through **BIO-17** is required.

Conclusion

The Project modifications would result in similar impacts compared to the 2012 EIR; therefore, the Project would not result in a new significant impact, or substantially increase the severity of an impact identified in the 2012 EIR. No new mitigation is required.

Cultural Resources

The geographic scope of potential cumulative impacts related to cultural resources includes the Project site and its immediate vicinity. The Valleys in the Project vicinity were important areas for gathering both salt and food resources for both the Mohave and Chemehuevi, and the remains of campsites are scattered throughout the valley, there are panels of rock art in the adjacent mountains, and historic resources such as railroad sidings are located along the pipeline alignment. Though no paleontological resources were observed on the site surface during 2010 surveys, construction of the Project would include earthmoving activities that could unearth previously unknown archaeological or paleontological resources. Cultural sites identified during construction would be recorded at the San Bernardino Archaeological Information Center. Of the historic structures near the Project, several of the resources located within the pipeline alignment could be affected by other planned or proposed projects that overlap geographically. The impacts on cultural resources of the Project, considered together with other development projects, would have less than cumulatively considerable effects on cultural resources and are considered less than significant.

Other development projects planned for the area could also encounter cultural resources. It is possible that the development of projects within the Iron Mountain CREZ, and of other projects likely to occur in the area, could contribute cumulatively to cultural resource impacts. However, further investigation in those areas would be needed, including a cultural resource survey of the affected areas of potential effects to identify resources; no surveys of the CREZs have occurred to date. Each project would be responsible for recording new sites appropriately. However, historic properties would be avoided or mitigated to the extent possible in accordance with state and federal regulations.

Similarly, through ongoing consultation with the California SHPO and appropriate Native American governments, it is likely that many adverse effects on significant resources in the Ward Valley could be mitigated to some extent. Uncovering archaeological and paleontological resources generally adds to the regional understanding of the area's history and would not result in a cumulatively considerable adverse impact to cultural resources unless those resources were destroyed. Impacts related to visual resources and Native American concerns related to views are addressed above, under Aesthetics. The impacts on cultural resources of the Project, considered together with other renewable energy development projects, would have less than cumulatively considerable effects on cultural resources and are considered less than significant.

Cumulative Analysis of Project Modifications

Impacts related to modification of the Project during construction and operation are consistent with those described in the 2012 EIR and no new mitigation is required. Therefore, Project impacts, as modified, would remain less than significant with mitigation incorporated. The Project modifications would not result in cumulatively considerable impacts.

Applicable Mitigation Measures

Implementation of mitigation measures **CUL-1**, **CUL-6, CUL-7**, and **CUL-11** is required.

Conclusion

The Project modifications would result in similar impacts compared to the 2012 EIR; therefore, the Project would not result in a new significant impact, or substantially increase the severity of an impact identified in the 2012 EIR. No new mitigation is required.

Geology and Soils

The geographic scope of the cumulative impact analysis for geology, soils, and seismicity, includes the Project site and areas immediately adjacent. The construction activities described in would include earthmoving, trenching, and some temporary stockpiling, which could lead to soil erosion. Most cumulative projects include some degree of ground-disturbance and excavation and therefore would have the potential to contribute to cumulative soil erosion effects. However, all projects, including the Project, must comply with pertinent federal, State, and local laws, which require preparation of SWPPPs to address stormwater, minimize erosion and sedimentation by implementing BMPs for erosion control features, and adhere to construction practices that prevent soil erosion. Further, implementation of Mitigation Measures **GEO-1** and **HYDRO-1** would ensure that Project impacts to stormwater runoff and water quality are minimized to the maximum extent feasible. The Project's contribution to soil erosion impacts would not be cumulatively considerable.

Cumulative Analysis of Project Modifications

The water treatment facilities would be constructed within the modified pipeline alignment. The construction of the new treatment plant and pipeline alignment would be done in accordance with the SWPPP and would implement BMPs. Further, the design of the structures would be in conformance with applicable standards established by the CBC to reduce potential impacts from seismic groundshaking and unstable soils. The Project modifications would not be cumulatively considerable.

Applicable Mitigation Measures

Implementation of **GEO-1** and **HYDRO-1** would be required.

Conclusion

The Project modifications would result in similar impacts compared to the 2012 EIR; therefore, the modifications to the Project would not result in a new significant impact, or substantially increase the severity of an impact identified in the 2012 EIR. No mitigation is required beyond the existing commitments contained within the 2012 EIR.

Greenhouse Gas Emissions

GHG and climate change-related impacts are considered to be exclusively cumulative impacts; there are no non-cumulative greenhouse gas emission impacts from a climate change perspective. Section 4.7, Greenhouse Gas Emissions, provides a detailed discussion of the Project's contribution to the cumulative impact of global warming. The geographic context for GHG emissions is global. However, the State of California has established protocols, policies and attainment goals that apply to the Project and all local projects listed in this analysis.

The MDAQMD does not have a GHG policy at this time, so the Project would not result in a conflict. The County is currently preparing their Countywide GHG Emissions General Plan Amendment, GHG Reduction Plan, and Development Code Amendments, which are in development. Mitigation Measures GHG-1 and GHG-2 provide for emissions reductions or the purchase of offsets to minimize emissions of GHG. As a result, as described in Section 4.7 Greenhouse Gases, the Project would not contribute considerably to global warming.

Cumulative Analysis of Project Modifications

Emissions from construction and operation of the Project modifications are less than the MDAQMD established thresholds of significance for annual GHG emissions of 100,000 MTCO2e per year. Therefore, Project modifications would not conflict with plans, policies or regulations for the purpose of reducing GHG emissions. In addition, when combined with the operational GHG emissions estimated in the 2012 EIR, the Project as a whole would not exceed MDAQMD significance threshold. The Project with or without the modifications would not exceed daily or annual GHG emissions thresholds of significance established by the MDAQMD.

Applicable Mitigation Measures

No mitigation measures are required.

Conclusion

The Project modifications would result in similar impacts compared to the 2012 EIR; therefore, the modifications to the Project would not result in a new significant impact, or substantially increase the severity of an impact identified in the 2012 EIR. No mitigation is required beyond the existing commitments contained within the 2012 EIR.

Hazards and Hazardous Materials

The geographic scope of impacts associated with hazardous materials generally encompasses the Project site and a 0.25-mile-radius area around the Project site. Hazardous materials used during construction also could be released in the event of accidental upset. However, the proposed modifications would not increase hazards significantly. Implementation of Mitigation Measures **HAZ-1, HAZ-2**, and **HAZ-3** would ensure that Project impacts associated with exposure to hazardous materials would be less than significant.

The Project would be located within a sparsely-vegetated desert area. The CAL FIRE, fire hazard severity zone map identifies the Project area as a non-very-high fire hazard severity zone, the lowest possible risk category. Implementation of the Project would have a beneficial impact on fire risk because new turn-outs at crossings and sidings would be used for fire suppression. Therefore, the cumulative contribution of the Project to the risk of wildland fires is not considerable.

Cumulative Analysis of Project Modifications

The new pipeline alignment and treatment plant would not expose humans or the environment to greater risks than those outlined in the 2012 EIR.

Applicable Mitigation Measures

Implementation of **HAZ-1** through **HAZ-3** would be required.

Conclusion

The Project modifications would result in similar impacts compared to the 2012 EIR; therefore, the Project would not result in a new significant impact, or substantially increase the severity of an impact identified in the 2012 EIR. No mitigation is required beyond the existing commitments contained within the 2012 EIR.

Hydrology and Water Quality

The geographic scope of potential cumulative water quality impacts encompasses the Fenner, Orange Blossom Wash, Bristol, and Cadiz Watersheds and the tributaries and associated drainage areas within the Project area. Because the Project is located within a topographically-closed drainage system, the drainage basin is separated from surrounding drainage basins by topographic divides. The proposed modifications would not increase impacts to hydrology and water quality. Direct and cumulative impacts to groundwater and surface water resources would be less than significant and would not be cumulatively considerable.

Cumulative Analysis of Project Modifications

The new pipeline alignment and treatment plant would not result in an increase in impacts to hydrology and water quality. The project modifications would not be cumulatively considerable and impacts would be less than significant.

Applicable Mitigation Measures

Implementation of mitigation measures **HYDRO-1** through **HYDRO-5** would be required.

Conclusion

The Project modifications would result in similar impacts compared to the 2012 EIR; therefore, the Project would not result in a new significant impact, or substantially increase the severity of an impact identified in the 2012 EIR. No mitigation is required beyond the existing commitments contained within the 2012 EIR.

Land Use and Planning

The geographic scope of land use impacts encompasses the communities located between the Morongo Basin and I-95, as they would be most affected by traffic accessing the Project site and other nearby development projects, most likely via SR-62 from the I-10. Access roads to most of the Project area currently exist, the water conveyance pipeline would be installed within an existing railroad ROW; and the wellfield and spreading basin areas, staging areas, and areas associated with potential power distribution facilities are privately owned and vacant. The proposed modifications would add approximately 2 miles of additional roadway and a 10-acre treatment plant adjacent to existing agricultural operations mostly on private land. The Project itself would not have a cumulatively considerable impact on land use.

Cumulative Analysis of Project Modifications

The Project modifications would be located in the same area as the Project on Cadiz Property near the wellfields. The treatment plant would not result in a considerable change in land use. The Project modifications would not have a cumulatively considerable impact on land use.

Applicable Mitigation Measures

No mitigation measures are required.

Conclusion

The Project modifications would result in similar impacts compared to the 2012 EIR; therefore, the Project would not result in a new significant impact, or substantially increase the severity of an impact identified in the 2012 EIR. No mitigation is required beyond the existing commitments contained within the 2012 EIR.

Mineral Resources

Most of the Project elements would be located away from existing or potential mineral resources. Some portions of the water conveyance pipeline cross areas of potential mineral resources (gypsum, metals and non-metals, sodium [salt], oil and gas, uranium and/or thorium) that are on public lands managed by the BLM. However, these mineral resources are not in active use and the BLM evaluation is largely based on limited data such as aerial surveys. In addition, the water conveyance pipeline would be located within the ARZC ROW, where potential future mineral resource exploration and use is not permitted for safety reasons. The wellfield facilities are located on private land do not support mineral extraction. The proposed modifications are located on private land near the existing agricultural operations. With mitigation, the Project's incremental effects on mining operations in the Project vicinity would not be cumulatively considerable.

Cumulative Analysis of Project Modifications

Cumulative impacts to nearby mining operations for sodium chloride could result from cumulative development. The Project modifications would be consistent with the impacts in the

2012 EIR. Therefore, the Project modifications would not result in cumulatively considerable impacts.

Applicable Mitigation Measures

Implementation of mitigation measure **MIN-1** is required.

Conclusion

The Project modifications would result in similar impacts compared to the 2012 EIR; therefore, the Project would not result in a new significant impact, or substantially increase the severity of an impact identified in the 2012 EIR. No mitigation is required beyond the existing commitments contained within the 2012 EIR.

Noise

Cumulative noise and vibration impacts are evaluated on the Project site and areas immediately adjacent, due to the attenuating effects of noise. Construction and operation of cumulative projects would generally not result in cumulative noise effects due to their scattered, remote locations. The construction and operation of the Project would result in less than significant noise impacts. The Project's individual contribution to noise impacts would not significantly contribute to the overall noise environment. During construction of cumulative projects, construction equipment could temporarily increase noise levels over short durations during the day. However, after the construction phases are complete, there would be very little noise associated with Project operations. The Project would not create a cumulatively considerable contribution to cumulative noise impacts due to the separation of projects, the sparse population of the region, and the short-term nature of noise-generating activities.

Cumulative Analysis of Project Modifications

Impacts related to modification of the Project during construction and operation are consistent with those described in Section 4.12 of the EIR. The Project modifications would not result in cumulatively considerable noise impacts. No new mitigation is required, therefore, Project impacts, as modified, would remain less than significant.

Applicable Mitigation Measures

No mitigation measures are required.

Conclusion

The Project modifications would result in similar impacts compared to the 2012 EIR; therefore, the Project would not result in a new significant impact, or substantially increase the severity of an impact identified in the 2012 EIR. No mitigation is required beyond the existing commitments contained within the 2012 EIR.

Public Services and Utilities

The Project would not result in significant impacts to public services. Approximately 240 workers would be employed at any given time at the Project site during construction. The Project does not include residential development and would not bring a substantial number of new, full-time employees to the Project area that would require the expansion of public facilities construction of which could result in adverse physical impacts. The proposed modifications would not increase the need for public services or utilities. The Project would not have a cumulatively considerable contribution on utility services.

Cumulative Analysis of Project Modifications

Impacts from construction and operation to regional utilities from the Project modifications are consistent with those identified in the 2012 EIR. Therefore, the Project modifications would not result in cumulatively considerable impacts to public services and utilities.

Applicable Mitigation Measures

No mitigation measures are required.

Conclusion

The Project modifications would result in similar impacts compared to the 2012 EIR; therefore, the Project would not result in a new significant impact, or substantially increase the severity of an impact identified in the 2012 EIR. No mitigation is required beyond the existing commitments contained within the 2012 EIR.

Transportation and Traffic

The geographic scope for evaluating cumulative traffic impacts consists of I-40 and Old US 66 (also known as National Trails Highway) to the north; SR-247 and SR-62 to the west; SR-62 and I-10 to the south; and US 95 and SR-177 to the east. The proposed modification would add approximately 5 truck trips per month of chemical deliveries and sediment removal trips. This level of additional trips would not contribute significantly to cumulative traffic impacts. The Project's contribution to traffic congestion (if any) would not be cumulatively considerable.

Cumulative Analysis of Project Modifications

The Project modifications would be consistent with the construction impacts in the 2012 EIR. The Project modifications would not result in an increase to average daily trips. The Project's modifications contribution to traffic impacts would not be cumulatively considerable and Project modification impacts would be less than significant.

Applicable Mitigation Measures

No mitigation measures are required.

Conclusion

The Project modifications would result in similar impacts compared to the 2012 EIR; therefore, the Project would not result in a new significant impact, or substantially increase the severity of an impact identified in the 2012 EIR. No mitigation is required beyond the existing commitments contained within the 2012 EIR.

Energy Usage

With the Project modifications, the Project as a whole would require approximately 15,170 HP. While there will be a net increase in power needs, the 2012 EIR conservatively estimated a total HP of 16,200. With the Project modifications, the Project as a whole would require approximately 15,170 HP to operate facilities. This total power requirement is less than the total power need assumptions of 16,200 HP (12 MW) modeled in the 2012 EIR (Appendix B) which included a standby power source. As a result of the availability of newer model engines, the estimated installed capacity to drive the Project groundwater pumps is now approximately 8,066 HP. The addition of the BPS would increase operational energy needs from approximately 8,066 to 15,170 HP. Therefore, overall Project energy usage with modifications, is expected to be less than the initial Project design evaluated in the 2012 EIR. The project would contribute to increased cumulative energy demands. However, the modifications would not increase energy demands above the previously analyzed levels. The proposed modifications would not be cumulatively considerable.

Applicable Mitigation Measures

No mitigation measures are required.

Conclusion

The Project modifications would result in similar impacts compared to the 2012 EIR; therefore, the Project would not result in a new significant impact, or substantially increase the severity of an impact identified in the 2012 EIR. No mitigation is required beyond the existing commitments contained within the 2012 EIR.

Wildfire

The geographic scope of impacts associated with wildfire generally includes the immediate area around the Project site. According to CAL FIRE Fire Hazard Severity Maps for Southeast San Bernardino County and Eastern Riverside County show that the local vicinity within and around the Project area is also at very low fire risk. Therefore, it is unexpected for other projects listed in Table 5-1 to result in significant cumulative impacts in the area.

The Project would be located within a sparsely-vegetated desert area. The CAL FIRE, fire hazard severity zone map identifies the Project area as a non-very-high fire hazard severity zone, the lowest possible risk category. Similar to cumulative projects, the Project would adhere to fire prevention requirements specified by the CCR and Cal/OSHA. The Project would not interfere with adopted emergency response plans or evacuation routes or significantly expose occupants to pollutant concentrations from wildfire or uncontrolled spread of wildfire. Implementation of the

Project would have a beneficial impact on fire risk because new turn-outs at crossings and sidings would be used for fire suppression. Therefore, the cumulative contribution of the Project to the risk of wildland fires is not considerable.

Cumulative Analysis of Project Modifications

The new pipeline alignment and treatment plant, storage and booster pumping station would not expose humans or the environment to greater risks than those outlined in the 2012 EIR.

Applicable Mitigation Measures

No mitigation measures are required.

Conclusion

Although the 2012 EIR did not evaluate this environmental effect, the Project modifications would not result in a new significant impact, substantial adverse change to the 2012 EIR, or substantially increase the severity of an impact identified in the 2012 EIR. No mitigation is required beyond the existing commitments contained within the 2012 EIR.

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Appendix A

Groundwater Management, Monitoring, and Mitigation Plan

Groundwater Management, Monitoring, and Mitigation Plan

For

The Cadiz Valley Groundwater Conservation, Recovery and Storage Project[1]

September 2012

[1] This Management Plan shall not become final or effective until approved by the Santa Margarita Water District and the County of San Bernardino Board of Supervisors.

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Groundwater Management, Monitoring, and Mitigation Plan For the Cadiz Valley Groundwater Conservation, Recovery, and Storage Project

EXECUTIVE SUMMARY

The fundamental purpose of the Cadiz Valley Groundwater Conservation, Recovery, and Storage Project (Project) is to conserve and recover substantial quantities of groundwater that in the absence of the Project would otherwise evaporate. The Project is a 50-year groundwater recovery, conservation and conjunctive use storage project located within the collective Fenner, Orange Blossom Wash, Bristol and Cadiz Watersheds in the Eastern Mojave Desert. It will provide reliable water supply to the Santa Margarita Water District (SMWD) and other participating water agencies. Phase I of the Project provides for the initial extraction of groundwater in amounts not to exceed an annual average of up to 50,000 acre-feet per year (afy)[2] from a wellfield in the area within and south/southwest of the Fenner Gap. Phase II of the Project, if proposed and implemented, would use available aquifer capacity to operate a one million acre-feet groundwater storage bank to facilitate the storage and recovery of imported water over the Project's 50-year term. Phase II is not proposed at this time and will be subject to subsequent environmental and regulatory review. The full term of the Project's operation, including Phase I and Phase II, shall be limited to 50 years.

This Groundwater Management, Monitoring, and Mitigation Plan (Management Plan) will govern the operation and management of the Project by Fenner Valley Mutual Water Company (FVMWC) through a joint powers agreement initially between FVMWC and SMWD. The Management Plan is prepared to comply with the County of San Bernardino's (County) Desert Groundwater Management Ordinance (Ordinance) as an excluded Project under the exclusion provisions set forth in Article 5, Section 33.06552 of the County Code. As part of its compliance with the exclusion provisions of the Ordinance, SMWD, FVMWC, Cadiz Inc. (Cadiz), and the County approved a May 2012 Memorandum of Understanding (MOU).

The Management Plan requires monitoring of aquifer health and safe yield, groundwater levels and rates of decline, groundwater quality, subsidence, surface vegetation, air quality, third-party wells and springs, and corrective measures to address potential significant adverse impacts to critical resources[3] and Undesirable

[2] Actual total pumping would vary depending on Project participant supply needs. The maximum extraction rate in any given year would be limited to 75,000 afy with the long-term average of up to 50,000 afy as measured over a rolling 10-year period.

[3] SMWD has prepared an Environmental Impact Report (EIR) that evaluates the potential for the Project to result in significant impacts to the environment pursuant to Public Resources Code section 21000 et

Results[4] attributable to the Project. The Management Plan sets forth the plan of action to optimally manage groundwater resources and monitor and mitigate physical effects of the Project, and it ensures that Project operations will be conducted without significant adverse impacts to critical resources and Undesirable Results attributable to the Project.

During operations, the initial extraction of an annual average of up to 50,000 afy is designed to capture annual native recharge plus groundwater in storage that is migrating toward the Bristol and Cadiz Dry Lakes. Additional extractions above annual native recharge are planned for the purpose of strategically lowering groundwater levels in the vicinity of the Project wellfield to realize two essential Project benefits that are not available under existing conditions. First, the lowering of groundwater levels will cause existing groundwater gradients to reverse so that the Project will retrieve substantial quantities of potable groundwater located to the south and east of the wellfield that would otherwise flow into the saline groundwater underlying the Dry Lakes and evaporate. Lowered groundwater levels at the end of pumping will further slow the loss of groundwater to evaporation at the Dry Lakes until these lowered groundwater levels recover as a result of natural recharge and restore the hydraulic gradient such that losses to evaporation return to pre-Project levels. Second, the managed lowering of groundwater levels will also establish dewatered space within the aquifer to facilitate the storage and recovery of imported water during the potential Phase II of the Project.

The Management Plan is designed to avoid significant adverse impacts and Undesirable Results to the critical resources within the region, including the following:

- Groundwater aquifers tapped by the Project;
- Local springs within the Fenner Watershed;
- Brine resources of Bristol and Cadiz Dry Lakes;

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seq. While certain of the mitigation measures recommended in the EIR mirror the corrective measures contained in the Management Plan, the use of the phrase "significant adverse impacts to critical resources" is specific to the Management Plan and is not a reference to a determination by SMWD of a significant impact to the environment pursuant to CEQA.

[4] "Undesirable Results" means any of the following: (i) the progressive decline in groundwater levels and freshwater storage below the "floor" established in this Management Plan; (ii) the progressive decline in groundwater levels and freshwater storage at a rate greater than the established rate in this Management Plan where the decline signifies a threat of other physical impacts enumerated including (a) land subsidence, (b) the progressive migration of hyper-saline water from beneath the Cadiz or Bristol Dry Lakes toward the Project well sites; (c) increases in air quality particulate matter; (vi) loss of surface vegetation; or (d) decreases in spring flows.

- Air quality in the Mojave Desert region;
- Vegetation in the Mojave Desert region; and
- Adjacent areas, including the Colorado River and its tributary sources of water.

By definition, the Project intends to implement a managed drawdown in water levels to achieve specific conservation objectives. This Management Plan is designed to prevent significant adverse impacts to critical resources and Undesirable Results traditionally associated with groundwater pumping by collecting data and determining if observed changes in groundwater levels, groundwater quality, and land subsidence are consistent with changes projected in groundwater modeling of Project impacts as described in this Management Plan and references cited herein. If there are deviations from the groundwater modeling projections of Project impacts, those deviations will prompt further investigation and assessment under this Management Plan, and if necessary, implementation of corrective measures so as to avoid potential adverse impacts to critical resources and Undesirable Results. The Project approval is limited to a defined period of operations (50 years).[5]

The Management Plan incorporates a comprehensive network of monitoring features and data collection facilities, which include:

- Local springs;
- Observation wells at various locations, several of which will be clustered wells with depth-discrete screened intervals;
- Project production wells;
- Land survey benchmarks and extensometers;
- Downhole flowmeter surveys;
- Gamma-ray and dual induction electric logs;

[5] The option agreements for the Project participants contemplate that the Project participants may elect to extend the term of the Project beyond the 50-year term. If such an election were made, new purchase agreements would be required and full environmental review would be developed prior to consideration and potential approval of an extended term, which would include the development of a new management plan. The new plan would be subject to discretionary review by the County under its Desert Groundwater Management Ordinance and pursuant to any surviving provisions of the MOU and Chapter 7 of this Management Plan.

- Nephelometers for dust monitoring; and
- Weather stations.

The Management Plan establishes a process for scientific review of the observations and data obtained from monitoring features and facilities, and sets forth action criteria, and if appropriate, corrective measures to be taken if an action criterion is or may be triggered. The Management Plan has taken a conservative approach in its action criteria and potential corrective measures in the following areas:

- Local springs;
- Third-party wells;
- Land subsidence;
- Induced flow of lower-quality water from Bristol and Cadiz Dry Lakes;
- Brine resources underlying Bristol and Cadiz Dry Lakes;
- Air quality;
- Project area vegetation; and
- Adjacent groundwater basins, including the Colorado River and its tributary sources of water.

This Management Plan includes measures that are also required by the California Environmental Quality Act (CEQA) as mitigation for potential Project impacts, as well as additional Project design features to monitor and verify Project operations and predicted effects and confirm protection of critical resources. These additional Project design features are not required under CEQA but, for the avoidance of doubt and to satisfy the County's Ordinance, they have been included to provide a comprehensive monitoring program for the groundwater basin and all critical resources within the watershed.

The Project will be carried out as a public-private partnership between SMWD and Cadiz. While the lands and water rights to be used for the Project are owned by Cadiz, SMWD will be responsible for management and control of Project operations and will act as the approving authority for the design and construction of the Project. The Project will be operated by FVMWC (all the memberships of which will be owned by SMWD and the other Project participants) under the management and supervision of SMWD through a Joint Powers Authority (JPA) formed initially between FVMWC and

SMWD. Through the JPA, FVMWC and SMWD will lease to own all Project facilities and control and operate the Project during its entire duration. As a mutual water company, FVMWC will be controlled by the Project participants, with SMWD being the lead participant, during both the Project development and operations periods. While SMWD and FVMWC will carry out the Project through the JPA, this Management Plan sets forth how the County will participate in the Project to ensure that groundwater resources within the County's jurisdiction are appropriately managed.

As set forth in the MOU, compliance with this Management Plan shall be overseen and enforced by the County. SMWD is the Project's Lead Agency with responsibility for mitigation of Project impacts pursuant to the Project's EIR and Public Resources Code section 21081.6. SMWD shall enforce, as a condition of Project approval, the implementation of all adopted mitigation measures, including those measures which correspond to provisions of the Management Plan. In recognition of the County's regulatory role in enforcing the Desert Groundwater Management Ordinance, SMWD shall share with the County enforcement responsibilities with regard to those impact areas and mitigations in the EIR's Mitigation Monitoring and Reporting Program (MMRP) that fall within the County's jurisdiction pursuant to the MOU and Ordinance. SMWD will, pursuant to CEQA Guideline section 15097(a), delegate the reporting and monitoring responsibilities for those mitigation measures to the County. SMWD shall be responsible for reviewing and considering the County's on-going determination of compliance with those mitigation measures, which are also provisions of this Management Plan, in assessing compliance with the MMRP and with conditions of Project approval. A Technical Review Panel (TRP) will be created to assist in evaluating monitoring protocols and methods of data collection and processing, water quality, the rate of decline in the groundwater elevations, monitoring the level of the water table in the Cadiz well-field in relation to an established safe floor, and the Project's potential to cause Undesirable Results, as defined in the MOU. The TRP may make recommendations to the County or the County may request recommendations from the TRP that require additional monitoring, mitigation, and modification to Project operations as set forth in Chapter 8.

SMWD as lead agency and the County, pursuant to Paragraph 3(d) of the 2012 MOU, will retain full authority and discretion to modify Project operations (including but not limited to the institution of corrective actions or the curtailment or cessation of Project-related groundwater pumping) as necessary to avoid Overdraft or Undesirable Results as such terms are defined in the MOU. This Management Plan and the work to be performed and liabilities that may be incurred under this Management Plan create no vested rights, express or implied, in Cadiz, SMWD, or any other party to produce groundwater from the Project at a quantity or rate of pumping that results in Overdraft as the term is defined in the MOU and the County shall not be liable for damages to Cadiz, SMWD, or any other party resulting from its enforcement of the terms and conditions of this Management Plan.

The Management Plan requires that all technical data be made available to the public in the form of annual reports reviewed and maintained by the County, and it also calls for periodic water resources model refinements and incremental five-year projections of the physical impacts of Project operations to be set forth in periodic reports, together with any recommendations for Project improvements.

CHAPTER 1
INTRODUCTION AND BACKGROUND

1.1 The Cadiz Valley Water Conservation, Recovery, and Storage Project

This Groundwater Management, Monitoring and Mitigation Plan (Management Plan) is an integral part of the oversight of the Cadiz Valley Groundwater Conservation, Recovery, and Storage Project (Project). The Project is a water conservation supply and potential conjunctive use storage project undertaken by SMWD, in collaboration with Cadiz, that would make optimal use of the groundwater resources within the collective Fenner, Orange Blossom Wash, Bristol, and Cadiz Watersheds in the Eastern Mojave Desert, without displacing other beneficial uses (see Figure 1-1). The Project will develop a new water supply from the surplus waters of the Watersheds and enable the use of groundwater storage for future banking with participating water agencies as described herein.

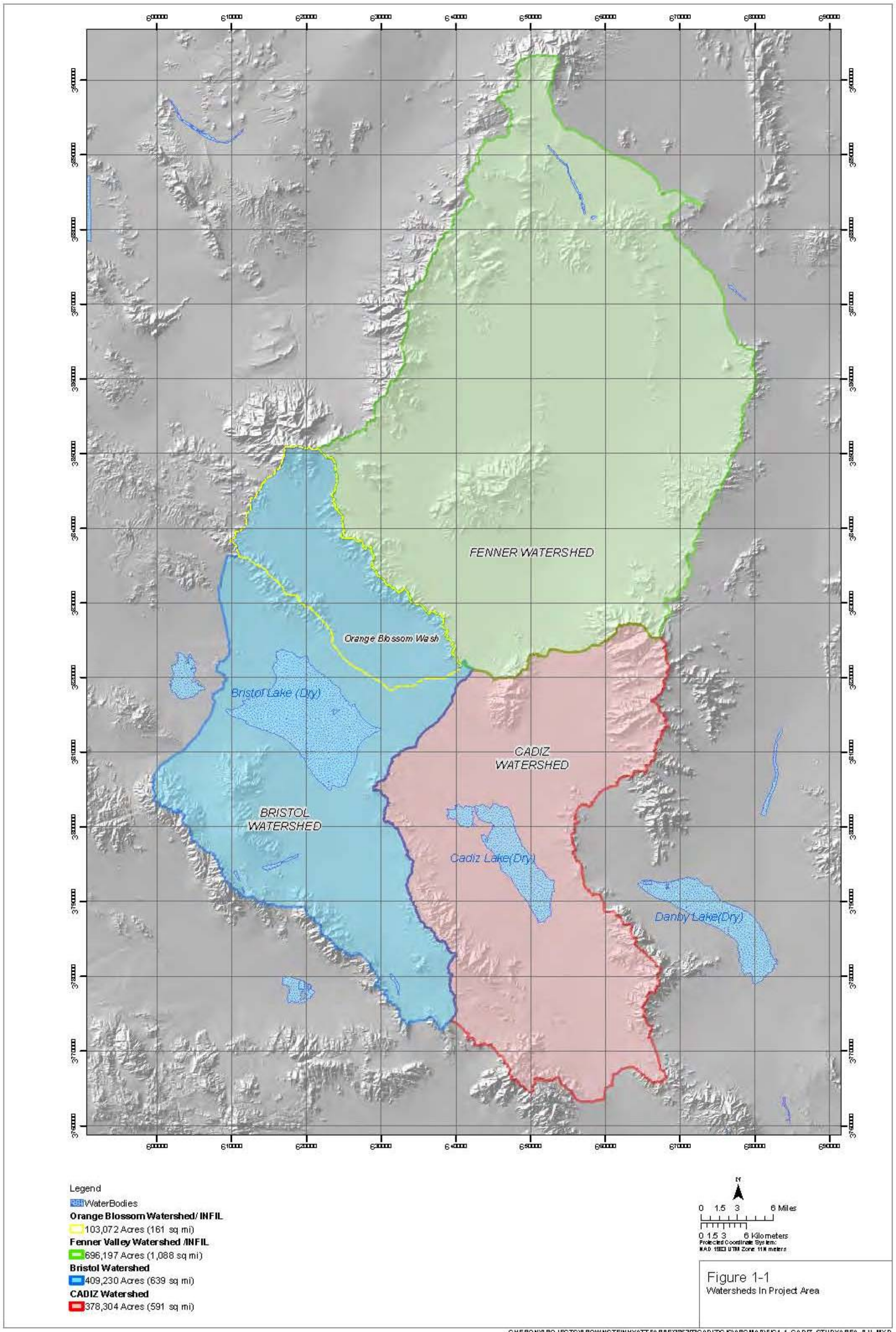


Figure 1-1
Watersheds In Project Area

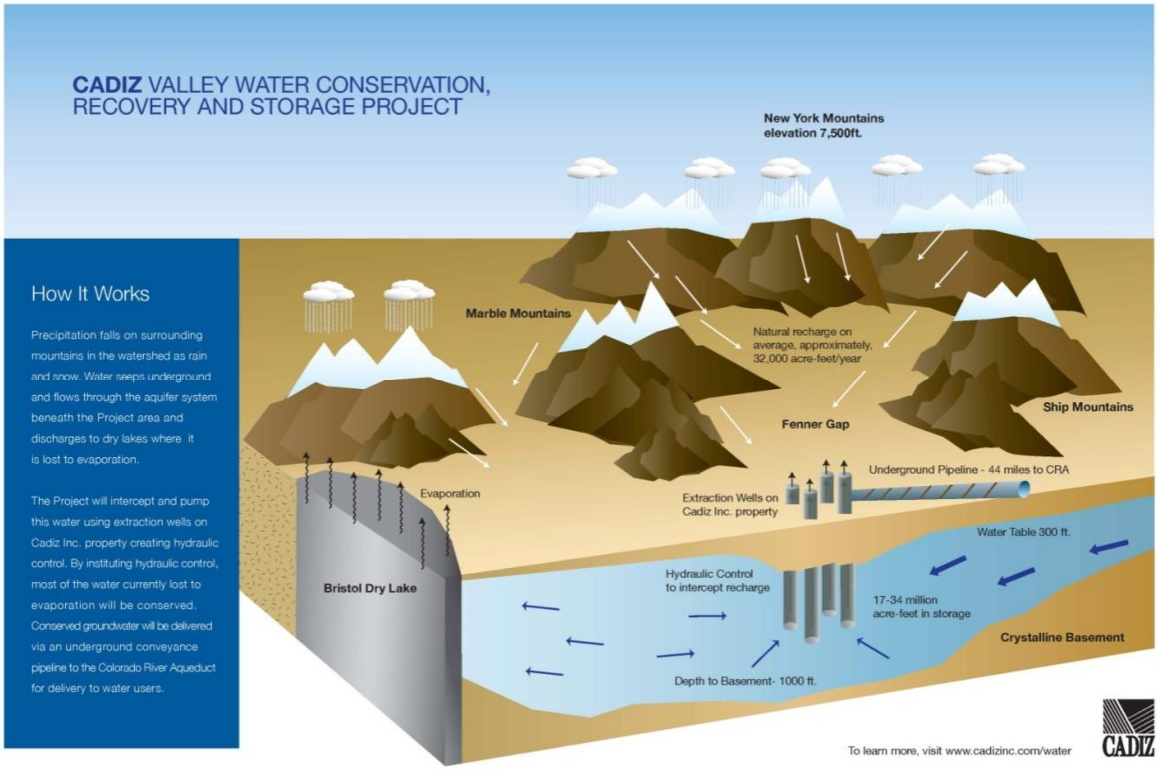
CHERON\PROJECTS\BROWNSTEINHYATTFARBER\386303CADIZ\GIS\ARCMAP\FIG1-1_CADIZ_STUDYAREA_BJL.MXD

The first phase of the Project, which is referred to herein as the "Conservation Component," would extract and convey groundwater at an initial average rate of up to 50,000 acre-feet per year (afy) from a wellfield in the area within and south/southwest of Fenner Gap via pipeline to the Colorado River Aqueduct (CRA). The 50,000 afy of extraction will make use of the long-term average annual natural recharge from the Fenner and Orange Blossom Wash Watersheds. Groundwater extraction will strategically lower groundwater levels within the immediate vicinity of the Project wellfield to intercept natural recharge and retrieve groundwater already held in storage beneath and downgradient of the wellfield before it can evaporate from the Dry Lakes, as discussed below.

The potential second phase of the Project, the Imported Water Storage Project, would involve managing the groundwater basin conjunctively by importing water during times of surplus, storing it in the basin, and recovering the stored water to meet drought, emergency, or other demands. The dewatered storage created by extracting more than the annual natural recharge in Phase I would create storage space facilitating a conjunctive use project to store surplus imported surface water when available to be recovered when needed. Imported water for storage would be conveyed to the Fenner Gap area by pipeline from the CRA and, potentially, an interconnection of the California Aqueduct to the Project through a converted natural gas pipeline. The water would be recharged into the groundwater basin via spreading basins constructed within or just north of the Fenner Gap.

Under the Imported Water Storage Component of the Project, up to 1 million acre-feet of dewatered capacity would be managed and made available for groundwater banking.

A conceptual model of the Project is shown in Figure 1-2.



Proposed monitoring in this Management Plan only addresses Phase I of the Cadiz Valley Groundwater Conservation, Recovery, and Storage Project. The potential storage and recovery of up to one million acre-feet of imported water was previously analyzed in 2000-2002 by the United States Bureau of Land Management in connection with its grant of a right-of-way for a project then proposed by the Metropolitan Water District of Southern California. This Management Plan will be updated and revised prior to any implementation of Phase II in order to integrate additional monitoring and mitigation requirements that may result from additional CEQA analysis and review associated with the proposed conjunctive use operations taking into account variables such as the identity of Phase II Project participants, the source of supply, volumes, and timing of deliveries.

1.2 Overview of the Management Plan

This Management Plan governs water extraction for the Project and is designed to ensure that Project operations and future irrigation under the Cadiz agricultural development will be conducted without significant adverse impacts to critical resources. While Cadiz may continue production of groundwater to irrigate agriculture within the Project area, such agricultural irrigation will be commensurately phased out as Project production increases in order to ensure that the initial average annual extraction rate of 50,000 afy is not exceeded. Under no circumstance shall combined

Project production and the Cadiz agricultural operations exceed the average rate of 50,000 afy as measured over any 10-year period.

This Management Plan is designed to prevent significant adverse impacts to critical resources and to avoid Undesirable Results by collecting data and determining if observed changes in groundwater levels, groundwater quality, and land subsidence are consistent with changes projected in groundwater modeling, as described in this Management Plan and references cited herein. Critical resources identified in this Management Plan are as follows:

- The basin aquifers tapped by the Project;
- Springs within the Fenner Watershed, including springs of the Mojave National Preserve and BLM-managed lands;
- Brine resources of Bristol and Cadiz Dry Lakes;
- Air quality in the Mojave Desert region;
- Project area vegetation; and
- Adjacent groundwater basins, including the Colorado River and its tributary sources of water.[6]

This Management Plan establishes a comprehensive network of monitoring and data collection facilities combined with procedures for comprehensive scientific review of all actions and decisions. The Management Plan includes action criteria prior to the occurrence of adverse impacts on critical resources resulting from Project operations. Implementation of specific corrective actions are meant to ensure that the adverse effects to critical resources are avoided or reduced to below specific objective standards designed to safeguard the critical resources. For example, third-party well owners can participate in a monitoring program that will trigger corrective action (e.g., provision of replacement water) if static groundwater levels in their wells drop due to Project operations. Third-party well owners not participating in the monitoring program can trigger corrective action by providing a written complaint to FVMWC. See Chapter 6 for full details of the action criteria and corrective measures. For several critical

[6] As explained in Chapter 2 of this Management Plan, technical analysis to date concludes that there is no hydrogeologic connection between groundwater that would be extracted by the Project, and groundwater supplies to the northeast within watersheds that are tributary to the Colorado River. Nonetheless, this Management Plan proposes the monitoring of groundwater levels in the adjacent Piute Watershed, which is tributary to the Colorado River.

resources, including local springs, air quality, and the groundwater resources of neighboring basins, the Management Plan provides for monitoring of such critical resources even though technical research and available scientific data demonstrate that the Project is not anticipated to impact these critical resources. The monitoring is being undertaken to comport with the County's Ordinance and the recommendations of the Groundwater Stewardship Committee, a multi-disciplinary panel of earth science and water professionals assembled by Cadiz and SMWD to provide advice and comment on the Project (see Appendix A Groundwater Stewardship Committee, Current Summary of Findings and Recommendations, Cadiz Valley Groundwater Conservation, Recovery, and Storage Project).

This Management Plan mandates specific action criteria (triggering levels) for impacts to critical resources and specified responses if an action criterion is reached. It establishes a defined process for scientific and objective review of groundwater management and a decision-making process to protect critical resources. Refinements to this Management Plan may occur during the life of the Project as more data and understanding becomes available. Such refinements will be developed in consultation with the TRP and subject to County and SMWD review and approval. Management Plan reports will be of public record. This Management Plan is intended to comply with the County's Guidelines for Preparation of a Groundwater Monitoring Plan and its Desert Groundwater Ordinance, which provides, in part, that installation of groundwater extraction wells may be excluded from the Ordinance's permitting provisions if the Project is subject to an enforceable agreement with the County and will be managed consistent with a County-approved groundwater management plan (San Bernardino County Code §33.06552).

The Project will be comprised of three time periods: a pre-operational period, an operational period of 50 years, and a post-operational/closure period that will span a minimum of 10 years, subject to review by the TRP, FVMWC, SMWD, and the County and as necessary to address any potential effects of the Project during the post-operational period. The pre-operational phase will commence upon start of construction and will last a minimum of 12 months. Cadiz will complete and deliver all needed permits for monitoring facilities prior to the pre-operational phase. Cadiz will construct all facilities that are agreed to in this Management Plan and for which permits have been received.

This Management Plan and the MOU are not subject to extension by the parties. At the end of the Project's operational life, however, Cadiz, FVMWC, and SMWD may seek a new authorization from the County for the extraction and conveyance of groundwater from the aquifer. Any new authorization will be subject to County review and approval and further environmental review, as well as new agreement(s) and a new groundwater management plan. The quantity of recoverable groundwater that might be available at that time would have to be re-evaluated based on operational and other data on the rates of recharge, safe yield of the aquifer, and appropriate groundwater levels.

1.3 The Project Area

The Project area is located in the eastern Mojave Desert of San Bernardino County, California approximately 200 miles east of Los Angeles, 60 miles southwest of Needles, and 40 miles northeast of Twentynine Palms. The Project wellfield is located within and south/southwest of the Fenner Gap which is centered between the Marble and Ship Mountains east of Cadiz.

The Project area can be divided into four areas for discussion purposes. The first and largest is the area encompassed by the totality of Bristol, Cadiz, and Fenner Watersheds as shown in Figure 1-3 and referred to herein as the "larger watershed area." Orange Blossom Wash is within the Bristol Watershed. The second area is the region beyond the larger watershed area which includes adjacent areas that are tributary to the Colorado River, such as the Piute Watershed. This second area is referred to herein as "adjacent regions." All precipitation within the larger watershed area that infiltrates to the groundwater table or runs off as surface flow, ultimately discharges to Bristol or Cadiz Dry Lakes. Groundwater flow from the Fenner Watershed converges and flows through Fenner Gap ultimately making its way to Bristol and Cadiz Dry Lakes. Similarly, groundwater flow in the Orange Blossom Wash area moves downgradient to Bristol Dry Lake. The third area is the freshwater zone located between the Fenner Gap and Bristol Dry Lake, as mapped by Shafer (1964), and is referred to herein as the northern Bristol/Cadiz Sub Basin (Figure 1-3). The fourth area is the area of the proposed wellfield, which is in the vicinity of the Fenner Gap and referred to herein as the wellfield area (Figure 1-3).

The total area of the Bristol (which includes Orange Blossom Wash), Cadiz, and Fenner Watersheds is approximately 2,320 square miles. The Bristol Watershed is approximately 640 square miles, the Cadiz Watershed is 590 square miles, and the Fenner Watershed is approximately 1,090 square miles.

These Watersheds are considered to be a single closed drainage system because all surface and groundwater drains to central lowland areas of the Bristol and Cadiz Dry Lakes. The Bristol, Cadiz, and Fenner Watersheds are separated from the surrounding watersheds within the adjacent regions by topographic divides (generally mountain ranges).

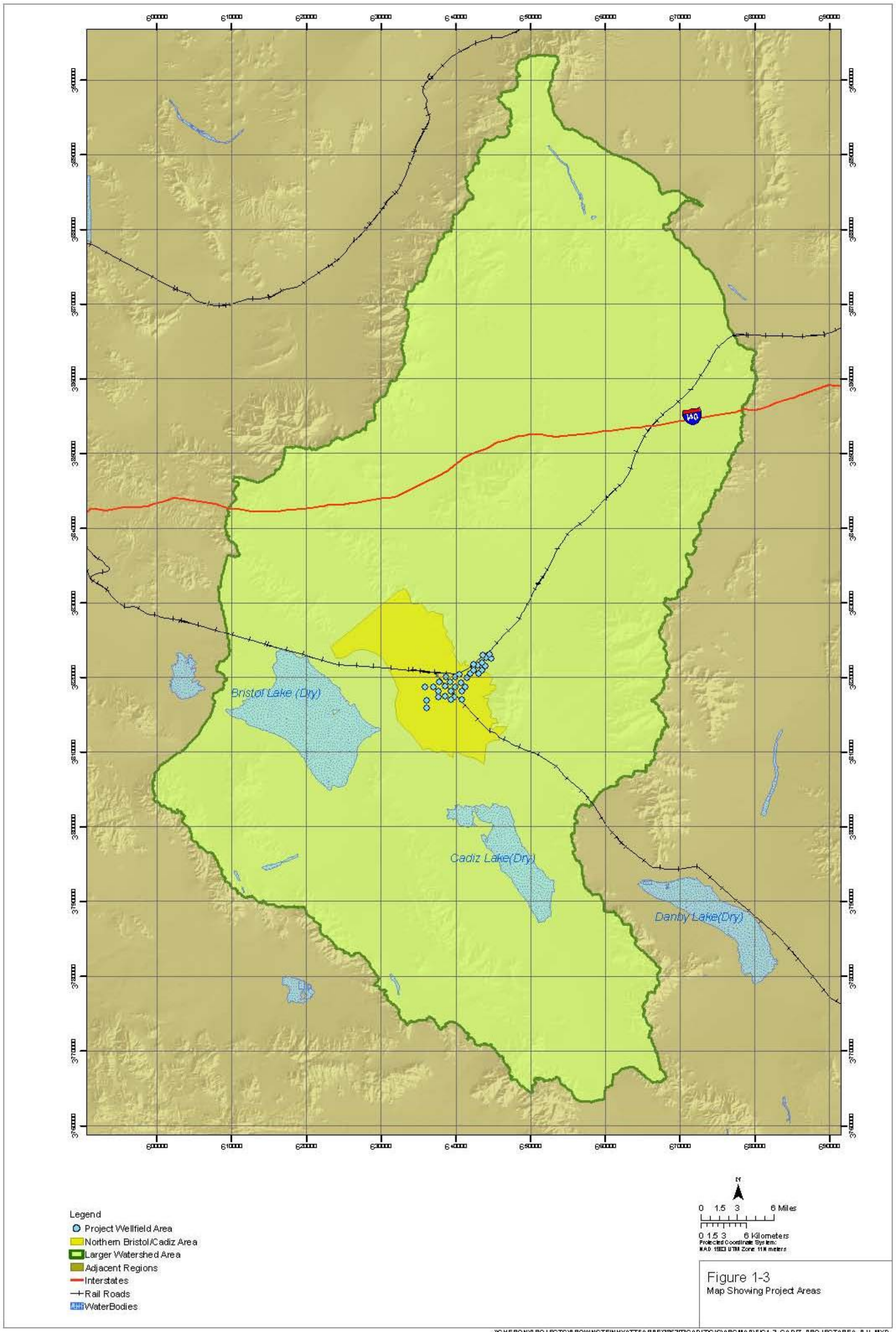
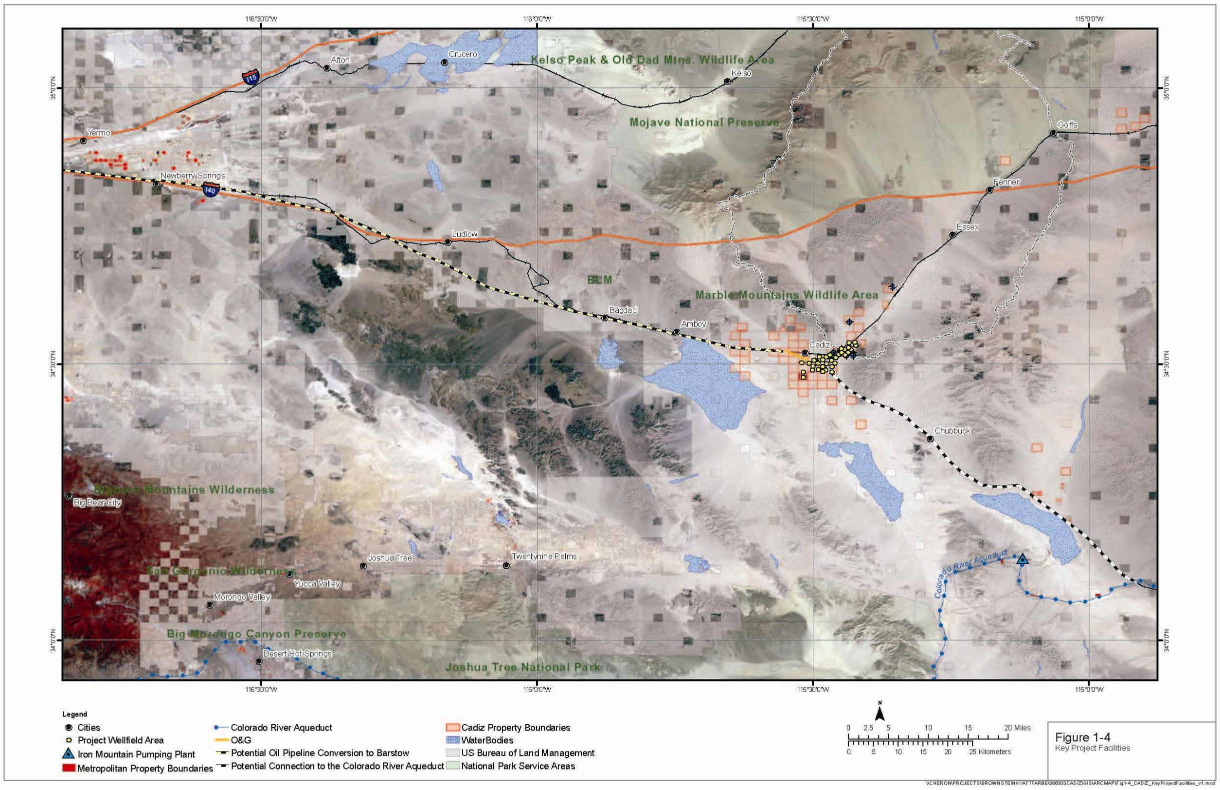


Figure 1-3
Map Showing Project Areas

\CHERON\PROJECTS\BROWNSTEINHYATTFARBER\3863\03CADIZ\GIS\ARCMAP\FIG1-3_CADIZ_PROJECTAREA_BJL.MXD

A map of key current and future Project facilities is shown in Figure 1-4.



1.4 The Parties

The Project and the Management Plan are the joint efforts of SMWD, Cadiz, FVMWC, and the County in accordance with the County's Guidelines for Preparation of a Groundwater Monitoring Plan.

1.4.1 *Santa Margarita Water District*

SMWD was initially formed in 1964 by landowners seeking a reliable water supply, and it has grown into the second largest retail water agency in Orange County. It supplies clean, affordable, reliable water and wastewater services to over 155,000 residents and businesses in Mission Viejo, Rancho Santa Margarita, and the unincorporated areas of Coto de Caza, Las Flores, Ladera Ranch, and Talega. When implemented, the Project will diversify SMWD's water portfolio and help drought-proof the District to ensure its water demands are met regardless of variability in State Water Project supplies. As part of a public-private partnership with Cadiz Inc., SMWD will be the public agency carrying out the Project and will also be the public agency with the greatest responsibility for supervising the Project. Specifically, SMWD will carry out and supervise the Project through its participation in a Joint Powers Authority with FVMWC and through its role as a shareholder in FVMWC. SMWD will be responsible for management and control of Project operations and will act as the approving authority for the design and construction of the Project. SMWD (through the JPA), FVMWC, and SMWD will lease-to-own all Project facilities and control and operate the Project during its entire duration. Accordingly, SMWD is the agency most responsible for carrying out the Project.

As the Lead Agency for the Project's California Environmental Quality Act (CEQA, Cal. Pub. Res. Code §§ 21000 *et seq*.) review process, SMWD is responsible for evaluating the Project's alternatives, environmental impacts, and potential mitigation measures. A draft of the Management Plan was included as an appendix to the EIR for the Project, and its provisions were evaluated in the EIR. Prior to approval of the Management Plan, SMWD as the lead agency and the County as a responsible agency will be required to determine whether the Project, including the Management Plan, were adequately evaluated in the EIR and to make any required findings under CEQA.

SMWD shall enforce the implementation of all adopted mitigation measures, including those measures which correspond to provisions of the Management Plan, as conditions of Project approval. SMWD will, pursuant to CEQA Guideline section 15097(a), delegate to the County the reporting and monitoring responsibilities for those mitigation measures and conditions of approval that are subject to County jurisdiction under its Ordinance and the MOU. SMWD shall review and consider the County's on-going determination of compliance with those mitigation measures which are also provisions of the Management Plan in assessing compliance with the Mitigation Monitoring and Reporting Program and with the conditions of Project approval.

1.4.2 *Cadiz Inc.*

Founded in 1983, Cadiz Inc. (Cadiz) is a renewable resources company based in Los Angeles. Using integrated satellite imagery and geological, geophysical, and geochemical survey methods, the company has identified and acquired 34,000 acres of land in Cadiz Valley situated over a large, naturally recharging basin. Cadiz's goal is for this basin to provide a high-quality, reliable water supply to Southern Californians, as well as much-needed underground storage for surplus water, all without causing material adverse impacts to the local environment.

1.4.3 *County of San Bernardino*

The proposed Project lies within the unincorporated desert area of eastern San Bernardino County, where groundwater production is regulated under the County's Desert Groundwater Management Ordinance (Ordinance) (San Bernardino Code §§ 33.06551 *et seq*.). A project may qualify for exclusion from the Ordinance's permitting procedures where the operator has developed a groundwater management, monitoring and mitigation plan approved by the County that is consistent with guidelines developed by the County[7] and the County and the operator have executed a memorandum of understanding that complies with the provisions of the Ordinance (San Bernardino Code §33.06552(b)(1)). This Management Plan and the MOU amongst FVMWC, SMWD, the County, and Cadiz together are designed to serve as the Project's compliance with the County Groundwater Management Ordinance and ensure the Project is operated to avoid significant adverse impacts to critical resources and Undesirable Results. Because approval of the Management Plan is necessary to qualify the Project for exclusion from the Ordinance and is a discretionary action, Santa Bernardino County's decision is subject to CEQA and the County is acting as a responsible agency.

1.4.4 *Fenner Valley Mutual Water Company*

FVMWC is a California mutual water company formed for the purpose of delivering water from the Project to its members at cost under the supervision of SMWD. Outstanding membership shares are available for issuance to Project participants, including SMWD. Cadiz will not own shares in FVMWC. FVMWC intends to contract with public agencies, including SMWD, for the purpose of forming a JPA (see California Government Code, § 6525). In the formation of this JPA, SMWD will be the designated agency in the joint powers agreement pursuant to Government Code section 6509. The Project will be operated by FVMWC (all memberships of which will be owned by SMWD and other Project participants) under the management and supervision of SMWD through a joint powers agreement between FVMWC and SMWD. FVMWC will lease all Project facilities and control and operate the Project during its entire duration. As a mutual water company, FVMWC will be controlled by the Project participants, with SMWD being the lead participant, during both the Project development and operations periods. Pursuant to this Management Plan, FVMWC shall assess technical data and responsive actions, propose refinements to the Management Plan, and corrective measures regarding compliance with the provisions of the Management Plan, and prepare and submit various annual and periodic technical reports, all in consultation with SMWD and the TRP and subject to the oversight of the County, as specified further in Chapters 6, 7, 8, and 9.

[7] This Groundwater Management Plan has been prepared to satisfy the County's Guidelines for Preparation of a Groundwater Monitoring Plan, which were last revised in June 2000. This Groundwater Management Plan, for example, includes methods and procedures to measure groundwater production, groundwater levels, water quality, and potential land subsidence (see County Guidelines for Preparation of a Groundwater Monitoring Plan, § 1.1).

1.4.5 *Other Anticipated Project Participants*

In addition to the three Project parties listed above, other water service providers and additional users are expected to participate in the Project. These participants include:

- Three Valleys Municipal Water District, which serves 133 square miles in Los Angeles County, California and includes Azusa, City of Industry, Covina, Claremont, Diamond Bar, Glendora, Hacienda Heights, La Puente, La Verne, Pomona, Rowland Heights, San Dimas, Walnut, and West Covina.

- Golden State Water Company, which provides service to three water service regions across 10 California counties. Region I consists of 7 customer service areas in northern and central California and Ventura County; Region II consists of 4 customer service areas located in Los Angeles and Orange County; and Region III consists of 10 customer service areas in eastern Los Angeles County and in Orange, San Bernardino, and Imperial Counties.

- Suburban Water Systems, which serves an area covering approximately 42 square miles, including all or portions of Glendora, Covina, West Covina, La Puente, Hacienda Heights, City of Industry, Whittier, La Mirada, La Habra, Buena Park, and unincorporated portions of California's Los Angeles and Orange Counties.

- Jurupa Community Services District (JCSD), which provides potable water, sewer, and street lighting services to over 101,000 people located throughout 48 square miles in the Jurupa area of Riverside County. JCSD serves unincorporated areas of Riverside County as well as the communities of Jurupa Valley and Eastvale.

- California Water Service Company (Cal Water) distributes and sells water to 1.7 million Californians through 435,000 connections. Its 24 separate water systems serve 63 communities from Chico in Northern California to the Palos Verdes Peninsula in Southern California.

- The Arizona and California Railroad Company (ARCZ) owns and operates a railway line in a right-of-way that runs between the Cadiz property and the Colorado River. Its parent company is RailAmerica.

1.5 Project Description

The Project will include two phases:

1.5.1 *Phase I*

Phase I will provide for initial extraction and delivery to the CRA of up to an annual average of 50,000 afy for delivery to Project participants in compliance with this Management Plan to avoid adverse impacts to critical resources and Undesirable Results. Extraction in any given year may range from 25,000 to 75,000 afy to accommodate carryover, but shall not exceed more than an average of 50,000 afy measured over a 10-year period, inclusive of agricultural production by Cadiz. Project participants can carry over their annual allocations by storing their water in the basin for later extraction and delivery during drought or emergency conditions within the 50-year operation period.

The Project involves construction and operation of the facilities shown on Figures 1-3 and 1-4 and as described below:

- A wellfield of up to approximately 34 extraction wells and appurtenant facilities;
- An approximately 43-mile long conveyance pipeline and appurtenant facilities from the CRA to the wellfield, including power, generally parallel to the conveyance;
- Instrumentation and control systems to monitor all Project operations; and
- Observation wells, cluster wells, land survey benchmarks, extensometers, weather stations, and other appurtenant facilities necessary for this Management Plan.

The conveyance and power distribution facilities, observation wells, land survey benchmarks, and other monitoring features, along with all Project facilities, will be located on land owned by Cadiz or on easements obtained from other landowners.

1.5.2 *Phase II*

Phase II, subject to approval of appropriate environmental documentation, would provide conjunctive-use storage, up to a total of one million acre-feet of storage at any given time, in compliance with an updated version of the Management Plan. The

County's and SMWD's approval of the MOU and this Management Plan does not include approval of Phase II. There are no agencies currently committed to participate in Phase II. Phase II requires potential future approvals by agencies not yet identified under terms not yet negotiated. Because of this, Phase II is still in the conceptual stage and is analyzed in the Environmental Impact Report programmatically. Subsequent CEQA review and updates to this Management Plan will be required prior to implementation of Phase II.

1.6 Project Objectives

The Project objectives are as follows:

- Maximize beneficial use of groundwater in the Bristol, Cadiz, and Fenner Valleys by conserving and using water that would otherwise be lost to brine and evaporation;
- Improve water supply reliability for SMWD and other Southern California water providers by developing a source of water that is not significantly affected by drought;
- Reduce dependence on imported water by utilizing a source of water that is not dependent upon surface water resources from the Colorado River or the Sacramento-San Joaquin Delta;
- Enhance dry-year water supply reliability within SMWD and other Southern California water provider Project participants;
- Enhance water supply opportunities and delivery flexibility for SMWD and other participating water providers through the provision of carry-over storage and, for Phase II, imported water storage;
- Support operational water needs of the ARZC in the Project area;
- Create additional water storage capacity in Southern California to enhance water supply reliability;
- Locate and design the Project in a manner that minimizes significant environmental effects and provides for sustainable operations.

1.7 Existing Groundwater Management

Cadiz owns 34,000 acres of largely contiguous land in the Cadiz and Fenner Valleys of eastern San Bernardino County, where it has farmed successfully for more than 15 years, as shown in Figure 1-3. Approximately 1,600 acres of this land has been cultivated for citrus and stone fruit orchards, vineyards, and specialty row crops.

In 1993, San Bernardino County certified an Environmental Impact Report (EIR), and granted various land use approvals for expansion of agricultural operations up to 9,600 acres on this property (referred to as the Cadiz Agricultural Program). The 1993 EIR indicated that there was, at the time, up to 1,440 acres in cultivation and that the Program would expand agricultural production in phases over a 10- to 15-year period at a rate of approximately one section (640 acres) per year. The Agricultural Program contemplated groundwater withdrawals to reach a maximum of 30,000 afy within a 40-year production period, ending in 2030. The 1993 approvals also required Cadiz to comply with a Mitigation Monitoring Program (MMP) to address the potentially significant impacts of the Agricultural Program on the environment, including groundwater resources.

As a component of the earlier approvals, the County identified specific groundwater monitoring activities to be undertaken by Cadiz. To comply with these monitoring requirements, Cadiz developed the Cadiz Valley Agricultural Development Ground Water Monitoring Plan (GWMP) to monitor water use, storage, and extraction under the proposed agricultural operations. The GWMP and MMP together were meant to ensure that Project operations and future irrigation under the Cadiz Valley agricultural development would be conducted without adverse impacts to critical resources.

In 2002, the County and Cadiz entered a Memorandum of Understanding (MOU) which granted Cadiz an exclusion from the County's newly enacted Desert Groundwater Management Ordinance for implementation of the Cadiz Agricultural Program. The 2002 MOU required Cadiz to implement and comply with the Agricultural Program MMP and GWMP. While Cadiz may continue production of groundwater to irrigate agriculture within the Project area, the County in its consideration of this Management Plan is expected to adopt the following conditions of approval: 1) production under the Agricultural Program shall remain subject to the Agricultural Program MMP and GWMP, 2) agricultural production cannot exceed 30,000 afy, and 3) will be phased out by 2030. Groundwater production that occurs after 2030 for agricultural purposes will be conducted under this Management Plan or a separate approval secured pursuant to the County's Desert Groundwater Management Ordinance. In addition, FVMWC shall ensure proper closure of any agricultural wells that will be taken out of production or used with the new Project. Regardless of any phasing, the average annual extraction over the 50 years of Project operations will not exceed 50,000 afy from all combined Cadiz Agricultural Program and Project pumping.

1.8 Purpose and Scope of Management Plan

The Management Plan is prepared to comply with the County Desert Groundwater Management Ordinance and the MOU by and between SMWD, FVMWC, Cadiz, and the County. The Management Plan requires monitoring of aquifer health and safe yield, groundwater levels, groundwater quality, subsidence, surface vegetation, air quality, third-party wells, and springs and to address, through corrective measures, potential significant adverse impacts to critical resources and Undesirable Results attributable to the Project. The Management Plan sets forth the plan of action to optimally manage groundwater resources, monitor and mitigate physical effects of the Project, and ensures that Project operations will be conducted without significant adverse impacts to critical resources.

This Management Plan includes the following:

1) Description of the Project location and objectives;

2) Description of physical characteristics of the groundwater basin;

3) Identification of the critical resources and assessment of potential impacts in and surrounding the Project area due to Project groundwater extraction;

4) Description of the modeling tools that will be used to refine the monitoring network and that will be used in the future to refine impact assessments and action criteria;

5) Description of the monitoring network and identification of the locations of the features of the monitoring network;

6) Description of the monitoring, testing, and reporting procedures that will be used to collect and analyze data;

7) Description of the action criteria established to avoid potential significant adverse impacts to critical resources;

8) Description of the decision-making process to be used once the action criteria are met or when the County considers refinements to this Management Plan;

9) Description of corrective measures that may be implemented to minimize potential significant adverse impacts to critical resources;

10) Description of objectives and requirements for a Closure Plan; and

11) Description of the TRP and its responsibilities and procedures.

CHAPTER 2
DESCRIPTION AND CHARACTERISTICS OF GROUNDWATER BASINS AND PRESENT USES

2.1 Geologic Setting

As shown above in Figure 1-3, the study area includes the Fenner, Bristol, and Cadiz Watersheds. These watersheds are located in the Eastern Mojave Desert, which is a part of the Basin and Range Province of the western United States. The Basin and Range Province is characterized by a series of northwest/southeast trending mountains and valleys formed largely by faulting. One of the prominent features of the area is the Bristol Trough, a major structural depression caused by faulting. The Bristol Trough encompasses the Bristol and Cadiz Watersheds that together form a relatively low-land area that extends from just south of Ludlow, California on the northwest to a topographic and surface drainage divide between the Coxcomb and Iron mountains on the southwest. The Bristol and Cadiz Valleys are bounded on the southwest by the Bullion, Sheep Hole, Calumet, and Coxcomb mountains and on the northeast by the Bristol, Marble, Ship, Old Woman, and Iron mountains. The Cadiz and Bristol Dry Lakes are separated by a low topographic and surface drainage divide. The Fenner Watershed is located north of the Bristol Trough. This watershed encompasses approximately 1,100 square miles (mi2). It is bounded by the Granite, Providence, and New York mountains on the west and north and the Piute, Ship, and Marble mountains on the east and south. Fenner Gap occurs between the Marble and Ship mountains, where the surface drainage exits Fenner Watershed and enters the Bristol and Cadiz Watersheds. The Clipper Mountains rise from the southern portion of the watershed, just northwest of Fenner Gap (CH2M Hill, July 2010).

The Orange Blossom Wash Watershed is a subarea of the Bristol Watershed, that is located in the western portion of the Project area between the Marble and Bristol mountains. The Orange Blossom Wash Watershed is bounded on the west by the Granite Mountains and drains to the southeast into the Bristol Dry Lake. The Bristol and Cadiz Watersheds are located in the southern portion of the Project area. The proposed Project wellfield is located in the northern Bristol and Cadiz valleys, within and south/southwest of the Fenner Gap (CH2M HILL, July 2010).

The total area of the Bristol, Cadiz, and Fenner Watersheds is approximately 2,330 square miles and consists of the Fenner Watershed (1,090 square miles), Bristol

Watershed (including the Orange Blossom Wash) (640 square miles), and Cadiz Watershed (590 square miles). The surface water drainage and groundwater flow from all four of the watersheds in this Project area drain into the Bristol and Cadiz Dry Lakes, where it joins the brine water underlying the Dry Lakes and evaporates (CH2M HILL, July 2010).

The alluvial sediments of the Fenner Valley are underlain by carbonate, granitic, and metamorphic rocks, forming a rock-bounded basin overlain with sands and gravels hundreds of feet thick. Groundwater ranges from approximately 270 to 400 feet bgs in the northeastern portion of the Project area to 140 feet bgs in the southwest, becoming shallower with increasing proximity to the Dry Lakes. Groundwater in storage has been estimated at between 17 and 34 million acre-feet. Of this amount, 4 to 10 million acre-feet is estimated to exist in the fresh water zone south of the Fenner Gap (CH2M HILL, July 2010).

2.2 Surface Water Resources

Native springs and localized wet areas associated with these springs are present in the mountain ranges in the Project vicinity, as shown in Figure 2-15 of CH2M Hill's July 2010 Report. The closest native springs to the Project site are located to the north, in the Granite, Clipper, and Old Woman Mountains. The nearest spring is Bonanza Spring (Spring 007N015E22DS01S), which is located in the Clipper Mountains, approximately 11 miles north of the center of Fenner Gap. These springs are located in hard rock (volcanic, granitic and metamorphic rocks) formations substantially higher in elevation than the carbonate and alluvial aquifers of the groundwater basin, such that they are not in hydraulic communication with the proposed wellfield and spreading basin areas. Therefore, pumping in the carbonate aquifer and alluvial aquifer in the Project wellfield should not affect groundwater levels in the hard rock formations that supply water to the vicinity springs. Nonetheless, this Management Plan provides for monitoring of the springs to confirm that Project operations have no impact on the spring flow from these springs consistent with recommendations of the Groundwater Stewardship Committee.

The Bristol and Cadiz Dry Lake playas are the lowest points in the Project area and are separated by a low topographic and surface drainage divide. Since the four Watersheds are part of a closed drainage system, the only natural outlet for surface water and groundwater is through evaporation at the Dry Lake surfaces.

2.3 Natural Recharge

The natural recharge in the Project area watersheds has been the subject of several studies since 1970 (see Appendix D to Geoscience, September 1, 2011). The most recent study, based on data obtained from field investigations in the Fenner Gap, use of INFIL3.0 watershed soil-moisture budget model released in 2008, and three-dimensional groundwater flow model simulations for the Fenner Gap, estimated the long-term average annual natural recharge of 32,000 afy (CH2M Hill, July 2010).

The primary sources of replenishment to the groundwater system within the larger watershed area include direct infiltration of precipitation (both rainfall and snowfall) in fractured bedrock exposed in mountainous terrain and infiltration of ephemeral stream flow in sand-bottomed washes, particularly in the higher elevations of the watershed. The source of much of the groundwater recharge within the larger watershed area occurs in the higher elevations, including Bristol Mountains, Granite Mountains, Providence Mountains, Marble Mountains, New York Mountains, Piute Mountains, Old Woman Mountains, Ship Mountains, Clipper Mountains, Wood Mountains, and Hackberry Mountains (CH2M Hill, July 2010).

Most of the precipitation in the Eastern Mojave Desert accumulates during the winter months from November through March. Early summer and late fall are typically periods of little rainfall. The amount of precipitation in the Bristol, Cadiz, and Fenner Watersheds vary with differences in altitude. Average annual precipitation ranges from approximately 3 inches on the Cadiz and Bristol Dry Lakes (elevations of 545 to 595 ft amsl) to over 12 inches in the Providence and New York mountains (elevations over 7,000 ft amsl). However, most of the larger watershed area receives, on the average, 4 to 6 inches of rain annually (Geoscience, September 2011). A conceptualized model of groundwater recharge in the area is shown in Figure 2-13.

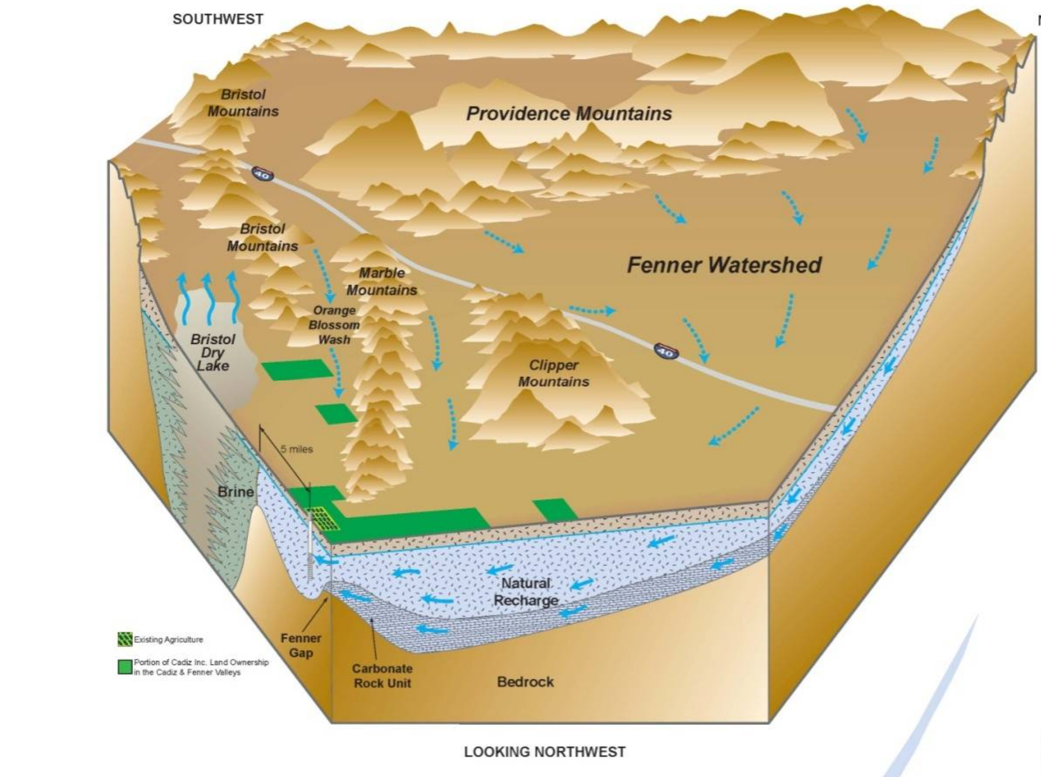


FIGURE 2-13
Conceptualization of Groundwater Occurrence and Movement In the Area of Study

2.4 Hydrogeology

Based on available geologic and geophysical data, the principal geologic deposits in the Project area that can store and transmit groundwater (i.e., aquifers) can be divided into three units: an upper alluvial aquifer, a lower alluvial aquifer, and a bedrock aquifer consisting of Tertiary fanglomerate, Paleozoic carbonates, and fractured and faulted granitic rock. In general, these three units are in hydraulic continuity with each other and the separation is primarily due to stratigraphic differences (Geoscience, September 2011).

The alluvial aquifer system consists mainly of Quaternary alluvial sediments which consist of stream-deposited sand and gravel with lesser amounts of silt. The thickness of the alluvial aquifer varies between 200 and 800 feet. To the west of Fenner Gap, the upper aquifer is separated from the lower aquifer system by discontinuous layers of silt and clay. The average thickness of the upper aquifer in Fenner Gap is approximately 500 feet. The upper aquifer is very permeable in places and can yield 3,000 gallons per minute (gpm) or more to wells with less than 20 feet of drawdown (Geoscience, September 2011).

The lower alluvial aquifer consists of older sediments, including interbedded sand, gravel, silt, and clay. The maximum thickness of the lower aquifer is unknown but may reach over 6,000 feet in the vicinity of Bristol Dry Lake. Where these materials extend below the water table, they yield water freely to wells but are generally less permeable than the upper aquifer sediments. The Cadiz agricultural wells are screened primarily in the lower alluvial aquifer and typically yield 1,000 to 2,000 gpm (Geoscience, September 2011).

Based on findings from recent drilling in the Fenner Gap area, Tertiary fanglomerate, fractured and faulted granitic rock, and Paleozoic carbonates located beneath the lower alluvial aquifer contain groundwater and are considered a third aquifer unit. Groundwater movement and storage within the carbonate bedrock aquifer primarily occurs within secondary porosity features (i.e., fracture zones associated with faulting and cracks and cavities developed within the rocks over time) (Geoscience, September 2011).

2.5 Groundwater Storage

The volume of groundwater in storage was estimated to be about 17 million to 34 million acre-feet in the alluvium of the Fenner Valley, Orange Blossom Wash, and northern Bristol/Cadiz area, where the conservation and storage Project will be sited. Four to ten million acre-feet of groundwater lie to the west and southwest of the proposed wellfield location (Geoscience Tech Memo September 20, 2011). Estimates of groundwater in storage in various zones within the general Project area are listed in Table 2-1, which also includes estimates of the following variables: volume of aquifer, determined as the volume between the groundwater table and the base of the alluvium (saturated thickness), percent of aquifer saturated thickness that is expected to be an aquifer (to exclude clay and silt intervals that do not yield water readily), and estimated specific yield. Low and high ranges are provided for each of these variables based on previous estimates (CH2M Hill, July 2010).

Table 2-1

Cadiz Study Area Groundwater Storage Calculations

Low Estimate					High Estimate				
Zones	Saturated Thickness Volume (ac-ft)	% of Saturated Thickness which is Aquifer	Specific Yield	Groundwater in Storage (ac-ft)	Zones	Saturated Thickness Volume (ac-ft)	% of Saturated Thickness which is Aquifer	Specific Yield	Groundwater in Storage (ac-ft)
Zone 1	11,251,515	75%	0.15	1,265,795	Zone 1	11,251,515	85%	0.20	1,912,758
Zone 2a	63,758,585	50%	0.10	3,187,929	Zone 2a	63,758,585	60%	0.15	5,738,273
Zone 2	93,083,800	50%	0.10	4,654,190	Zone 2	93,083,800	60%	0.15	8,377,542
Zone 3	13,052,800	20%	0.10	261,056	Zone 3	13,052,800	40%	0.15	783,168
Zone 4	489,237	50%	0.10	24,462	Zone 4	489,237	75%	0.15	55,039
Zone 5	88,466,500	50%	0.10	4,423,325	Zone 5	88,466,500	75%	0.15	9,952,481
Fenner	93,676,400	50%	0.05	2,341,910	Fenner	93,676,400	60%	0.10	5,620,584
Goffs	32,917,900	50%	0.05	822,948	Goffs	32,917,000	60%	0.10	1,975,074
				16,981,615					**34,414,919**

This storage estimate does not include water contained within the carbonate and fractured portion of the bedrock beneath the alluvial units. Recent drilling has revealed that these units also store groundwater. As such, the estimated volume of groundwater in storage is a conservative underestimate; the actual volume of groundwater in storage is larger by some unknown amount (Geoscience, September 2011). Figure 2-2 shows the storage zones used in the calculations of groundwater in storage.

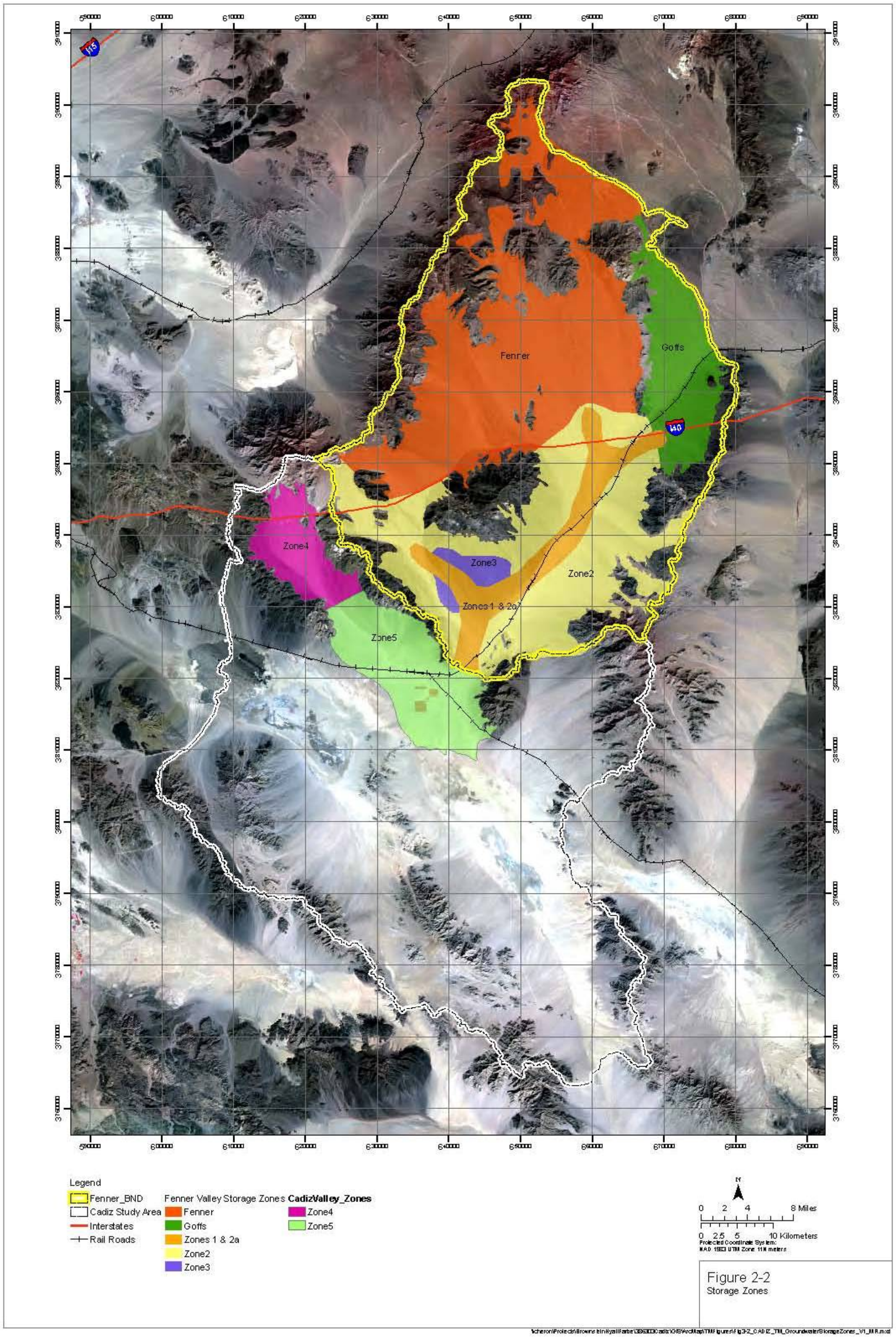


Figure 2-2
Storage Zones

2.6 Groundwater Quality

With the exception of the areas underlying and immediately adjacent to the Bristol and Cadiz Dry Lakes, the quality of the groundwater in the northern Bristol, Cadiz, and Fenner Gap area is relatively good, with total dissolved solids (TDS) concentrations typically in the range of 300 to 400 milligrams per liter (mg/L). Table 2-2 summarizes water quality data collected from an existing well on the Cadiz agricultural operations property, south/southwest of the Fenner Gap. The State of California guideline for drinking water is a maximum TDS of 1,000 mg/L. However, all groundwater having a TDS below 3,000 mg/L is considered by the State to be a potential domestic or municipal source of water supply.

TABLE 2-2: GROUNDWATER CHEMISTRY AT CADIZ ALLUVIAL AQUIFER

	CA MCL	CA SMCL	CADIZ GROUNDWATER
TDS		500-1000 mg/L	260 mg/L
Arsenic	10 μg/L		3.1 μg/L
Chloride		250-500 mg/L	34 mg/L
Total Chromium	50 μg/L		16 μg/L
Fluoride	2.0 mg/L		1.6 mg/L
Manganese		50 μg/L	Not Detected (< 20 μg/L)
Nitrate as NO3	45 mg/L		12 mg/L
Sulfate		250-500 mg/L	11 mg/L

CA MCL: California primary maximum contaminant levels for drinking water (chemicals affecting health and safety)

CA SMCL: California secondary maximum contaminant level for drinking water (chemicals affecting taste and odor)

mg/L = milligrams per liter

μg/L = micrograms per liter

Not Detected = not detected at or above the reportable detection limit

Source: 22 CCR §§ 64431, 64449

Table 2-3 shows water quality data obtained from recent hydrogeologic investigations in the Fenner Gap area. Overall, groundwater quality in the alluvial and carbonate aquifers is of very high quality, with low total dissolved solids. Chromium, and in particular hexavalent chromium, is a constituent of potential concern given the recently adopted California Public Health Goal for hexavalent chromium of 0.02 ug/l. Groundwater containing hexavalent chromium and/or chromium (III) could require treatment depending on the water quality standard developed by the State. Groundwater in the deeper section of the bedrock shows elevated concentrations of iron and manganese; however, the relative contribution of groundwater from these deeper bedrock units is expected to be small, such that the quality of groundwater in production is expected to be representative of the water quality of the alluvial and carbonate aquifers.

Table 2-3

Summary of Water Quality Results

Parameter	Regulatory Action Levels				Analytical Results[1]			
	CA Primary MCL	USEPA Primary MCL	CA Secondary MCL	USEPA Secondary MCL	TW-1 Carbonate 11/10/2009	TW-1 Alluvium 12/04/2009	TW-2 Alluvium 11/24/2009	DT-1 Bedrock 02/24/2011
***Anions*:**								
Chloride (mg/L)			250 to 500	250	38	34	35	110
Fluoride (mg/L)	2	4		2	1.5	1.6	1.6	3.6
Nitrate as NO_3 (mg/L)	45				13	12	12	ND < 1.0
Sulfate (mg/L)			250 to 500	250	32	11	30	110
Total Anions (me/L)					4.23	3.46	4.09	-
***Alkalinity*:**								
Total Alkalinity (mg/L)					110	100	110	130
Bicarbonate Alkalinity (mg/L)					130	130	130	160
Carbonate Alkalinity (mg/L)					ND < 3.0	ND < 3.0	ND < 3.0	ND < 3.0
Hydroxide Alkalinity (mg/L)					ND < 3.0	ND < 3.0	ND < 3.0	ND < 3.0
***Cations*:**								
Calcium (μg/L)					24	27	26	13
Magnesium (μg/L)					5.7	5.2	5.7	5.0
Potassium (μg/L)					5.0	4.9	5.2	4.9
Sodium (μg/L)					60	48	53	170
Total Hardness (mg/L)					84	89	88	54
Total Cations (me/L)					4.4	4	4.2	-
***General Parameters*:**								
pH				6.5 to 8.5	8.0	8.0	7.9	8.6
Langlier Index at 25 C					0.01	-0.01	-0.11	-
Total Dissolved Solids (mg/L)			500 to 1,000	500	220	260	300	530
***Metals and Metalloids*:**								
Arsenic (μg/L)	10	10			7.5	3.1	6.5	11
Total Chromium (μg/L)	50	100			14	16	18	2.9
Hexavalent Chromium (μg/L)	[2]				16	14	14	-
Iron (μg/L)			300	300	ND < 100	ND < 100	ND < 100	11,000
Manganese (μg/L)			50	50	ND < 20	ND < 20	ND < 20	210

Notes:
(1) TW-1 and TW-2 samples were collected at the end of constant rate pumping tests.
DT-1 sample airlifted through the drill string after achieving total depth (1,500 feet).
(2) Hexavalent chromium is currently regulated under the MCL for total chromium.
CA = California
USEPA = United States Environmental Protection Agency
MCL = maximum contaminant level

At the Bristol and Cadiz Dry Lakes, surface water and shallow groundwater evaporation has concentrated dissolved salts resulting in TDS concentrations as high as 298,000 mg/L (Shafer, R. A., *Report on Investigations of Conditions which Determine the Potentials for Development in the Desert Valleys of Eastern San Bernardino County, California* (1964); Engineering Department Southern California Edison Company, Unpublished Report at 172, pp 12 plates; *cited in* Metropolitan and Cadiz Inc., *Environmental Impact Report/Environmental Impact Statement (EIR/EIS) for the Cadiz Groundwater Storage and Dry-Year Supply Program (Cadiz Project)*, pages 5-72, 5-80, and 5-81 (September 2001)). The location of the interface between the low-TDS "fresh" groundwater (i.e., TDS concentrations less than 1,000 mg/L) and high-TDS "saline" groundwater underlying the Dry Lakes has been mapped on the basis of data from observation wells in the area, and is shown in Figure 2-3.

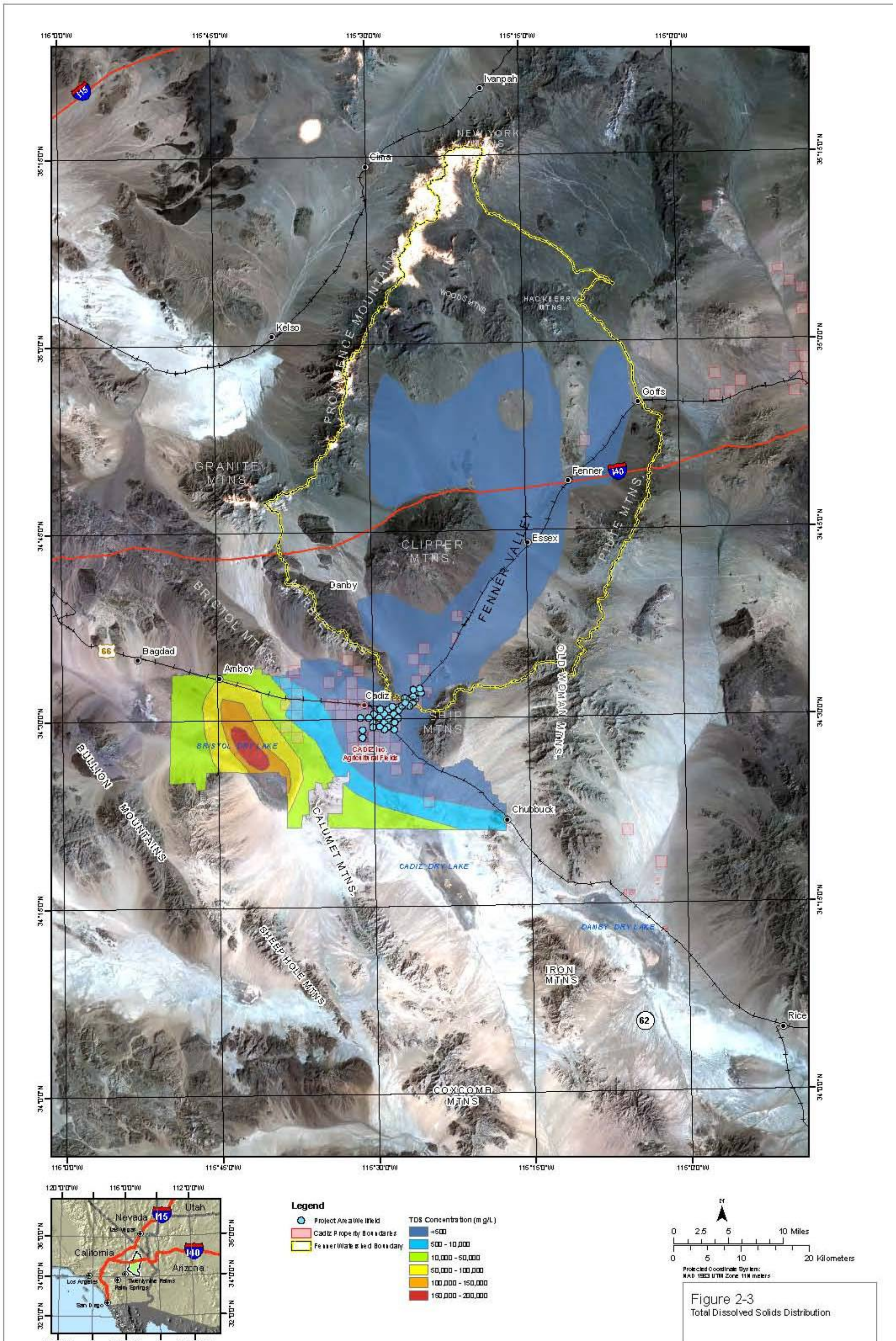


Figure 2-3
Total Dissolved Solids Distribution

2.7 Present Groundwater Production and Uses

Land use in the area consists primarily of desert conservation open space and agriculture, with limited chloride mining of the brine from the Dry Lakes and other mining, military uses, recreation, railroad, and electrical, gas, and oil utility corridors. Cadiz used, on average, 5,000 to 6,000 afy of groundwater between 1994 and 2007 for its agricultural operations. This annual usage was reduced beginning in 2007 in connection with the removal of approximately 500 acres of vineyard that had reached the end of its commercial life. Based on the current crop mix (lemons on 370 acres and grapes on 160 acres and seasonal row crops), the agricultural operations are using approximately 1800-1900 acre-feet of water per year. Another 1,070 acres are fallow and currently not irrigated.

There are also two existing salt mining operations at the Bristol and Cadiz Dry Lakes. These operations involve evaporation of the hyper-saline groundwater from the Dry Lakes to obtain remaining salts (calcium chloride and sodium chloride). One operation uses approximately 500 afy of the hyper-saline groundwater based upon recorded water extractions pursuant to California Water Code Section 4999 et seq., while it is estimated that the other operation, being approximately one-half of the size, uses approximately 250 afy for a total of 750 afy of hyper-saline groundwater.

CHAPTER 3
GROUNDWATER CONSERVATION

The Project is designed to operate consistent with California's constitutional requirement that all waters of the state not be wasted, but rather put to fullest beneficial use. By lowering water levels in the northern Bristol/Cadiz Sub-Basin, the Project will intercept natural recharge flowing through the Fenner Gap and from Orange Blossom Wash and, during Project pumping, reverse existing groundwater gradients and retrieve water stored in alluvial aquifers to the immediate southwest and southeast of the Fenner Gap back to the Project wellfield (Geoscience, September, 20 2011). Existing groundwater gradients cause water within these alluvial aquifers to flow towards the Bristol and Cadiz Dry Lakes, where it blends with brine beneath the Dry Lakes and ultimately evaporates. Thus, the Project's goal of lowering the water table will facilitate the recovery and conservation of this water before it is lost to the Dry Lakes where it evaporates.

This premise was studied and reported on in a technical memorandum issued by Project consultant Geoscience Support Services Inc. (Geoscience), titled Supplemental Assessment of Pumping Required for the Cadiz Valley Groundwater Conservation, Storage and Recovery Project, dated September 20, 2011. Geoscience used a variable density groundwater flow and transport model that it developed for the Project (see discussion of groundwater flow models in Chapter 4) to evaluate the savings of fresh groundwater as a result of the Project, water that would otherwise evaporate from the Dry Lakes absent the Project.

Table 3-1: Summary of Net Savings from Proposed Project Production (Average 50,000 afy/50 Years)

Natural Recharge	Time	Cumulative Reduction of Evaporative Losses [acre-feet]	Cumulative Depletion of Storage [acre-feet]	Fresh Groundwater Storage Impacted by Saline Migrations [acre-feet]	Cumulative Net Water Saving[8] from Project [acre-feet]
32,000 acre-ft/yr	At the End of 100 Years	2,210,000	220,000	173,000	1,817,000
	At the End of 50 years	1,360,000	1,090,000	177,000	93,000
16,000 acre-ft/yr	At the End of 100 Years	1,544,000	870,000	215,000	459,000
	At the End of 50 Years	745,000	1,684,000	175,000	-1,114,000
5,000 acre-ft/yr	At the End of 100 Years	470,000	1,870,000	183,000	-1,583,000
	At the End of 50 Years	221,000	2,155,000	126,000	-2,060,000

By lowering groundwater levels in the alluvial aquifers, the Project will also create space in the Sub-Basin to store imported water as part of the potential future water

[8] Net water savings is derived from subtracting depletion of storage and amount of freshwater storage impaired by migration of saline water from the reduction of evaporative losses. The 100-year time frame assumes no Project pumping during years 51 through 100. Calculations of projected conservation benefits are reduced if pumping is expected to occur during years 51 through 100.

banking project use that may occur for the second phase of the Project. In sum, the Project will capture natural recharge, optimize conservation by retrieving groundwater presently in storage before it can evaporate, allow for the carryover of native water in storage, and set the stage of a new water bank storage opportunity that does not presently exist. As explained below in Chapters 5 and 6, this Management Plan provides for comprehensive monitoring of potential significant adverse impacts to critical resources, together with a series of action criteria and potential corrective measures, to ensure that the Project does not cause significant adverse environmental impacts to critical resources or Undesirable Results.

CHAPTER 4
ASSESSMENTS OF POTENTIAL SIGNIFICANT ADVERSE IMPACTS TO CRITICAL RESOURCES IN OR ADJACENT TO THE PROJECT AREA

As discussed above, the objectives of this Management Plan are to ensure compliance with the County Groundwater Management Ordinance and MOU and avoid material adverse impacts to critical resources or Undesirable Results. This Management Plan addresses the following critical resources:

- The basin aquifers tapped by the Project;
- Brine resources of Bristol and Cadiz Dry Lakes;
- Springs within the Fenner Watershed including springs of the Mojave National Preserve and BLM-managed lands;
- Air quality in the Mojave Desert region;
- Project area vegetation; and
- Adjacent groundwater basins, including the Colorado River and its tributary sources of water.

This chapter takes a conservative approach in its technical analysis of the potential adverse impacts to these critical resources as a result of the Project operations.

4.1 Potential Significant Adverse Impacts to Critical Resources Related to Basin Aquifers

For the purposes of this Management Plan, the basin aquifers include aquifers of the Fenner, Bristol, and Cadiz Watersheds as described in Section 2.4. However, emphasis is placed on the aquifers in the vicinity of the northern Bristol/Cadiz Sub-Basin and

Fenner Valley Watershed along with any aquifers that extend toward the Bristol and Cadiz Dry Lakes where analysis has shown that Project operations may have an effect. Potential impacts to critical resources or Undesirable Results include:

- Progressive decline in groundwater levels and freshwater storage below the floor established in Section 6.9 of this Management Plan;
- Impacts to wells owned by neighboring landowners (including wells operated in the larger Fenner Watershed area) due to Project operations;
- Land subsidence and loss of groundwater storage capacity due to groundwater withdrawal; and
- Induced flow of lower quality water from Bristol and Cadiz Dry Lakes.

Water resources models were developed and applied to assess these potential impacts. The specific models and their application are described below in Sections 4.1.1.1 and 4.1.1.2.

4.1.1 *Water Resources Modeling*

Water resources models developed during the pre-operational phase of the Project have been, and are planned to be, used to simulate the impacts of planned Project operations. These models include the INFIL3.0 soil-moisture budget model, MODFLOW-2000/MT3D groundwater flow and solute transport model, and SEAWAT-2000 model (note that selection of models may change subject to concurrence with the TRP, SMWD, and the County based on either updates to these models or availability of comparable models). The results of simulations using these models have been used to assess potential impacts during Project operations. Results of these simulations are used to identify monitoring features and conditions to be monitored and locations and frequency of monitoring during Project operations in order to verify these model projections. During Project operations, the results of monitoring will be used to evaluate whether any action criteria are triggered and to verify simulations. Evaluation of monitoring results could result in refinements to action criteria as well as identifying areas where collection of additional data may be needed to improve the monitoring network and accuracy of simulations. Any refinements to models that monitoring data indicate may be needed will be made in accordance with the decision-making process described in Chapters 6 and 8. The specific attributes of, and simulation results from, each of the models is discussed next.

4.1.1.1 INFIL3.0

INFIL3.0 is a grid-based, distributed–parameter, deterministic water-balance watershed model, released for public use by the USGS in 2008, which is used to estimate the areal and temporal net infiltration of precipitation below the root zone (USGS, 2008). This model was used to estimate potential recoverable water for the Project. The model is based on earlier versions of INFIL code that were developed by the USGS in cooperation with the Department of Energy to estimate net infiltration and groundwater recharge at the Yucca Mountain high-level nuclear-waste repository site in Nevada. Net infiltration is the downward movement of water that escapes below the root zone, is no longer affected by evapotranspiration, and is capable of percolating to and recharging groundwater. Net infiltration may originate as three sources: rainfall, snow melt, and surface water runon (runoff and streamflow). Application of INFIL3.0 to the Fenner and Orange Blossom Wash Watersheds produced long-term average annual natural recharge estimates of approximately 32,000 afy.

This model will be updated and refined during Project operations based on data obtained from the monitoring features.

4.1.1.2 MODFLOW-2000/MT3D - Groundwater Flow and Transport Model

Geoscience Support Services, Inc. (Geoscience) developed a numerical groundwater flow and solute transport simulation of a large portion of the larger watershed area, utilizing MODFLOW2000 and MT3D. This model provides the basis for developing the variable density model described in the next section. This model, along with other identified models in Section 4.1.1.1, will be updated and refined during Project operations based on monitoring data, and the monitoring network and action criteria refined during the Project. MODFLOW-2000 is a modular finite-difference flow model developed by the USGS to solve the groundwater flow equation.

The numerical groundwater flow and solute transport model was developed based on a conceptual model developed during the pre-operations stage incorporating the area of interest, aquifer systems, and boundary conditions. This conceptual model of hydrogeology and groundwater flow conditions in the larger watershed area will be further refined based upon a thorough analysis of the available hydrogeologic data for the modeled area, as additional information is collected from installation of the monitoring wells and extraction wells, and as monitoring data are compiled during the operations stage. The groundwater flow model will integrate quantities and distribution of recharge and discharge estimated from updates to INFIL3.0 and Project extractions. INFIL3.0 was released for public use by USGS in 2008.

4.1.1.3 Variable Density Groundwater Flow And Transport Model, Including Subsidence

A variable density flow and transport simulation utilizing SEAWAT-2000 Version 4 was also developed by Geoscience. SEAWAT-2000 Version 4 was developed by the USGS in 2008. This model simulates the transport of solute mass through a numerical solution of a mass balance equation involving fluid density, and was specifically designed to estimate the likely effects of Project operations on the projected saline/freshwater interface (northerly of the margins of the Dry Lakes). The single solute species, total dissolved solids (TDS) is transported conservatively (i.e., there is no absorption or any other losses of TDS) in the model. Sources and boundary conditions of solutes are specified as sources of salts, such as the Dry Lakes.

The model domain extends over the same area as the flow and solute transport model domain. The height and horizontal and vertical grid spacing was selected based on available data and the intended use of the model. These models include hydraulic conductivity, specific storage, effective porosity, and dispersion coefficients for each model element. Specified flux and chloride mass fraction was provided by the regional groundwater flow and solute transport model described previously.

In addition, in order to simulate subsidence potential, the variable density flow and transport model was augmented by incorporating the Subsidence and Aquifer-System Compaction (SUB) Package (Hoffmann, et. al, 2003). The SUB Package is used in conjunction with SEAWAT-2000 to simulate the elastic (recoverable) compaction and expansion and inelastic (permanent) compaction of compressible fine-grained beds (interbeds) within the aquifers. The deformation of interbeds is caused by changes in effective stress as a result of groundwater level changes. If the stress is less than the preconsolidation stress of the sediments, the deformation is elastic (i.e., recoverable). If the stress is greater than the preconsolidation stress, the deformation is inelastic (i.e., permanent).

If necessary, this model will be updated and refined during Project operations based on data obtained from the monitoring features.

4.1.2 *Application of Water Resources Models*

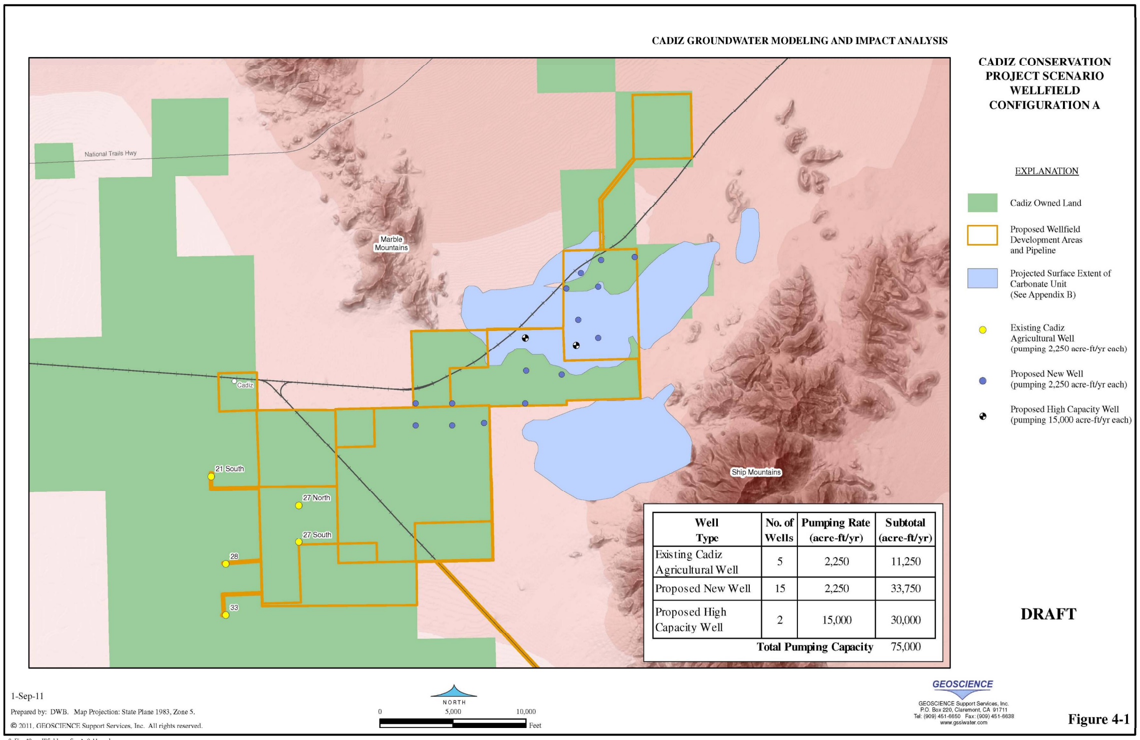
Building on prior technical investigations of area groundwater resources, geologic mapping, and recent exploratory drilling and testing, Geoscience developed a three-dimensional variable density groundwater flow and solute transport model of a portion of the total watershed area tributary to the Fenner, Bristol, and Cadiz Valleys to simulate the operation of the proposed wellfield and its effects on groundwater levels, groundwater in storage, the freshwater/saltwater interface near the Dry Lakes, and potential land subsidence. The results of Geoscience's investigation and modeling are set forth in its report titled Cadiz Groundwater Modeling and Impact Analysis, dated September 1, 2011.

Geoscience's groundwater model consists of a six-layer variable density flow and solute transport model constructed to simulate the groundwater conditions that underlie Fenner Valley, Fenner Gap, and a portion of the Bristol and Cadiz Dry Lakes. Recent geologic mapping, interpretive geologic cross-sections, and lithologic logs from exploratory borings and water wells, along with geologic and hydrologic data available in the literature, are used to develop the six model layers. The model layers consist of the following:

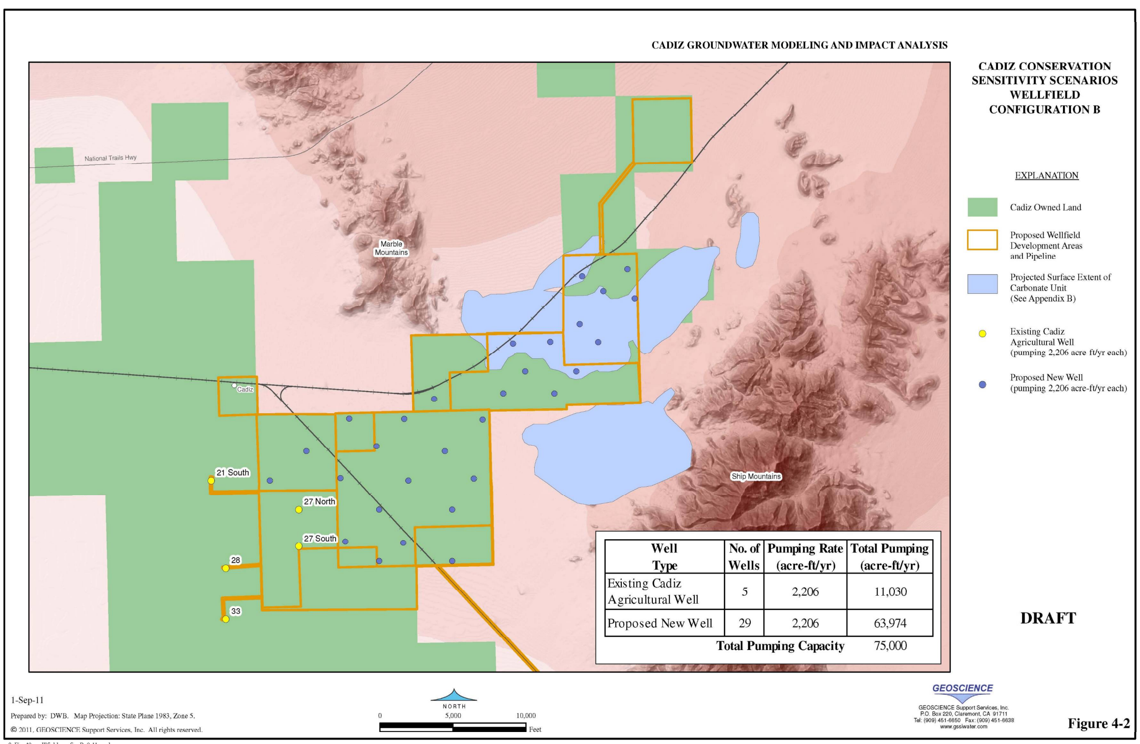
- Layer 1 - Upper Alluvium
- Layer 2 - Alluvium beneath the Upper Alluvium to a depth of approximately 1,200 ft
- Layer 3 - Alluvium beneath a depth of 1,200 ft
- Layer 4 - Fanglomerate, carbonate, lower Paleozoic sequence, and weathered granitic rocks
- Layer 5 - Carbonate, lower Paleozoic sequence, and weathered granitic rocks
- Layer 6 - A Detachment Fault Zone (approximately 200 ft thick) in the Fenner Gap area and weathered granitic rocks.

(Geoscience, September 1, 2011).

Geoscience simulated two wellfield configurations as shown in Figures 4-1 and 4-2. The first simulation (Configuration A) modeled a wellfield configuration of two large-capacity wells in the carbonate units encountered in the Fenner Gap area, which results in a more tightly clustered wellfield in the Fenner Gap area. The second simulation (Configuration B) assumed a more dispersed wellfield with pumping more evenly distributed among the wells.



Well Type	No. of Wells	Pumping Rate (acre-ft/yr)	Subtotal (acre-ft/yr)
Existing Cadiz Agricultural Well	5	2,250	11,250
Proposed New Well	15	2,250	33,750
Proposed High Capacity Well	2	15,000	30,000
		Total Pumping Capacity	75,000



Well Type	No. of Wells	Pumping Rate (acre-ft/yr)	Total Pumping (acre-ft/yr)
Existing Cadiz Agricultural Well	5	2,206	11,030
Proposed New Well	29	2,206	63,974
		Total Pumping Capacity	75,000

The groundwater model developed by Geoscience assumed horizontal groundwater flow through each model layer, with vertical leakage providing hydraulic connection between the layers. The model accounted for both natural and artificial recharge, as well as discharge via evaporation at the Dry Lakes and agricultural pumping. Geoscience applied the industry standard "history matching" technique to both steady state and transient calibration. For each calibration run, the relative error was 0.15 percent for the steady-state model and 1.7 percent for the transient model, both well below the recommended relative error of 10 percent.

Geoscience simulated three recharge scenarios, including 5,000 afy, 16,000 afy, and 32,000 afy to assess effects on groundwater levels, the movement of the freshwater/saltwater interface near the Dry Lakes, and land subsidence. The 32,000 afy recharge scenario is based on USGS INFIL3.0 modeling of the soil-moisture water budget for the Fenner and Orange Blossom Wash Watershed areas. Geoscience simulated this large range in long-term average annual recharge by reducing the projected recharge by 50 percent (16,000 afy) and then to an amount that is generally equivalent to Cadiz historical agricultural pumping (5,000 afy) in order to increase the conservatism of the analysis (identify potential worst-case impacts).

After the model was calibrated, Geoscience simulated 100-year predictive runs for each of the three ranges of recharge scenarios, including 32,000 afy, 16,000 afy, and 5,000 afy. The Project Scenario assumed 32,000 afy of natural recharge and a Project wellfield clustered around Fenner Gap (Configuration A). The 32,000 afy recharge scenario was based on USGS INFIL3.0 modeling of the soil-moisture water budget for the Fenner and Orange Blossom Wash Watersheds. The two Sensitivity Scenarios, which assumed less natural recharge and a Project wellfield spread out from the Fenner Gap (Configuration B), allowed Geoscience to evaluate the potential range of worst-case impacts on groundwater levels, migration of the saline-freshwater interface, and subsidence.[9] Configuration A was utilized for the Project Scenario to account for higher transmissivity values allowing for use of fewer high capacity wells installed in the carbonate aquifer with less drawdown than comparable wells in the alluvial aquifer. Configuration B was used under the two Sensitivity Scenarios due to lower transmissivity values and the corresponding need for a greater number of wells spread out over the wellfield to limit drawdown. The model scenarios and assumptions used in each are summarized in Table 4-1.

[9] The Project is intended to pump an average of 50,000 AFY for 50 years. The Sensitivity Scenarios, however, were used to evaluate potential environmental impacts of the Project under CEQA and are not an authorization of any specific operating scenario that would cause Overdraft or Undesirable Results as the terms are defined in this Management Plan. This Management Plan in some respects involves stricter operating parameters as a precaution against Overdraft and Undesirable Results.

TABLE 4-1: GEOSCIENCE GROUNDWATER MODEL ASSUMPTIONS

Model Scenario	Model Assumptions			
	Natural Recharge (afy)	Wellfield Configuration	Groundwater Pumping Years 1 to 50 (afy)	Groundwater Pumping Years 50 to 100 (afy)
Project Scenario	32,000	Configuration A	50,000	0
Sensitivity Scenario 1	16,000	Configuration B	50,000	0
Sensitivity Scenario 2	5,000	Configuration B	50,000	0

4.1.2.2 Project Impact Findings from Groundwater Flow Model

Based on the results of its groundwater model, Geoscience made the determinations about the impact of the Project discussed in this section below. As the Project is implemented, data will be obtained from drilling and testing of Project production and monitoring wells, and monitoring data will be obtained as a part of the monitoring plan described in Chapter 5. As data are obtained, these water resources models will be periodically updated, at minimum annually during development of the Project, to continuously assess effects on critical resources and, if necessary, to revise the monitoring program, action triggers, and mitigation responses as described in Chapter 6.

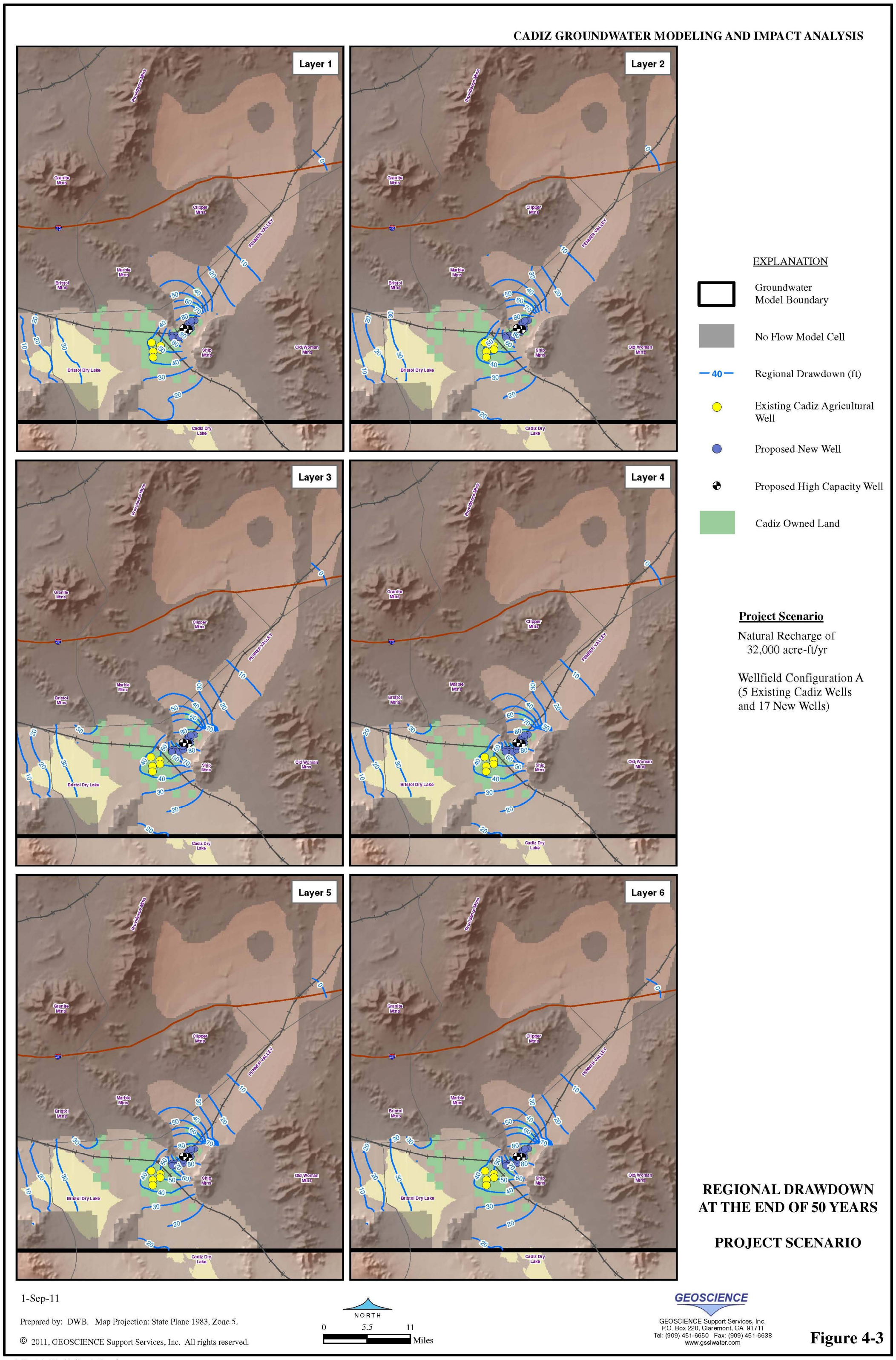
4.1.2.3 Groundwater Elevations

Table 4-2 below shows the change in groundwater elevations at the end of Year 50 under each model-calculated scenario. The lowest groundwater levels (i.e., greatest impact) would occur at the center of the Project wellfield. The pumping would create a cone of depression and groundwater would flow toward the proposed wellfield from Fenner, Bristol, and Cadiz Valleys. At the end of 100 years, groundwater levels in the wellfield approach pre-Project levels for the Project scenario (full recovery in Year 117 or 67 years after cessation of pumping) (Geoscience, September 1, 2011). For the two scenarios simulating lower recharge values, the water table would return to pre-pumping levels with most of the recovery occurring near the wellfield within the first 10 years and full recovery to pre-Project levels to occur approximately 100 to almost 400 years after pumping stops. The groundwater flow model simulations show that groundwater levels are drawn down to effect capture of water that would otherwise evaporate to the Dry Lakes, and then groundwater levels recover upon cessation of pumping after Year 50. During the 50-year span of the Project, the groundwater flow model simulations show that the Project's operation will cause a decline of groundwater levels.

TABLE 4-2: GROUNDWATER DRAWDOWN IMPACTS

Model Scenario	End of 50 Years (End of Project Pumping)		End of 100 Years (End of Model Simulation or 50 Years After Pumping Stops)	
	Drawdown at Wellfield (feet)	**Drawdown at Bristol Dry Lake (feet)**	**Drawdown at Wellfield (feet)**	**Drawdown at Bristol Dry Lake (feet)**
Project Scenario	70 – 80	10 – 30	0 – 10	10 – 20
Sensitivity Scenario 1	120 – 130	10 – 60	10 – 20	30 – 40
Sensitivity Scenario 2	260 – 270	0 – 80	50 – 60	10 – 70

Figures 4-3 through 4-8 show groundwater-level drawdown for those various recharge scenarios simulated, both at the end of 50 years of pumping and then for the 50 years following the cessation of Project pumping (for a total of simulated period of 100 years). Groundwater-level drawdown decreases northward into Fenner Valley, such that drawdown effects near Danby decrease to about 15 feet, and at Interstate 40 (and certainly at Goffs) are negligible.



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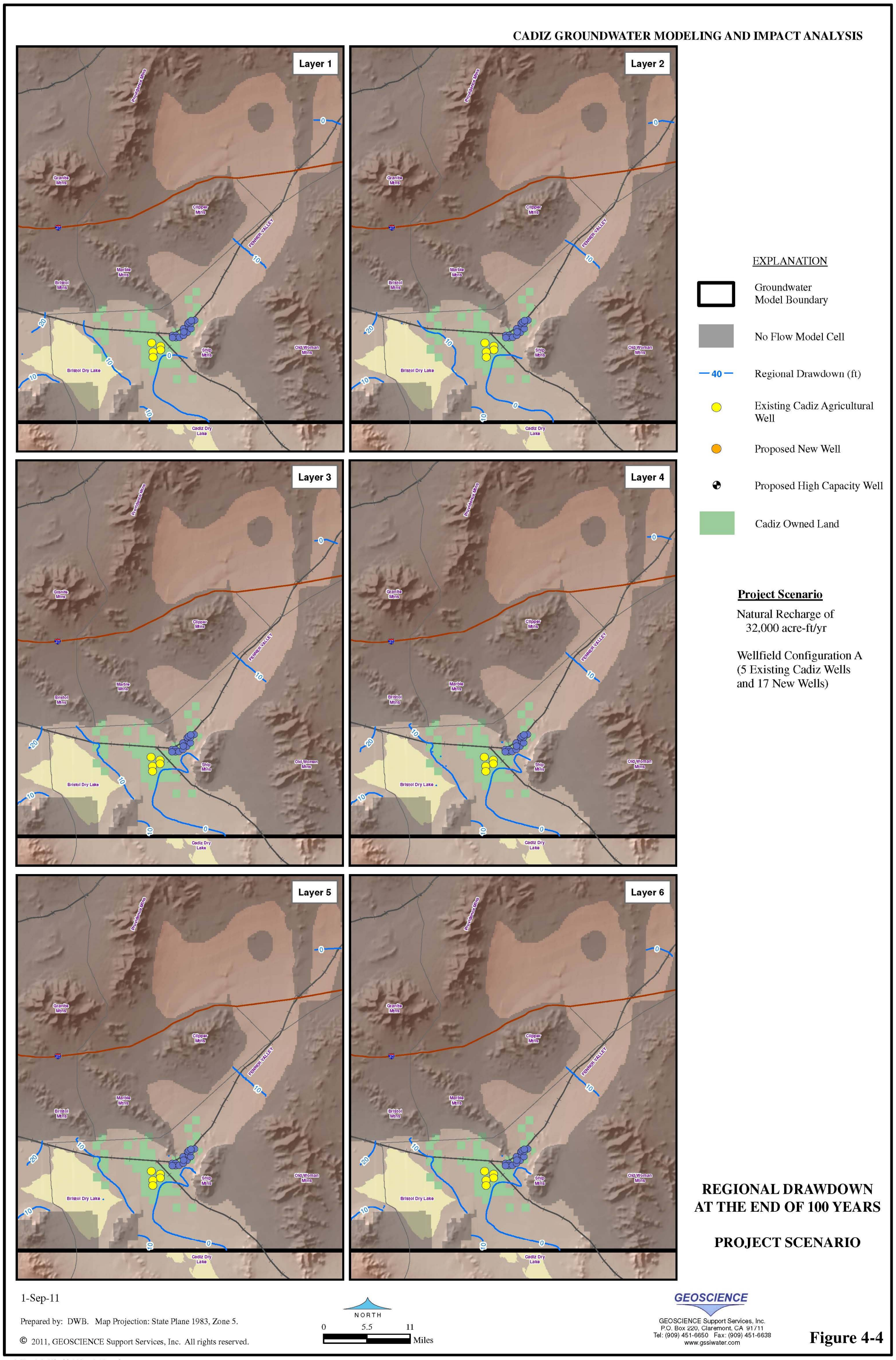

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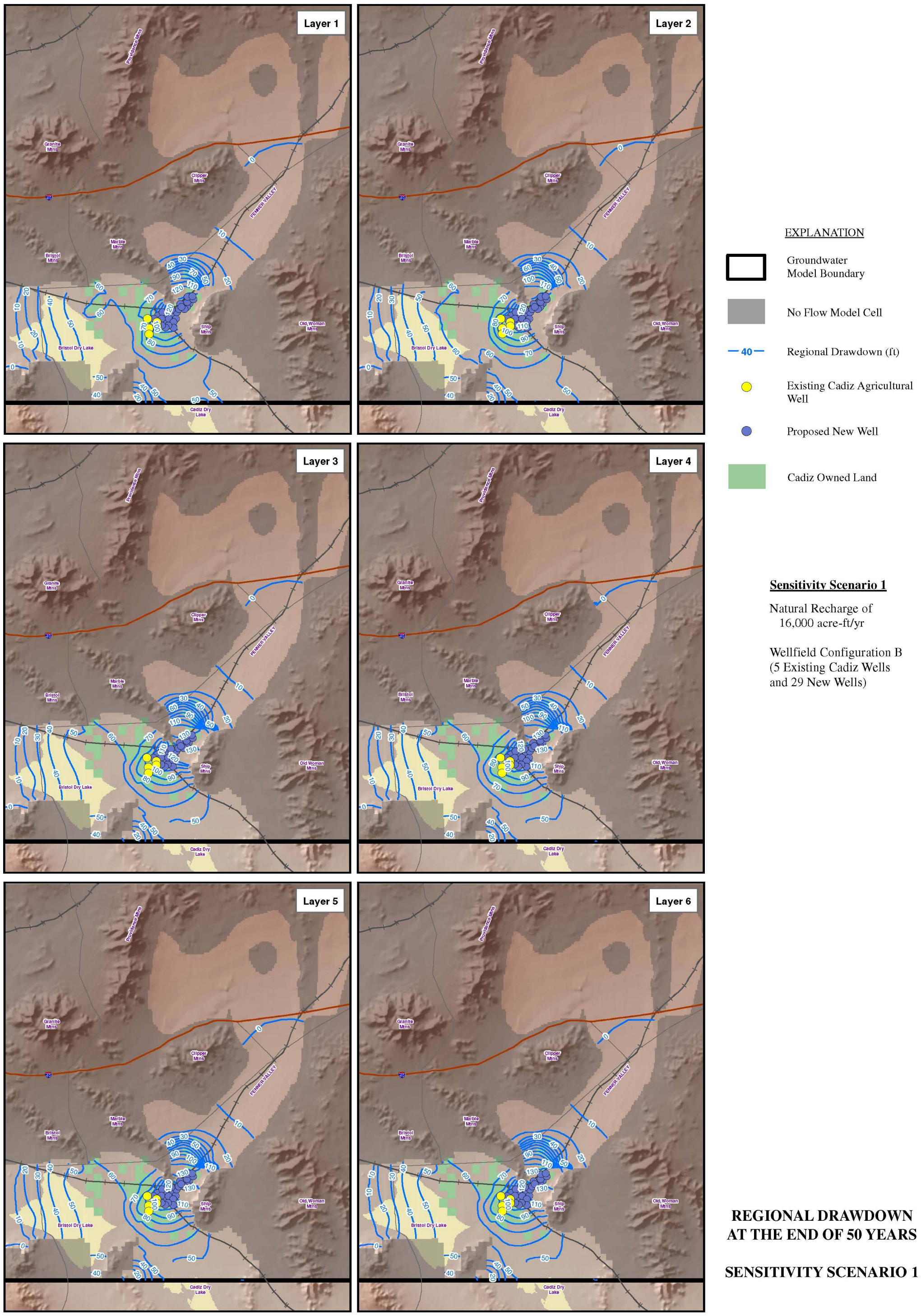
CADIZ GROUNDWATER MODELING AND IMPACT ANALYSIS



REGIONAL DRAWDOWN AT THE END OF 50 YEARS

SENSITIVITY SCENARIO 1

1-Sep-11

Prepared by: DWB. Map Projection: State Plane 1983, Zone 5.

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GEOSCIENCE Support Services, Inc.
P.O. Box 220, Claremont, CA 91711
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Figure 4-5

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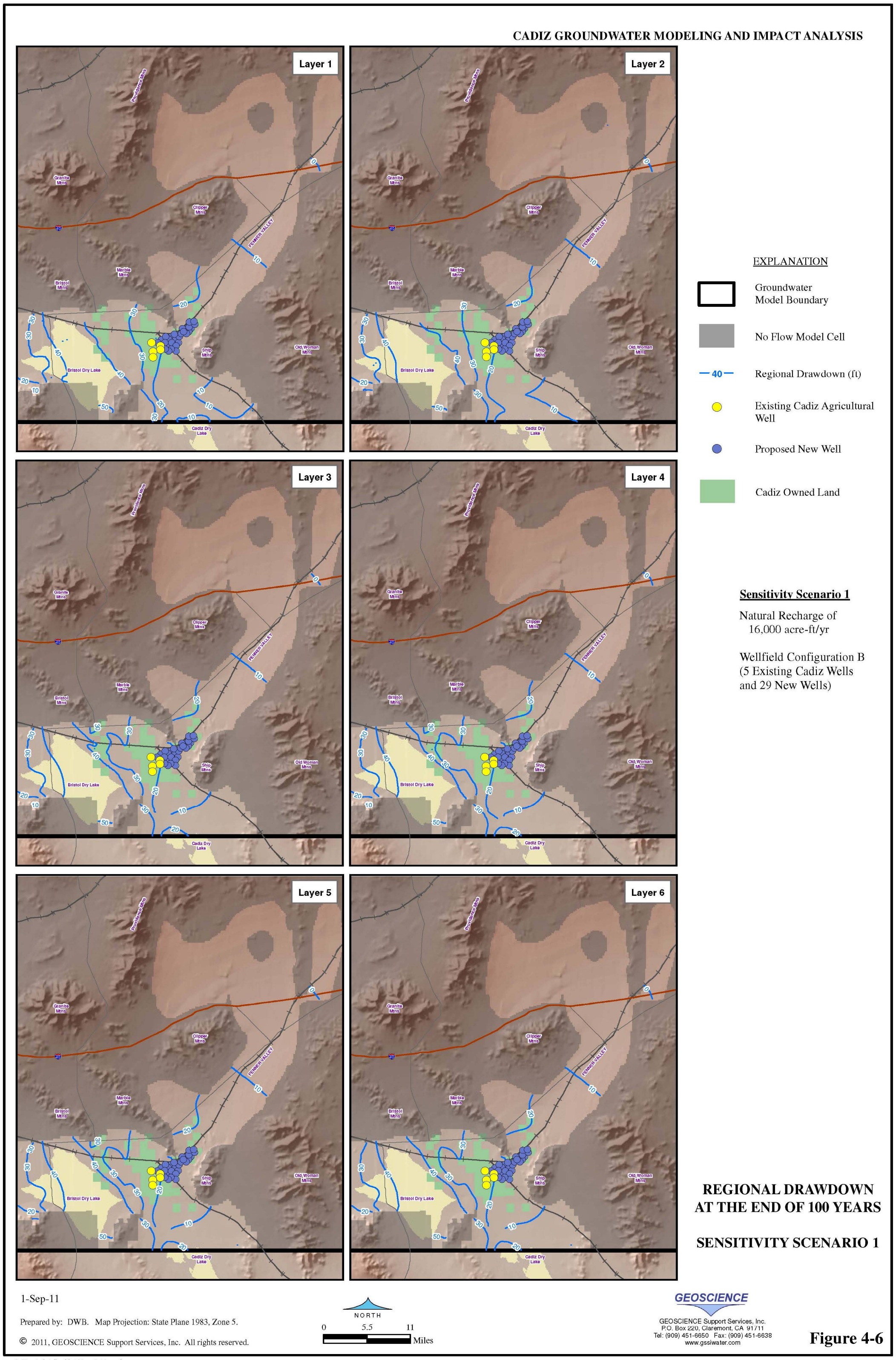

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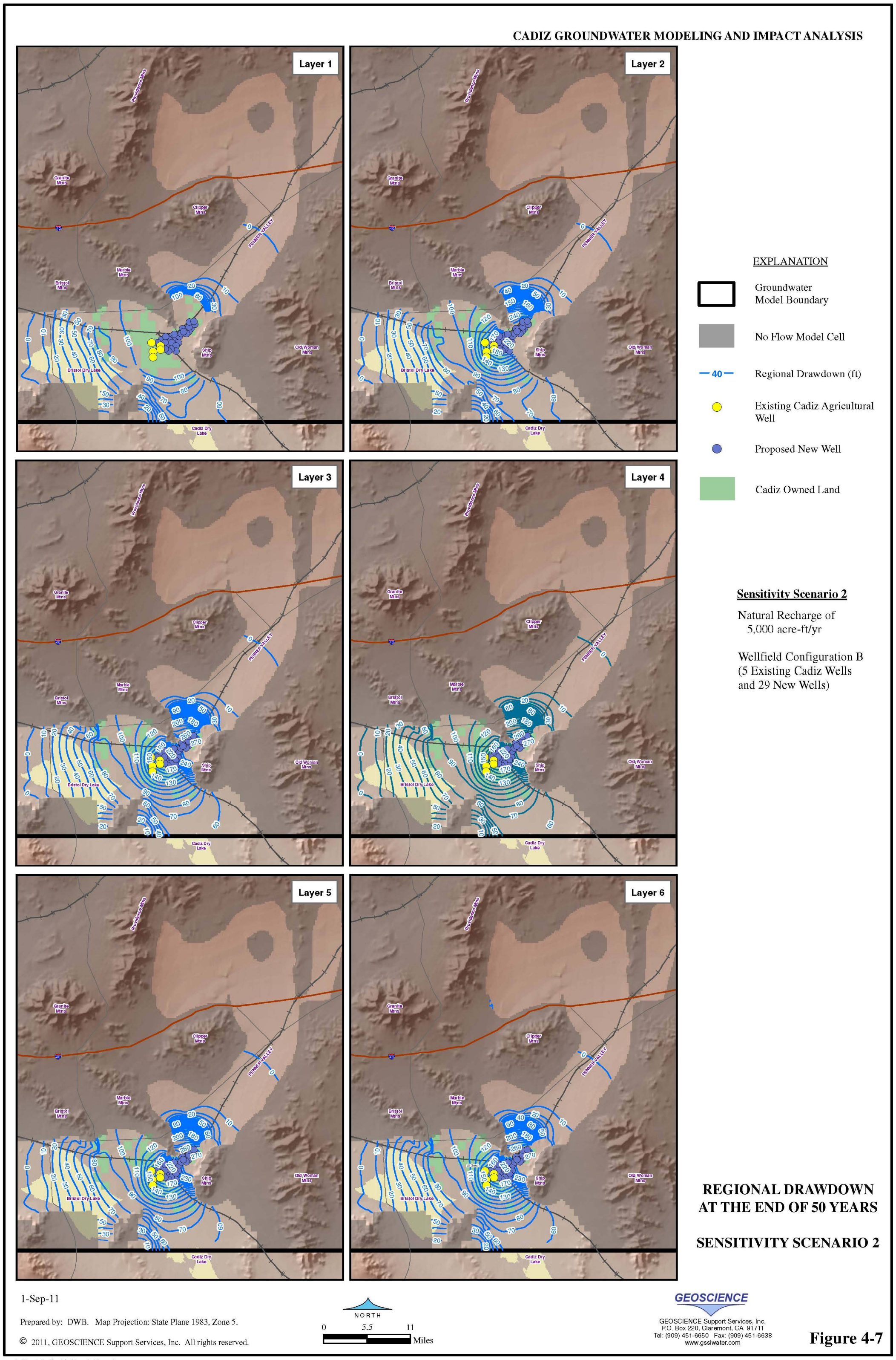

Figure 4-7

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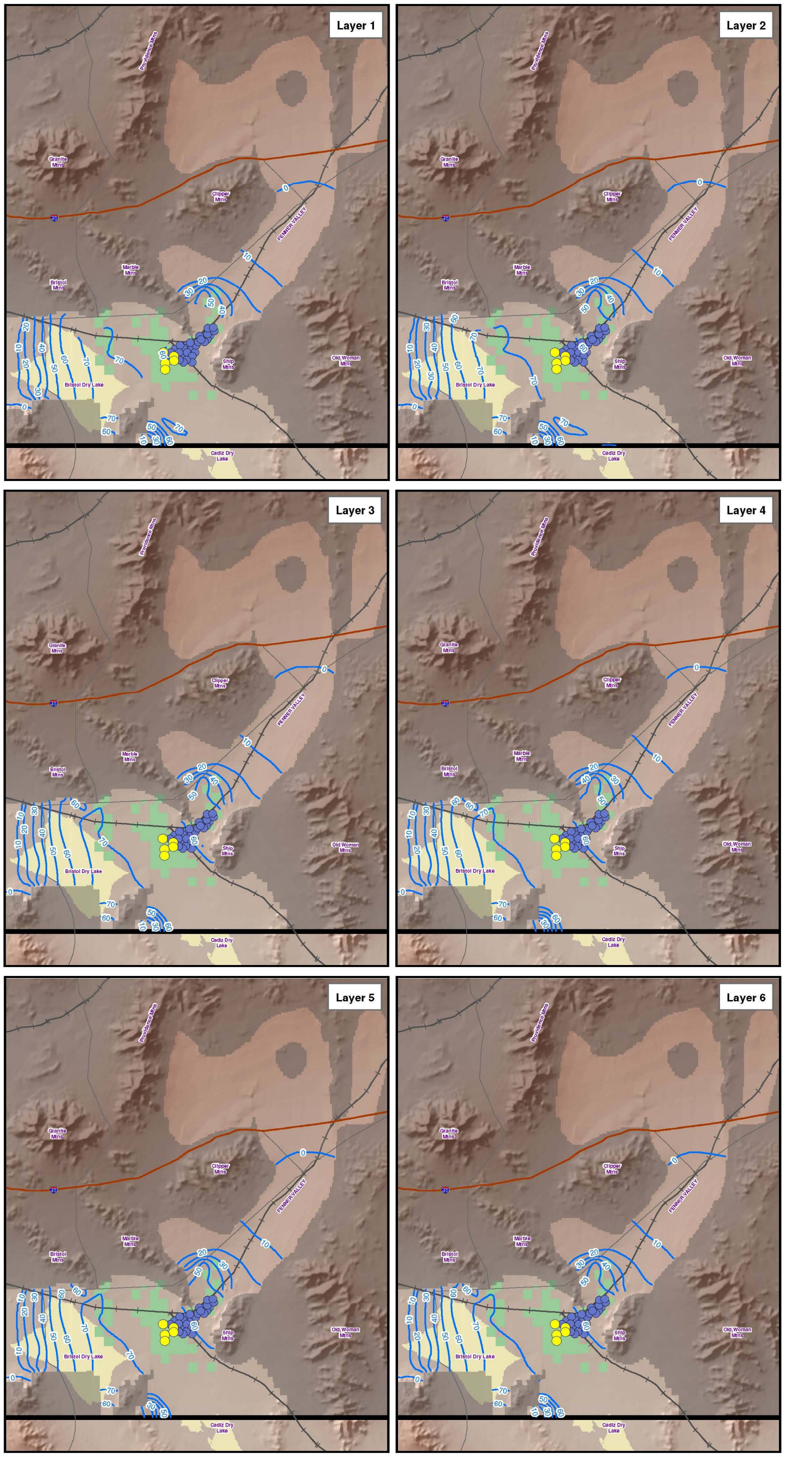
CADIZ GROUNDWATER MODELING AND IMPACT ANALYSIS



EXPLANATION

Groundwater Model Boundary

No Flow Model Cell

40 Regional Drawdown (ft)

Existing Cadiz Agricultural Well

Proposed New Well

Cadiz Owned Land

Sensitivity Scenario 2

Natural Recharge of 5,000 acre-ft/yr

Wellfield Configuration B (5 Existing Cadiz Wells and 29 New Wells)

REGIONAL DRAWDOWN AT THE END OF 100 YEARS

SENSITIVITY SCENARIO 2

1-Sep-11

Prepared by: DWB. Map Projection: State Plane 1983, Zone 5.

NORTH

0 5.5 11 Miles

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Figure 4-8

0_Fig_4-8_5k_dd_100yr_2-12.mxd

4.1.2.4 Depth to Groundwater

Table 4-3 shows the predicted depth to groundwater during the 50-year and 100-year model simulation period at selected locations including the center of the Project wellfield, the existing Cadiz Inc. wells, the edge of the Bristol Dry Lake, the center of Bristol Dry Lake, and the edge of Cadiz Dry Lake (Geoscience, September 1, 2011). Groundwater levels decline during the limited term of the Project (50 years) to satisfy the Project's intended goal of capturing groundwater that is flowing to the Dry Lakes.

Pursuant to the MOU, the parties agreed to work in good faith to (i) identify the groundwater levels that will serve as monitoring targets and a "floor" for the maximum groundwater drawdown level in the Project wellfield, and (ii) establish a Projected rate of decline in the groundwater table. The floor and rate of decline are to be designed to help assess trends and operate the Project in a manner that avoids Undesirable Results or other potential significant adverse impacts to critical resources enumerated in the MOU (including saline water migration).

TABLE 4-3: GROUNDWATER MODEL DEPTH IMPACTS

Location	Time	Depth to Groundwater (feet)			
		Existing	Project Scenario	Sensitivity Scenario 1	Sensitivity Scenario 2
Center of Wellfield	End of 50 Years	354	435	486	627
	End of 100 Years		351	371	412
Existing Cadiz Inc. Wells	End of 50 Years	156	197	241	315
	End of 100 Years		154	181	219
Edge of Bristol Dry Lake	End of 50 Years	33	68	95	118
	End of 100 Years		42	74	108
Center of Bristol Dry Lake	End of 50 Years	18	50	63	54
	End of 100 Years		33	62	79
Edge of Cadiz Dry Lake	End of 50 Years	7	21	59	72
	End of 100 Years		10	17	68

4.1.2.5 Saline-Freshwater Interface

Geoscience used the SEAWAT-2000 variable density groundwater flow and solute transport model to predict the movement of the saline-freshwater interface as a result of Project pumping. The location of the current saline-freshwater interface is defined by the location of the 1,000 mg/L total dissolved solids (TDS) concentration contour, which is based on groundwater quality data from historical data from wells in the area.

Results of the modeling indicate that the saline-freshwater interface in the Bristol Dry Lake area would move up to 10,400 feet northeast during Years 1 to 50 under the Project Scenario, up to 9,700 feet under Sensitivity Scenario 1, and up to 6,300 feet under Sensitivity Scenario 2. During years 50 to 100, after Project pumping has ceased and without any physical measures to impede migration, the saline-freshwater interface would continue to move northeast, reaching a total distance of 11,500 feet, 11,100 feet, and 9,200 feet under the Project Scenario, Sensitivity Scenario 1, and Sensitivity Scenario 2, respectively. Table 4-4 summarizes the maximum migration distance of the saline-freshwater boundary (Geoscience, September 1, 2011). As a precautionary measure to limit the migration of hyper-saline groundwater and protect the health of the aquifer under the County Ordinance, the saline-freshwater boundary shall be monitored and its migration limited to 6,000 ft northeast of the Dry Lakes through physical measures (e.g., injection or extraction wells) or pumping restrictions if physical measures prove ineffective.

TABLE 4-4: SALINE/FRESHWATER BOUNDARY MIGRATION

Model Scenario	Maximum Migration of Saline-Freshwater Boundary at Year 50	Maximum Migration of Saline-Freshwater Boundary at Year 100
Project Scenario	10,400 ft Northeast	11,500 ft Northeast
Sensitivity Scenario 1	9,700 ft Northeast	11,100 ft Northeast
Sensitivity Scenario 2	6,300 ft Northeast	9,200 ft Northeast

4.1.2.6 Groundwater in Storage

Based on its groundwater model, Geoscience determined that the cumulative annual change in groundwater storage would reach a maximum of -1,090,000 acre-feet (a negative sign represents a decline in groundwater storage) in Year 50 under the Project Scenario conditions. This change in storage reflects ongoing evaporation from the Dry Lakes of approximately 244,000 acre-feet and about 33,000 acre-feet of water contributed from interbed storage ("squeezing" of water out of fine-grained units, which results in the compaction as discussed below), thus resulting in an additional net loss of about 211,000 acre-feet of groundwater storage during the initial 50 years, in addition to pumping beyond the natural recharge rate. This decline in storage is approximately 3 percent to 6 percent of the total groundwater in storage in the entire watershed area, which is estimated to be 17 to 34 million acre-feet. Upon cessation of pumping after Year 50, groundwater in storage would begin to recover and the cumulative annual change in groundwater storage would be approximately -220,000 acre-feet in Year 100 under the Project Scenario. Evaporative losses to the Dry Lakes accelerate through time as groundwater levels recover between Years 50 and 100. Based on the rate of recovery projected for Years 51 to 100, the groundwater in storage would fully recover in Year 117 (67 years after Project pumping stopped). The contribution of water from interbed storage increases and the losses due to evaporation from the Dry Lakes decreases in the sensitivity scenarios, thereby resulting in conservation benefits. Table 4-5 summarizes the cumulative annual changes in groundwater storage as calculated from Geoscience's model simulations of the three scenarios (Geoscience, September 1, 2011). The Project's operation establishes drawdown in groundwater levels for the purposes of capturing water that would otherwise discharge to the Dry Lakes and evaporate.

TABLE 4-5: REDUCTION IN ALLUVIAL GROUNDWATER IN STORAGE

Model Scenario	Cumulative Annual Changes in Groundwater Storage at Year 50		Cumulative Annual Changes in Groundwater Storage at Year 100		Time to Full Recovery after Pumping Ceases in Year 50
	Volume (acre-feet)	% of Total Groundwater Storage	Volume (acre-feet)	% of Total Groundwater Storage	
Project Scenario	-1,090,000	3% - 6%	-220,000	1%	67 (year 117)
Sensitivity Scenario 1	-1,680,000	5% - 10%	-870,000	3% - 5%	103 (year 153)
Sensitivity Scenario 2	-2,160,000	6% - 13%	-1,870,000	6% - 11%	390 (year 440)

4.1.2.7 Potential Land Subsidence

Because the Project involves a lowering of groundwater levels as discussed above in Chapter 3, potential land subsidence is a concern that must be evaluated and monitored. In general, the potential for land subsidence corresponds to the magnitude of groundwater level decline and the thickness of the fine-grained layers in the aquifer. Based on the results of the Geoscience groundwater model, any predicted subsidence would occur gradually and be dispersed laterally over a large area from the Fenner Gap to the Bristol and Cadiz Dry Lakes. Table 4-6 summarizes the model-predicted land subsidence over time at selected locations including the center of the wellfield, existing Cadiz wells, the edge of Bristol Dry Lake, the center of Bristol Dry Lake, and the edge of Cadiz Dry Lake (Geoscience, September 1, 2011). This degree of potential land subsidence is not expected to significantly impact the alluvial aquifer's storage capacity because consolidation of the aquifer will occur in clay and silt intervals, which do not contribute to the useable storage capacity. Potential subsidence in the range projected is also unlikely to harm any surface structures (for example, subsidence is not expected to exceed thresholds established for railroad tracks by the Federal Railroad

Administration Track Safety Standards Compliance Manual, April 1, 2007). This Management Plan provides in Chapter 6 monitoring and action criteria triggers and corrective actions that may be taken in response to the triggering of those action criteria in order to prevent significant adverse impacts to critical resources or the occurrence of Undesirable Results (including progressive subsidence).

TABLE 4-6: MAXIMUM POTENTIAL LAND SUBSIDENCE

Location	Time	Maximum Potential Land Subsidence (feet)		
		Project Scenario	Sensitivity Scenario 1	Sensitivity Scenario 2
Center of Wellfield	End of 50 Years	0.2	0.4	0.7
	End of 100 Years	0.2	0.4	0.7
Existing Cadiz Wells	End of 50 Years	0.6	1.0	1.5
	End of 100 Years	0.6	1.0	1.5
Edge of Bristol Dry Lake	End of 50 Years	0.5	1.0	1.4
	End of 100 Years	0.5	1.0	1.7
Center of Bristol Dry Lake	End of 50 Years	0.9	1.7	1.2
	End of 100 Years	0.9	2.1	2.7
Edge of Cadiz Dry Lake	End of 50 Years	0.1	0.4	0.5
	End of 100 Years	0.1	0.4	0.6

4.2 Potential Significant Adverse Impacts to Critical Resources: Springs Within the Fenner Watershed

As discussed in the EIR, a potential adverse environmental impact that, depending on physical conditions, can result from the lowering of regional groundwater levels is the cessation or reduction of flow from area springs. Native springs are present in the vicinity of the Project within the Fenner Watershed, as shown in Figure 4-9 (CH2M Hill, August 2011). These springs support habitat of the desert environment, and some are located within the Mojave National Preserve and BLM-managed lands. However, for the reasons discussed below, the EIR concluded that the lowering of groundwater levels with the proposed Project would not impact the flow from Fenner Watershed springs.

The springs closest to the proposed Project extraction wellfield are located in the adjacent mountains and include: Bonanza Spring, Hummingbird Spring, and Chuckwalla Spring in the Clipper Mountains to the north; Willow Spring, Honeymoon Spring, Barrel Spring, and Fenner Spring in the Old Woman and Piute Mountains on the east; and Van Winkle Spring, Dripping Spring, Unnamed-17BS1, Unnamed-17GS1, Granite Cove Spring, Cove Spring, and BLM-1 and BLM-2 springs at the Southern End of the Providence Mountains. (*Id.*) The Bonanza Spring in the Clipper Mountains, which is the closest spring to the proposed extraction wellfield, is over 11 miles from the center of the Fenner Gap. (*Id.*) All Fenner Watershed springs, including Bonanza Spring, are located in crystalline hard rock formations substantially higher in elevation than the alluvial aquifer. (*Id.*)

CH2M HILL was retained to evaluate the potential that the lowering of groundwater levels, as proposed by the Project, could impact the flow from Fenner Watershed springs. The results of CH2M HILL's analysis are set forth in a report titled "Assessment of Effects of the Cadiz Groundwater Conservation Recovery and Storage Project Operations on Springs," dated August 3, 2011. CH2M HILL reviewed the groundwater flow modeling results reported by Geoscience (Geoscience, September 1, 2011), and developed two conceptual models of the Bonanza Spring, which was chosen as an appropriate indicator spring of all springs in the Fenner Watershed because it is the closest spring to the Project's proposed wellfield, and thus would be the most likely to experience any effect from the Project.

In the first conceptual model (Concept-1), the model assumes that there is no physical connection of the springs to a regional groundwater table. This model is based on the absence of data of a physical connection of the springs to a regional groundwater table, the elevation differences between the groundwater in the alluvial aquifer and elevation of the springs, and the distance between the saturated alluvial aquifer and springs. Under this conceptual model, the spring is fed by upstream fracture flows that are not hydraulically connected to the regional water table, and thus flow rates at the spring are independent of groundwater levels in the alluvium, and no impacts would occur to the spring as a result of Project operations.

Although there has been no data developed to date that demonstrates a direct hydraulic connection between the springs and a regional groundwater table, the second conceptual model (Concept-2) hypothetically assumed that such a connection exists to address any outstanding uncertainty. A simple numerical groundwater flow model was developed for this conceptual model to evaluate potential impacts under Concept-2, where hydraulic continuity is assumed and the regional water table forms the source of water to the springs. The model was a simple representation of a generic mountain system with similar characteristics to the Clipper Mountains, and was intended to evaluate the general response of a water table in fractured bedrock of mountains under various assumptions that are specific to the Bonanza Spring hydrogeologic conditions. The results of the Concept-2 model suggest that a ten-foot decline in groundwater levels in the alluvium adjacent to the bedrock of Bonanza Spring (an assumption derived from simulations by Geoscience discussed above) could result in about one foot of drawdown at the springs after 50 years and six to seven feet of drawdown at the springs after hundreds of years and assuming that the decline in the adjacent alluvial aquifer was maintained at ten feet of drawdown indefinitely. For example, CH2M HILL explains that after about 50 years, the drawdown would be about 10 percent of the potential maximum drawdown in the alluvial aquifer. Similarly, after about 100 years, the drawdown would be about 25 percent of the potential maximum drawdown in the alluvial aquifer. In addition, it is possible that, depending on how muted the water table response is to annual changes in precipitation, natural fluctuations of groundwater levels at the spring due to climate variability could be of a similar order of magnitude to potential Project-induced drawdown at the springs.

CH2M HILL further determined, under CEQA, that potential impacts to other springs in the southern part of Fenner Watershed are expected to be less than significant and even more remote than hypothetical potential impacts on the Bonanza Spring because those springs are at higher elevations and greater distances from the adjacent alluvial aquifer compared to Bonanza Spring. Consequently, CH2M HILL determined that any Project effect on other springs in the Fenner Watershed, assuming hydraulic continuity, should be less than significant.

In sum, because of the distance, change in elevation, and lack of hydraulic connection between the fractured crystalline bedrock and groundwater feeding the Fenner Watershed springs and the alluvial groundwater developed by the Project, there is no anticipated impact of the Project on Fenner Watershed springs. Hypothetically assuming that a hydraulic connection exists (as CH2M HILL modeled in Concept-2), impacts would be less than significant. Nonetheless, consistent with the recommendations of the Groundwater Stewardship Committee and as discussed in Chapters 5 and 6, this Management Plan provides for visual, monitoring of spring flows from Bonanza Spring, Whiskey Spring, and Vontrigger Spring. As a further precautionary management measure consistent with the County Ordinance, Project induced reductions to spring flows will be mitigated.

4.3 Potential Significant Adverse Impacts to Critical Resources: Brine Resources at Bristol and Cadiz Dry Lakes

The brine groundwater at the Bristol and Cadiz Dry Lakes support two existing salt mining operations. These operations involve evaporation of the hyper-saline groundwater from the Dry Lakes to obtain remaining salts. Potential significant adverse impacts to brine resources on Bristol and Cadiz Dry Lakes include lowering of the groundwater or brine water levels within wells and brine supply trenches used by the salt mining operations, as well as Project impacts to the chemistry of the hyper-saline groundwater evaporated by the salt mining operators (e.g., reduced calcium chloride or sodium chloride within the brine).

4.4 Potential Significant Adverse Impacts to Critical Resources: Air Quality

The Project is in the Mojave Desert Air Basin (MDAB). The MDAB is an assemblage of mountain ranges interspersed with long broad valleys that often contain Dry Lakes. Many of the lower mountains which dot the vast terrain rise from 1,000 to 4,000 feet above the valley floor. Prevailing winds in the MDAB are out of the west and southwest. These prevailing winds are due to the proximity of the MDAB to coastal and central regions and the blocking nature of the Sierra Nevada Mountains to the north; air masses pushed onshore in Southern California by differential heating are channeled through the MDAB. The MDAB is separated from the Southern California coastal and Central California valley regions by mountains where the highest elevation reaches approximately 10,000 feet, and whose passes form the main channels for these air masses.

The Mojave Desert is bordered on the southwest by the San Bernardino Mountains, which are separated from the San Gabriel Mountains by the Cajon Pass (4,200 feet). A lesser channel, the Morongo Valley, lies between the San Bernardino Mountains and the Little San Bernardino Mountains.

One potential significant adverse impact to critical resources related to air quality that, depending on physical conditions, can result from dewatering of aquifers in the vicinity of Dry Lakes is the potential to materially increase fugitive dust from the playa surface, thereby increasing the severity of area dust storms. Examples of this problem have been documented in the Mojave Desert at the Owens and Franklin Playas. To evaluate the potential for increased fugitive dust resulting from the Project, the consulting firm HydroBio was retained to evaluate whether the Project's intended groundwater production would have an adverse effect on the generation of dust from the surface playas of the Bristol and Cadiz Dry Lakes. The results of HydroBio's investigation are set forth in a report titled Fugitive Dust and Effects from Changing Water Table at Bristol and Cadiz Playas, San Bernardino County, California, dated August 30, 2011.

Based on sampling, HydroBio's investigation characterized the soil chemistry and structure on the Bristol and Cadiz Playas and their immediate margins to evaluate the relationship between groundwater and surface soils (HydroBio, Fugitive Dust and Effects from Changing Water Table at Bristol and Cadiz Playas, San Bernardino, California, August 30, 2011). HydroBio's study found that the soil and water chemistry of both Cadiz and Bristol Playas have very low quantities of the sodium salts of carbonate, bicarbonate, and sulfate that are known to cause severe fugitive dust storms from Owens and Franklin Playas. (*Id.*) The study explains that Bristol Playa does produce fugitive dust from erosion by sand grains driven by high wind across the playa surface. In this process, the quantity of sand available on the playa margin is responsible for the magnitude of the dust release. The available sand appears to have diminished over time and this is hypothesized to be due to the action of a mix of weedy species that have grown increasingly dominant over the past 50 years. As a result, the severity of Bristol Playa fugitive dust is believed to be diminishing with time. (*Id.*) Importantly, the HydroBio study concluded that changes in groundwater level, which may result from the Project's groundwater production, will likely have no impact upon the amount of dust production from the playas or the severity of area dust storms. (*Id.*)

With respect to the Cadiz Playa, the study concluded that the Cadiz Playa appears to be the sink for the sand blown from the region of the Bristol Playa directly upwind to the northwest. (*Id.*) This sand tends to be stabilized by the growth of Russian thistle (tumbleweed). While the Cadiz Playa has the same soil and water chemistry as the Bristol Playa, the copious sand dunes around the shore, particularly in the north to northeast regions result in large amounts of available sand to erode the playa surface, thereby adding dust to area dust storms. (*Id.*) However, the HydroBio study concluded that the potential lowering of groundwater levels within the Cadiz Dry Lake will not affect the amount of dust or severity of dust storms emanating from the Playa. (*Id.*)

The HydroBio study explains that the reason that the potential lowering of water levels in the Bristol and Cadiz Playas will not affect fugitive dust concentrations and occurrence is that the chemistry of the soil comprising the central portions of the Playas is not of the type that causes an increase in fugitive dust as a result of lowered groundwater levels. Specifically, the study explains that the chemistry of the Bristol and Cadiz Playas is low in carbonate, bicarbonate and sulfate ions that are implicated in other playas that produce major dust storms (such as Owens and Franklin Playas). Instead, the Bristol and Cadiz Dry Lakes playa contains chemistry that has been noted to induce surface stability (Ca, Na and Cl). For these reasons, the EIR and HydroBio study concluded that the Project is not anticipated to have any material effect on the concentration of dust emanating from the Bristol and Cadiz Playas nor the severity of area dust storms. Nonetheless, consistent with the County's anticipated conditions under its Ordinance, the recommendations of the Groundwater Stewardship Committee, and as discussed in Chapters 5 and 6, this Management Plan provides for the installation and monitoring of four nephelometers to confirm these technical conclusions and institute corrective actions if necessary.

4.5 Potential Significant Adverse Impacts to Critical Resources: Project Area Vegetation

Another potential significant adverse impact to critical resources that, depending on physical conditions, can result from lowering of groundwater levels is the lowering of groundwater tables that are accessed by area vegetation, thereby causing the stress or death of that vegetation. Vegetation in environments like that found in the Project area provides important stabilization of soils against the action of wind erosion. The consulting firm HydroBio was retained to evaluate whether the Project's intended groundwater production would have an adverse effect on the occurrence and health of area vegetation. The results of HydroBio's investigation are set forth in a report titled, Vegetation, Groundwater Levels and Potential Impacts from Groundwater Pumping Near Bristol and Cadiz Playas, San Bernardino, California, dated September 1, 2011. The HydroBio study concludes that there is no connection of vegetation to groundwater in the Project area, and hence, no vegetation will be affected by changes in water table elevation (HydroBio, September 1, 2011).

HydroBio began its investigation by locating the most likely vegetation in the area potentially affected by the planned groundwater pumping. This "most likely" cover was identified by its higher activity (denser growth, larger plants) than all other locations around the Bristol Playa. Observations of the Cadiz Playa indicated that this region could be eliminated from concern because the vegetation around the playa is generally no more verdant than the surrounding area, hence obviously receiving no promotion from groundwater. HydroBio observed that the lowermost edge of the higher shrub zone was the region with higher vegetation activity that appeared to have the highest potential for connection of vegetation to groundwater. (*Id.*)

The HydroBio study explains that there are three shrub species that grow around the Bristol Playa: creosote bush [Larrea tridentata], cattle saltbush [Atriplex polycarpa] and four-wing saltbush [Atriplex canescens]. Of these, the only species that may act as a phreatophyte (a plant species that uses groundwater), is the four-wing saltbush, and this species is specifically a facultative phreatophyte, meaning it can benefit from but does not require shallow groundwater. (*Id.*) To determine whether any of the four-wing salt brush in the area are presently accessing groundwater, HydroBio reconstructed a curve for depth to water (DTW) versus elevation based on hydrographic data collected in the region of the Cadiz Ranch. A DTW point was added on the Bristol Playa that was reconstructed using photogrammetry. The study found that together, these points describe a highly linear relationship of DTW versus elevation above sea level (r2 = 99.9%). (*Id.*) Based on the robust and accurate relationship of the DTW curve, HydroBio estimated the DTW at the lowermost edge of the higher vegetation cover – the location most likely to have a vegetation/groundwater connection was 65 feet. Root excavations of four-wing saltbush have been measured to reach a maximum of 25 feet on only rare occasions when soils and hydrology permit, while typical root depths for the species average about 13 feet. Thus, based on measured and estimated DTW, the HydroBio study concluded that the shallowest water table position is 40 feet below the record rooting depth for the four-wing salt brush – the only species that could be potentially affected by groundwater decline. HydroBio therefore concluded that there is no connection of vegetation to groundwater in the Project area. (*Id.*) HydroBio further hypothesized that the promotional effect of periodic surface flows from the upstream catchments is the reason for the apparent promotion of this vegetation. (*Id.*) For these reasons, the EIR and HydroBio study concluded that the Project is not anticipated to have any material effect on surface vegetation in the Project area. Nonetheless, consistent with the County's anticipated conditions under its Ordinance and as discussed in Chapters 5 and 6, this Management Plan provides for monitoring to confirm these technical conclusions and corrective actions if necessary.

4.6 Potential Significant Adverse Impacts to Critical Resources: the Colorado River and its Tributary Sources of Water

It is assumed that the groundwater that would be extracted by the Project at the Fenner Gap is not tributary to the Colorado River because the aquifer systems within the Fenner, Bristol and Cadiz Watersheds are believed to be a closed basin, isolated from aquifer systems to the east that are tributary to the Colorado River by bedrock and groundwater divides. It is important to ensure that the Project groundwater is not tributary to the Colorado River for several reasons. First, the Colorado River is fully appropriated and rights to divert water therefrom are governed by a complex set of federal and state laws. Material extractions of tributary groundwater could reduce flows in the Colorado River, thus frustrating the administration of the Colorado River and affected environmental resources.

It is also important to confirm that the Project groundwater is not tributary to the Colorado River for purposes of satisfying the provisions of the Colorado River Interim Guidelines for Lower Basin Shortages and the Coordinated Operations for Lake Powell and Lake Mead (Guidelines) administered by the U.S. Bureau of Reclamation (Reclamation), for purposes of establishing Intentionally Created Surplus (ICS) credits under the Guidelines for potential Project participants that have contracts with Reclamation for diversions from the Colorado River. Under the Conservation Component of the Project, groundwater that is non-tributary to the Colorado River would be introduced into the Colorado River Aqueduct as "new," non-tributary water. For potential participants who have contracts with Reclamation for Colorado River water, the receipt of Project water creates the opportunity to establish ICS Credits based on the use of non-tributary water supplies in lieu of Colorado River diversions pursuant to Reclamation contracts. This opportunity could allow a participant to further augment its water supplies and improve overall water supply reliability. To qualify for ICS credits under the Guidelines, the surplus water used in lieu of Colorado River diversions must be non-tributary to the Colorado River.

While the assumption that the Project groundwater is non-tributary to the Colorado River is supported by substantial physical evidence (e.g., bedrock and groundwater divides), two monitoring wells (one existing and another to be installed) on property owned by Cadiz within the adjacent Piute Watershed that is tributary to the Colorado River will be monitored.

CHAPTER 5
MONITORING NETWORK

To ensure continued protection of the watershed and other resources, a comprehensive monitoring network has been developed to assess and continually evaluate the technical aspects of the Project, and any potential impacts to critical resources during the life of the Project, as designated in Chapter 4. The development of the monitoring network was based on the groundwater flow model that has been developed to better understand the hydrogeologic impacts of the Project's proposed groundwater production. The groundwater flow model will be continuously refined as additional monitoring data are obtained (see discussion of groundwater flow model in Chapter 4).

This Management Plan will be implemented with a set of monitoring features and parameters as discussed in this Chapter 5. The term "feature" refers to any fixed object, either natural or man-made, from which data will be collected. Man-made features include wells from which water level measurements and water quality samples could be retrieved, weather stations, bench marks, etc. A detailed list of monitoring features is given in this Chapter 5. As new data become available during Project operations, these monitoring features, monitored parameters, and monitoring frequency may be refined to protect critical resources in and adjacent to the Project area. Refinements to monitoring features will be made in accordance with the decision-making process described in Chapters 6 and 8.

A total of thirteen different types of monitoring features have been identified for assessing potential impacts to critical resources during the term of the Project, as identified in Chapter 4. A summary of these thirteen types of monitoring features, as well as monitoring frequencies and parameters to be monitored, is provided in Tables 5-1 and 5-2. Locations are shown in Figures 5-1 and 5-2.

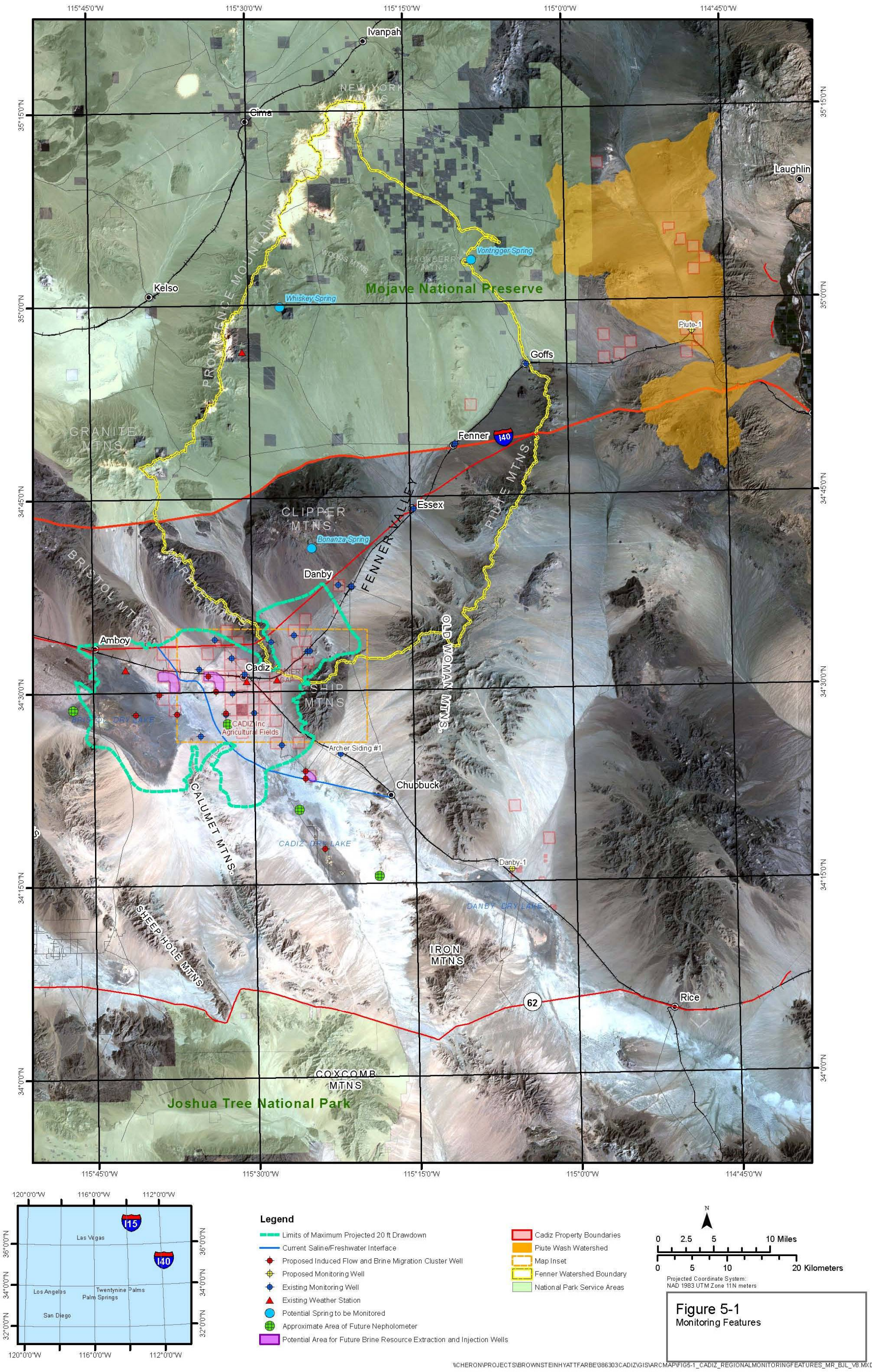

Figure 5-1
Monitoring Features

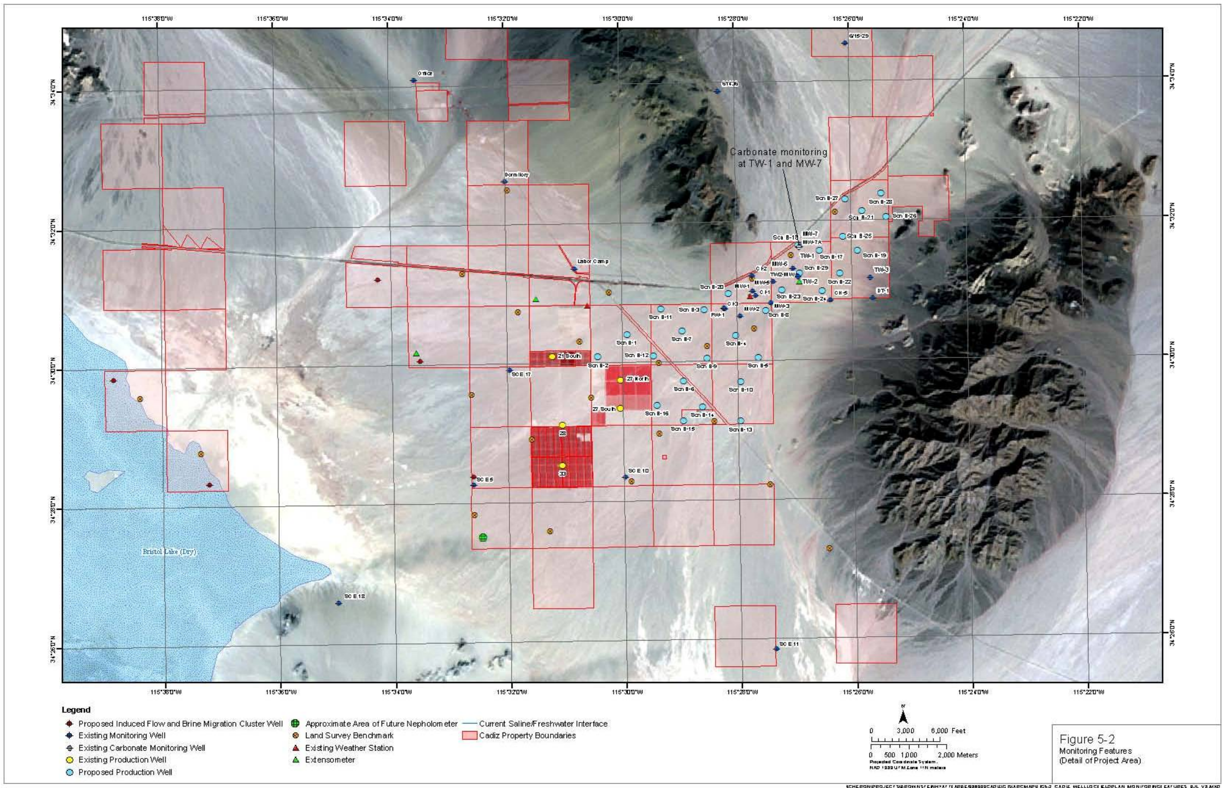

Figure 5-2
Monitoring Features
(Detail of Project Area)

Installation of certain monitoring features, where construction of facilities is required, will be subject to site-specific approval and permitting by applicable regulatory agencies. Cadiz will complete and deliver all needed permits for monitoring facilities as soon as practicable prior to the 12-month pre-operational phase. Cadiz will construct all facilities that are agreed to in this Management Plan and for which permits have been received. Construction of these facilities will be completed within one year of receipt of permits. If the implementation of monitoring features currently contained in this Management Plan is not approved, Cadiz will evaluate and implement alternate monitoring sites subject to approval by SMWD and the County and the applicable regulatory agencies.

The following text describes in detail the various proposed monitoring features.

5.1 Springs (Feature 1)

An inventory of 28 known springs within the Fenner Watershed was completed by the USGS (USGS, 1984). Locations of these springs are shown on Figure 5-3. As discussed in detail in Chapter 4, the potential significant adverse impacts to these critical spring resources has been evaluated. It is not anticipated that the Project will have any impact on the springs. Nonetheless, this Management Plan provides for quarterly monitoring of the Bonanza Spring as an "indicator spring" because it is the spring that is in closest proximity to the Project wellfield (approximately 11 miles from the center of Fenner

Gap), and, of all springs within the Fenner Watershed, this one would be the first one to be affected by the Project, if it were somehow possible to be in hydraulic connection with the alluvial aquifers, which appears unlikely. The Whiskey and Vontrigger Springs, which are located beyond the Project's projected effects on groundwater levels in the alluvial aquifers of the Fenner Watershed, will also be monitored quarterly to compare variations in spring flow from those springs to variations in spring flow from the Bonanza Spring to assist in determining whether any material reduction of flow at the Bonanza Spring is attributable to the Project operation, or instead, is attributable to regional climate conditions.

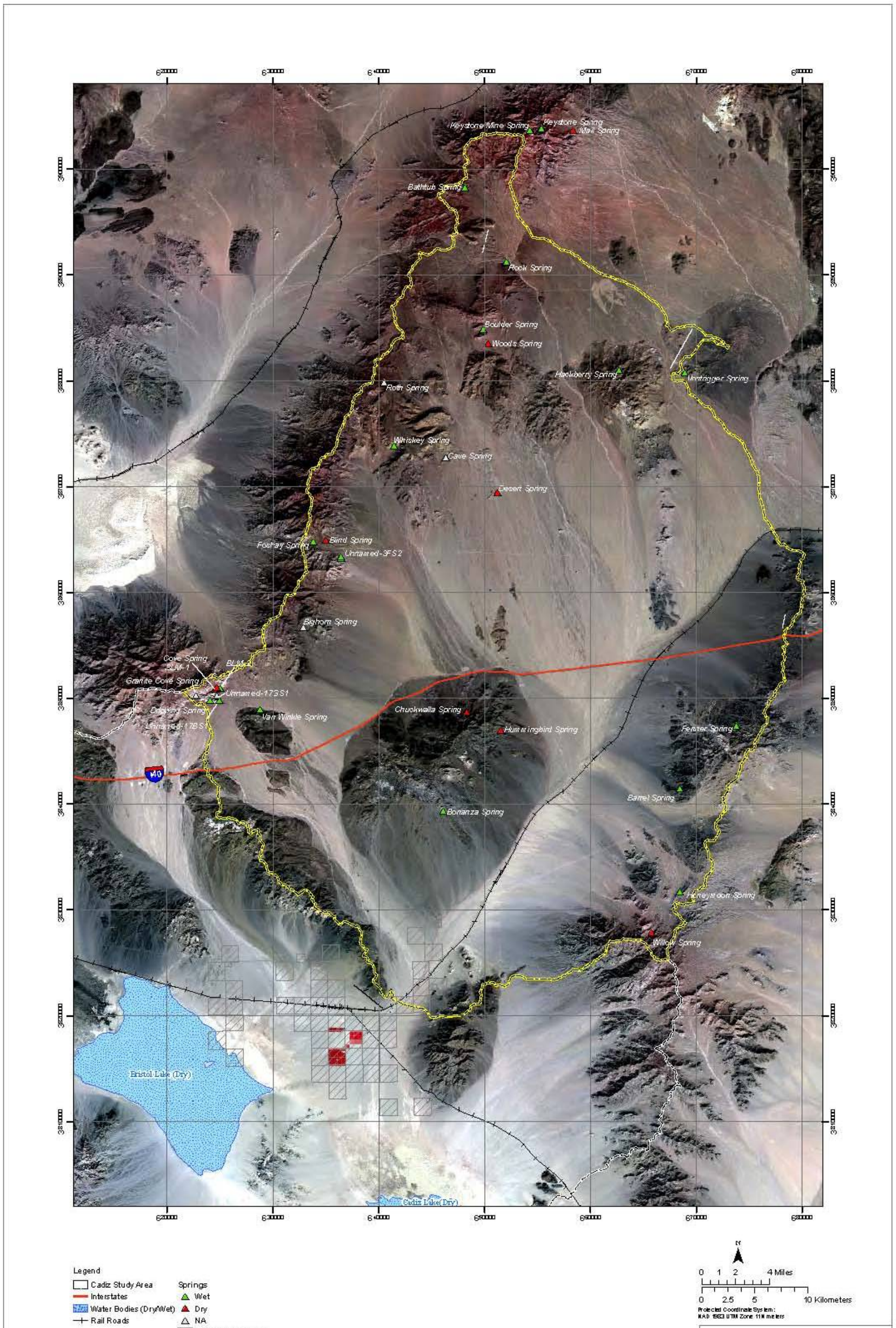

Figure 5-3
Location of Springs

The springs will be monitored on a quarterly basis by visual observations and flow measurements described in more detail in Section 6.7.2, below. Visual observations will include starting and ending points of observed ponded or flowing water, estimated depth of ponded water and flow rate of flowing water, conductivity, pH and temperature of water, any colorations of water, and general type and extent of adjacent vegetation.

5.2 Observation Wells (Feature 2)

A total of 14 existing observation wells and 2 new observation wells will be used to monitor groundwater levels during the Project (see Tables 5-1 and 5-2). Locations of these wells are shown on Figures 5-1 and 5-2. Six of these wells were installed in the 1960's by Southern California Edison as part of a regional investigation (wells whose designation begins with "SCE"). Four of the observation wells (Labor Camp, Dormitory, 6/15-29, 6/15-1) are owned and monitored by Cadiz as part of their agricultural operation. Existing well CI-3 was installed in Fenner Gap during the pilot spreading basin test for the Project. Existing wells at Essex, Fenner, Goffs, and Archer Siding #1 are related to railroad operations or municipal supply. All of these existing wells will be inspected to assess their ability to be utilized as observation wells, provided that appropriate permission and approval is obtained. If they are not in a condition to be utilized as observation wells, replacement wells will be constructed in the vicinity of each well deemed unusable.

One new well, Piute-1, will be installed in the Piute Watershed, north of the Fenner Watershed, and is tributary to the Colorado River. This well will be installed on property owned by Cadiz and will be used as a "background" monitoring well to monitor undisturbed groundwater levels in an adjacent watershed, to provide information on groundwater level variations due to climatic changes only. In addition, this will serve to demonstrate that the Project will not impact groundwater that is tributary to the Colorado River.

Another new well, Danby-1, will be installed in the Danby Watershed to the east. Similar to Piute-1, this Danby-1 observation well will be used to demonstrate that impacts on groundwater levels do not extend beyond the Cadiz Watershed on the west. This well will also provide information on regional groundwater level conditions and is expected to provide additional background monitoring and information concerning groundwater level changes that may be due to climatic variations as well.

In addition to the observation wells, new monitoring facilities, each composed of well clusters will be located between Cadiz and Bristol Dry Lakes on the freshwater side of the saline-freshwater interface to monitor the potential migration of saline water in an area in which historical data on subsurface conditions is limited and a greater degree of certainty on geologic conditions and saline water migration is necessary. These new well clusters are set forth in Features 3, 8 and 9 and are depicted in Figures 5-1 and 5-2 as Proposed Induced Flow and Brine Migration Cluster Wells.

Groundwater levels will be measured in accordance with the monitoring procedure presented in Appendix B. All water samples would be collected according to the protocol described in Appendix C. Field parameters such as groundwater temperature, pH, electrical conductivity, and total dissolved solids (TDS) will be collected at each well during well purging and prior to sampling. Samples from each well will be analyzed for the general mineral and physical parameters specified in Appendix D. In addition, all samples collected during the pre-operational phase will also be analyzed for bromide, boron, iodide barium, arsenic, hexavalent chromium, total chromium, nitrate, and perchlorate. The sample analytical protocol is presented in Appendix D.

Groundwater monitoring frequency will be revisited as determined appropriate by the decision-making process should any of the action criteria be exceeded, as discussed in Chapter 6.

5.3 Proposed Observation Well Clusters in Project Vicinity (Feature 3)

Two well clusters will be established in the immediate vicinity of the Project wellfield (see Figure 5-2). These cluster wells will provide a basis to compare groundwater level and water quality changes in both the shallow and deep portions of the alluvial and bedrock aquifer systems. The well clusters will consist of existing monitoring wells. One well cluster will include monitoring wells MW-7, MW-7a, and TW-1, and the second cluster will use TW-2 and TW-2MW. Bother well clusters will allow for monitoring in the immediate vicinity of the Project. Selected wells have screened intervals in either the upper alluvial, carbonate aquifer, and bedrock. TW-1 and MW-7 will monitor depths in the carbonate aquifer in their clusters respectively.

In addition, three new Proposed Induced Flow and Brine Migration Cluster Wells will be installed on the freshwater side of the interface between Bristol Dry Lake and the Project wellfield to monitor groundwater elevations and water quality (the locations of the wells are depicted in Figure 5-2). All new Project monitoring wells shall be designed, installed, and completed in manner consistent with all applicable state and local regulations and industry standards. Monitoring will occur as presented in Tables 5-1 and 5-2.

5.4 Project Production Wells (Feature 4)

Data from the wellfield (new Project wells and existing Cadiz agricultural wells) will be collected to provide information on the groundwater levels and discharge rates. Each well will be equipped with a flow meter to monitor well discharge and a sounding tube for obtaining groundwater level measurements. Production data from the Project wells will also be collected using totaled readings of flow at the CRA.

5.4.1 *Existing Cadiz Agricultural Wells*

The Cadiz agricultural operation owns and operates seven agricultural wells used for irrigation, which are located west and southwest of Fenner Gap (see Figure 1-3). Five of the seven Cadiz irrigation wells could be incorporated into the Project wellfield (Wells 21S, 27N, 27S, 28, and 33). The remaining two wells (21N and 22) could used as standby pumping or monitoring wells.

5.4.2 *New Production Wells*

The Project wellfield would consist of between approximately 17 and 29 additional production wells (depending on Configuration) to be located as shown on Figure 5-2. Each new well would be completed to a depth of about 1,000 feet (see Figure 5-4). This well design may be modified based on observations in the field and expectations of drawdown that may be encountered during Project operations. The total capacity of the wellfield would allow for a pumping range of 25,000 afy to 75,000 afy. All new Project production wells shall be designed, installed, and completed in manner consistent with all applicable state and local regulations, and industry standards, and shall be equipped with flow meters.[10]

[10] County Guidelines for Preparation of a Groundwater Monitoring Plan, § 2.0.

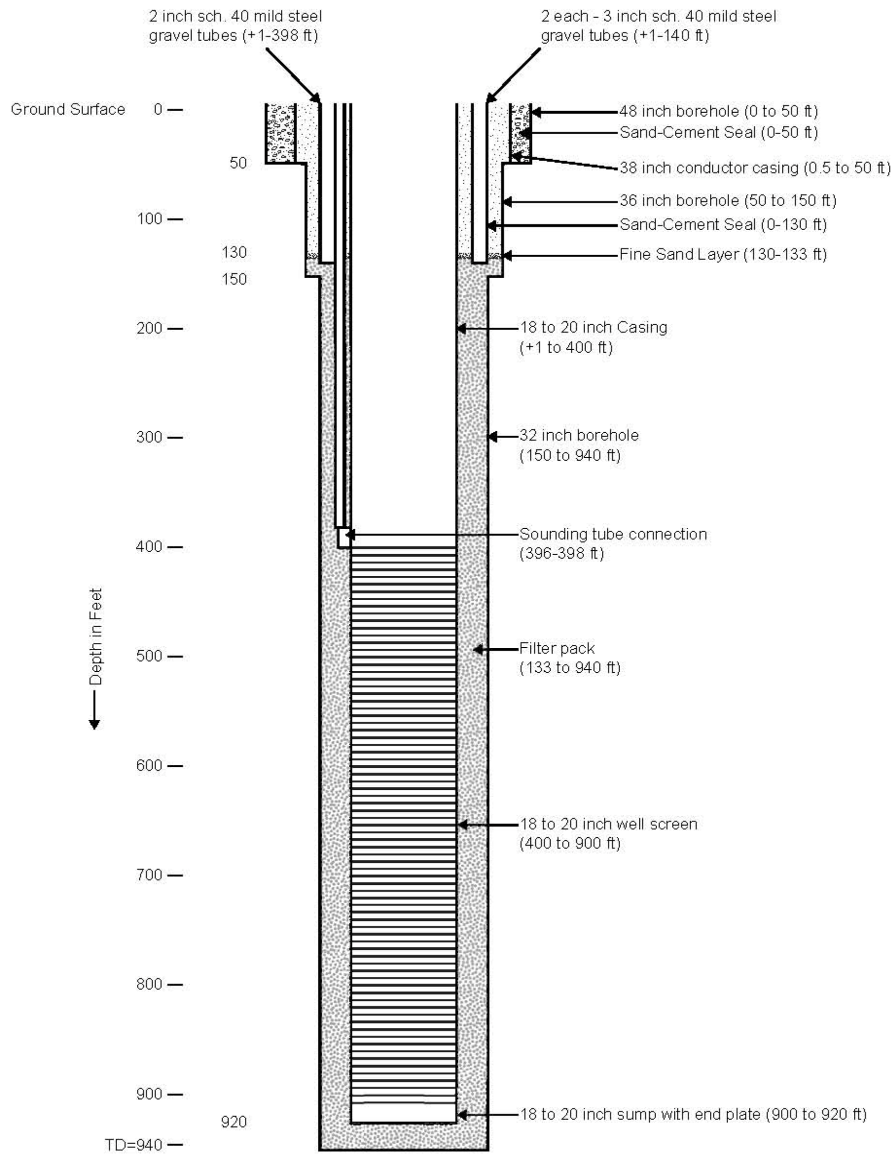

FIGURE 5-4
Conceptual Well Design Diagram

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5.5 Land Surface Monitoring (Feature 5)

A network of approximately 23 land survey benchmarks will be installed at the approximate locations shown on Figure 5-2 to monitor changes in land surface elevation should they occur. Horizontal and vertical accuracy will be established in accordance with a second order Class I survey standard (1:50,000). Each benchmark will be established and surveyed by a California licensed land surveyor. All locations will be dependent upon permitting from the appropriate agencies. Benchmark surveys will be conducted on an annual basis during the term of the Project (see Table 5-1).

Pre-operational baseline Interferometric Synthetic Aperture Radar (InSAR) will be used to evaluate potential impacts in conjunction with the benchmarks. Cadiz will obtain surveyed baseline land surface elevations which then will be compared to each other along with any InSAR data collected by FVMWC during the course of the Project. The InSAR data would be used to monitor relative changes of land surface elevation that could be related to aquifer system deformation in the Project area. This pre-operational InSAR data (collected at two separate times during the year prior to the operational phase of the Project) will complement the land survey data to establish changes in land surface elevations. During the operational phase, annual benchmark surveys will be conducted and InSAR images will be obtained and evaluated every 5 years to evaluate potential impacts. During the post-operational phase, InSAR data and benchmark survey will be obtained every 5 years (Table 5-1).

5.6 Extensometers (Feature 6)

To evaluate potential impacts during the operational phase, FVMWC will construct three extensometers in the area of the highest probability of subsidence (see Figure 5-2). One extensometer will be located north of existing Cadiz agricultural supply well 21S. Another extensometer will be located at the eastern margin of Bristol Dry Lake near the location of a planned monitoring well cluster described in Section 5.8 below. Another extensometer will be located near well TW-2 within the wellfield. The extensometers will be constructed to continuously measure non-recoverable compaction of fine-grained materials interbedded within the alluvial aquifer systems.

5.7 Flowmeter Surveys (Feature 7)

Downhole static and dynamic flowmeter surveys will be generated in five selected new extraction wells. This is expected to occur during the initial period of operation and also after 10 years to assess whether flow conditions have changed as a result of Project operations. The flowmeter surveys will provide data regarding vertical variation in groundwater flow to the well screens. Depth-specific water quality samples will also be collected to assess vertical variation of groundwater quality in the Project wellfield area. Data will be used to help refine geohydrologic parameters regarding layer boundaries used in the groundwater models.

5.8 Proposed Observation Well Clusters At Bristol Dry Lake (Feature 8)

A total of three new observation well clusters will be installed and monitored in the vicinity of Bristol Dry Lake during the initial phases of the Project (see Table 5-1 and Figure 5-2). Two well clusters will be located along the eastern margin of Bristol Dry Lake to monitor the effects of Project operations on the movement of the saline-freshwater interface on the saline side of the interface as shown (see Figure 5-2). One additional well cluster will be installed on the Bristol Dry Lake playa to monitor brine levels and chemistry at different depths beneath the Dry Lake surface. This well cluster will be positioned in relation to the well clusters at the margin of the Dry Lake so as to provide optimum data for the variable density transport model.

A typical observation well cluster completion is illustrated on Figure 5-5. Screened intervals for each of the wells within each cluster will be determined from the logging of cuttings and geophysical logging of the deep borehole which will be drilled first. Each deep well will be completed with PVC or other suitable well casings and screens to allow for dual induction geophysical logging. Shallow wells will be completed with PVC or other suitable well casings and screens.

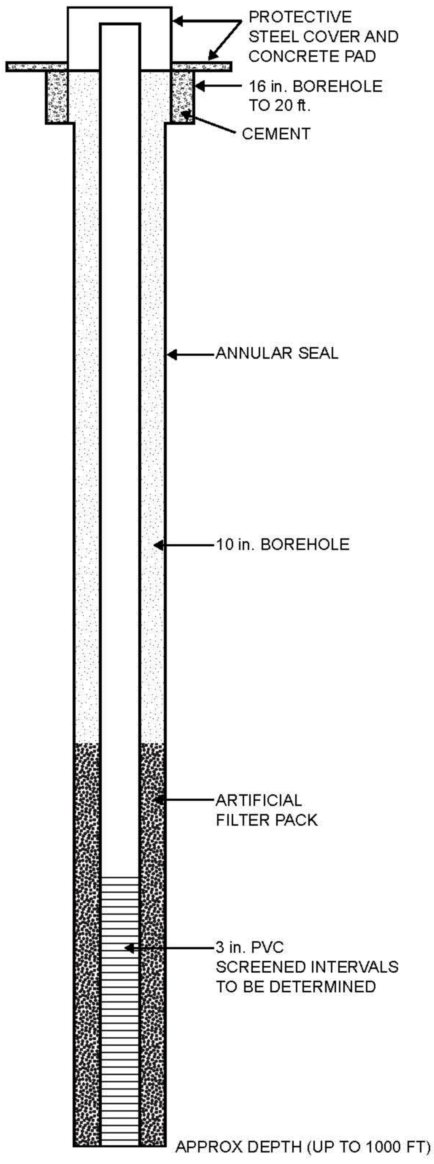

FIGURE 5-5
Typical Observation Well Cluster

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During the pre-operational phase, static groundwater levels will be monitored on a continuous basis from each well cluster using downhole pressure transducers. Project monitoring will begin immediately following well installation and development.

5.9 Proposed Observation Well Clusters At Cadiz Dry Lake (Feature 9)

At least two well clusters will be located along the northern margin of Cadiz Dry Lake to monitor the migration of the saline water on the freshwater side of the interface (proximate locations are illustrated on Figure 5-1). The final precise locations of these well clusters will be identified in consultation with the TRP and County. The third well cluster will monitor brine levels and depth distribution of water quality on the Cadiz Dry Lake, similar in nature to Bristol Dry Lake. This well cluster will be positioned in relation to the well clusters at the margin of the Dry Lake so as to provide optimum data for the variable density transport model. During the pre-operational phase, static groundwater levels will be monitored on a continuous basis from the well clusters using downhole transducers. Project monitoring will begin immediately following well installation and development and continue through the post-operational period (Gamma-Ray/Dual Induction Downhole Geophysical Logs (Feature 10)).

5.10 Gamma Ray/Dual Induction Logging (Feature 10)

Gamma-Ray and Dual Induction electric logs will be run for the deepest observation wells of each well cluster to be installed at the Dry Lakes (four total). These Downhole geophysical techniques allow for the measurement of groundwater electrical conductivity with depth and could be conducted in observation wells constructed of PVC casings and screens.

Gamma-Ray/Dual Induction geophysical logs will be run as a one-time measurement to be conducted during observation well cluster installation during the pre-operational phase of the Project.

5.11 Weather Stations (Feature 11)

Data from four existing weather stations will be collected over the course of the Project (see Figures 5-1). Existing weather stations include the Mitchell Caverns weather station (located in the Providence Mountains), the Project weather station (located in Fenner Gap adjacent to the spreading basins), the Cadiz CIMIS station (operated by/for CDWR at the Cadiz Field Office), and the Amboy weather station (located near Bristol Dry Lake in the town of Amboy).

The Mitchell Caverns weather station would provide precipitation, temperature, and other climatic data for the mountain regions of the Fenner Watershed. The Fenner Gap weather station would provide climatic data in the immediate vicinity of the Project area. The Amboy and Cadiz Field Office weather stations would provide climatic data representative of the lowest area of the regional watershed. Data obtained from the weather stations will be incorporated into the water resource models described in Chapter 4, along with complementing data analysis of Feature 12.

5.12 Air Quality Monitoring (Feature 12)

5.12.1 Monitoring at Bristol and Cadiz Dry Lakes

The relationship between groundwater and the surface of Bristol and Cadiz Dry Lakes has been evaluated in a technical study conducted by HydroBio.[11] The technical study concludes that unlike some other playas in the arid southwest such as Owens and Franklin Playas, the soil and water chemistry of both Cadiz and Bristol Dry Lakes has very low quantities of the sodium salts of carbonate, bicarbonate and sulfate that are known to generate excessive fugitive dust in high wind storms. Rather, the Bristol and Cadiz Dry Lakes are characterized by sodium and calcium chlorides that maintain a rigid structure when desiccated, reducing the amount of loose dust on the ground surface that can be lofted by the wind. This surface crust is not aided or maintained by direct contact or indirect contact with the groundwater through capillary action.

Under current conditions, dust storms are not uncommon in the valley as sand particles saltate across the desert floor, dislodging other sand particles and lofting dust into the air.[12] Under current conditions, depth to groundwater in some areas beneath the Dry Lakes is over 60 feet below ground surface, and the surface soils in these areas exhibit the same crusty surface as areas with shallow groundwater. This crusty surface soil provides some resistance to wind erosion and limits dust emissions. It is not reliant on groundwater for maintenance of its crust integrity. Therefore, drawdown of the groundwater beneath the Dry Lakes is not expected to have an effect on surface soils or dust emissions in the valley.

To monitor the condition of the Dry Lakes consistent with recommendations of the Groundwater Stewardship Committee and to provide additional data on the environment of the area, four nephelometers will be installed, including one downwind and one upwind of Bristol Dry Lake and one downwind and one upwind of Cadiz Dry

[11] HydroBio, Fugitive Dust and Effects from Changing Water Table at Bristol and Cadiz Playas, San Bernardino, California, August 30, 2011, pg. i

[12] HydroBio, Fugitive Dust and Effects from Changing Water Table at Bristol and Cadiz Playas, San Bernardino, California, August 30, 2011, pg. 6

Lake. These nephelometers will be placed on privately-owned property and outside the wind shadow of the agricultural properties.

In addition, FVMWC will conduct annual visual observations at four points on each of the Dry Lakes to record surface soil conditions. The visual observations will note soil texture and record susceptibility to wind erosion. Photographs of the soil will be taken. This data will record conditions over time on the two Dry Lake surfaces at the same locations each time.

These nephelometers will provide data on a daily basis that records opacity of the air, measuring the effect of dust on visibility. Data will be collected in the pre-operational phase of the Project and in the early years of the Project, establishing a baseline before groundwater levels beneath the Dry Lakes are affected. Since wind velocity and dust storms are highly variable, the data will record trends over time. Data will also be collected during the operational and post-operational phase of the Project and compared to baseline data to evaluate whether Project operations result in a significant adverse impact to critical air quality resources.

5.13 Project Area Vegetation (Feature 13)

As discussed in Chapter 4, above, it is not anticipated that the Project will have any impact on surface vegetation. Nonetheless, this Management Plan provides for baseline and annual monitoring of surface vegetation in the Project area to verify whether any material reduction in the extent or character of vegetation is attributable to Project operations or, instead, to seasonal or regional climatic conditions.

CHAPTER 6
MONITORING AND MITIGATION OF SIGNIFICANT ADVERSE IMPACTS TO CRITICAL RESOURCES (ACTION CRITERIA, DECISION-MAKING PROCESS AND CORRECTIVE MEASURES)

This Management Plan identifies specific quantitative criteria or trends (action criteria) that will "trigger" review and corrective actions where necessary to protect critical resources or otherwise avoid Undesirable Results. When action criterion are triggered, a review of the triggering event will be conducted to determine whether the event is attributable to or exacerbated by Project operations, and if so, which specific corrective measures should be implemented to avoid adverse impacts to critical resources or Undesirable Results. It is the intent of this Management Plan to identify deviations from baseline conditions, along with deviations from groundwater model projections, at monitoring features as early as possible in order to identify and prevent the occurrence of adverse impacts to critical resources or Undesirable Results as a result of

Project operations.[13] Triggering events may, in some circumstances, necessitate immediate corrective actions and subsequent review to ensure that the triggering event resulted from Project operations.

6.1 Decision-Making Process

A decision-making process has been developed which outlines the process to be followed in the event an action criterion is triggered, or when refinements to the Management Plan are considered. Potential corrective measures to be implemented, if appropriate, are identified. Critical resources and Undesirable Results, action criteria, the decision-making process, and potential corrective measures are discussed in Chapter 6 and summarized in Table 6-1.

The initial action criteria and corrective measures presented in this Management Plan are considered conservative. Refinements to the action criteria and monitoring network may be proposed after additional data has been accumulated. However, any such refinement would occur in accordance with the terms of this Management Plan. If FVMWC proposes a refinement to action criteria or monitoring features, it will submit a written proposal describing the refinement along with supporting data and materials to the TRP. The TRP will then issue a recommendation concerning the proposed refinement to the County and SMWD, which will determine whether the refinement is warranted, based on all available technical data, all Project conditions of approval, the analysis set forth in the Project EIR, and adopted CEQA findings. Before any refinement to an action criteria or monitoring feature which is also a mitigation measure adopted by SMWD as part of its approval of the Project may occur, SMWD must first determine that substantial evidence supports a finding that the refined action criteria or monitoring feature will continue to mitigate the impact identified in the Project EIR. The County and SMWD will make a decision regarding the proposed refinement in accordance with the decision-making process presented here, and further described in Chapter 8.

Action criteria are intended to be used as predictors of potential adverse impacts to critical resources, and these criteria as applied are meant to help avoid material adverse impacts to critical resources and Undesirable Results.

The decision-making process followed in this Management Plan, if an action criterion is triggered or when the County considers refinements to the Management Plan, is described in detail as follows.

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[13] "Project operations" in this Chapter 6 shall include groundwater pumping attributed solely to this Project or to the combined operations of this Project and the Cadiz Agricultural Program.

Initial Notification – 10 Business Days

If an action criterion (as defined in this Chapter 6) is triggered, FVMWC will, within ten (10) business days of the triggering event, inform SMWD, the County Representative (Chief Executive Officer), and the members of TRP that an action criterion has been triggered and commence the decision-making process described herein. If the action criterion threatens an immediate or irreparable injury to a critical resource or other immediate Undesirable Result, FVMWC will promptly implement appropriate corrective action(s) or the County may promptly issue an administrative order as set forth in Section 8.2, below.

Initial Assessment and Recommendation – 60 Calendar Days

Within sixty (60) calendar days of issuing notice that an action criterion is triggered, FVMWC will undertake a three-step assessment process. First, FVMWC will assess whether the triggering of any action criterion is attributable to Project operations. Second, for any triggering of an action criterion attributable to Project operations, FVMWC will assess whether the triggering of the action criterion constitutes a potential adverse impact. Third, for any triggering of an action criterion that is attributable to the Project and constitutes a potential adverse impact or threatens to cause an Undesirable Result, FVMWC will assess, recommend, and implement corrective measure(s) (including refinements in monitoring or to this Management Plan) necessary to avoid or mitigate the potential adverse impact or Undesirable Result.

FVMWC shall provide its written assessment and recommendation, along with supporting and any conflicting data, to SMWD, the County Representative, and the members of TRP within the sixty (60) day assessment period.

TRP Review and Recommendation – 90 Calendar Days

Upon receiving FVMWC's written assessment and recommendation, the TRP will have ninety (90) calendar days to determine whether it concurs with the assessment and recommendation (including but not limited to modifications to the monitoring network, corrective actions, etc.). During the TRP review period, the TRP may request additional data and analysis from FVMWC and will have access to all monitoring data. Within the ninety (90)-day TRP review period, the TRP will issue a written report of its review of FVMWC's assessment and recommendation, including whether it concurs with the assessment and recommendation, to the County Representative, FVMWC, and SMWD, and if it does not concur, the basis of its disagreement and any alternative recommended actions. The TRP's written report shall state whether or not the report reflects a consensus of the TRP members. If the TRP members cannot reach a consensus, the members' differing opinions and recommendations shall be set forth in the written report.

County Review and Determination

The County Representative will consider the findings and actions taken or recommended by FVMWC and the TRP, but will exercise his or her own independent judgment concerning whether the triggering of the action criterion is attributable to Project operations, whether the triggering of the action criterion involves a potential adverse impact or Undesirable Result, and to determine the appropriate corrective measure(s) necessary to avoid or mitigate the potential adverse impact or Undesirable Result. The County will issue its determination in writing to FVMWC, SMWD, and to each member of the TRP. FVMWC shall promptly comply with the determination and instructions set forth in the County's written correspondence concerning the matter. With the exception of corrective actions necessary to address an immediate or irreparable threat of harm, the oversight, management, and enforcement actions concerning assessment, application, and refinement of action criteria and corrective measures shall be made by the County subject to the dispute resolution provisions of the MOU set forth in Chapter 8.

As lead agency for the Project, SMWD shall enforce the implementation of all adopted mitigation measures as conditions of Project approval. SMWD will, pursuant to CEQA Guideline section 15097(a), delegate oversight responsibilities for those mitigation measures which correspond to provisions of the Management Plan to the County. SMWD shall review and consider the County's ongoing determination of compliance with those mitigation measures in assessing the Project's overall compliance with the Mitigation Monitoring and Reporting Program and the Project's conditions of approval.

Because compliance with the Management Plan is a condition of SMWD's approval of the Project, SMWD in its discretion, will also consider the findings and actions taken or recommended by FVMWC and the TRP, and will exercise its own independent judgment concerning whether the triggering of the action criterion is attributable to Project operations, whether the triggering of the action criterion involves a potential adverse impact or Undesirable Result, and to determine the appropriate corrective measure(s) necessary to avoid or mitigate the potential adverse impact or Undesirable Result. If SMWD determines that appropriate corrective measure(s) are necessary to avoid or mitigate the potential adverse impact or Undesirable Result, but the County does not, SMWD will independently impose those corrective measures it determines necessary to avoid adverse impacts to critical resources or Undesirable Results, provided that independent enforcement by SMWD shall be subject to the same procedural requirements and remedies applicable as if the County were enforcing the Management Plan, including the dispute resolution procedure in Section 8.3.

Communications by and to FVMWC, the TRP, SMWD and the County, as provided in this chapter, shall be made by and to, respectively, a point of contact for the FVMWC designated by the FVMWC Board of Directors (FVMWC Representative), a member of the TRP designated by the TRP as its point of contact (TRP Chair), the SMWD General Manager and a point of contact for the County designated by the County (County Representative).

6.2 Third-Party Wells

It is the intent of the Project to operate without adverse material impacts to wells owned by neighboring landowners in the vicinity of the Project area, and those operated in conjunction with salt mining operations on the Bristol or Cadiz Dry Lakes. To avoid such potential impacts, the groundwater monitoring network will include monitoring wells located in and around the wellfield, near neighboring landholdings, and on and adjacent to the Dry Lakes (see Figures 5-1 and 5-2). Groundwater levels will be monitored on a continuous to semi-annual basis (see Table 5-1) during the pre-operational and operational periods, then annually during the post-operational period. Water quality will be monitored on a quarterly to annual basis during the pre-operational period, annually during the operational period of the Project, and triennially during the post-operational period (see Table 5-1). Further, FVMWC shall monitor static (non-pumping) water levels within any third-party wells that are representative of the local groundwater impacts and located within the northern Bristol/Cadiz Sub-Basin or elsewhere in the Fenner Watershed. Such monitoring of third-party wells will be performed on a semi-annual basis during the pre-operational and operational periods, then annually during the post-operational period as established in the Closure Plan.

6.2.1 *Action Criteria*

The decision-making process will be initiated if any of the action criteria are triggered. The action criteria are: 1) a decline of static water levels of more than twenty feet from pre-Project static water levels or to a degree in which the reduction in static water levels results in an inability to meet existing production of any third-party well drawing water from the northern Bristol/Cadiz Sub-Basin or elsewhere in the Fenner Watershed; or 2) the receipt of a written complaint from one or more well owner(s) regarding decreased groundwater production yield, degraded water quality, or increased pumping costs submitted by neighboring landowners or the salt mining operators on the Bristol and

Cadiz Dry Lakes. Any written complaint by a well owner in accordance with this action criterion shall be directed to FVMWC.

6.2.2 *Decision-Making Process*

If any of the action criteria are triggered, the decision-making process will include:

- If a written complaint with a documented change in water level as provided for in Section 6.2.1 is received from a third-party well owner located within the Limits of the Maximum Projected 20 ft Drawdown (see Figure 5-1), FVMWC will immediately implement Corrective Measure 6.2.3.1, below;

- Assessment of whether water level changes, decreased yields, increased pumping costs, and/or degraded water quality in the third-party wells are attributable to Project operations or other causes;

- If such water level changes, decreased yields, increased pumping costs and/or degraded water quality are determined to not be attributable to Project operations in conformance with the decision-making process in Section 6.1, then FVMWC would discontinue any interim arrangement to provide water as set forth in Section 6.2.3.1;

- If such water level changes, decreased yields, increased pumping costs and/or degraded water quality are determined to be attributable to Project operations, then one or more of the corrective measures set forth in Section 6.2.3 shall be implemented.

6.2.3 *Corrective Measures*

6.2.3.1 *Interim Water Supply*. If a written complaint as provided for in Section 6.2.1 is received from a third-party well owner located within the area described above (see Figure 5-1), FVMWC will arrange for an immediate interim supply of water to the third-party well owner until the decision-making process is complete in an amount necessary to fully offset any reduced yield to the third-party well owner, as compared to the yield from the impacted well prior to Project operations or, if the impacted well was installed after Project operations commenced, then as compared to the yield of the well immediately after installation.

6.2.3.2 *Further Corrective Measures*. If any of the Action Criteria set forth in 6.2.1 are triggered and the impacts are determined to be attributable to Project operations, one or more of the following further corrective measures shall be implemented to correct the impairment to the beneficial use of the groundwater:

- Continued provision of substitute water supplies;
- Deepening or otherwise improving the efficiency of the impacted well(s);
- Blending of impacted well water with another local source;
- Constructing replacement well(s) on disturbed land subject to the same mitigation measures imposed on the Project wellfield as set forth in the SMWD's Mitigation Monitoring and Reporting Program;
- Paying the impacted third-party well owner for any increased material pumping costs incurred by the well owner; or
- Entering into a mitigation agreement with the impacted third-party well owner.

6.2.3.3 *Alternative Corrective Measures*. If the preceding corrective measures are ineffective or infeasible, Project operations shall be modified to address the adverse impacts on third-party wells. For the purposes of these action criteria, "ineffective" shall be defined as a corrective measure that when put into place did not meet the objective set forth in the corrective action. "Infeasible" is a corrective measure which cannot be implemented due to cost, technical challenges, or legal restraints. Modifications to Project operations shall include one or more of the following:

- Reduction in pumping from Project well(s);
- Revision or reconfiguration of pumping locations within the Project wellfield; or
- Stoppage of groundwater extraction for a duration necessary to correct the adverse impact.

6.3 Land Subsidence

Twenty three land survey benchmarks will be established and surveyed by a licensed land surveyor on an annual basis to identify and quantify potential subsidence within the Project area (see Figures 5-1 and 5-2). Three extensometers will be constructed in areas of projected subsidence (see Figure 5-2). The extensometers, which would be monitored continuously from installation through the post-operational period, would verify if the land surface changes (also potentially identified from land surveys and InSAR satellite data obtained and analyzed every 5 years through the post-operational period) are due to (1) subsidence due to groundwater withdrawal; or (2) other mechanisms (e.g. regional tectonic movement).

6.3.1 *Action Criteria*

The decision-making process will be initiated if either of the action criteria is triggered. The action criteria are: 1) subsidence that would result in a decline in the ground surface elevation of more than 0.3 feet when compared to baseline data collected from the extensometers and corroborated by the land survey benchmarks or InSAR data and analysis; or 2) a trend in subsidence which, if continued, would be of a magnitude within 10 years that impacts existing infrastructure within the Project area. The magnitude for the railroad tracks is more than one inch vertically over 62 feet linearly along the existing railroad tracks.

6.3.2 *Decision-Making Process*

If either of the action criteria is triggered, the decision-making process will include:

- Assessment as to whether the subsidence is attributable to Project operations;

- If the subsidence is determined to be attributable to Project operations, then an assessment will be made to update trends and projections in subsidence over the remaining Project life and to determine whether the subsidence constitutes a potential adverse impact to aquifer health or surface uses. Potential adverse impacts include potential damage to surface structures as a result of differential settlement or fissuring, general subsidence sufficient to alter natural drainage patterns or cause damage to structures, or adverse changes to the geologic integrity of the aquifer, its storage capacity, or its water quality;

- If no such significant adverse impacts to critical resources are identified, potential actions may include:

  - No action;
  - Proposed refinements to the action criteria;
  - Additional verification monitoring, including a field reconnaissance to assess and detect any differential settlement; or
  - Proposed revisions to the benchmark survey and/or InSAR monitoring frequency.

- If the subsidence is determined to be attributable to Project operations and the subsidence is determined to constitute a potential adverse impact to surface drainage, aquifer health, surface uses or infrastructure, then one or more of the corrective measures set forth in Section 6.3.4 shall be implemented.

6.3.3 *Criteria for Subsequent Review of Subsidence and Overdraft*

As an additional management feature, if during the decision-making process in Section 6.3.2, above, it is determined that permanent subsidence is anticipated to exceed the predicted subsidence by fifty percent under Sensitivity Scenario 1 at the locations monitored and shown on Table 4.6 within 50 years as measured by at least two extensometers and corroborated by benchmark surveys and InSAR data and analysis, then the County in consultation with the TRP shall conduct a comprehensive review and analysis of subsidence. The comprehensive review will evaluate whether, notwithstanding post-project replenishment, the imposed floor on groundwater levels, and prior and planned corrective actions, the subsidence involves a progressive, long-term, and permanent decline in ground surface elevations over the pumping period of the Project and, if so, whether that subsidence evidences the occurrence of Overdraft as defined in this Management Plan. If the County or SMWD reasonably determines that the levels of subsidence indicate that Overdraft will occur, then Project operations shall be modified by one or more of the following corrective measures:

- Reduction in pumping from Project well(s);
- Revision or reconfiguration of pumping locations within the Project wellfield; or
- Stoppage of groundwater extraction for a duration necessary to arrest the subsidence.

6.3.4 *Corrective Measures*

Corrective measures that shall be implemented to repair damaged structures and/or arrest the subsidence shall include one or more of the following:

- Repairing any structures damaged as a result of subsidence attributable to Project operations;
- Entering into a mitigation agreement with any impacted party(s).

If the forgoing corrective measures are ineffective or infeasible or if subsidence would potentially alter natural drainage patterns or result in adverse changes to the geologic integrity of the aquifer, its storage capacity, or its water quality, Project operations shall be modified to arrest the subsidence. For the purposes of these action criteria, "ineffective" shall be defined as a corrective measure that when put into place will not meet the objective set forth in the corrective action (e.g., it will not protect aquifer health or repair damaged structures and arrest the subsidence). "Infeasible" is a corrective measure which cannot be implemented due to cost, technical challenges, or legal restraints. Modifications to Project operations shall include one or more of the following:

- Reduction in pumping from Project well(s);
- Revision or reconfiguration of pumping locations within the Project wellfield; or
- Stoppage of groundwater extraction for a duration necessary to correct the adverse impact.

6.4 Induced Flow of Lower-Quality Water from Bristol and Cadiz Dry Lakes

Saline water migration is allowed up to and not to exceed 6,000 feet from the baseline location of the saline-freshwater interface. To prevent migration of saline groundwater beyond 6,000 feet, FVMWC will implement mitigation measures that may include injection or extraction wells or other physical means to maintain the saline-freshwater interface. If these physical measures prove ineffective, reductions in Project pumping will be required (see Section 6.4.4, below).

6.4.1 *Monitoring*

To monitor the influence of the Project's operation on the migration of the saline-freshwater interface located between the Project wellfield and the Bristol and Cadiz Dry

Lakes, a network of "cluster type" observation wells will be established between the Project wellfield and the saline-freshwater interface. Groundwater TDS concentrations in the well clusters will be monitored on a quarterly basis during the pre-operational period of the Project, semi-annually throughout the operational period, and annually during the post-operational period of the Project. Of the monitoring well network, SCE Well no. 5 and SCE Well no. 11, along with other newly installed well clusters located between the interface and the Project wellfield will be located such that that they are appropriate to serve as "sentinel" wells to determine whether there is a progressive migration of the saline-freshwater interface. The locations of SCE Well no. 5, SCE Well no. 11, and the other sentinel well clusters are shown in Figures 5-1 and 5-2. As an additional management feature, an analysis shall be conducted of Project operations as part of the first Five Year Report to locate at least two additional monitoring well clusters along the saline-freshwater interface (and on Cadiz owned lands). The location of new monitoring well clusters shall be approved by the County representative and SMWD representative in consultation with the TRP and new wells will be placed by FVMWC within 10 years of commencement.

6.4.2 *Action Criteria*

The decision-making process will be initiated if the action criterion is triggered. The action criterion is a migration of the interface, as measured by an increase in TDS concentration in excess of 600 mg/L in any cluster or observation well located within a distance of 6,000 feet from pre-Project locations of the interface.

6.4.3 *Decision-Making Process*

If the action criterion is triggered, the decision-making process will include:

- Assessment of whether the increased TDS concentration or migration of the saline-freshwater interface is attributable to Project operations;

- Assessment of trends and updated projections of whether and when the saline-freshwater interface is expected to migrate 6,000 feet from its baseline location;

- If the increased TDS concentration within the monitoring wells is determined to be attributable to the Project and the saline-freshwater interface is expected to migrate more than 6,000 feet from its baseline location within 10 years and at any time during the Project's operation or post-operation periods, then one or more of the corrective measures set forth in Section 6.4.4 shall be implemented.

6.4.4 *Corrective Measures*

Corrective measures that will be implemented to eliminate the further migration of saline groundwater towards the Project wellfield may include the following:

- Installing one or more extraction well(s) or injection well(s) at the northeastern edge of Bristol Playa and/or north of Cadiz Playa where the salt mining source wells are located to maintain the saline-freshwater interface within its 6,000-foot limit subject to the same mitigation measures imposed on the Project well-field as set forth in the SMWD Mitigation Monitoring and Reporting Program (see Figures 5-1 and 5-2).

If the forgoing corrective measures are ineffective or infeasible, Project operations shall be modified to eliminate the further migration of saline groundwater towards the Project wellfield. Modifications to Project operations will include one or more of the following:

- Reduction in pumping from Project wells;
- Revision of pumping locations within the Project wellfield; or
- Stoppage of groundwater extraction for a duration necessary to correct the predicted impact.

6.5 Brine Resources Underlying Bristol and Cadiz Dry Lakes

To monitor potential Project impacts on the salt mining operations on the Bristol and Cadiz Dry Lakes, a network of "cluster type" monitoring wells will be established between the Project wellfield and the margins of the Dry Lakes (see Figures 5-1 and 5-2). Groundwater levels will be monitored on a continuous basis throughout the operational and post-operational term of the Project.

6.5.1 *Action Criteria*

The decision-making process will be initiated if either of the action criteria is triggered. The action criteria are:

- A declining trend in groundwater or brine water levels of greater than 50 percent of either (a) the water column above the intake of any of the salt mining operators' wells, or (b) the average depth of brine water level within the brine supply trenches operated by the salt mining operators. Changes in such groundwater or brine water levels, shall be determined by monitoring changes in the static water levels within the network of clustered monitoring wells identified above, as changes in the static water levels within these monitoring wells are correlated with the groundwater or brine water levels within the salt mining operator's wells and brine supply trenches; or

- The receipt of a written complaint from a salt mining operator regarding decreased groundwater production yield or increased pumping costs from one or more of its wells, or decreased water levels within its brine supply trenches. Any written complaint by a salt mining operator in accordance with this action criteria shall be directed to FVMWC.

6.5.2 *Decision-Making Process*

If either of the action criteria is triggered, the decision-making process will include:

- Assessment of whether the change in groundwater/brine level in excess of the action criteria is attributable to Project operations;
- If the change in groundwater/brine water level in excess of the action criteria is determined to be attributable to Project operations, then an assessment will be made to determine whether the groundwater/brine level change constitutes a potential adverse impact to one or more of the salt mining operations on the Dry Lakes. Adverse impacts include changes to brine chemistry or yields from existing brine production wells or brine supply trenches attributable to Project operations. If no such impacts are identified, potential actions may include:
    - Continued or additional verification monitoring;
    - Proposed refinements to the action criteria;
    - Proposed revision to the monitoring frequency at the observation well clusters at the margins of the Dry Lakes;
    - If the decline in groundwater/brine water level(s) approaching the action criteria is determined to be attributable to Project operations, and the changes constitute a potential adverse impact to one or more of the salt mining operations on the Dry Lakes, then one or

more of the corrective measures set forth in Section 6.5.3 shall be implemented.

6.5.3 *Corrective Measures*

Action(s) necessary to mitigate changes to brine chemistry or yields from existing brine production wells or brine supply trenches attributable to Project operations, and thereby maintain or restore the beneficial use of the groundwater/brine water by the salt mining operations, shall include one or more of the following:

- Compensating the mining operator(s) for the additional costs of pumping;
- Installing one or more brine extraction well(s) and/or injection well(s) where the salt mining source wells are located subject to the same mitigation measures imposed on the Project well-field as set forth in the SMWD Mitigation Monitoring and Reporting Program (see Figure 5-1); or
- Entering into a mitigation agreement with the salt mining operator(s).

If the forgoing corrective measures are ineffective or infeasible, Project operations shall be modified until adverse impacts to the salt mining operations are eliminated. For the purposes of these action criteria, "ineffective" shall be defined as a corrective measure that when put into place did not meet the objective set forth in the corrective action, i.e., to maintain or restore the beneficial use of the groundwater/brine water by the salt mining operations. "Infeasible" is a corrective measure which cannot be implemented due to cost, technical challenges, or environmental and permitting issues as defined under CEQA. Modifications to Project operations shall include one or more of the following:

- Reduction in pumping from Project wells;
- Revision of pumping locations within the Project wellfield; or
- Stoppage of groundwater extraction for a duration necessary to correct the predicted impact.

6.6 Adjacent Basins, Including The Colorado River and its Tributary Sources of Water

Adjacent basins will be monitored to provide verification that the Project does not impact groundwater levels in these adjacent basins. Because the Bristol, Cadiz, and Fenner Watersheds are assumed to be closed watersheds, it is expected that the observation wells will demonstrate no Project impact. Baseline groundwater conditions observed in these adjacent basins will also provide information on climatic change effects on groundwater levels on a regional basis.

The Piute Watershed is tributary to the Colorado River. Groundwater flow from this watershed ultimately discharges to the Colorado River, so it is a part of the water resource of the Colorado River. As discussed above, it would be an adverse impact if this groundwater flow was impacted by Project operations. The Piute-1 observation well will provide data on groundwater levels in this basin. In addition, the Piute-1 well is located approximately equi-distant from the next southerly well from the proposed Goffs observation well, so this well can be compared to these observation wells to assess groundwater level differences between them, if any.

The Danby basin is located immediately to the east. A new observation well, Danby-1, will provide information on groundwater conditions in this adjacent basin.

6.6.1 *Monitoring*

Because the Bristol, Cadiz, and Fenner Watersheds are assumed to be closed watersheds that are isolated from aquifer systems in neighboring basins by bedrock and groundwater divides, no action criteria are necessary to protect these critical resources. However, to accommodate requests of stakeholders in the Danby area, and to demonstrate the lack of any hydrogeologic connectivity between the alluvial groundwater developed by the Project and the Piute Basin, the monitoring wells in these adjacent basins, along with all the other Project observation wells, will be monitored to verify these factual conclusions.

6.7 Springs

As discussed at Section 4.2 of Chapter 4 above, because of the distance, change in elevation, and lack of hydraulic connection between the fractured bedrock groundwater feeding the Fenner Watershed springs and the alluvial groundwater developed by the Project, the Project is not anticipated to affect the spring flows within any of the Fenner Watershed springs.

6.7.1 *Monitoring*

The Project is not anticipated to have an effect on the spring flows in any of the Fenner Watershed springs. However, consistent with the recommendations of the Groundwater Stewardship Committee and as a conservative monitoring protocol conditioned under the County's Groundwater Management Ordinance, baseline and periodic visual observation and flow estimates shall be performed at the Bonanza Spring in the Clipper Mountains, the Whiskey Springs in the Providence Mountains (near Colton Hills), and Vontrigger Spring in the Vontrigger Hills east of the Hackberry Mountains no less often than quarterly during the pre-operational and operational period of the Project and annually during the post-operational period. The Bonanza Spring will be monitored as an "indicator spring" because it is the spring that is in closest proximity to the Project wellfield (approximately 11 miles from the center of Fenner Gap). The Whiskey and Vontrigger Springs will be monitored to compare variations in spring flow and other spring characteristics (e.g., location and elevation, spring type, discharge, spring length, water depth and width, water quality measurements, vegetative bank and emergent cover, substrate composition, photographic records, etc.)[14] from those springs to variations in spring flow and characteristics from the Bonanza Spring to determine whether reductions of flow at the Bonanza Spring are attributable to the Project operations, or instead, are attributable to annual precipitation. Monitoring of groundwater levels in monitoring wells located between Bonanza Spring and the wellfield will also be conducted to provide data which could be used to correlate changes in groundwater levels attributed to the Project to changes in flow in the Bonanza Spring.

6.7.2 *Action Criteria*

The decision-making process will be initiated if the action criterion is triggered. The action criterion is a reduction in the average annual or seasonal flows or degradation in the average annual or seasonal characteristics at Bonanza Spring that exceed the baseline annual (or seasonal) flow fluctuations or that deviate from annual baseline conditions established during the first 10 years of monitoring. If such a reduction of flow or spring condition is observed, the decision-making process will be initiated.

6.7.3 *Decision-Making Process*

If the action criteria is triggered, the decision-making process will include:

[14] See, for example, the spring monitoring described by the Desert Research Institute in Spring Inventory and Monitoring Protocols (Conference Proceedings, Spring-fed Wetlands: Important Scientific and Cultural Resources of the Intermountain Region, 2002, http://www.wetlands.dri.edu).

- Assessment of whether the reduction in flow or spring condition is attributable to Project operations and not the result of changes in annual precipitation, climatic conditions, or other conditions unrelated to the Project (e.g., fire, disease, etc.);
- If the reduction in flow or spring condition is determined to be attributable to Project operations, one or more of the corrective measures shall be implemented.

6.7.4 *Corrective Measures*

Action(s) necessary to re-establish baseline spring conditions and flows shall include one or more of the following in addition to a reevaluation of the relationship between the aquifer and the springs within the watershed:

- Reduction in pumping from Project wells;
- Revision of pumping locations within the Project wellfield;
- Stoppage of groundwater extraction for a duration necessary to correct the predicted impact.

6.8 Air Quality

The EIR concludes that groundwater is not connected to the erosion potential of the Dry Lake surface soils and therefore the lowering groundwater levels beneath the Dry Lakes is not expected to increase dust generation from the Dry Lakes or otherwise affect regional air quality. Consistent with the recommendations of the Groundwater Stewardship Committee and as a conservative monitoring protocol to be conditioned by the County under its Ordinance, Cadiz will prepare a monitoring plan in consultation with the TRP to address possible sources of fugitive dust emissions (depth to groundwater, surface vegetation, surface soil chemistry) and local air quality over time (nephelometers and weather stations) to verify that the Project does not increase dust generation (i.e., particulate matter) from the Dry Lakes. The monitoring plan, at a minimum, shall set forth specific performance criteria and identify monitoring methods, the location of weather stations and nephelometers, measures to protect quality assurance and quality control, and reporting parameters. The monitoring plan shall be reviewed and approved by the County Representative before the Project commences construction.

6.8.1 *Monitoring*

As described in Section 5.2, above, a network of observation wells will be established between the Project wellfield and Bristol and Cadiz Dry Lakes (see Figures 5-1 and 5-2). Groundwater levels will be monitored in many wells on a continuous basis throughout the term of the Project, which can help identify specific depths to groundwater and hydrological connections to surface soils and vegetation.

Furthermore, Cadiz will install weather stations and four nephelometers—upwind and downwind of the Bristol and Cadiz Dry Lakes—to establish baseline data of visibility in the valley, along with providing air quality data throughout the duration of Project operations. In addition, FVMWC will conduct annual visual observations at four points on each of the Dry Lakes to record surface soil conditions. The visual observations will note soil texture and record susceptibility to wind erosion. Photographs of the soil will be taken. This data will record conditions over time at the same locations on each of these Dry Lake surfaces.

These nephelometers will provide data on a daily basis that records opacity of the air, measuring the effect of dust on visibility. Data will be collected in the early years of the Project, establishing a baseline before groundwater levels beneath the Dry Lake are affected and will continue during Project operations. Since wind velocity and dust storms are highly variable, the data will record trends over time. Data from the nephelometers will be analyzed by FVMWC, with the results of the analysis and associated data summaries submitted annually to the TRP. This data will inform the TRP on the environmental setting, augmenting the weather station data, and provide information for the long term management of the facilities in the valley. The TRP will provide recommendations over time regarding modifications to the verification data collection activities if needed.

6.8.2 *Action Criteria*

The decision-making process will be initiated if the action criteria are triggered. The action criteria are (1) changes in annual average or peak concentrations of airborne particulate matter as measured by nephelometers that exceed average annual or peak baseline conditions by 5 percent or more, or (2) changes in surface soil conditions on the Dry Lakes that show a degradation of soil structure and increased susceptibility to wind erosion compared to baseline conditions established through monitoring prior to Project pumping. If such changes are measured, the decision-making process will be initiated.

6.8.3 *Decision-Making Process*

If the action criteria is triggered, the decision-making process will include:

- Assessment of whether the change in air quality or soil conditions are attributable to Project operations;
- If air quality changes are determined to be attributable to Project operations or if degradation of soil structure and increased susceptibility of wind erosion are determined to be attributable to Project operations, one or more of the corrective measures shall be implemented.

6.8.4 *Corrective Measures*

Action(s) necessary to re-establish baseline airborne particulate levels and soil structure shall include one or more of the following:

- Reduction in pumping from Project wells;
- Revision of pumping locations within the Project wellfield;
- Stoppage of groundwater extraction for a duration necessary to restore baseline air quality conditions to correct for Project impacts.

6.9 Management of Groundwater Floor

Pursuant to the MOU, the parties agreed to (i) identify the groundwater levels that will serve as monitoring targets and a "floor" for the maximum groundwater drawdown level in the Project wellfield, and (ii) establish a projected rate of decline in the groundwater table. The floor and rate of decline are designed to, among other things, set a designated maximum drawdown elevation in the Project wellfield and help assess trends and operate the Project in a manner that avoids Undesirable Results or other physical impacts enumerated in the MOU (including saline water migration).

6.9.1 *Groundwater Management Level*

The Project may drawdown the aquifer in the center of the Project wellfield area to a maximum drawdown level (the "floor") of elevation 530 feet (80 feet below baseline elevations). The floor will be calculated as an average groundwater elevation within a 2-mile radius from the center of the Project wellfield area. The rate of decline in groundwater elevation can be expected to vary, being higher initially and gradually stabilizing to a lower long-term rate. With the 80-foot floor, the projected rate of decline is approximately 1.6 feet per year averaged over the Project's 50-year lifespan. Once the floor is reached, and absent approval of a new floor by the County, pumping must be reduced to a quantity at or below the amount that will maintain water levels at or above the 80-foot floor. The floor is a management level, meaning annual, short-term incursions below the floor (3 consecutive years or less) are acceptable under the following conditions:

(a) No management criteria or corrective actions under this Management Plan have been triggered as necessary to avoid the threat of Undesirable Results; and

(b) Average groundwater levels must remain at or above the floor as measured on a 10-year average.

6.9.2 *Monitoring*

As described above, monitoring wells within a two-mile radius from the center of the Project wellfield will be used to monitor declines in groundwater levels and to develop data to evaluate actual rates of recharge. Monitoring wells will be selected from the following existing wells located in the Project wellfield area: CI-1, CI-2, CI-3, MW-1, MW-2, MW-3, MW-4, MW-5, MW-6, MW-7, MW-7A, PW-1, TW-1, TW-2, TW2-MW, TW-3, CH-5 (the locations of these existing wells are depicted in Figure 5-2). Selected monitoring wells within the set may be substituted, if necessary, after the 5-Year project review period. Additional monitoring wells may be added within the 2-mile radius, if necessary, after the 5-Year project review period. Groundwater levels will be monitored on a continuous basis throughout the term of the Project.

6.9.3 *Adaptive Management*

Any time after 15 years of operation, FVMWC or SMWD may apply to the County to lower the floor below elevation 530 feet (80 feet below baseline) to elevation 510 feet (100 feet below baseline), on the following conditions:

(a) FVMWC or SMWD shall first consult with and obtain a recommendation from the TRP on whether the following requirements can be satisfied:

(i) Sufficient operational data exists to support a decision concerning the floor or whether additional operational data is needed;

(ii) The Project will achieve additional conservation benefits at the proposed floor; and

(iii) The lowering of the floor will not trigger either the management criteria or the corrective actions under this Management Plan (other than the floor itself) in order to avoid the threat of Undesirable Results.

(b) The County must approve a lowering in the floor if it can make the following findings:

(i) Sufficient operational data exists to support a decision to lower the floor and avoid Undesirable Results;

(ii) The urban water management plans for each of the municipal water agencies and purveyors receiving water from the Project have disclosed the 50-year limit on the Cadiz water supply;

(iii) Additional conservation benefits will be realized at the proposed floor;

(iv) Lowering the floor would not result in the triggering of either the action criteria or the corrective actions under this Management Plan as necessary to avoid the occurrence of Undesirable Results; and

(v) There is no other threat of adverse environmental consequences that may arise due to changed or unforeseen circumstances.

(c) The new 510-foot (100-foot) floor would operate as a new management level, meaning annual, short-term incursions below the floor would be acceptable under the conditions set forth in Sections 6.9.1(a)-(b), above.

6.9.4 *Action Criteria*

The decision-making process will be initiated if the action criteria are triggered. The action criteria are trends in groundwater levels (rate of decline) that demonstrate that the designated floor elevation will be exceeded within 10 years. If such changes are measured, the decision-making process will be initiated.

6.9.5 *Decision-Making Process*

If the action criteria is triggered, the decision-making process will be include:

- Assessment of trends and updated projections of whether and when the Project is anticipated to reach the designated floor;

- If it is determined that the groundwater levels may drop below the designated floor within 10 years, one or more of the corrective measures shall be implemented.

6.9.6 *Corrective Measures*

Action(s) necessary to manage or avoid incurring below the designated floor shall include one or more of the following.

- Reduction in pumping from Project wells;
- Revision of pumping locations within the Project wellfield;
- Stoppage of groundwater extraction for a duration necessary to correct the predicted impact.

6.10 Project Area Vegetation

As discussed at Section 4.5 of Chapter 4 above, the Project is not anticipated to affect surface vegetation surrounding the wellfields, at the Playas, or within the surrounding Playa margins.

6.10.1 *Monitoring*

The Project is not anticipated to affect surface vegetation in the Project Area. However, as a conservative monitoring protocol conditioned under the County's Groundwater Management Ordinance and MOU, baseline and periodic visual observations shall be performed around the wellfields and at the Playas and surrounding Playa margins annually during the pre-operational and operational periods of the Project. Monitoring of groundwater levels will also be conducted to provide data which could be used to correlate changes in groundwater levels attributed to Project operations to changes in surface vegetation.

6.10.2 *Action Criteria*

The decision-making process will be initiated if the action criterion is triggered. The action criterion is a reduction in the extent or character of Project area vegetation from the baseline established in the first 10 years of monitoring. If such changes are observed, the decision-making process will be initiated.

6.10.3 *Decision-Making Process*

If the action criteria is triggered, the decision-making process will include:

- Assessment of whether the reduction in extent or character of surrounding surface vegetation is attributable to Project operations and not the result of changes in annual precipitation or climatic conditions;
- If the reduction in the extent or character of surface vegetation is determined to be attributable to Project operations, one or more of the corrective measures shall be implemented.

6.10.4 *Corrective Measures*

Action(s) necessary to re-establish baseline vegetation shall include one or more of the following in addition to a reevaluation of the relationship between the aquifer and surface vegetation within the watershed:

- Reduction in pumping from Project wells;
- Revision of pumping locations within the Project wellfield;
- Stoppage of groundwater extraction for a duration necessary to correct the predicted impact.

CHAPTER 7
CLOSURE PLAN AND POST-OPERATIONAL REPORTING

A Closure Plan will be developed as part of this Management Plan to ensure that no residual effects of Project operations after 50 years will result in adverse impacts to the groundwater system and environment (as defined in Chapter 4) in or adjacent to the Project wellfield area and outlying areas that monitoring has determined have been influenced by Project operations.

7.1 Closure Plan Approval

A draft Closure Plan will be prepared by FVMWC and submitted to SMWD, the TRP, and the County no later than December 31 of the 25th year of Project operations. FVMWC will consult with the TRP to provide input and guidance throughout the development and refinement of the draft Closure Plan. The TRP shall submit a formal written recommendation to the County within one year of its receipt of the draft Closure Plan from FVMWC. A final Closure Plan will be approved by the County, as it determines appropriate in its discretion after consideration of the draft Closure Plan and any recommendations of the TRP.

Once prepared, the Closure Plan will be reevaluated every 5 years in consultation with the TRP. Such reevaluation may include refinements to the Closure Plan. Any modification to the Closure Plan must be reviewed and approved by the County.

7.2 Closure Criteria

Subject to additional or alternative terms and conditions that may be developed as part of the Phase II Imported Water Storage Component, the Closure Plan shall, at a minimum, include the following conditions:

- Monitor groundwater levels and groundwater quality for a minimum period of 10 years to confirm no significant environmental effects or Undesirable Results may occur and to protect critical resources and groundwater quality;
- All Project wells that are abandoned shall be destroyed in manner consistent with all applicable state and local regulations and industry standards;
- Injection wells or other mitigation to address saline water migration shall continue unless and until stable groundwater flow gradients from the wellfield toward the Dry Lake playas are restored such that the saline-freshwater boundary can be maintained naturally at 6,000’ (or less);
- The Project as proposed and approved is a 50-year project. Any proposal to pump water after Year 50 will require new discretionary approvals and subsequent environmental review. Post-closure groundwater pumping by the Project, if approved, would be expected to be limited to average rates at or less than the rate of recharge and as necessary to avoid Undesirable Results;
- The provisions and mitigation obligations under this Management Plan will remain in effect and run concurrently with the term of the Closure Plan; and
- To ensure that the Closure Plan can be fully implemented, FVMWC will establish and maintain an escrow account or other equivalent financial assurances mechanism for post-closure operations.

Under this Management Plan, FVMWC will collect data and review and analyze groundwater levels, water quality information, air quality, and other monitoring data, as well as prepare the annual reports for review by TRP and approval by the County. One purpose of the annual reports is to identify any actions that may be taken to ensure that any decline in groundwater levels would recover to levels necessary to protect critical resources and avoid Undesirable Results during or after the post-operational phases of the Project.

CHAPTER 8
PROJECT OVERSIGHT, MANAGEMENT, AND ENFORCEMENT

8.1 Technical Review Panel

An integral part of this Management Plan involves regular and ongoing review of data collected during the term of the Project. The understanding and analysis of the data will require technical expertise. For this reason, a Technical Review Panel (TRP) will be organized for the purpose of data review and analysis, report preparation, and advising the parties on technical aspects of the Project as set forth in Chapter 8. TRP Operating Procedures will be developed by the parties before the TRP is constituted to aid the TRP in fulfilling its roles under this Management Plan.

8.1.1 *Members*

The TRP shall consist of one technical representative appointed by the SMWD and one technical representative appointed by the County. Each of these individual appointments shall be in the discretion of the SMWD and the County, respectively. A third technical representative shall be jointly selected by the technical representatives from SMWD and the County, subject to review and approval by the County and SMWD. All three members of the TRP shall possess professional technical qualifications appropriate to the tasks of the TRP (e.g., state certifications in engineering, hydrology, or geology) and must have a minimum of 10 years professional experience working in the groundwater field. In the event the County and SMWD representatives cannot agree on the designation of the third representative, they may petition the San Bernardino Superior Court for the appointment of the third technical representative.

8.1.2 *Responsibilities*

The TRP is responsible for critical review and analysis of protocols for monitoring (including quality assurance and quality control) and methods of data collection and processing; data analysis, the rate of decline in the groundwater elevations; groundwater levels and quality; and the Project's potential to cause Undesirable Results. The TRP may make recommendations to SMWD and/or the County or SMWD and/or the County may request recommendations from the TRP on additional monitoring, mitigation, and modification to Project operations as set forth in Chapter 8.

As discussed above in Chapter 6, the TRP shall be responsible for data review and analysis along with advising SMWD and the County with respect to FVMWC's assessment of any triggering of an action criterion, corrective measures proposed or adopted, and any proposed refinements to the Management Plan. Determinations and recommendations from the TRP are to be provided to SMWD and the County for final oversight decisions. Whenever there are differing views among the TRP, those views will be provided, and the views of all members of the TRP shall be considered.

The TRP shall coordinate with FVMWC to review and monitor Project data and conditions in the northern Bristol/Cadiz Sub-Basin, as well as in the larger watershed area and adjacent region, including all information set forth for monitoring and reporting pursuant to Chapter 9 below, and shall issue recommendations to the County concerning monitoring and reporting efforts for the Project. The TRP may also undertake or cause to be made studies which may assist in determining the following: (i) status and trends in the progressive decline in groundwater levels and freshwater storage below the "floor" established in this Management Plan; (ii) the progressive decline in groundwater levels and freshwater storage at a rate greater than the established rate in this Management Plan; (iii) land subsidence; (iv) the progressive migration of hyper-saline water from beneath the Cadiz or Bristol Dry Lakes toward the Project wellsites; (v) increases in air quality particulate matter; (vi) loss of surface vegetation; or (vii) decreases in spring flows. FVMWC shall have the preliminary responsibility for collecting, collating, and verifying the data required under the monitoring program, and shall present the results thereof in annual monitoring reports provided to the TRP. FVMWC shall also make all raw data available to the TRP via an electronic network (e.g., a web page or FTP site within 90 days of its collection) or other appropriate means to enable regular updates on Project operation and management activities and to allow the TRP to verify the data and any results therefrom.

The TRP shall also review and comment to the County on annual reports developed by FVMWC as provided for in Chapter 9 below.

TRP's costs will be borne by FVMWC, including those of the technical representatives, provided that annual costs do not exceed $60,000 per year, escalated by 2 percent per year. Special reports recommended or prepared by the TRP may necessitate additional funding if so ordered by the County or SMWD or accepted by FVMWC.

8.1.3 *TRP Convening, Determinations, and Reporting*

As discussed above in Chapter 6, the TRP shall convene as necessary to review and advise the County with respect to any monitoring data or other assessments provided by FVMWC concerning the triggering of action criterion and any associated impacts to a critical resource, corrective measures adopted, and any proposed refinements to the Management Plan. The TRP shall also convene at least once every year to discuss and take action with respect to its other responsibilities set forth in Chapter 8. Convening of the TRP may occur by face-to-face meetings, telephone conferencing, or video conferencing.

The TRP shall designate one of its members as the Chair and this position shall shift among the members annually such that each member shall be the Chair every third year. The Chair shall take minutes of all convening meetings of the TRP, which shall be submitted to the County Representative and the SMWD Representative within 10 days of the TRP convening. The minutes shall also be submitted to the General Manager of SMWD within ten days of the TRP convening in order to facilitate SMWD's monitoring of compliance with those mitigation measures which correspond to provisions of the Management Plan.

Determinations and recommendations of the TRP shall require the affirmative agreement of at least two of the TRP Members, and the Chair shall notify the County Representative and SMWD's Representative in writing within 10 days of any determination by the TRP. In the event a determination or recommendation does not reach a consensus, the views and opinions of the dissenting member shall also be submitted.

8.2 Oversight and Enforcement by The County

The MOU and this Management Plan provide for the County to exercise oversight and enforcement of the Management Plan subject to the dispute resolution process referenced in Section 8.3, below. The County exercises its management authority over County groundwater resources through its Desert Groundwater Management Ordinance (Ordinance). Through the MOU and Management Plan, the County is responsible for ensuring that the Project is operated to avoid Overdraft[15] and Undesirable Results as set forth in the MOU. The County must separately fulfill its

[15] "Overdraft" means the condition of a groundwater supply in which the average annual amount of water withdrawn by pumping exceeds (i) the average annual amount of water replenishing the aquifer in any ten-year period, and (ii) groundwater that may be available as Temporary Surplus. MOU p. 3 ¶ 2(g).

duties as a Responsible Agency under CEQA to ensure compliance with those measures in the MMRP that are within the County's jurisdiction.

The County Representative (Chief Executive Officer) will consider written reports submitted by the TRP and will review actions taken or recommended by FVMWC and the TRP. The County, in its sole determination, will issue any final determination of whether FVMWC's assessment of the triggering of action criteria and recommended responsive actions are appropriate based on all available technical data and are otherwise consistent with the EIR and its MMRP, the MOU, and the County Ordinance. If the County determines that FVMWC's assessment or recommended responsive actions are not appropriate, the County may order FVMWC to take alternative corrective actions as set forth in Chapter 6, above. If it is concluded by the County that corrective action or alternative corrective action is necessary, the County will provide notice of its determination and any administrative order in writing to FVMWC, SMWD, and to each member of the TRP. FVMWC shall, within a time period reasonable to the applicable circumstances, comply with the determination and instructions set forth in SMWD's or the County's written administrative order. The County in its administrative order may specify the time period that it deems reasonable for FVMWC to implement any corrective actions under the given circumstances. With the exception of enforcement actions concerning the threat of immediate or irreparable injury, including actions necessary to avoid Overdraft or Undesirable Results, the County's written determinations and administrative orders will be subject to the dispute resolution provisions of the MOU as referenced in Section 8.3. Likewise, certain administrative actions are subject to direct judicial review, as set forth in Paragraph 8 of the MOU.

Because compliance with the Management Plan is a condition of SMWD's approval of the Project, SMWD in its discretion, will also consider the findings and actions taken or recommended by FVMWC and the TRP, and will exercise its own independent judgment concerning whether the triggering of the action criterion is attributable to Project operations, whether the triggering of the action criterion involves a potential adverse impact or Undesirable Result, and to determine the appropriate corrective measure(s) necessary to avoid or mitigate the potential adverse impact or Undesirable Result. If SMWD determines that appropriate corrective measure(s) are necessary to avoid or mitigate the potential adverse impact or Undesirable Result, but the County does not, SMWD will independently impose those corrective measures it determines necessary to avoid adverse impacts to critical resources or Undesirable Results, provided that independent enforcement by SMWD shall be subject to the same procedural requirements and remedies applicable as if the County were enforcing the Management Plan, including the dispute resolution procedure in Section 8.3.

Nothing in this process is intended to alter or supersede SMWD's responsibility, as the lead agency for the Project, to enforce, as a condition of Project approval, the implementation of all adopted mitigation measures, including those measures which correspond to provisions of the Management Plan.

8.3 Dispute Resolution

The County, SMWD, FVMWC, and Cadiz will exercise good faith and reasonable efforts to implement the Management Plan and to make any required determinations and resolve any issues, claims, or disputes that arise under the oversight and enforcement of the Management Plan, including without limitations matters concerning implementation and funding, the triggering of action criterion pertaining to critical resources, corrective measures, proposed refinements to action criteria or corrective measures, development and approval of the Closure Plan provided for in Chapter 7, edits to and completion of the reports provided for in Chapter 9, and any necessary actions to enforce the provisions of this Management Plan. As set forth in the MOU, in the event a dispute arises between the County, SMWD, FVMWC, and/or Cadiz relating to an action taken by FVMWC or a decision or determination concerning the County's and SMWD's management and enforcement responsibility under this Management Plan, the parties shall first attempt in good faith to resolve the dispute through informal means. In the event that such efforts are unsuccessful, any party may invoke the dispute resolution provisions set forth in Paragraph 8 of the MOU except where dispute resolution is excused due to the threat of immediate or irreparable injury (see MOU and Section 8.2, above).

CHAPTER 9
MONITORING AND REPORTING

9.1 Project Data Monitoring

Monitoring is essential to making informed decisions regarding Project operations. FVMWC will be responsible for preparation of the annual reports beginning one year after agreements for delivery of Project water are entered into or commencement of Project construction, whichever occurs first. Five Year Reports shall be prepared beginning 5 years from commencement of Project construction. The annual and 5 Year Reports will be prepared by a California Professional Geologist, Certified Hydrogeologist, or Professional Engineer with a minimum of 10 years professional experience in groundwater.

9.2 Project Reports

9.2.1 *Annual Reports*

Each year during the operational and post-operational periods of the Project, an annual report shall be prepared by FVMWC that shall include a summary, interpretation, and analysis of all Project data obtained through the monitoring described in Chapters 5 and 6, above. The report shall also include any requested or suggested changes in the monitoring proposed to occur in successive years. In addition to the components required under Section 2.5.1 of the County Guidelines for Preparation of a Groundwater Management Plan (June 2000), annual monitoring reports will include the following components:

- Summary of precipitation from climate stations;
- Baseline groundwater level and water quality conditions (as referenced in the EIR). Presentation of baseline conditions will include groundwater level elevation contours, water quality contours, and a figure showing the results of the initial land survey;
- Tables summarizing annual groundwater production for each Project extraction well and cumulative extraction from the Project;
- Tables summarizing depth to static water level and groundwater elevation measurements for all observation wells;
- Report on Bonanza, Whiskey and Vontrigger Springs, including visual observations such as starting and ending points of observed ponded or flowing water, estimated depth of ponded water and flow rate of flowing water, conductivity, pH and temperature of water, any colorations of water, and general type and extent of vegetation;
- Hydrographs for all production and observation wells;
- Groundwater elevation contours;
- Summary and results of surface vegetation monitoring;
- Tables summarizing water quality analyses for the observation wells;
- Results of land subsidence monitoring surveys and any changes relative to baseline;

- Summary tables of any data collected from wells owned by neighboring landowners in proximity to the Project area (provided that permission was granted for such data collection);

- Summary of Project developments, such as changes in storage or extraction operations or construction of new production wells;

- Discussion of Project storage and extraction operations, and trends in groundwater levels and groundwater quality as compared to the baseline conditions;

- Updated groundwater flow, transport and variable density model results;

- Tables summarizing changes in frequency and severity of dust mobilization recorded on Bristol and Cadiz Dry Lakes and analysis correlating dust emissions with wind speed and direction, groundwater levels underlying the Dry Lakebeds and soil surface chemistry;

- Tables and figures (wind roses) summarizing wind data from regional meteorological towers addressing wind speed and direction, and stability frequency distributions. This data shall be collected during the operation phase of the Project, and may be extended if required by the County to address the post-operational (closure) period;

- Summary of FVMWC and TRP assessments, proposed refinements to the Management Plan, and corrective measures.

9.2.2 *Five-Year Reports*

As discussed in Chapters 2 and 4 above, it is anticipated that as the Project proceeds, new data and analysis as well as any new Project operational considerations will be used to refine the calibration of the Project's various water resources models. It is also appropriate to periodically report on observed trends in data from the monitoring features and on predictions of future trends. Thus, a "Five-Year Report" shall be prepared 5 years from commencement of construction, and on every five-year anniversary thereafter. In addition to the report components required under Section 2.5.2 of the County's Guidelines for Preparation of a Groundwater Monitoring Report, the Five-Year Report shall report on the following matters in addition to the contents of previous annual reports:

- Changes to the number or locations of monitoring features;
- Changes in monitoring frequency;
- Changes in monitoring technology;
- Refinements in the action criteria for critical resources;
- Refinements in the models;
- Modifications of this Management Plan;
- Summary of total Project storage and extraction operations;
- Documentation of any trends in groundwater levels evident from the monitoring data;
- Hydrogeologic analysis and interpretation of all Project storage and extraction operations during the previous five-year period;
- Hydrogeologic analysis and interpretation of all water level elevation, water quality, and land survey data collected during the previous five-year period;
- Results of refined model output from the INFIL3.0 (or updated) model, saturated groundwater flow and solute transport models, the variable density groundwater flow model and the solute transport model;
- Detailed evaluation of impacts (if any) of Project operations on surface or groundwater resources;
- Proposed refinements to the Management Plan to address any identified gaps or inadequacies in the monitoring regimes or operational data;
- Summary of projections and trends associated with groundwater elevations and description of any Project operations designed to prevent declines in static groundwater levels in excess of the designated floor and projected rates of decline both during the operation and post-operational phases of the Project;
- Documentation of any trends in water quality measurements or migration in the saline boundary evident from the monitoring data;

- Aquifer specific contours of the most recent static groundwater level elevations and groundwater level elevation changes over the previous 5 years;

- Documentation of any complaints or possible impacts to wells owned by neighboring landowners recorded for the period;

- Tables summarizing changes in frequency and magnitude (to the extent that can be determined from the data) of dust mobilization recorded on Bristol and Cadiz Dry Lakes, and analysis correlating wind-mobilized particulate matter with wind speed and direction, groundwater levels underlying the Dry Lakebeds, and soil moisture on the lakebed surfaces;

- Summary and trends of regional wind and air quality data with conclusions for potential for Project-mobilized lakebed dust to be transported throughout the Mojave Desert region; and

- Once the draft Closure Plan is developed on or before Year 25 of operations, recommended revisions to the Closure Plan.

All Five-Year Reports will include electronic data files and model input and output files. The annual reports will be available to agencies, organizations, interest groups, and the general public upon written notification to the County. All Five-Year Reports shall be distributed to the lead and responsible agencies and made available to the public electronically.

9.2.3 *Report Preparation Process*

The draft reports and supporting data as provided for in this chapter shall be prepared by FVMWC and submitted to the TRP, General Manager of SMWD, and the County Representative on or before April 1 of each year for Annual Reports, and on or before December 31 for Five-Year Reports. Annual reports prepared for any continuing agricultural operations by Cadiz shall also be provided. The TRP shall then review the report and determine whether any recommended edits or additions are appropriate, which it shall provide to the County Representative, FVMWC, and the General Manager of SMWD within 45 days of receipt from FVMWC.

Within 60 days of receipt of the TRP's recommendation, the County Representative shall then consider the report and any recommended edits or additions by the TRP, and determine whether the report is complete or requires revisions or additions. If complete, the County shall accept and file the report as complete and provide written notice of its determination to FVMWC, SMWD, and the TRP. If questions arise and revisions are required, however, FVMWC shall submit a revised report to the TRP, the General Manager of SMWD, and the County Representative within 45 days of notice of the County Representative's request for revisions or clarifications. If, upon receipt of the revised report, questions or disputes over the content of the report remain, any party may either meet and confer on a mutual resolution of the final report or invoke the Dispute Resolution provisions in Section 8.3 of this Management Plan.

Table 5-1

Critical Resource Area	Feature No.	Monitoring Features		No.	Pre-Operational Monitoring Frequency			Operational Monitoring Frequency Extraction			Post-Operational Monitoring Frequency		
					Water Level	Water Quality	Other Monitoring	Water Level	Water Quality	Other Monitoring	Water Level	Water Quality	Other Monitoring
Springs	**1**	**Springs, Monitoring**	Existing	3	Quarterly	Quarterly	Quarterly, Visual Observations and Flow at 3 Springs	Quarterly	Quarterly	Quarterly, Visual Observations and Flow at 3 Springs	Annual	Annual	Annual, Visual Observations and Flow 3 Springs
Aquifer System	**2**	**Observation Wells (16 total)**	Existing	12	Monthly	4 Quarterly, 8 Annually	-	Monthly for First 3 Months of Cycle, then Semi-Annually	Annually	-	Annually	Triannually	-
			Existing	2	Continuous	Annually	-	-	Annually	-	Annually	Triannually	-
			New	2	Monthly	Quarterly	-	Monthly for First 3 Months of Cycle, then Semi-Annually	Annually	-	Annually	Triannually	-
	3	**Project Area Well Clusters - Saturated Zone Only (1 x 3 well cluster + 2 x 2 well cluster = 2 existing and 3x2 new well**	Existing	5 wells	Continuous	Quarterly	-	Continuous	Semi-Annually	-	Continuous (Until No Longer Deemed Necessary)	Annually	-

		cluster for 5 total Clusters)	New	6 wells	Continuous	Quarterly	-	Continuous	Semi-Annually		Continuous (Until No Long Deemed Necessary)	-Annually	-
	4	**Production Wells (34 total)**	Existing	5	Depth to Water Upon Completion	Sample after completion	-	Continuous	Composite Quarterly	Summarize Data Monthly	Annually	-	-
			New	29	Depth to Water Upon Completion	Sample after completion	-	Continuous	Composite Quarterly	Summarize Data Monthly	Annually	-	-
	5	**Land Surface Elevation Surveys (20 total)**	New Benchmark	23	-	-	Annually, reduce if warranted	-	-	Annually, reduce if warranted	-	-	Annually, reduce if warranted
			InSAR (New)	2/yr (If Warranted)	-	-	Once	-	-	Every 5 years	-	-	Twice at 5-year interval
	6	**Extensometer (3 total)**	New	3	-	-	Establish baseline	-	-	Records Daily	-	-	Summarize data annually
Aquifer System	**7**	**Flowmeter Surveys (5 total)**	New	5	-	One Time	One Time	-	-	-	-	-	-
Bristol and Cadiz Dry Lakes	**8**	**Bristol Dry Lake Well Clusters (2 per Cluster x 3 total Clusters)**	New	3 clusters 6 wells	Continuous	Quarterly	-	Continuous	Semi-Annually	-	Continuous (until no longer deemed necessary)	Annually as necessary	-

	9	**Cadiz Dry Lake Well Clusters (2 per Cluster x 3 total Clusters)**	New	3 clusters 6 wells	Continuous	Quarterly	-	Continuous	Semi-Annually	-	Continuous (until no longer deemed necessary)	Annually as necessary	-
	10	**Gamma / EM Logs (up to 6 total)**	New	6	-	-	One Time	-	-	-	-	-	-
Other (Regional)	**11**	**Weather Stations (4 total)**	Existing	3	-	-	Records Daily	-	-	Records Daily	-	-	-
			Cadiz Field Office	1	-	-	Records Hourly	-	-	Records Hourly	-	-	-
Air Quality	**12**	**Nephelometers**	New	4	-	-	Hourly	-	-	Hourly	-	-	-

NOTES:

a - See Table 5-2 for details of monitoring features.

b - Monitoring frequencies pertain to the initial monitoring period of each program operational phase. Monitoring frequency may be increased or decreased based on the initial monitoring results.

Table 5-2

Critical Resource Area	Feature No.	Feature Type	When Monitored	Name	State Well Number	Location Coordinates	Monitoring Protocol		
							Water Level	Water Quality	Other Monitoring
Springs in the Mojave National Preserve and BLM Wilderness Area	1	Springs, Monitoring	Pre-Operational Operational Post-Operational	Bonanza Spring	NA	34° 41' 08" N 115° 24' 20" W	-	-	See Sections 5.1 and 6.1
		Springs, Monitoring	Pre-Operational Operational Post-Operational	Whiskey Spring	NA	34° 59' 52" N 115° 26' 59" W	-	-	See Sections 5.1 and 6.1
		Springs, Monitoring	Pre-Operational Operational Post-Operational	Vontrigger Spring	NA	35° 03' 20" N 115° 08' 52" W	-	-	See Sections 5.1 and 6.1
Aquifer System	2	Observation Well	Pre-Operational Operational Post-Operational	Dormitory	5N/14E-5F1	34° 32' 38" N 115° 31' 57" W	Transducer, See Sections 5.2 and 6.3	See Appendices B, C & D	-
		Observation Well	Pre-Operational Operational Post-Operational	6/15-1	6N/15E-01H	34° 38' 23" N 115° 21' 22" W	Transducer, See Sections 5.2 and 6.4	See Appendices B, C & D	-
		Observation Well	Pre-Operational Operational Post-Operational	6/15-29	6N/15E-29P1	34° 34' 20" N 115° 26' 04" W	Transducer, See Sections 5.2 and 6.4	See Appendices B, C & D	-
		Observation Well	Pre-Operational Operational Post-Operational	SCE-11	4N/14E-13J1	34° 25' 51 N 115° 27' 25" W	Transducer, See Sections 5.2 and 6.5	See Appendices B, C & D	-

		Observation Well	Pre-Operational Operational Post-Operational	CI-3	5N/14E-24D2	34° 30' 40" N 115° 28' 01" W	Transducer, See Sections 5.2 and 6.6	See Appendices B, C & D	-
		Observation Well	Pre-OperationalOperationalPost-Operational	Archer Siding #1	4N/15E-24E1	34° 25' 11" N115° 21' 57" W	Manual,See Appendix B	See Appendices C & D	-
Aquifer System	2	Observation Well	Pre-Operational Operational Post-Operational	Essex	8N/17E-31	34° 43' 49" N 115° 14' 53" W	Manual, See Appendix B	See Appendices C & D	-
		Observation Well	Pre-Operational Operational Post-Operational	Fenner	8N/17E-2	34° 48' 59" N 115° 10' 40" W	Manual, See Appendix B	See Appendices C & D	-
		Observation Well	Pre-Operational Operational Post-Operational	Goffs	10N/18E-26	34° 54' 57" N 115° 03' 44" W	Manual, See Appendix B	See Appendices C & D	-
		Observation Well	Pre-Operational Operational Post-Operational	Labor Camp	5N14E-16H1	34° 31' 22" N 115° 30' 46" W	Transducer, See Sections 5.2 and 6.6	See Appendices B, C & D	-
		Observation Well	Pre-Operational Operational Post-Operational	SCE-5	5N/14E-32N1	34° 28' 17" N 115° 32' 37" W	Manual, See Appendix B	See Appendices C & D	-
		Observation Well	Pre-Operational Operational Post-Operational	SCE-10	5N/14E-34Q1	34° 28' 22" N 115° 29' 59" W	Manual, See Appendix B	See Appendices C & D	-
		Observation Well	Pre-OperationalOperationalPost-Operational	SCE-17	5N/14E-29B1	34° 29' 54" N115° 31' 58" W	Manual,See Appendix B	See Appendices C & D	-

		Observation Well	Pre-Operational Operational Post-Operational	SCE-18	5N/13E-11R1	34° 26' 37" N 115° 34' 59" W	Manual, See Appendix B	See Appendices C & D	-
Aquifer System	2	Observation Well	Pre-Operational Operational Post-Operational	Danby-1	5N/13E-11R1	34° 26' 37" N 115° 34' 59" W	Manual, See Appendix B	See Appendices C & D	-
		Observation Well	Pre-Operational Operational Post-Operational	Piute-1	TBD	34° 57' 22" N 114° 48' 16 W	Manual, See Appendix B	See Appendices C & D	-
	3	Project Area Well Cluster-Groundwater (3 well Cluster)	Pre-Operational Operational Post-Operational	MW-7a MW-7 TW-1	TBD	34° 31' 39" N 115° 26' 55" W	Transducer, See Sections 5.3 and 6.4	See Appendices C & D	Monitor Alluvium/Carbonates/Bedrock
		Project Area Well Cluster-Groundwater (2 well Cluster)	Pre-Operational Operational Post-Operational	TW-2MW TW-2	TBD	34° 31' 13" N 115° 26' 57" W	Transducer, See Sections 5.3 and 6.4	See Appendices C & D	Monitor Alluvium//Bedrock
		Project Area Well Cluster-Groundwater (2 well Cluster)	Pre-Operational Operational Post-Operational	New Cluster Well	TBD	TBD	Transducer, See Sections 5.3 and 6.4	See Appendices C & D	Monitor Alluvium//Bedrock
		Project Area Well Cluster-Groundwater (2 well Cluster)	Pre-Operational Operational Post-Operational	New Cluster Well	TBD	TBD	Transducer, See Sections 5.3 and 6.4	See Appendices C & D	Monitor Alluvium/Bedrock
		Project Area Well Cluster-Groundwater (2 well Cluster)	Pre-Operational Operational Post-Operational	New Cluster Well	TBD	TBD	Transducer, See Sections 5.3 and 6.4	See Appendices C & D	Monitor Alluvium/Bedrock
	4		Operational	28	5N/14E-28Q1	34° 31' 05" N 115° 29' 59" W	-	-	See Section 5.4

			Operational	27N	5N/14E-27B1	34° 29' 54" N115° 29' 59" W	-	-	See Section 5.4
			Operational	27S	5N/14E-27Q1	34° 28' 14" N 115° 29' 59" W	-	-	See Section 5.4
Project Area Aquifer	4		Operational	21S	5N/14E-21P1	34° 30' 08" N 115° 31' 12" W	-	-	See Section 5.4
	4		Operational	33	5N/14E-33K1	34° 28' 32" N 115° 31' 07" W	-	-	See Section 5.4
	4	New Production Wells (29 total)	Operational	TBD (see Figure 5-2)	TBD	TBD	-	-	See Section 5.4
	5	Benchmark Stations (23 total)	Pre-Operational Operational Post-Operational	TBD	NA	Figure 5-2	-	-	See Sections 5.5 and 6.3
	5	InSAR (2 per year)	Pre-Operational Operational Post-Operational	NA	NA	NA	-	-	See Sections 5.5 and 6.3
	6	Extensometer (3 total)	Pre-Operational Operational Post-Operational	TBD	NA	Figure 5-2	-	-	See Sections 5.5 and 6.3
	7	Flowmeter Surveys (5 total)	Pre-Operational	TBD	TBD	TBD	-	-	See Section 5.7

Bristol and Cadiz Dry Lakes	8	Bristol Dry Lake Well Cluster[b]	Pre-Operational Operational Post-Operational	TBD	TBD	Figure 5-2	Transducer, See Sections 5.8, 5.9, 6.4 and 6.5	See Appendices C & D	-
		Bristol Dry Lake Well Cluster[b]	Pre-Operational Operational Post-Operational	TBD	TBD	Figure 5-2	Transducer, See Sections 5.8, 5.9, 6.4 and 6.5	See Appendices C & D	-
		Bristol Dry Lake Well Cluster[c]	Pre-Operational Operational Post-Operational	TBD	TBD	Figure 5-2	Transducer, See Sections 5.8, 5.9, 6.4 and 6.5	See Appendices C & D	-
	9	Cadiz Dry Lake Well Cluster[d]	Pre-Operational Operational Post-Operational	TBD	TBD	Figure 5-2	Transducer, See Sections 5.8, 5.9, 6.4 and 6.5	See Appendices C & D	-
		Cadiz Dry Lake Well Cluster[d]	Pre-Operational Operational Post-Operational	TBD	TBD	Figure 5-2	Transducer, See Sections 5.8, 5.9, 6.4 and 6.5	See Appendices C & D	-
		Cadiz Dry Lake Well Cluster[e]	Pre-Operational Operational Post-Operational	TBD	TBD	Figure 5-2	Transducer, See Sections 5.8, 5.9, 6.4 and 6.5	See Appendices C & D	-
	10	Gamma/EM Logs (up to 6 total)	Pre-Operational	TBD	TBD	TBD	-	-	See Section 5.10

Other (Basin-wide)	11	Weather Station	Pre-Operational Operational Post-Operational	Amboy	NA	34° 31' 52" N 115° 41' 42" W	-	-	See Section 5.11
		Weather Station	Pre-Operational Operational Post-Operational	Mitchell Caverns	NA	34° 56' 06" N 115° 30' 58" W	-	-	See Section 5.11
		Weather Station	Pre-Operational Operational	Fenner Gap	NA	34° 30' 57" N 115° 27' 45" W	-	-	See Section 5.11
		Weather Station	Pre-Operational Operational Post-Operational	Cadiz Field Office (CIMIS Station)	NA	34° 30' 49" N 115° 30' 39" W	-	-	See Section 5.11
Air Quality	12	Nephelometers	Pre-Operational Operational Post-Operational	TBD	NA	TBD	-	-	See Section 5.12
Vegetation	13	Vegetation Monitoring	Pre-operation Operational Post-Operational	NA	NA	Wellfields and Surrounding Bristol and Cadiz Playas	-	-	See Section 5.13

NOTES:
a - Location coordinates to be verified in the field during initial Pre-Operational activity.
b - Two new well clusters to be installed at eastern margin of Bristol Dry Lake (see Figure 5-1).
c - One new well cluster to be installed on Bristol Dry Lake (see Figure 5-1).
d - Two new well clusters to be installed north of Cadiz Dry Lake (see Figure 5-1).
e- One new well cluster to be installed on Cadiz Dry Lake (see Figure 5-1).
Also see Table 5-1 for details of proposed monitoring features and frequencies.

Table 6-1

Cadiz Groundwater Conservation Recovery and Storage Project

Summary of Action Criteria, Impacts and Corrective Measures

Potential Impact	Method of Measurement	Triggers (Action Criteria)	"Close Watch" Measures	Corrective Measures
Third-Party Wells	Groundwater observation wells; voluntary third-party well monitoring	A decline of static water levels of more than twenty (20) feet from pre-Project static water levels or to a degree in which the reduction in static water levels results in an inability to meet existing production of any third-party well drawing water from the northern Bristol/Cadiz Sub-Basin or elsewhere in the Fenner Watershed Receipt of a written complaint by from one or more well owner(s) regarding documented decreased groundwater production yield, degraded water quality, or increased pumping costs submitted by neighboring landowners or the salt mining operators on the Bristol and Cadiz Dry Lakes	Investigation to determine if caused by Project operations, and significance of impact Provision of substitute water to impacted party	Continued provision of substitute water supplies Deepen or otherwise improve the efficiency of the impacted well(s) Blend impacted well water with another local source Construct replacement well(s) Compensation Enter into a mitigation agreement Modification of Project wellfield operations

Land subsidence	Benchmark stations; InSAR; extensometers	Land surface elevation decline of greater than 0.3 ft when compared to baseline conditions A declining trend which if continued would be of a magnitude within ten years which impacts existing infrastructure in the Project area. The magnitude for railroad tracks is more one inch vertically over 62 feet linearly along the existing railroad tracks	Determine if elevation changes were directly attributable to Project operations Conduct ground surveys to look for evidence of differential compaction	Repair damaged structures Enter into a mitigation agreement Modification of Project wellfield operations to arrest subsidence
		A land surface elevation decline greater than predicted by fifty percent over Sensitivity Scenario 1 when compared to baseline conditions to trigger comprehensive review	Comprehensive review includes examination of effects of subsidence on permanent overdraft	Modification of Project wellfield operations to arrest subsidence
Induced flow of lower-quality water from Bristol and Cadiz Dry Lakes	Groundwater observation wells and cluster wells at Dry Lakes; cluster wells and sentinel wells between Dry Lakes and well-field	TDS concentration changes in excess of 600 mg/L at cluster wells located within a distance of 6,000 feet from pre-Project locations of the interface	Determine if concentration changes are directly attributable to Project operations Determine saline-freshwater interface is expected to	Compensation Installation of injection and/or extraction well(s) to maintain saline-freshwater interface within its 6,000-foot limit

			migrate more than 6,000 feet within ten years Install additional observation wells to further assess saline water migration	Modification of Project operations to maintain beneficial use
Brine resources underlying Bristol and Cadiz Dry Lakes	Groundwater observation wells and cluster wells at Dry Lakes	Changes in brine water levels of greater than 50 percent above water column of the brine company's pump intake in comparison to pre-operational static levels in cluster wells at the margins of the Dry Lakes Receipt of a written complaint from salt mining company	Determine if brine water level changes are directly attributable to Project operations	Compensation Installation of injection and/or extraction well(s) Enter into a mitigation agreement Modification of Project operations to maintain beneficial use
Adjacent groundwater basins	Groundwater observation wells	No action criteria necessary; verification monitoring only	None	None
Springs	Visual observation and manual flow measurements and spring characteristics annually of bonanza, whiskey, and Vontrigger springs and groundwater levels measurements in observation wells	Reduction in average annual or seasonal flow or degradation in characteristics at Bonanza Spring as correlated to precipitation	Determine if reduction in flow or degradation in characteristics is attributable to Project operations	Modification of Project operations to re-establish baseline flow and spring characteristics
Air quality	Groundwater observation wells (cluster wells at Dry Lakes), open-air nephelometers Soil testing	Changes in air quality that exceed baseline conditions by 5 percent Changes in soil conditions showing degradation of soil structure	Determine if change is air quality or soil structure is attributable to Project operations	Modification of Project operations to re-establish baseline air quality levels
Management of groundwater drawdown	Well monitoring within 2-mile radius of center of	Lowering of groundwater level in Project wellfield area	None	Modification of Project operations to avoid

	Project wellfield	below management "floor"		drawdown below management "floor."
Vegetation	Visual observation and correlation with groundwater levels	Reduction in the extent or character of Project area baseline vegetation	None	Modification of Project operations to re-establish baseline vegetation

Appendix B
Air Emissions Technical Study

Construction Emissions-WTP

	ROG	NOx	CO	SO2	PM10	PM2.5
Activity	lb/day					
WTP	29.36	54.59	34.19	0.06	20.61	12.17
Pipeline, extra 2-miles	--	--	--	--	--	--
Total	29.4	54.6	34.2	0.1	20.6	12.2
MDAQMD Thresholds of Significance	137	137	548	--	82	65
Exceed?	no	no	no	--	no	no

Notes: *Project ROG may be over-estimated based on majority of impacts*

Daily pipeline construction rate expected to remain unchanged

Operation Emissions-WTP and Project

	ROG	NOx	CO	SO2	PM10	PM2.5
Activity	lb/day					
WTP	0.77	0.56	0.66	0.00	0.13	0.05
Pipeline, extra 2-miles	5.83	5.49	10.94	0.00	1.99	0.36
Existing Project, EIR (mitigated total)	125.33	117.99	235.18	0	42.69	7.68
Total	131.9	124.0	246.8	0.0	44.8	8.1
MDAQMD Thresholds of Significance	137	137	548	--	82	65
Exceed?	no	no	no	--	no	no

Emissions NG Backup generator calculated in CalEEMod
Pipeline Extension operational emissions more likely are negligible (most likely) - the values presented here are very conservative

Construction GHG Emissions -- WTP and Project

Activity	GHG Emissions (Metric tons CO_2e/year)
WTP	223.10
Pipeline, extra 2-miles	571.00
Existing Project, EIR (mitigated total)	13,448.00
Total	14,242.10
Amoritized Over 30-Year	474.74

Operation GHG Emissions -- WTP and Project

Activity	GHG Emissions (Metric tons CO_2e/year)
WTP	220.50
Pipeline, extra 2-miles	1,290.00
Existing Project, EIR (mitigated total)	47,820
Total	49,330.50

Cadiz WTP 051619

Mojave Desert AQMD Air District, Annual

1.0 Project Characteristics

1.1 Land Usage

Land Uses	Size	Metric	Lot Acreage	Floor Surface Area	Population
User Defined Industrial	0.00	User Defined Unit	9.34	0.00	0
General Light Industry	25.00	1000sqft	0.57	25,000.00	0
Parking Lot	10.00	Space	0.09	4,000.00	0

1.2 Other Project Characteristics

Urbanization Urban **Wind Speed (m/s)** 2.6 **Precipitation Freq (Days)** 30

Climate Zone 15 **Operational Year** 2021

Utility Company Southern California Edison

CO2 Intensity (lb/MWhr) 702.44 **CH4 Intensity (lb/MWhr)** 0.029 **N2O Intensity (lb/MWhr)** 0.006

1.3 User Entered Comments & Non-Default Data

Project Characteristics -

Land Use - 10 acre plot; 25,000 sq footage in light industrial buildings for the WTP building & booster pump stations (BPSs); net acreage as user defined industrial.

Construction Phase - Default schedule assumed, but assuming no demo

Grading - Assume 10 acres grades

Architectural Coating -

Vehicle Trips - 2 x 5 workers/day / 25 k-sqft = 0.4 wk trips/size/day [assume no weekend trips]
2 x 5 delivery trucks per month / 25 k-sqft = 0.328 trucks/size/day

Stationary Sources - Emergency Generators and Fire Pumps - 500 HP generator to serve backup power ~ 300 hp pumps; assuming 1 hour per day T&M, 200 hours per year MDAQMD limit

Table Name	Column Name	Default Value	New Value
tblGrading	AcresOfGrading	50.00	10.00
tblLandUse	LotAcreage	0.00	9.34
tblStationaryGeneratorsPumpsUse	HorsePowerValue	0.00	500.00
tblStationaryGeneratorsPumpsUse	HoursPerDay	0.00	1.00
tblStationaryGeneratorsPumpsUse	HoursPerYear	0.00	200.00
tblStationaryGeneratorsPumpsUse	NumberOfEquipment	0.00	1.00
tblVehicleTrips	ST_TR	1.32	0.00
tblVehicleTrips	SU_TR	0.68	0.00
tblVehicleTrips	WD_TR	6.97	0.73

2.0 Emissions Summary

2.1 Overall Construction

Unmitigated Construction

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Year	tons/yr										MT/yr					
2019	0.2093	2.0108	1.4647	2.5000e-003	0.1656	0.1096	0.2752	0.0860	0.1023	0.1882	0.0000	221.6864	221.6864	0.0567	0.0000	223.1034
2020	0.4348	1.3033	1.1764	1.9700e-003	8.9200e-003	0.0736	0.0825	2.4200e-003	0.0691	0.0715	0.0000	170.9229	170.9229	0.0404	0.0000	171.9325
Maximum	**0.4348**	**2.0108**	**1.4647**	**2.5000e-003**	**0.1656**	**0.1096**	**0.2752**	**0.0860**	**0.1023**	**0.1882**	**0.0000**	**221.6864**	**221.6864**	**0.0567**	**0.0000**	**223.1034**

Mitigated Construction

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Year	tons/yr										MT/yr					
2019	0.2093	2.0108	1.4647	2.5000e-003	0.1656	0.1096	0.2752	0.0860	0.1023	0.1882	0.0000	221.6862	221.6862	0.0567	0.0000	223.1032
2020	0.4348	1.3033	1.1764	1.9700e-003	8.9200e-003	0.0736	0.0825	2.4200e-003	0.0691	0.0715	0.0000	170.9227	170.9227	0.0404	0.0000	171.9323
Maximum	**0.4348**	**2.0108**	**1.4647**	**2.5000e-003**	**0.1656**	**0.1096**	**0.2752**	**0.0860**	**0.1023**	**0.1882**	**0.0000**	**221.6862**	**221.6862**	**0.0567**	**0.0000**	**223.1032**

	ROG	**NOx**	**CO**	**SO2**	**Fugitive PM10**	**Exhaust PM10**	**PM10 Total**	**Fugitive PM2.5**	**Exhaust PM2.5**	**PM2.5 Total**	**Bio- CO2**	**NBio-CO2**	**Total CO2**	**CH4**	**N20**	**CO2e**
Percent Reduction	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**

Quarter	Start Date	End Date	Maximum Unmitigated ROG + NOX (tons/quarter)	Maximum Mitigated ROG + NOX (tons/quarter)
1	**5-16-2019**	**8-15-2019**	1.0343	1.0343
2	**8-16-2019**	**11-15-2019**	0.7927	0.7927
3	**11-16-2019**	**2-15-2020**	0.7565	0.7565
4	**2-16-2020**	**5-15-2020**	0.7049	0.7049
5	**5-16-2020**	**8-15-2020**	0.6697	0.6697
		Highest	1.0343	1.0343

2.2 Overall Operational

Unmitigated Operational

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Area	0.1270	0.0000	3.2000e-004	0.0000		0.0000	0.0000		0.0000	0.0000	0.0000	6.3000e-004	6.3000e-004	0.0000	0.0000	6.7000e-004
Energy	4.3800e-003	0.0398	0.0335	2.4000e-004		3.0300e-003	3.0300e-003		3.0300e-003	3.0300e-003	0.0000	124.6410	124.6410	4.1900e-003	1.4900e-003	125.1894
Mobile	5.0300e-003	0.0447	0.0555	2.3000e-004	0.0146	1.5000e-004	0.0148	3.9200e-003	1.4000e-004	4.0600e-003	0.0000	20.9112	20.9112	1.6300e-003	0.0000	20.9519
Stationary	0.4399	0.0339	1.1458	1.5000e-004		2.4300e-003	2.4300e-003		2.4300e-003	2.4300e-003	0.0000	25.4969	25.4969	0.0533	0.0000	26.8297
Waste						0.0000	0.0000		0.0000	0.0000	6.2927	0.0000	6.2927	0.3719	0.0000	15.5900
Water						0.0000	0.0000		0.0000	0.0000	1.8341	23.9851	25.8192	0.1894	4.6500e-003	31.9401
Total	**0.5763**	**0.1184**	**1.2351**	**6.2000e-004**	**0.0146**	**5.6100e-003**	**0.0202**	**3.9200e-003**	**5.6000e-003**	**9.5200e-003**	**8.1268**	**195.0347**	**203.1616**	**0.6204**	**6.1400e-003**	**220.5017**

2.2 Overall Operational

Mitigated Operational

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Area	0.1270	0.0000	3.2000e-004	0.0000		0.0000	0.0000		0.0000	0.0000	0.0000	6.3000e-004	6.3000e-004	0.0000	0.0000	6.7000e-004
Energy	4.3800e-003	0.0398	0.0335	2.4000e-004		3.0300e-003	3.0300e-003		3.0300e-003	3.0300e-003	0.0000	124.6410	124.6410	4.1900e-003	1.4900e-003	125.1894
Mobile	5.0300e-003	0.0447	0.0555	2.3000e-004	0.0146	1.5000e-004	0.0148	3.9200e-003	1.4000e-004	4.0600e-003	0.0000	20.9112	20.9112	1.6300e-003	0.0000	20.9519
Stationary	0.4399	0.0339	1.1458	1.5000e-004		2.4300e-003	2.4300e-003		2.4300e-003	2.4300e-003	0.0000	25.4969	25.4969	0.0533	0.0000	26.8297
Waste						0.0000	0.0000		0.0000	0.0000	6.2927	0.0000	6.2927	0.3719	0.0000	15.5900
Water						0.0000	0.0000		0.0000	0.0000	1.8341	23.9851	25.8192	0.1894	4.6500e-003	31.9401
Total	**0.5763**	**0.1184**	**1.2351**	**6.2000e-004**	**0.0146**	**5.6100e-003**	**0.0202**	**3.9200e-003**	**5.6000e-003**	**9.5200e-003**	**8.1268**	**195.0347**	**203.1616**	**0.6204**	**6.1400e-003**	**220.5017**

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N20	CO2e
Percent Reduction	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**

3.0 Construction Detail

Construction Phase

Phase Number	Phase Name	Phase Type	Start Date	End Date	Num Days Week	Num Days	Phase Description
1	Paving	Paving	6/11/2020	7/8/2020	5	20	
2	Site Preparation	Site Preparation	6/13/2019	6/26/2019	5	10	
3	Grading	Grading	6/27/2019	7/24/2019	5	20	
4	Architectural Coating	Architectural Coating	7/9/2020	8/5/2020	5	20	
5	Building Construction	Building Construction	7/25/2019	6/10/2020	5	230	

Acres of Grading (Site Preparation Phase): 0

Acres of Grading (Grading Phase): 10

Acres of Paving: 0.09

Residential Indoor: 0; Residential Outdoor: 0; Non-Residential Indoor: 37,500; Non-Residential Outdoor: 12,500; Striped Parking Area: 240 (Architectural Coating – sqft)

<u>OffRoad Equipment</u>

Phase Name	Offroad Equipment Type	Amount	Usage Hours	Horse Power	Load Factor
Architectural Coating	Air Compressors	1	6.00	78	0.48
Grading	Excavators	2	8.00	158	0.38
Building Construction	Cranes	1	7.00	231	0.29
Building Construction	Forklifts	3	8.00	89	0.20
Building Construction	Generator Sets	1	8.00	84	0.74
Paving	Pavers	2	8.00	130	0.42
Paving	Rollers	2	8.00	80	0.38
Grading	Rubber Tired Dozers	1	8.00	247	0.40
Building Construction	Tractors/Loaders/Backhoes	3	7.00	97	0.37
Grading	Graders	1	8.00	187	0.41
Grading	Tractors/Loaders/Backhoes	2	8.00	97	0.37
Paving	Paving Equipment	2	8.00	132	0.36
Site Preparation	Tractors/Loaders/Backhoes	4	8.00	97	0.37
Site Preparation	Rubber Tired Dozers	3	8.00	247	0.40
Grading	Scrapers	2	8.00	367	0.48
Building Construction	Welders	1	8.00	46	0.45

Trips and VMT

Phase Name	Offroad Equipment Count	Worker Trip Number	Vendor Trip Number	Hauling Trip Number	Worker Trip Length	Vendor Trip Length	Hauling Trip Length	Worker Vehicle Class	Vendor Vehicle Class	Hauling Vehicle Class
Site Preparation	7	18.00	0.00	0.00	10.80	7.30	20.00	LD_Mix	HDT_Mix	HHDT
Grading	8	20.00	0.00	0.00	10.80	7.30	20.00	LD_Mix	HDT_Mix	HHDT
Building Construction	9	12.00	5.00	0.00	10.80	7.30	20.00	LD_Mix	HDT_Mix	HHDT
Paving	6	15.00	0.00	0.00	10.80	7.30	20.00	LD_Mix	HDT_Mix	HHDT
Architectural Coating	1	2.00	0.00	0.00	10.80	7.30	20.00	LD_Mix	HDT_Mix	HHDT

3.1 Mitigation Measures Construction

3.2 Paving - 2020

Unmitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Off-Road	0.0136	0.1407	0.1465	2.3000e-004		7.5300e-003	7.5300e-003		6.9300e-003	6.9300e-003	0.0000	20.0282	20.0282	6.4800e-003	0.0000	20.1902
Paving	1.2000e-004					0.0000	0.0000		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total	**0.0137**	**0.1407**	**0.1465**	**2.3000e-004**		**7.5300e-003**	**7.5300e-003**		**6.9300e-003**	**6.9300e-003**	**0.0000**	**20.0282**	**20.0282**	**6.4800e-003**	**0.0000**	**20.1902**

Unmitigated Construction Off-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Hauling	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Vendor	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Worker	6.3000e-004	5.1000e-004	4.6600e-003	1.0000e-005	1.2100e-003	1.0000e-005	1.2200e-003	3.2000e-004	1.0000e-005	3.3000e-004	0.0000	1.0290	1.0290	4.0000e-005	0.0000	1.0299
Total	**6.3000e-004**	**5.1000e-004**	**4.6600e-003**	**1.0000e-005**	**1.2100e-003**	**1.0000e-005**	**1.2200e-003**	**3.2000e-004**	**1.0000e-005**	**3.3000e-004**	**0.0000**	**1.0290**	**1.0290**	**4.0000e-005**	**0.0000**	**1.0299**

3.2 Paving - 2020

Mitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Off-Road	0.0136	0.1407	0.1465	2.3000e-004		7.5300e-003	7.5300e-003		6.9300e-003	6.9300e-003	0.0000	20.0282	20.0282	6.4800e-003	0.0000	20.1901
Paving	1.2000e-004					0.0000	0.0000		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total	**0.0137**	**0.1407**	**0.1465**	**2.3000e-004**		**7.5300e-003**	**7.5300e-003**		**6.9300e-003**	**6.9300e-003**	**0.0000**	**20.0282**	**20.0282**	**6.4800e-003**	**0.0000**	**20.1901**

Mitigated Construction Off-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Hauling	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Vendor	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Worker	6.3000e-004	5.1000e-004	4.6600e-003	1.0000e-005	1.2100e-003	1.0000e-005	1.2200e-003	3.2000e-004	1.0000e-005	3.3000e-004	0.0000	1.0290	1.0290	4.0000e-005	0.0000	1.0299
Total	**6.3000e-004**	**5.1000e-004**	**4.6600e-003**	**1.0000e-005**	**1.2100e-003**	**1.0000e-005**	**1.2200e-003**	**3.2000e-004**	**1.0000e-005**	**3.3000e-004**	**0.0000**	**1.0290**	**1.0290**	**4.0000e-005**	**0.0000**	**1.0299**

3.3 Site Preparation - 2019

Unmitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Fugitive Dust					0.0903	0.0000	0.0903	0.0497	0.0000	0.0497	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Off-Road	0.0217	0.2279	0.1103	1.9000e-004		0.0120	0.0120		0.0110	0.0110	0.0000	17.0843	17.0843	5.4100e-003	0.0000	17.2195
Total	**0.0217**	**0.2279**	**0.1103**	**1.9000e-004**	**0.0903**	**0.0120**	**0.1023**	**0.0497**	**0.0110**	**0.0607**	**0.0000**	**17.0843**	**17.0843**	**5.4100e-003**	**0.0000**	**17.2195**

Unmitigated Construction Off-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Hauling	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Vendor	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Worker	4.1000e-004	3.5000e-004	3.1400e-003	1.0000e-005	7.3000e-004	0.0000	7.3000e-004	1.9000e-004	0.0000	2.0000e-004	0.0000	0.6373	0.6373	2.0000e-005	0.0000	0.6379
Total	**4.1000e-004**	**3.5000e-004**	**3.1400e-003**	**1.0000e-005**	**7.3000e-004**	**0.0000**	**7.3000e-004**	**1.9000e-004**	**0.0000**	**2.0000e-004**	**0.0000**	**0.6373**	**0.6373**	**2.0000e-005**	**0.0000**	**0.6379**

3.3 Site Preparation - 2019

Mitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Fugitive Dust					0.0903	0.0000	0.0903	0.0497	0.0000	0.0497	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Off-Road	0.0217	0.2279	0.1103	1.9000e-004		0.0120	0.0120		0.0110	0.0110	0.0000	17.0843	17.0843	5.4100e-003	0.0000	17.2195
Total	**0.0217**	**0.2279**	**0.1103**	**1.9000e-004**	**0.0903**	**0.0120**	**0.1023**	**0.0497**	**0.0110**	**0.0607**	**0.0000**	**17.0843**	**17.0843**	**5.4100e-003**	**0.0000**	**17.2195**

Mitigated Construction Off-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Hauling	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Vendor	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Worker	4.1000e-004	3.5000e-004	3.1400e-003	1.0000e-005	7.3000e-004	0.0000	7.3000e-004	1.9000e-004	0.0000	2.0000e-004	0.0000	0.6373	0.6373	2.0000e-005	0.0000	0.6379
Total	**4.1000e-004**	**3.5000e-004**	**3.1400e-003**	**1.0000e-005**	**7.3000e-004**	**0.0000**	**7.3000e-004**	**1.9000e-004**	**0.0000**	**2.0000e-004**	**0.0000**	**0.6373**	**0.6373**	**2.0000e-005**	**0.0000**	**0.6379**

3.4 Grading - 2019

Unmitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Fugitive Dust					0.0655	0.0000	0.0655	0.0337	0.0000	0.0337	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Off-Road	0.0474	0.5452	0.3338	6.2000e-004		0.0238	0.0238		0.0219	0.0219	0.0000	55.7013	55.7013	0.0176	0.0000	56.1419
Total	**0.0474**	**0.5452**	**0.3338**	**6.2000e-004**	**0.0655**	**0.0238**	**0.0894**	**0.0337**	**0.0219**	**0.0556**	**0.0000**	**55.7013**	**55.7013**	**0.0176**	**0.0000**	**56.1419**

Unmitigated Construction Off-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Hauling	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Vendor	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Worker	9.2000e-004	7.7000e-004	6.9700e-003	2.0000e-005	1.6100e-003	1.0000e-005	1.6200e-003	4.3000e-004	1.0000e-005	4.4000e-004	0.0000	1.4163	1.4163	5.0000e-005	0.0000	1.4177
Total	**9.2000e-004**	**7.7000e-004**	**6.9700e-003**	**2.0000e-005**	**1.6100e-003**	**1.0000e-005**	**1.6200e-003**	**4.3000e-004**	**1.0000e-005**	**4.4000e-004**	**0.0000**	**1.4163**	**1.4163**	**5.0000e-005**	**0.0000**	**1.4177**

3.4 Grading - 2019

Mitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Fugitive Dust					0.0655	0.0000	0.0655	0.0337	0.0000	0.0337	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Off-Road	0.0474	0.5452	0.3338	6.2000e-004		0.0238	0.0238		0.0219	0.0219	0.0000	55.7013	55.7013	0.0176	0.0000	56.1418
Total	**0.0474**	**0.5452**	**0.3338**	**6.2000e-004**	**0.0655**	**0.0238**	**0.0894**	**0.0337**	**0.0219**	**0.0556**	**0.0000**	**55.7013**	**55.7013**	**0.0176**	**0.0000**	**56.1418**

Mitigated Construction Off-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Hauling	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Vendor	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Worker	9.2000e-004	7.7000e-004	6.9700e-003	2.0000e-005	1.6100e-003	1.0000e-005	1.6200e-003	4.3000e-004	1.0000e-005	4.4000e-004	0.0000	1.4163	1.4163	5.0000e-005	0.0000	1.4177
Total	**9.2000e-004**	**7.7000e-004**	**6.9700e-003**	**2.0000e-005**	**1.6100e-003**	**1.0000e-005**	**1.6200e-003**	**4.3000e-004**	**1.0000e-005**	**4.4000e-004**	**0.0000**	**1.4163**	**1.4163**	**5.0000e-005**	**0.0000**	**1.4177**

3.5 Architectural Coating - 2020

Unmitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Archit. Coating	0.2911					0.0000	0.0000		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Off-Road	2.4200e-003	0.0168	0.0183	3.0000e-005		1.1100e-003	1.1100e-003		1.1100e-003	1.1100e-003	0.0000	2.5533	2.5533	2.0000e-004	0.0000	2.5582
Total	**0.2935**	**0.0168**	**0.0183**	**3.0000e-005**		**1.1100e-003**	**1.1100e-003**		**1.1100e-003**	**1.1100e-003**	**0.0000**	**2.5533**	**2.5533**	**2.0000e-004**	**0.0000**	**2.5582**

Unmitigated Construction Off-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Hauling	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Vendor	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Worker	8.0000e-005	7.0000e-005	6.2000e-004	0.0000	1.6000e-004	0.0000	1.6000e-004	4.0000e-005	0.0000	4.0000e-005	0.0000	0.1372	0.1372	0.0000	0.0000	0.1373
Total	**8.0000e-005**	**7.0000e-005**	**6.2000e-004**	**0.0000**	**1.6000e-004**	**0.0000**	**1.6000e-004**	**4.0000e-005**	**0.0000**	**4.0000e-005**	**0.0000**	**0.1372**	**0.1372**	**0.0000**	**0.0000**	**0.1373**

3.5 Architectural Coating - 2020

Mitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Archit. Coating	0.2911					0.0000	0.0000		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Off-Road	2.4200e-003	0.0168	0.0183	3.0000e-005		1.1100e-003	1.1100e-003		1.1100e-003	1.1100e-003	0.0000	2.5533	2.5533	2.0000e-004	0.0000	2.5582
Total	**0.2935**	**0.0168**	**0.0183**	**3.0000e-005**		**1.1100e-003**	**1.1100e-003**		**1.1100e-003**	**1.1100e-003**	**0.0000**	**2.5533**	**2.5533**	**2.0000e-004**	**0.0000**	**2.5582**

Mitigated Construction Off-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Hauling	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Vendor	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Worker	8.0000e-005	7.0000e-005	6.2000e-004	0.0000	1.6000e-004	0.0000	1.6000e-004	4.0000e-005	0.0000	4.0000e-005	0.0000	0.1372	0.1372	0.0000	0.0000	0.1373
Total	**8.0000e-005**	**7.0000e-005**	**6.2000e-004**	**0.0000**	**1.6000e-004**	**0.0000**	**1.6000e-004**	**4.0000e-005**	**0.0000**	**4.0000e-005**	**0.0000**	**0.1372**	**0.1372**	**0.0000**	**0.0000**	**0.1373**

3.6 Building Construction - 2019

Unmitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Off-Road	0.1346	1.2015	0.9783	1.5300e-003		0.0735	0.0735		0.0691	0.0691	0.0000	134.0094	134.0094	0.0327	0.0000	134.8255
Total	**0.1346**	**1.2015**	**0.9783**	**1.5300e-003**		**0.0735**	**0.0735**		**0.0691**	**0.0691**	**0.0000**	**134.0094**	**134.0094**	**0.0327**	**0.0000**	**134.8255**

Unmitigated Construction Off-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Hauling	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Vendor	1.1200e-003	0.0325	8.3600e-003	8.0000e-005	1.9000e-003	2.0000e-004	2.1000e-003	5.5000e-004	1.9000e-004	7.4000e-004	0.0000	7.9940	7.9940	7.4000e-004	0.0000	8.0125
Worker	3.1500e-003	2.6500e-003	0.0238	5.0000e-005	5.5200e-003	4.0000e-005	5.5600e-003	1.4700e-003	3.0000e-005	1.5000e-003	0.0000	4.8438	4.8438	1.8000e-004	0.0000	4.8484
Total	**4.2700e-003**	**0.0351**	**0.0322**	**1.3000e-004**	**7.4200e-003**	**2.4000e-004**	**7.6600e-003**	**2.0200e-003**	**2.2000e-004**	**2.2400e-003**	**0.0000**	**12.8377**	**12.8377**	**9.2000e-004**	**0.0000**	**12.8609**

3.6 Building Construction - 2019

Mitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Off-Road	0.1346	1.2015	0.9783	1.5300e-003		0.0735	0.0735		0.0691	0.0691	0.0000	134.0092	134.0092	0.0327	0.0000	134.8254
Total	**0.1346**	**1.2015**	**0.9783**	**1.5300e-003**		**0.0735**	**0.0735**		**0.0691**	**0.0691**	**0.0000**	**134.0092**	**134.0092**	**0.0327**	**0.0000**	**134.8254**

Mitigated Construction Off-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Hauling	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Vendor	1.1200e-003	0.0325	8.3600e-003	8.0000e-005	1.9000e-003	2.0000e-004	2.1000e-003	5.5000e-004	1.9000e-004	7.4000e-004	0.0000	7.9940	7.9940	7.4000e-004	0.0000	8.0125
Worker	3.1500e-003	2.6500e-003	0.0238	5.0000e-005	5.5200e-003	4.0000e-005	5.5600e-003	1.4700e-003	3.0000e-005	1.5000e-003	0.0000	4.8438	4.8438	1.8000e-004	0.0000	4.8484
Total	**4.2700e-003**	**0.0351**	**0.0322**	**1.3000e-004**	**7.4200e-003**	**2.4000e-004**	**7.6600e-003**	**2.0200e-003**	**2.2000e-004**	**2.2400e-003**	**0.0000**	**12.8377**	**12.8377**	**9.2000e-004**	**0.0000**	**12.8609**

3.6 Building Construction - 2020

Unmitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Off-Road	0.1230	1.1128	0.9772	1.5600e-003		0.0648	0.0648		0.0609	0.0609	0.0000	134.3338	134.3338	0.0328	0.0000	135.1531
Total	**0.1230**	**1.1128**	**0.9772**	**1.5600e-003**		**0.0648**	**0.0648**		**0.0609**	**0.0609**	**0.0000**	**134.3338**	**134.3338**	**0.0328**	**0.0000**	**135.1531**

Unmitigated Construction Off-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Hauling	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Vendor	9.9000e-004	0.0301	7.4400e-003	9.0000e-005	1.9400e-003	1.4000e-004	2.0700e-003	5.6000e-004	1.3000e-004	6.9000e-004	0.0000	8.0669	8.0669	7.3000e-004	0.0000	8.0852
Worker	2.9400e-003	2.3800e-003	0.0216	5.0000e-005	5.6200e-003	4.0000e-005	5.6500e-003	1.4900e-003	3.0000e-005	1.5200e-003	0.0000	4.7745	4.7745	1.6000e-004	0.0000	4.7786
Total	**3.9300e-003**	**0.0325**	**0.0291**	**1.4000e-004**	**7.5600e-003**	**1.8000e-004**	**7.7200e-003**	**2.0500e-003**	**1.6000e-004**	**2.2100e-003**	**0.0000**	**12.8415**	**12.8415**	**8.9000e-004**	**0.0000**	**12.8638**

3.6 Building Construction - 2020

Mitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Off-Road	0.1230	1.1128	0.9772	1.5600e-003		0.0648	0.0648		0.0609	0.0609	0.0000	134.3336	134.3336	0.0328	0.0000	135.1530
Total	**0.1230**	**1.1128**	**0.9772**	**1.5600e-003**		**0.0648**	**0.0648**		**0.0609**	**0.0609**	**0.0000**	**134.3336**	**134.3336**	**0.0328**	**0.0000**	**135.1530**

Mitigated Construction Off-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Hauling	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Vendor	9.9000e-004	0.0301	7.4400e-003	9.0000e-005	1.9400e-003	1.4000e-004	2.0700e-003	5.6000e-004	1.3000e-004	6.9000e-004	0.0000	8.0669	8.0669	7.3000e-004	0.0000	8.0852
Worker	2.9400e-003	2.3800e-003	0.0216	5.0000e-005	5.6200e-003	4.0000e-005	5.6500e-003	1.4900e-003	3.0000e-005	1.5200e-003	0.0000	4.7745	4.7745	1.6000e-004	0.0000	4.7786
Total	**3.9300e-003**	**0.0325**	**0.0291**	**1.4000e-004**	**7.5600e-003**	**1.8000e-004**	**7.7200e-003**	**2.0500e-003**	**1.6000e-004**	**2.2100e-003**	**0.0000**	**12.8415**	**12.8415**	**8.9000e-004**	**0.0000**	**12.8638**

4.0 Operational Detail - Mobile

4.1 Mitigation Measures Mobile

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Mitigated	5.0300e-003	0.0447	0.0555	2.3000e-004	0.0146	1.5000e-004	0.0148	3.9200e-003	1.4000e-004	4.0600e-003	0.0000	20.9112	20.9112	1.6300e-003	0.0000	20.9519
Unmitigated	5.0300e-003	0.0447	0.0555	2.3000e-004	0.0146	1.5000e-004	0.0148	3.9200e-003	1.4000e-004	4.0600e-003	0.0000	20.9112	20.9112	1.6300e-003	0.0000	20.9519

4.2 Trip Summary Information

	Average Daily Trip Rate			Unmitigated	Mitigated
Land Use	Weekday	Saturday	Sunday	Annual VMT	Annual VMT
User Defined Industrial	0.00	0.00	0.00		
General Light Industry	18.33	0.00	0.00	38,214	38,214
Parking Lot	0.00	0.00	0.00		
Total	18.33	0.00	0.00	38,214	38,214

4.3 Trip Type Information

	Miles			Trip %			Trip Purpose %		
Land Use	H-W or C-W	H-S or C-C	H-O or C-NW	H-W or C-W	H-S or C-C	H-O or C-NW	Primary	Diverted	Pass-by
User Defined Industrial	9.50	7.30	7.30	0.00	0.00	0.00	0	0	0
General Light Industry	9.50	7.30	7.30	59.00	28.00	13.00	92	5	3
Parking Lot	9.50	7.30	7.30	0.00	0.00	0.00	0	0	0

4.4 Fleet Mix

Land Use	LDA	LDT1	LDT2	MDV	LHD1	LHD2	MHD	HHD	OBUS	UBUS	MCY	SBUS	MH
User Defined Industrial	0.538252	0.036119	0.174699	0.110250	0.018708	0.005523	0.008817	0.093315	0.001422	0.002225	0.008861	0.000710	0.001098
General Light Industry	0.538252	0.036119	0.174699	0.110250	0.018708	0.005523	0.008817	0.093315	0.001422	0.002225	0.008861	0.000710	0.001098
Parking Lot	0.538252	0.036119	0.174699	0.110250	0.018708	0.005523	0.008817	0.093315	0.001422	0.002225	0.008861	0.000710	0.001098

5.0 Energy Detail

Historical Energy Use: N

5.1 Mitigation Measures Energy

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Electricity Mitigated						0.0000	0.0000		0.0000	0.0000	0.0000	81.2963	81.2963	3.3600e-003	6.9000e-004	81.5871
Electricity Unmitigated						0.0000	0.0000		0.0000	0.0000	0.0000	81.2963	81.2963	3.3600e-003	6.9000e-004	81.5871
NaturalGas Mitigated	4.3800e-003	0.0398	0.0335	2.4000e-004		3.0300e-003	3.0300e-003		3.0300e-003	3.0300e-003	0.0000	43.3448	43.3448	8.3000e-004	7.9000e-004	43.6023
NaturalGas Unmitigated	4.3800e-003	0.0398	0.0335	2.4000e-004		3.0300e-003	3.0300e-003		3.0300e-003	3.0300e-003	0.0000	43.3448	43.3448	8.3000e-004	7.9000e-004	43.6023

5.2 Energy by Land Use - NaturalGas

Unmitigated

	NaturalGas Use	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Land Use	kBTU/yr	tons/yr										MT/yr					
General Light Industry	812250	4.3800e-003	0.0398	0.0335	2.4000e-004		3.0300e-003	3.0300e-003		3.0300e-003	3.0300e-003	0.0000	43.3448	43.3448	8.3000e-004	7.9000e-004	43.6023
Parking Lot	0	0.0000	0.0000	0.0000	0.0000		0.0000	0.0000		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
User Defined Industrial	0	0.0000	0.0000	0.0000	0.0000		0.0000	0.0000		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total		**4.3800e-003**	**0.0398**	**0.0335**	**2.4000e-004**		**3.0300e-003**	**3.0300e-003**		**3.0300e-003**	**3.0300e-003**	**0.0000**	**43.3448**	**43.3448**	**8.3000e-004**	**7.9000e-004**	**43.6023**

Mitigated

	NaturalGas Use	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Land Use	kBTU/yr	tons/yr										MT/yr					
General Light Industry	812250	4.3800e-003	0.0398	0.0335	2.4000e-004		3.0300e-003	3.0300e-003		3.0300e-003	3.0300e-003	0.0000	43.3448	43.3448	8.3000e-004	7.9000e-004	43.6023
Parking Lot	0	0.0000	0.0000	0.0000	0.0000		0.0000	0.0000		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
User Defined Industrial	0	0.0000	0.0000	0.0000	0.0000		0.0000	0.0000		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total		**4.3800e-003**	**0.0398**	**0.0335**	**2.4000e-004**		**3.0300e-003**	**3.0300e-003**		**3.0300e-003**	**3.0300e-003**	**0.0000**	**43.3448**	**43.3448**	**8.3000e-004**	**7.9000e-004**	**43.6023**

5.3 Energy by Land Use - Electricity

Unmitigated

	Electricity Use	Total CO2	CH4	N2O	CO2e
Land Use	kWh/yr	MT/yr			
General Light Industry	253750	80.8502	3.3400e-003	6.9000e-004	81.1394
Parking Lot	1400	0.4461	2.0000e-005	0.0000	0.4477
User Defined Industrial	0	0.0000	0.0000	0.0000	0.0000
Total		**81.2963**	**3.3600e-003**	**6.9000e-004**	**81.5871**

Mitigated

	Electricity Use	Total CO2	CH4	N2O	CO2e
Land Use	kWh/yr	MT/yr			
General Light Industry	253750	80.8502	3.3400e-003	6.9000e-004	81.1394
Parking Lot	1400	0.4461	2.0000e-005	0.0000	0.4477
User Defined Industrial	0	0.0000	0.0000	0.0000	0.0000
Total		**81.2963**	**3.3600e-003**	**6.9000e-004**	**81.5871**

6.0 Area Detail

6.1 Mitigation Measures Area

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Mitigated	0.1270	0.0000	3.2000e-004	0.0000		0.0000	0.0000		0.0000	0.0000	0.0000	6.3000e-004	6.3000e-004	0.0000	0.0000	6.7000e-004
Unmitigated	0.1270	0.0000	3.2000e-004	0.0000		0.0000	0.0000		0.0000	0.0000	0.0000	6.3000e-004	6.3000e-004	0.0000	0.0000	6.7000e-004

6.2 Area by SubCategory

Unmitigated

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
SubCategory	tons/yr										MT/yr					
Architectural Coating	0.0291					0.0000	0.0000		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Consumer Products	0.0979					0.0000	0.0000		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Landscaping	3.0000e-005	0.0000	3.2000e-004	0.0000		0.0000	0.0000		0.0000	0.0000	0.0000	6.3000e-004	6.3000e-004	0.0000	0.0000	6.7000e-004
Total	**0.1270**	**0.0000**	**3.2000e-004**	**0.0000**		**0.0000**	**0.0000**		**0.0000**	**0.0000**	**0.0000**	**6.3000e-004**	**6.3000e-004**	**0.0000**	**0.0000**	**6.7000e-004**

6.2 Area by SubCategory

Mitigated

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
SubCategory	tons/yr										MT/yr					
Architectural Coating	0.0291					0.0000	0.0000		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Consumer Products	0.0979					0.0000	0.0000		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Landscaping	3.0000e-005	0.0000	3.2000e-004	0.0000		0.0000	0.0000		0.0000	0.0000	0.0000	6.3000e-004	6.3000e-004	0.0000	0.0000	6.7000e-004
Total	**0.1270**	**0.0000**	**3.2000e-004**	**0.0000**		**0.0000**	**0.0000**		**0.0000**	**0.0000**	**0.0000**	**6.3000e-004**	**6.3000e-004**	**0.0000**	**0.0000**	**6.7000e-004**

7.0 Water Detail

7.1 Mitigation Measures Water

	Total CO2	CH4	N2O	CO2e
Category	MT/yr			
Mitigated	25.8192	0.1894	4.6500e-003	31.9401
Unmitigated	25.8192	0.1894	4.6500e-003	31.9401

7.2 Water by Land Use

Unmitigated

	Indoor/Outdoor Use	Total CO2	CH4	N2O	CO2e
Land Use	Mgal	MT/yr			
General Light Industry	5.78125 / 0	25.8192	0.1894	4.6500e-003	31.9401
Parking Lot	0 / 0	0.0000	0.0000	0.0000	0.0000
User Defined Industrial	0 / 0	0.0000	0.0000	0.0000	0.0000
Total		**25.8192**	**0.1894**	**4.6500e-003**	**31.9401**

7.2 Water by Land Use

Mitigated

	Indoor/Outdoor Use	Total CO2	CH4	N2O	CO2e
Land Use	Mgal	MT/yr			
General Light Industry	5.78125 / 0	25.8192	0.1894	4.6500e-003	31.9401
Parking Lot	0 / 0	0.0000	0.0000	0.0000	0.0000
User Defined Industrial	0 / 0	0.0000	0.0000	0.0000	0.0000
Total		**25.8192**	**0.1894**	**4.6500e-003**	**31.9401**

8.0 Waste Detail

8.1 Mitigation Measures Waste

Category/Year

	Total CO2	CH4	N2O	CO2e
	MT/yr			
Mitigated	6.2927	0.3719	0.0000	15.5900
Unmitigated	6.2927	0.3719	0.0000	15.5900

8.2 Waste by Land Use

Unmitigated

	Waste Disposed	Total CO2	CH4	N2O	CO2e
Land Use	tons	MT/yr			
General Light Industry	31	6.2927	0.3719	0.0000	15.5900
Parking Lot	0	0.0000	0.0000	0.0000	0.0000
User Defined Industrial	0	0.0000	0.0000	0.0000	0.0000
Total		**6.2927**	**0.3719**	**0.0000**	**15.5900**

8.2 Waste by Land Use

Mitigated

	Waste Disposed	Total CO2	CH4	N2O	CO2e
Land Use	tons	MT/yr			
General Light Industry	31	6.2927	0.3719	0.0000	15.5900
Parking Lot	0	0.0000	0.0000	0.0000	0.0000
User Defined Industrial	0	0.0000	0.0000	0.0000	0.0000
Total		**6.2927**	**0.3719**	**0.0000**	**15.5900**

9.0 Operational Offroad

Equipment Type	Number	Hours/Day	Days/Year	Horse Power	Load Factor	Fuel Type

10.0 Stationary Equipment

Fire Pumps and Emergency Generators

Equipment Type	Number	Hours/Day	Hours/Year	Horse Power	Load Factor	Fuel Type
Emergency Generator	1	1	200	500	0.73	CNG

Boilers

Equipment Type	Number	Heat Input/Day	Heat Input/Year	Boiler Rating	Fuel Type

User Defined Equipment

Equipment Type	Number

10.1 Stationary Sources

Unmitigated/Mitigated

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Equipment Type	tons/yr										MT/yr					
Emergency Generator - CNG (500 - 9999 HP)	0.4399	0.0339	1.1458	1.5000e-004		2.4300e-003	2.4300e-003		2.4300e-003	2.4300e-003	0.0000	25.4969	25.4969	0.0533	0.0000	26.8297
Total	**0.4399**	**0.0339**	**1.1458**	**1.5000e-004**		**2.4300e-003**	**2.4300e-003**		**2.4300e-003**	**2.4300e-003**	**0.0000**	**25.4969**	**25.4969**	**0.0533**	**0.0000**	**26.8297**

11.0 Vegetation

2012 EIR Supplemental Air and GHG Emissions Appendix

POLLUTANT EMISSIONS FROM LOCOMOTIVE DELIVERY OF CONSTRUCTION EQUIPMENT

FUEL CONSUMPTION RATE (TON-MILES/GAL): 400

LINE-HAUL EMISSION FACTORS (g/bhp-hr)				
	PM10	HC	NOx	CO
Uncontrolled	0.32	0.48	13	1.28
Tier 0	0.32	0.48	8.6	1.28
Tier 0+	0.2	0.3	7.2	1.28
Tier 1	0.32	0.47	6.7	1.28
Tier 1+	0.2	0.29	6.7	1.28
Tier 2	0.18	0.26	4.95	1.28
Tier 2+ & Tier 3	0.08	0.13	4.95	1.28
Tier 4	0.015	0.04	1	1.28

CONVERSION FACTOR (bhp-hr/gal)

Large Line-Haul and Passenger: **20.8**

HC to VOC CONVERSTION FACTOR: 1.053

TRANSPORTATION LOAD (tons): 2000

TRANSPORTATION DISTANCE (mi): 180

POLLUTANT EMISSIONS (lbs)

	PM10	**VOC**	**NOx**	**CO**	**PM2.5**[a]
Uncontrolled	13.21	20.86	536.61	52.84	12.15
Tier 0	13.21	20.86	354.99	52.84	12.15
Tier 0+	8.26	13.04	297.20	52.84	7.60
Tier 1	13.21	20.43	276.56	52.84	12.15
Tier 1+	8.26	12.60	276.56	52.84	7.60
Tier 2	7.43	11.30	204.32	52.84	6.84
Tier 2+ & Tier 3	3.30	5.65	204.32	52.84	3.04
Tier 4	0.62	1.74	41.28	52.84	0.57

Source: USEPA, Office of Transportation and Air Quality, EPA-420-F-09-025, *Emission Factors for Locomotives, April 2009.*

[a] PM2.5 emissions for hauling trains were calculated as 92% of PM10 emissions, based on ARB's CEIDARS database for PM2.5 fractions.

DELIVERY TRUCK EMISSIONS DURING CONSTRUCTION

EMISSION FACTORS

Scenario Year: **2012**

All model years in the range 1968 to 2012

Delivery Trucks[a] (pounds/mile)	
CO	0.015457411
NOx	0.017324228
ROG	0.002237757
SOx	2.66688E-05
PM10	0.000649749
PM2.5	0.000549539

TRAVEL DISTANCE (MILES): 320

NUMBER OF TRUCKS DAILY: 10

POLLUTANT EMISSIONS

	pounds/day
CO	49.46371424
NOx	55.43753031
ROG	7.160821076
SOx	0.08534023
PM10	2.079198319
PM2.5	1.758525941

[a] Based on EMFAC 2007 (v2.3) Burden Model Emission Factors compiled by SCAQMD for on-road delivery trucks (>8,500 pounds) in 2012.

SITE ACCESS - FUGITIVE DUST

Conservation and Recovery Component

Unpaved Road Fugitive Dust from Trucks During Construction

VMT [1] (miles/day)	Emission Factors (pounds/VMT) [2]		Emissions Without Dust Control (pounds/day)	
	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$
160	1.4	0.1	221.4	22.1
			Emissions With Dust Control [3] (pounds/day)	
			55.8	**5.6**

1 Total VMT from constructon worker trips

2 Based on AP-42 Emission Factor: E (lbs/VMT) =k (s/12)^a (W/3)^b

Where:

E = emission rate in pounds per vehicle mile traveled

k = particle size multiplier (assumed 1.5 lb/VMT for PM10 and 0.15 lb/VMT for PM2.5 per AP-42, Table 13.2.2-2)

a = 0.9

b = 0.45

s = silt content (assumed 8.5% for a construction site per AP-42, Table 13.2.2-1)

W = averge weight (tons) of vehicles (assumed 100% shuttle buses that weight 5 tons)

3 Dust control mesures include limiting maximum speed on unpaved roads to 25 miles per hour and watering of of unpaved roads at least twice daily.

PIPELINE TRENCHING FUGITIVE DUST EMISSIONS

Worst-Case Daily Grading	10,000	Square Feet[a]
Trenching Duration -	**10**	**days[b]**

Fugitive Dust Stockpiling Parameters

Silt Content[c]	**Precipitation Days**	**Mean Wind Speed Percent[d]**	**TSP Fraction**	**Area[e] (acres)**
6.9	0	100	0.5	0.02

Fugitive Dust Material Handling

Aerodynamic Particle Size Multiplier[f]	**Mean Wind Speed**	**Moisture Content[c]**	**Dirt Handled**	**Dirt Handled[g]**
	mph		cy	lb/day
0.35	10	7.9	3704	926,000

Bulldozing Fugitive Dust Parameters

Number of Dozers Daily	**Hours of Operation**	**Overburden Coefficient[h]**	**Silt Content[i]**	**PM10 Scaling Factor[j]**
1	8	1	6.9	0.75

Incremental Increase in Fugitive Dust Emissions from Construction Operations

Equations:

Storage Piles[k]: PM10 Emissions (lb/day) = 1.7 x (silt content/1.5) x ((365-precipitation days)/235) x wind speed percent/15 x TSP fraction x Area) x (1 - control efficiency)

Material Handling[l] PM10 Emissions (lb/day) = (0.0032 x aerodynamic particle size multiplier x (wind speed (mph)/5)$^{1.3}$/(moisture content/2)$^{1.4}$ x dirt handled (lb/day)/2,000 (lb/ton)
(1 - control efficiency)

Bulldzing[m] PM10 Emissions (lb/day) = (overburden coefficient x silt content$^{1.5}$)/moisture content$^{1.4}$ x PM_{10} scaling factor x hours of operation x (1-control efficiency)

Description	**Control Efficiency** %	**PM10[n]** lb/day	**PM2.5[io]** lb/day
Storage Piles	61	0.32	0.07
Material Handling	61	0.07	0.01
Bulldozing	61	2.35	0.49
Total		**2.74**	**0.56**

Notes:
a) Area to be trenched (100-foot segments).
b) Trenching duration per 100-foot segment.
c) USEPA, AP-42, July 1998, Table 11.9-3 Typical Values for Correction Factors Applicable to the Predictive Emission Factor Equations
d) Mean wind speed percent - percent of time mean wind speed exceeds 12 mph.
e Assumed storage piles are 0.02 acres in size
f) USEPA, AP-42, Jan 1995, Section 13.2.4 Aggregate Handling and Storage Piles, p 13.2.4-3 Aerodynamic particle size multiplier for < 10 µm
g) Assuming 3704 cubic yards of dirt handled [(3704 cyd x 2,500 lb/cyd)/10 days = 926,000 lb/day)
h) USEPA, AP-42, October 1998, Section 11.9 Western Surface Coal Mining, Table 11.9-1, Equation for Overburden Bulldozing.
i) USEPA, AP-42, October 1998, Table 11.9-3 Typical Values for Correction Factors Applicable to the Predictive Emission Factor Equations
j) USEPA, AP-42, October 1998, Section 11.9 Wester Surface Coal Mining, Table 11.9-1 Scaling Factors.
k) USEPA, Fugitive Dust Background Document and Technical Information Document for Best Available Control Measures, Sept 1992, EPA-450/2-92-004, Equation 2-12
l) USEPA, AP-42, Jan 1995, Section 13.2.4 Aggregate Handling and Storage Piles, Equation 1
m) USEPA, AP-42, October 1998, Table 11.9-1, Equation for Overburden Bulldozing.
n) Includes watering at least three times a day (61% control efficiency)
o) ARB's CEIDARS database PM2.5 fractions - construction dust category for fugitive emissions.

WELLFIELD FUGITIVE DUST EMISSIONS

Worst-Case Daily Grading 125,000 Square Feet[a]

Fugitive Dust Grading Parameters

Vehicle Speed (mph)[b]	Vehicle Miles Traveled[c]
7.1	2.15

Fugitive Dust Material Handling

Aerodynamic Particle Size Multiplier[d]	Mean Wind Speed	Moisture Content[e]	Dirt Handled[f]	Dirt Handled[g]
	mph		cy/day	lb/day
0.35	10	7.9	6130	15,325,000

Bulldozing Fugitive Dust Parameters

Number of Dozers Daily	Hours of Operation	Overburden Coefficient[h]	Silt Content[i]	PM10 Scaling Factor[j]
1	8	1	6.9	0.75

Incremental Increase in Fugitive Dust Emissions from Construction Operations

Equations:

Grading[k]: PM10 Emissions (lb/day) = 0.60 x 0.051 x mean vehicle speed$^{2.0}$ x VMTx (1 - control efficiency)

Material Handling[l] PM10 Emissions (lb/day) = (0.0032 x aerodynamic particle size multiplier x (wind speed (mph)/5)$^{1.3}$/(moisture content/2)$^{1.4}$ x dirt handled (lb/day)/2,000 (lb/ton)
(1 - control efficiency)

Bulldzing[m] PM10 Emissions (lb/day) = (overburden coefficient x silt content$^{1.5}$)/moisture content$^{1.4}$ x PM_{10} scaling factor x hours of operation x (1-control efficiency)

Description	Control Efficiency %	PM10[n] lb/day	PM2.5[o] lb/day
Earthmoving	61	1.29	0.27
Material Handling	61	1.20	0.25
Bulldozing	61	2.35	0.49
Total		**4.84**	**1.02**

Notes:

a) Grading of well pads - one acre/day.
b)The AP-42 default value is 7.1 mph.
c) Assumed 13 foot wide blade with 2 foot overlap (11 foot wide). Vehicle miles traveled (VMT) = (125,000 sq ft/11 foot x mile/5,280 ft) = 2.15220385674931 mile
d) USEPA, AP-42, Jan 1995, Section 13.2.4 Aggregate Handling and Storage Piles, p 13.2.4-3 Aerodynamic particle size multiplier for < 10 µm
e) USEPA, AP-42, July 1998, Table 11.9-3 Typical Values for Correction Factors Applicable to the Predictive Emission Factor Equations
f) Amount of dirt to be handled daily assuming 125,000 sf area graded at a depth of 1 feet.
g) Assuming 6130 cubic yards of dirt handled (6130 cyd x 2,500 lb/cyd) = 15,325,000 lb/day)
h) USEPA, AP-42, October 1998, Section 11.9 Western Surface Coal Mining, Table 11.9-1, Equation for Overburden Bulldozing.
i) USEPA, AP-42, October 1998, Table 11.9-3 Typical Values for Correction Factors Applicable to the Predictive Emission Factor Equations
j) USEPA, AP-42, October 1998, Section 11.9 Wester Surface Coal Mining, Table 11.9-1 Scaling Factors.
k) USEPA, AP-42, July 1998, Table 11.9-1, Equation for Site Grading ≤ 10 µm
l) USEPA, AP-42, Jan 1995, Section 13.2.4 Aggregate Handling and Storage Piles, Equation 1
m) USEPA, AP-42, October 1998, Table 11.9-1, Equation for Overburden Bulldozing.
n) Includes watering at least three times a day (61% control efficiency)
o) ARB's CEIDARS database PM2.5 fractions - construction dust category for fugitive emissions.

DELIVERY TRUCK EMISSIONS DURING PROJECT OPERATIONS
commute to Cadiz
EMISSION FACTORS

Scenario Year: **2013**

All model years in the range 1969 to 2013

Delivery Trucks[a] (pounds/mile)	
CO	0.014077785
NOx	0.015773115
ROG	0.002062954
SOx	2.68223E-05
PM10	0.000599558
PM2.5	0.000501736

TRAVEL DISTANCE (MILES): 320

NUMBER OF TRUCKS DAILY: 2

POLLUTANT EMISSIONS

	pounds/day
CO	9.009782266
NOx	10.09479331
ROG	1.320290312
SOx	0.017166299
PM10	0.383717261
PM2.5	0.32111076

[a] Based on EMFAC 2007 (v2.3) Burden Model Emission Factors compiled by SCAQMD for on-road delivery trucks (>8,500 pounds) in 2013, which is when project operations would commence.

OPERATIONAL - FUGITIVE DUST

Unpaved Road Fugitive Dust from Trucks During Project Operations

VMT [1] (miles/day)	Emission Factors (pounds/VMT) [2]		Emissions Without Dust Control (pounds/day)	
	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$
60	1.1	0.1	66.0	6.6
			Emissions With Dust Control [3] (pounds/day)	
			37.0	**1.7**

1 Total VMT from constructon worker trips for conveyance pipeline.

2 Based on AP-42 Emission Factor: E (lbs/VMT) =k (s/12)^a (W/3)^b

Where:

E = emission rate in pounds per vehicle mile traveled

k = particle size multiplier (assumed 1.5 lb/VMT for PM10 and 0.15 lb/VMT for PM2.5 per AP-42, Table 13.2.2-2)

a = 0.9

b = 0.45

s = silt content (assumed 8.5% for a construction site per AP-42, Table 13.2.2-1)

W = averge weight (tons) of vehicles (assumed 3 tons)

3 Dust control mesures include limiting maximum speed on unpaved roads to 25 miles per hour

CH2MHILL

JOB NAME	Cadiz Water Project	JOB NO.	425035
		Calc#	
		SHEET NO.	1 of 1
SUBJECT	Heat rate and emission data screen test for gas recip engines	DATE	8-May-12
			Rev. 2
		COMPUTED BY	RE Menze
		CHECKED BY	

PURPOSE: List the various heat rate, output power, and annual emission totals for different RE's and CTG's

REFERENCES:
1. CAT - MWM Spec sheet from CAT - MWM email of 30-April-2012
2. GE-Western Energy - Tech Data Sheets
3. GE-Jenbacher email of 01-May-2012 with emission data plus spec data sheet of 23-July-2010 for the J624
4. Table 4.3-6 from the project EIR, page 4.3.14

ASSUMPTIONS:
1. Ambient air temperature is **95** ° F
2. Site elevation is **790** ft ASL
3. Fuel consumption at LHV
4. Data given for single units only, except for daily emissions shown for all units
5. Annual hours of operation for each RE is 8760 , though unrealistic due to maintenance requirements.
6. UHC Emissions are generally considered to include VOC's, and other Unburned Hydrocarbon compounds
7. Output power shown at **100% load**
8. Post combustion treatment reductions are: Nox = 85% CO = 90% VOC = 70%
9. The project output capacity will be: 2 x 4MW = 8 MW plus 2 x 2 MW units = Total capacity of - 12 MW

INPUT DATA:

		Caterpillar - MWM		GE - Jenbacher		MDAQMD Thresholds of Significance	
Engine - Make & Model #		TCG 2020	TCG 2032	J612	J624		
Electrical output	(kW)	2,000	4,000	1,951	4,002	lb/day	Pollutant
Mechanical output	(bhp)	2,790	5,507	2,760	5,521	**137**	NOX
Engine speed	(rpm)	1,500	900	1,500	1,500	**548**	CO
No. of cylinders / engine		20	16	12	24	**137**	VOC
Number of cylinders all engines		72		72			

CALCULATIONS:

			TCG 2020	TGC 2032	J612	J624		
	Fuel Use	(MM Btu/hr)	15.801	31.366	15.71	31.245		
	Power Output	(kW)	2,000	4,000	1,951	4,002		
	Heat Rate	(Btu/kW-hr)	7,901	7,842	8,052	7,807		
	Efficiency	(%)	43.20	43.52	42.39	43.72		
Emission rates	Nox	(gm / bhp)	1.20	1.20	1.10	0.60		
	CO	(gm / bhp)	1.90	2.30	2.50	2.50		
	VOC	(gm / bhp)	?	?	0.60	0.40		
Before SCR	Nox Emissions	(lb / hr)	7.37	14.56	6.69	7.30		
Mass flow rate	CO Emissions	(lb / hr)	11.68	27.90	15.20	30.40		
	VOC Emissions	(lb / hr)	?	?	3.65	4.86		
After SCR	Nox	(gm / bhp)	0.18	0.18	0.17	0.09		
	CO	(gm / bhp)	0.19	0.23	0.24	0.25		
	VOC	(gm / bhp)	?	?	0.18	0.12		
After SCR	Nox Emissions	(lb / hr)	1.11	2.18	1.00	1.09	GEJenbacher	CAT - MWM
Mass flow rate	CO Emissions	(lb / hr)	1.17	2.79	1.46	3.04	**Project Daily Total**	Project Daily Total
	VOC Emissions	(lb / hr)	?	?	1.09	1.46		
Daily flow	Daily Nox - 4 units	(lb / day)	53.10	104.80	48.15	52.53	**100.68**	157.90
	Daily CO - 4 units	(lb / day)	56.05	133.91	70.03	145.93	**215.96**	189.96
	Daily VOC - 4 units	(lb / day)	?	?	52.53	70.05	**122.57**	

PROJECT OPERATIONAL PM EMISSIONS - NATURAL GAS-FIRED RECIPRICATING ENGINES

Project: Cadiz

	Caterpillar - MWM		GE - Jenbacher	
Unit	TCG 2020	TCG 2032	J612	J624
(MMBTU/hr)[a]	15.801	31.366	15.71	31.245
(MMBTU/day)	379.224	752.784	377.04	749.88

AT 75,000 AFY[b]

Pollutant	Emission Factor[c] lb/MMBTU	Emissions per day lbs/day	Emissions per year tons/year
PM10	0.0000771	0.173771064	0.031713219
PM2.5	0.0000771	0.173771064	0.031713219

AT 50,000 AFY[d]

Pollutant	Emission Factor[c] lb/MMBTU	Emissions per day lbs/day	Emissions per year tons/year
PM10	0.0000771	0.115955316	0.021161845
PM2.5	0.0000771	0.115955316	0.021161845

[a] CH2MHILL, Heat rate and emission data screen test for gas receip engines, May 3, 2012.
[b] For 75,000 AFY, two J612 engines and two J624 engines would be used for a total output capacity of 12 MW.
[c] AP-42, Chapter 3.2 Natural Gas-Fired Recipricating Engines, August 2000.
[d] For 50,000 AFY, two J612 engines and one J624 engine would be used for a toal output capacity of 8 MW.

POLLUTANT EMISSIONS FROM LOCOMOTIVE DELIVERY OF CONSTRUCTION EQUIPMENT

FUEL CONSUMPTION RATE (TON-MILES/GAL): **400**

LINE-HAUL EMISSION FACTORS (g/bhp-hr)				
	PM10	HC	NOx	CO
Uncontrolled	0.32	0.48	13	1.28
Tier 0	0.32	0.48	8.6	1.28
Tier 0+	0.2	0.3	7.2	1.28
Tier 1	0.32	0.47	6.7	1.28
Tier 1+	0.2	0.29	6.7	1.28
Tier 2	0.18	0.26	4.95	1.28
Tier 2+ & Tier 3	0.08	0.13	4.95	1.28
Tier 4	0.015	0.04	1	1.28

CONVERSION FACTOR (bhp-hr/gal)
Large Line-Haul and Passenger: **20.8**

HC to VOC CONVERSTION FACTOR: **1.053**

TRANSPORTATION LOAD (tons): 2000

TRANSPORTATION DISTANCE (mi): 180

POLLUTANT EMISSIONS (lbs)

	PM10	**VOC**	**NOx**	**CO**	**PM2.5**[a]
Uncontrolled	13.21	20.86	536.61	52.84	12.15
Tier 0	13.21	20.86	354.99	52.84	12.15
Tier 0+	8.26	13.04	297.20	52.84	7.60
Tier 1	13.21	20.43	276.56	52.84	12.15
Tier 1+	8.26	12.60	276.56	52.84	7.60
Tier 2	7.43	11.30	204.32	52.84	6.84
Tier 2+ & Tier 3	3.30	5.65	204.32	52.84	3.04
Tier 4	0.62	1.74	41.28	52.84	0.57

Source: USEPA, Office of Transportation and Air Quality, EPA-420-F-09-025,
Emission Factors for Locomotives, April 2009.

[a] PM2.5 emissions for hauling trains were calculated as 92% of PM10 emissions, based on ARB's CEIDARS database for PM2.5 fractions.

DELIVERY TRUCK EMISSIONS DURING CONSTRUCTION

EMISSION FACTORS

Scenario Year: **2012**

All model years in the range 1968 to 2012

Delivery Trucks[a] (pounds/mile)	
CO	0.015457411
NOx	0.017324228
ROG	0.002237757
SOx	2.66688E-05
PM10	0.000649749
PM2.5	0.000549539

TRAVEL DISTANCE (MILES): 320

NUMBER OF TRUCKS DAILY: 10

POLLUTANT EMISSIONS

	pounds/day
CO	49.46371424
NOx	55.43753031
ROG	7.160821076
SOx	0.08534023
PM10	2.079198319
PM2.5	1.758525941

[a] Based on EMFAC 2007 (v2.3) Burden Model Emission Factors compiled by SCAQMD for on-road delivery trucks (>8,500 pounds) in 2012.

SITE ACCESS - FUGITIVE DUST

Conservation and Recovery Component

Unpaved Road Fugitive Dust from Trucks During Construction

VMT [1] (miles/day)	Emission Factors (pounds/VMT) [2]		Emissions Without Dust Control (pounds/day)	
	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$
160	1.4	0.1	221.4	22.1
			Emissions With Dust Control [3] (pounds/day)	
			55.8	**5.6**

1 Total VMT from constructon worker trips

2 Based on AP-42 Emission Factor: E (lbs/VMT) =k (s/12)^a (W/3)^b

Where:

E = emission rate in pounds per vehicle mile traveled

k = particle size multiplier (assumed 1.5 lb/VMT for PM10 and 0.15 lb/VMT for PM2.5 per AP-42, Table 13.2.2-2)

a = 0.9

b = 0.45

s = silt content (assumed 8.5% for a construction site per AP-42, Table 13.2.2-1)

W = averge weight (tons) of vehicles (assumed 100% shuttle buses that weight 5 tons)

3 Dust control mesures include limiting maximum speed on unpaved roads to 25 miles per hour and watering of

of unpaved roads at least twice daily.

PIPELINE TRENCHING FUGITIVE DUST EMISSIONS

Worst-Case Daily Grading	10,000	Square Feet[a]
Trenching Duration -	**10**	**days[b]**

Fugitive Dust Stockpiling Parameters

Silt Content[c]	Precipitation Days	Mean Wind Speed Percent[d]	TSP Fraction	Area[e] (acres)
6.9	0	100	0.5	0.02

Fugitive Dust Material Handling

Aerodynamic Particle Size Multiplier[f]	Mean Wind Speed	Moisture Content[c]	Dirt Handled	Dirt Handled[g]
	mph		cy	lb/day
0.35	10	7.9	3704	926,000

Bulldozing Fugitive Dust Parameters

Number of Dozers Daily	Hours of Operation	Overburden Coefficient[h]	Silt Content[i]	PM10 Scaling Factor[j]
1	8	1	6.9	0.75

Incremental Increase in Fugitive Dust Emissions from Construction Operations

Equations:

Storage Piles[k]: PM10 Emissions (lb/day) = 1.7 x (silt content/1.5) x ((365-precipitation days)/235) x wind speed percent/15 x TSP fraction x Area) x (1 - control efficiency)

Material Handling[l] PM10 Emissions (lb/day) = (0.0032 x aerodynamic particle size multiplier x (wind speed (mph)/5)$^{1.3}$/(moisture content/2)$^{1.4}$ x dirt handled (lb/day)/2,000 (lb/ton)
(1 - control efficiency)

Bulldzing[m] PM10 Emissions (lb/day) = (overburden coefficient x silt content$^{1.5}$)/moisture content$^{1.4}$ x PM_{10} scaling factor x hours of operation x (1-control efficiency)

Description	Control Efficiency %	PM10[n] lb/day	PM2.5[io] lb/day
Storage Piles	61	0.32	0.07
Material Handling	61	0.07	0.01
Bulldozing	61	2.35	0.49
Total		**2.74**	**0.56**

Notes:

a) Area to be trenched (100-foot segments).
b) Trenching duration per 100-foot segment.
c) USEPA, AP-42, July 1998, Table 11.9-3 Typical Values for Correction Factors Applicable to the Predictive Emission Factor Equations
d) Mean wind speed percent - percent of time mean wind speed exceeds 12 mph.
e Assumed storage piles are 0.02 acres in size
f) USEPA, AP-42, Jan 1995, Section 13.2.4 Aggregate Handling and Storage Piles, p 13.2.4-3 Aerodynamic particle size multiplier for < 10 µm
g) Assuming 3704 cubic yards of dirt handled [(3704 cyd x 2,500 lb/cyd)/10 days = 926,000 lb/day)
h) USEPA, AP-42, October 1998, Section 11.9 Western Surface Coal Mining, Table 11.9-1, Equation for Overburden Bulldozing.
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l) USEPA, AP-42, Jan 1995, Section 13.2.4 Aggregate Handling and Storage Piles, Equation 1
m) USEPA, AP-42, October 1998, Table 11.9-1, Equation for Overburden Bulldozing.
n) Includes watering at least three times a day (61% control efficiency)
o) ARB's CEIDARS database PM2.5 fractions - construction dust category for fugitive emissions.

WELLFIELD FUGITIVE DUST EMISSIONS

Worst-Case Daily Grading	125,000	Square Feet[a]

Fugitive Dust Grading Parameters

Vehicle Speed (mph)[b]	Vehicle Miles Traveled[c]
7.1	2.15

Fugitive Dust Material Handling

Aerodynamic Particle Size Multiplier[d]	Mean Wind Speed	Moisture Content[e]	Dirt Handled[f]	Dirt Handled[g]
	mph		cy/day	lb/day
0.35	10	7.9	6130	15,325,000

Bulldozing Fugitive Dust Parameters

Number of Dozers Daily	Hours of Operation	Overburden Coefficient[h]	Silt Content[i]	PM10 Scaling Factor[j]
1	8	1	6.9	0.75

Incremental Increase in Fugitive Dust Emissions from Construction Operations

Equations:

Grading[k]: PM10 Emissions (lb/day) = 0.60 x 0.051 x mean vehicle speed$^{2.0}$ x VMTx (1 - control efficiency)

Material Handling[l]PM10 Emissions (lb/day) = (0.0032 x aerodynamic particle size multiplier x (wind speed (mph)/5)$^{1.3}$/(moisture content/2)$^{1.4}$ x dirt handled (lb/day)/2,000 (lb/ton)
(1 - control efficiency)

Bulldzing[m] PM10 Emissions (lb/day) = (overburden coefficient x silt content$^{1.5}$)/moisture content$^{1.4}$ x PM_{10} scaling factor x hours of operation x (1-control efficiency)

Description	Control Efficiency %	PM10[n] lb/day	PM2.5[o] lb/day
Earthmoving	61	1.29	0.27
Material Handling	61	1.20	0.25
Bulldozing	61	2.35	0.49
Total		**4.84**	**1.02**

Notes:

a) Grading of well pads - one acre/day.
b)The AP-42 default value is 7.1 mph.
c) Assumed 13 foot wide blade with 2 foot overlap (11 foot wide). Vehicle miles traveled (VMT) = (125,000 sq ft/11 foot x mile/5,280 ft) = 2.15220385674931 mile
d) USEPA, AP-42, Jan 1995, Section 13.2.4 Aggregate Handling and Storage Piles, p 13.2.4-3 Aerodynamic particle size multiplier for < 10 µm
e) USEPA, AP-42, July 1998, Table 11.9-3 Typical Values for Correction Factors Applicable to the Predictive Emission Factor Equations
f) Amount of dirt to be handled daily assuming 125,000 sf area graded at a depth of 1 feet.
g) Assuming 6130 cubic yards of dirt handled (6130 cyd x 2,500 lb/cyd) = 15,325,000 lb/day)
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m) USEPA, AP-42, October 1998, Table 11.9-1, Equation for Overburden Bulldozing.
n) Includes watering at least three times a day (61% control efficiency)
o) ARB's CEIDARS database PM2.5 fractions - construction dust category for fugitive emissions.

DELIVERY TRUCK EMISSIONS DURING PROJECT OPERATIONS
commute to Cadiz
EMISSION FACTORS

Scenario Year: **2013**

All model years in the range 1969 to 2013

Delivery Trucks[a] (pounds/mile)	
CO	0.014077785
NOx	0.015773115
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SOx	2.68223E-05
PM10	0.000599558
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TRAVEL DISTANCE (MILES): 320

NUMBER OF TRUCKS DAILY: 2

POLLUTANT EMISSIONS

	pounds/day
CO	9.009782266
NOx	10.09479331
ROG	1.320290312
SOx	0.017166299
PM10	0.383717261
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[a] Based on EMFAC 2007 (v2.3) Burden Model Emission Factors compiled by SCAQMD for on-road delivery trucks (>8,500 pounds) in 2013, which is when project operations would commence.

OPERATIONAL - FUGITIVE DUST

Unpaved Road Fugitive Dust from Trucks During Project Operations

VMT [1] (miles/day)	Emission Factors (pounds/VMT) [2]		Emissions Without Dust Control (pounds/day)	
	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$
60	1.1	0.1	66.0	6.6
			Emissions With Dust Control [3] (pounds/day)	
			37.0	**1.7**

1 Total VMT from constructon worker trips for conveyance pipeline.

2 Based on AP-42 Emission Factor: E (lbs/VMT) =k (s/12)^a (W/3)^b

Where:

E = emission rate in pounds per vehicle mile traveled

k = particle size multiplier (assumed 1.5 lb/VMT for PM10 and 0.15 lb/VMT for PM2.5 per AP-42, Table 13.2.2-2)

a = 0.9

b = 0.45

s = silt content (assumed 8.5% for a construction site per AP-42, Table 13.2.2-1)

W = averge weight (tons) of vehicles (assumed 3 tons)

3 Dust control mesures include limiting maximum speed on unpaved roads to 25 miles per hour

CH2MHILL

JOB NO.	425035
Calc#	
SHEET NO.	1 of 1
DATE	8-May-12
	Rev. 2
COMPUTED BY	RE Menze
CHECKED BY	

JOB NAME **Cadiz Water Project**

SUBJECT **Heat rate and emission data screen test for gas recip engines**

PURPOSE: List the various heat rate, output power, and annual emission totals for different RE's and CTG's

REFERENCES:
1. CAT - MWM Spec sheet from CAT - MWM email of 30-April-2012
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4. Table 4.3-6 from the project EIR, page 4.3.14

ASSUMPTIONS:
1. Ambient air temperature is **95** ° F
2. Site elevation is **790** ft ASL
3. Fuel consumption at LHV
4. Data given for single units only, except for daily emissions shown for all units
5. Annual hours of operation for each RE is 8760 , though unrealistic due to maintenance requirements.
6. UHC Emissions are generally considered to include VOC's, and other Unburned Hydrocarbon compounds
7. Output power shown at **100% load**
8. Post combustion treatment reductions are: Nox = 85% CO = 90% VOC = 70%
9. The project output capacity will be: 2 x 4MW = 8 MW plus 2 x 2 MW units = Total capacity of - 12 MW

INPUT DATA:

		Caterpillar - MWM		GE - Jenbacher	
Engine - Make & Model #		TCG 2020	TCG 2032	J612	J624
Electrical output	(kW)	2,000	4,000	1,951	4,002
Mechanical output	(bhp)	2,790	5,507	2,760	5,521
Engine speed	(rpm)	1,500	900	1,500	1,500
No. of cylinders / engine		20	16	12	24
Number of cylinders all engines		72		72	

MDAQMD Thresholds of Significance

lb/day	Pollutant
137	NOX
548	CO
137	VOC

CALCULATIONS:

			TCG 2020	TGC 2032	J612	J624	GEJenbacher	CAT - MWM
	Fuel Use	(MM Btu/hr)	15.801	31.366	15.71	31.245		
	Power Output	(kW)	2,000	4,000	1,951	4,002		
	Heat Rate	(Btu/kW-hr)	7,901	7,842	8,052	7,807		
	Efficiency	(%)	43.20	43.52	42.39	43.72		
Emission rates	Nox	(gm / bhp)	1.20	1.20	1.10	0.60		
	CO	(gm / bhp)	1.90	2.30	2.50	2.50		
	VOC	(gm / bhp)	?	?	0.60	0.40		
Before SCR	Nox Emissions	(lb / hr)	7.37	14.56	6.69	7.30		
Mass flow rate	CO Emissions	(lb / hr)	11.68	27.90	15.20	30.40		
	VOC Emissions	(lb / hr)	?	?	3.65	4.86		
After SCR	Nox	(gm / bhp)	0.18	0.18	0.17	0.09		
	CO	(gm / bhp)	0.19	0.23	0.24	0.25		
	VOC	(gm / bhp)	?	?	0.18	0.12		
After SCR	Nox Emissions	(lb / hr)	1.11	2.18	1.00	1.09		
Mass flow rate	CO Emissions	(lb / hr)	1.17	2.79	1.46	3.04	**Project Daily Total**	Project Daily Total
	VOC Emissions	(lb / hr)	?	?	1.09	1.46		
Daily flow	Daily Nox - 4 units	(lb / day)	53.10	104.80	48.15	52.53	**100.68**	157.90
	Daily CO - 4 units	(lb / day)	56.05	133.91	70.03	145.93	**215.96**	189.96
	Daily VOC - 4 units	(lb / day)	?	?	52.53	70.05	**122.57**	

PROJECT OPERATIONAL PM EMISSIONS - NATURAL GAS-FIRED RECIPRICATING ENGINES

Project: Cadiz

	Caterpillar - MWM		GE - Jenbacher	
Unit	TCG 2020	TCG 2032	J612	J624
(MMBTU/hr)[a]	15.801	31.366	15.71	31.245
(MMBTU/day)	379.224	752.784	377.04	749.88

AT 75,000 AFY[b]

Pollutant	Emission Factor[c] lb/MMBTU	Emissions per day lbs/day	Emissions per year tons/year
PM10	0.0000771	0.173771064	0.031713219
PM2.5	0.0000771	0.173771064	0.031713219

AT 50,000 AFY[d]

Pollutant	Emission Factor[c] lb/MMBTU	Emissions per day lbs/day	Emissions per year tons/year
PM10	0.0000771	0.115955316	0.021161845
PM2.5	0.0000771	0.115955316	0.021161845

[a] CH2MHILL, Heat rate and emission data screen test for gas receip engines, May 3, 2012.
[b] For 75,000 AFY, two J612 engines and two J624 engines would be used for a total output capacity of 12 MW.
[c] AP-42, Chapter 3.2 Natural Gas-Fired Recipricating Engines, August 2000.
[d] For 50,000 AFY, two J612 engines and one J624 engine would be used for a toal output capacity of 8 MW.

EMISSIONS OF GREENHOUSE GAS EMISSIONS FROM CONSTRUCTION

Project Name:	Cadiz
Analysis Year:	2012
Analysis Scenario:	Proposed Project

EMISSION FACTORS[a]

	Carbon Dioxide Emission Factors (kg/gal):	Methane Emission Factors (kg/gal):	Nitrous Oxide Emission Factors (kg/gal):
Diesel Fuel :	10.21	0.00058	0.00026
Gasoline:	8.78	0.0005	0.00022

Offroad and Onroad Diesel Construction Equipment Emissions

Carbon Dioxide (metric tons)[b]:	10577.23
Gallons of Diesel Fuel Consumed:	1036897.44

Onroad Gasoline Emissions (Worker Trips)

Carbon Dioxide (metric tons)[c]:	1702.31
Gallons of Gasoline Consumed:	194058.97

Methane and Nitrous Oxide Emissions

	Diesel Fuel Consumption Emissions	Gasoline Consumption Emissions
Methane (metric tons):	0.59663	0.09626
Nitrous Oxide (metric tons):	0.26746	0.04235

GREENHOUSE GAS EMISSIONS

		Emissions (metric tons)	CO_2 Equivalency Factors	CO_2 Equivalent Emissions (metric tons)
Carbon Dioxide		12,279.54	1	12,279.54
Methane		0.693	21	14.55
Nitrous Oxide		0.310	310	96.04
	Total Emissions:	**12,280.54**		**12,390.13**

[a] 2012 Climate Registry Default Emisison Factors, Table 13.1 and Table 13.7.

[b] From URBEMIS outputs.

[c] From calculations based on EMFAC2007 emission factors.

DELIVERY TRUCK GHG EMISSIONS DURING CONSTRUCTION

EMISSION FACTORS

Scenario Year: **2012**

All model years in the range 1968 to 2012

Delivery Trucks[a] (pounds/mile)	
CO_2	2.766284144
CH_4	0.000106675

TRAVEL DISTANCE (MILES): 320

NUMBER OF TRUCKS DAILY: 10

TOTAL PROJECT CONSTRUCTION DAYS: 264

ANNUAL CO2 and CH4 POLLUTANT EMISSIONS

	pounds/day	metric tons/year	CO2e factors	CO2e emissions (metric tons/year)
CO2	8852.109261	1051.63058	1	1051.63058
CH4	0.341360918	0.040553677	21	0.851627218

ANNUAL N2O POLLUTANT EMISSIONS

	CH4 Factors (kg/gal):	N2O Factors (kg/gal):
Diesel Fuel [b]:	0.00058	0.00026

	pounds/day	metric tons/year	CO2e factors	CO2e emissions (metric tons/year)
N2O	0.153159806	0.018195385	310	5.640569343

GREENHOUSE GAS EMISSIONS

Total Emissions (metric tons/year): **1058.12**

[a] Based on EMFAC 2007 (v2.3) Burden Model Emission Factors compiled by SCAQMD for on-road delivery trucks (>8,500 pounds).

[b] 2012 Climate Registry Default Emisson Factors, Table 13.7

DELIVERY TRUCK GHG EMISSIONS DURING PROJECT OPERATIONS

EMISSION FACTORS

Scenario Year: **2013**

All model years in the range 1968 to 2012

Delivery Trucks[a] (pounds/mile)	
CO2	2.781634585
CH4	9.70338E-05

TRAVEL DISTANCE (MILES):	320
NUMBER OF TRUCKS DAILY:	2
TOTAL PROJECT OPERATION DAYS:	365

ANNUAL CO2 and CH4 POLLUTANT EMISSIONS

	pounds/day	metric tons/year	CO2e factors	CO2e emissions (metric tons/year)
CO2	1780.246134	292.4054276	1	292.4054276
CH4	0.062101609	0.010200189	21	0.214203976

ANNUAL N2O POLLUTANT EMISSIONS

	CH4 Factors (kg/gal):	N2O Factors (kg/gal):
Diesel Fuel [b]:	0.00058	0.00026

	pounds/day	metric tons/year	CO2e factors	CO2e emissions (metric tons/year)
N2O	0.027863384	0.004576561	310	1.418733871

GREENHOUSE GAS EMISSIONS

Total Emissions (metric tons/year): **294.04**

[a] Based on EMFAC 2007 (v2.3) Burden Model Emission Factors compiled by SCAQMD for on-road delivery trucks (>8,500 pounds) in 2013, which is the year project operations would commence.

[b] 2012 Climate Registry Default Emisson Factors, Table 13.7

PROJECT OPERATIONAL GHG EMISSIONS - METROPOLITAN CRA CONVEYANCE

Project: Cadiz

Conversion Factors:	Acre-Foot	Gallons (Water)	Million Gallons
	1	325,851	0.325851

Metropolitan CRA Conveyance Rate (kWh/MG): 3886

Project Extraction Values (Acre-Feet Per Year): 50000
75000

Project Energy Demand (kWh/Year):

AFY	(kWh/Year)	(MWh/Year)
50000	63312849.30	63312.8493
75000	94969273.95	94969.27395

GREENHOUSE GAS EMISSIONS (50,000 AFY)

Emissions	Emission Factors[a] (lbs/MWh)	Emissions (metric tons/year)	CO_2 Equivalency Factors	CO_2 Equivalent Emissions (tons per year)
Carbon Dioxide	681.01	19,557.42	1	19,557.42
Methane	0.028	0.804	21	16.89
Nitrous Oxide	0.006	0.172	310	53.42
	Total Emissions:	19,558.40		19,627.72

GREENHOUSE GAS EMISSIONS (75,000 AFY)

Emissions	Emission Factors[a] (lbs/MWh)	Emissions (metric tons/year)	CO_2 Equivalency Factors	CO_2 Equivalent Emissions (tons per year)
Carbon Dioxide	681.01	29,336.13	1	29,336.13
Methane	0.028	1.206	21	25.33
Nitrous Oxide	0.006	0.258	310	80.12
	Total Emissions:	29,337.60		29,441.59

[a] Emission factors from The Climate Registry, Table 14.1 US Emission Factors by eGRID Subregion: http://www.theclimateregistry.org/downloads/2009/05/2011-Emission-Factors.pdf

Appendix C
Biological Resources Survey

ESA

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memorandum

date	May 17, 2019
to	Diane De Felice, Brownstein Hyatt Farber Schreck, LLP
cc	
from	Travis Marella and Greg Ainsworth, ESA
subject	Biological Resources Survey for the Cadiz Valley Water Conservation, Recovery and Storage Project: Revised Pipeline Right of Way Segment.

This letter report documents the findings of a biological resources and jurisdictional drainages survey conducted for the Cadiz Valley Water Conservation, Recovery and Storage Project (Project). The survey was focused on the revised pipeline right of way (ROW) segment. Please find below an overview of the existing conditions within this area as well as the methods and results of the survey.

Methodology

A biological resources survey was conducted by ESA biologists Travis Marella and Greg Ainsworth on December 28, 2017. The entirety of the revised pipeline segment was traversed, including an approximate 50-foot buffer on each side of the alignment. A total of nine ephemeral washes, ranging from approximately five to 100 feet wide, cross the revised pipeline alignment segment. The habitat within these washes were characterized and the limits of State-agency jurisdiction (i.e., California Department of Fish and Wildlife [CDFW] and Regional Water Quality Control Board [RWQCB]) were delineated. Photos were taken along the revised alignment that were surveyed and at each wash crossing. In addition to delineating potential State-jurisdictional washes, special attention was afforded to assessing the potential for other sensitive biological resources to be present, most notably, any burrows capable of supporting desert tortoise (*Gopherus agassizii*), burrowing owl (*Athene cunicularia*) and American badger (*Taxidea taxus*), including any sign of these species such as (but not limited to) scat, tracks and carcasses, as well as, the overall habitat value for supporting these species and other State- or federally-listed species that have been historically recorded in the region of the Project. In addition, the assessment evaluated the habitat potential for supporting special-status plants that were evaluated within the well-field and conveyance pipeline alignment by ESA in May 2017.

Results

As with the majority of the Cadiz well-field and conveyance pipeline alignment, the habitat consists entirely Mojave creosote bush scrub. This community is dominated by creosote bush (*Larrea tridentata*) and burrobush (*Ambrosia dumosa*), and is characterized by widely spaced, tall shrubs, usually separated by bare ground. The washes that cross the revised alignment segment are characterized as Mojave wash scrub and have higher concentrations of creosote. Dominant perennials observed within the washes include creosote, burrobush, arrow weed (*Pluchea sericea*), wash rabbitbrush (*Chrysothamnus paniculatus*), smoke tree (*Dalea spinosa)* and bladderpod (*Isomerus arborea*).

The nine ephemeral washes that cross the revised alignment segment are within the jurisdictional authority of the CDFW and RWQCB.

No sign of desert tortoise, burrowing owl, American badger or any other special-status animal species were observed along the revised alignment segment or in any of the drainages. Based on the overall habitat in the general area and a close review of aerial imagery, the area has a low potential to support special-status wildlife species. In particular, the potential for desert tortoise to occur is considered low, because the areas that were surveyed are at an elevation that is considered too low for desert tortoise, but more importantly, no sign of desert tortoise, including any burrows capable of supporting the species, were observed. Small, approximate 2-to-3-inch reptile burrows were observed within the survey area, none of which could support desert tortoise, burrowing owl or American badgers. The potential for rare plants to occur is similar as determined in the Rare Plant Survey Report prepared by ESA on May 15, 2017 for the wellfield and conveyance pipeline alignment, since the habitat is the same.

Conclusions

No special-status wildlife species, including desert tortoise, are expected to occur along the revised alignment segment. The revised alignment will cross 9 desert washes, including Schuyler Wash, which carried substantial flows during the winter of 2016/17. The extent of CDFW's and RWQCB's jurisdiction of the washes could increase if these agencies decide to take the outer limits of the braided washes that supported historic flows; however, ESA believes their jurisdiction should be limited to the extent delineated on the attached maps.

ATTACHMENTS:

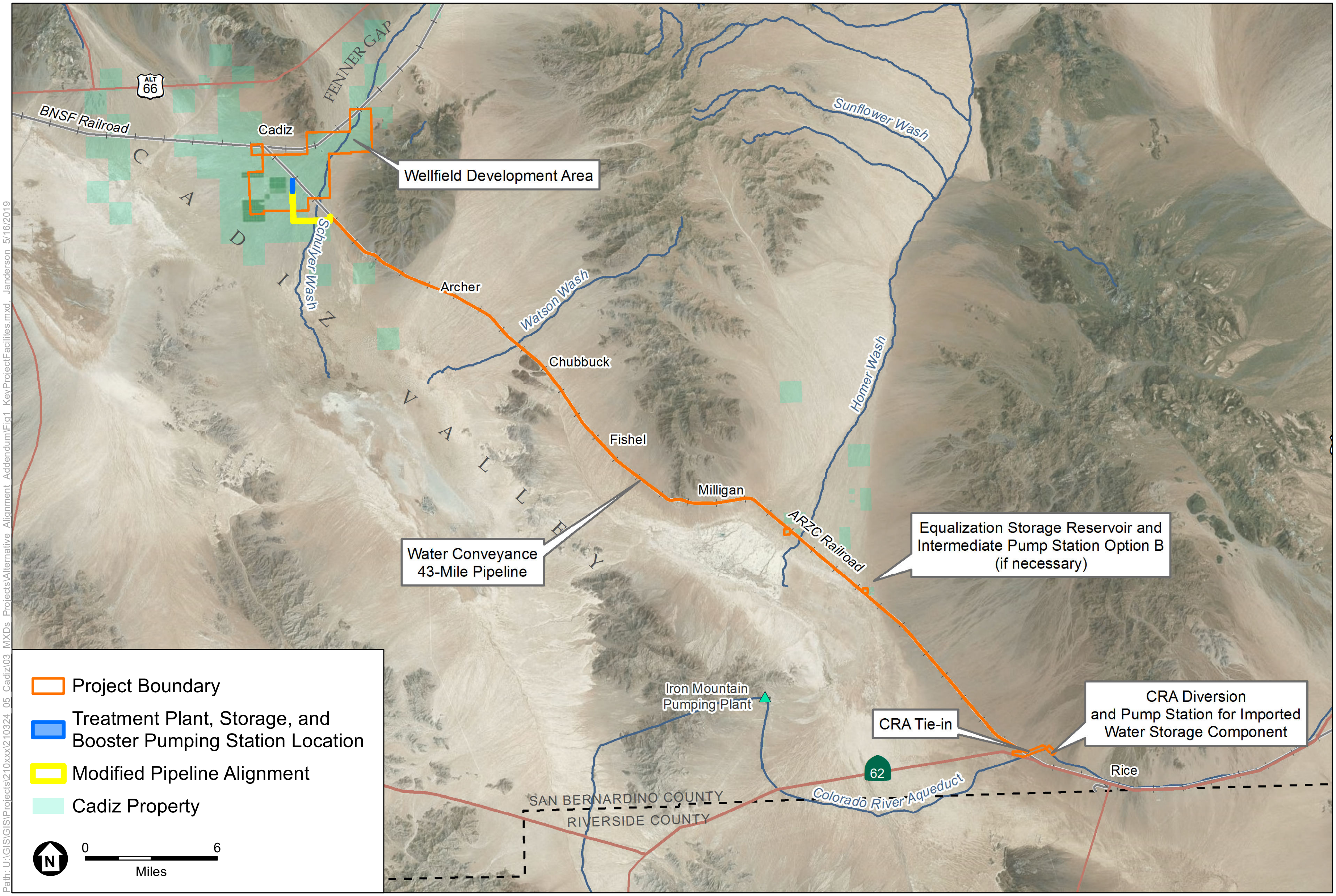
- Photographs
- Figures
- Preliminary Jurisdictional Drainage Map of Revised Pipeline Alignment Segment

PHOTOGRAPHS

Photos 1 and 2. Typical Mojave creosote bush scrub within the survey area.

Photo 3. View of evidence of heavy flows in Schuyler Wash from the winter of 2016/17

Figures

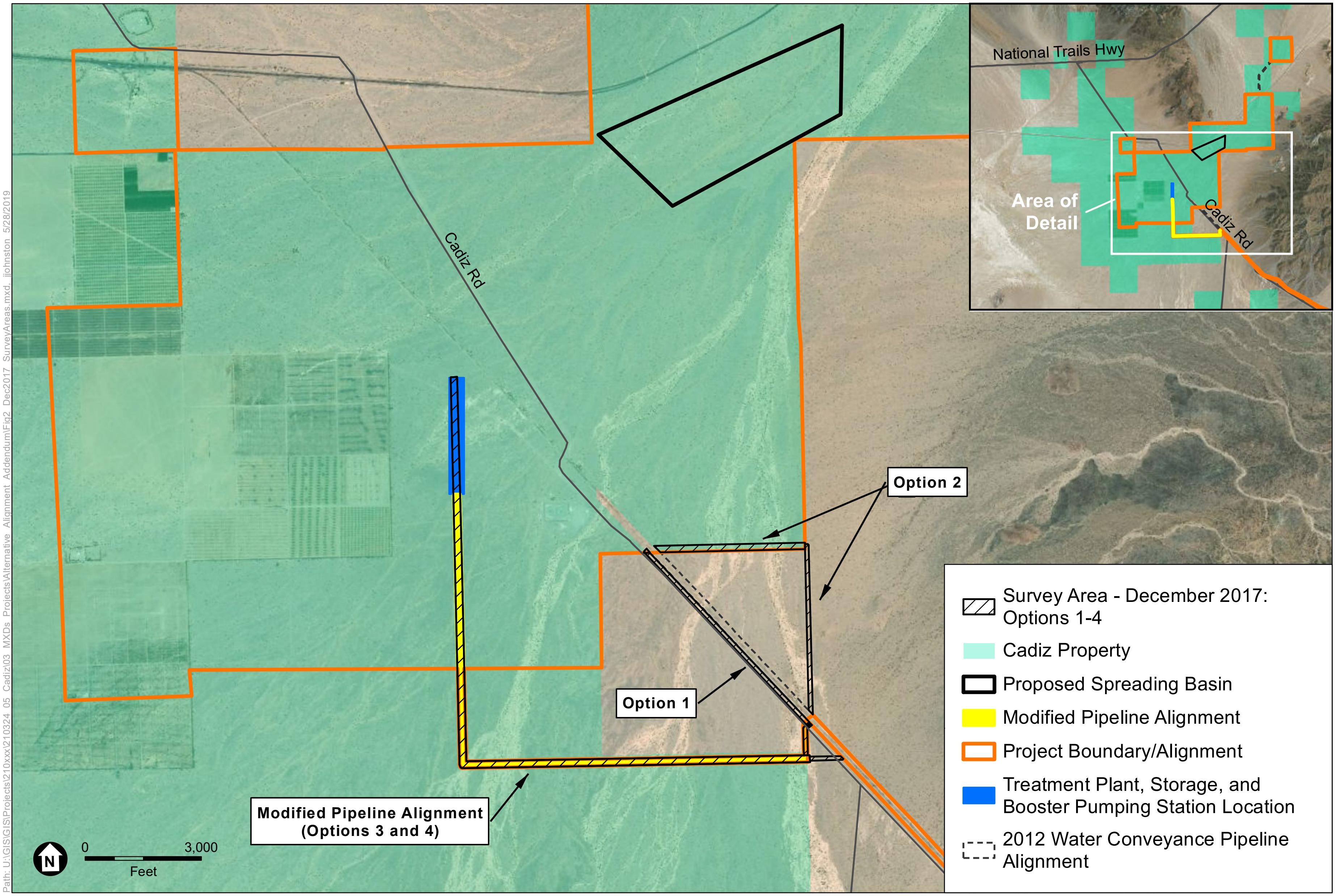


SOURCE: Bing Maps, 2011; ESRI, 2010; Cadiz Inc., 2011; and ESA, 2011

Cadiz Groundwater Project

Figure 1
Project Location and Facilities

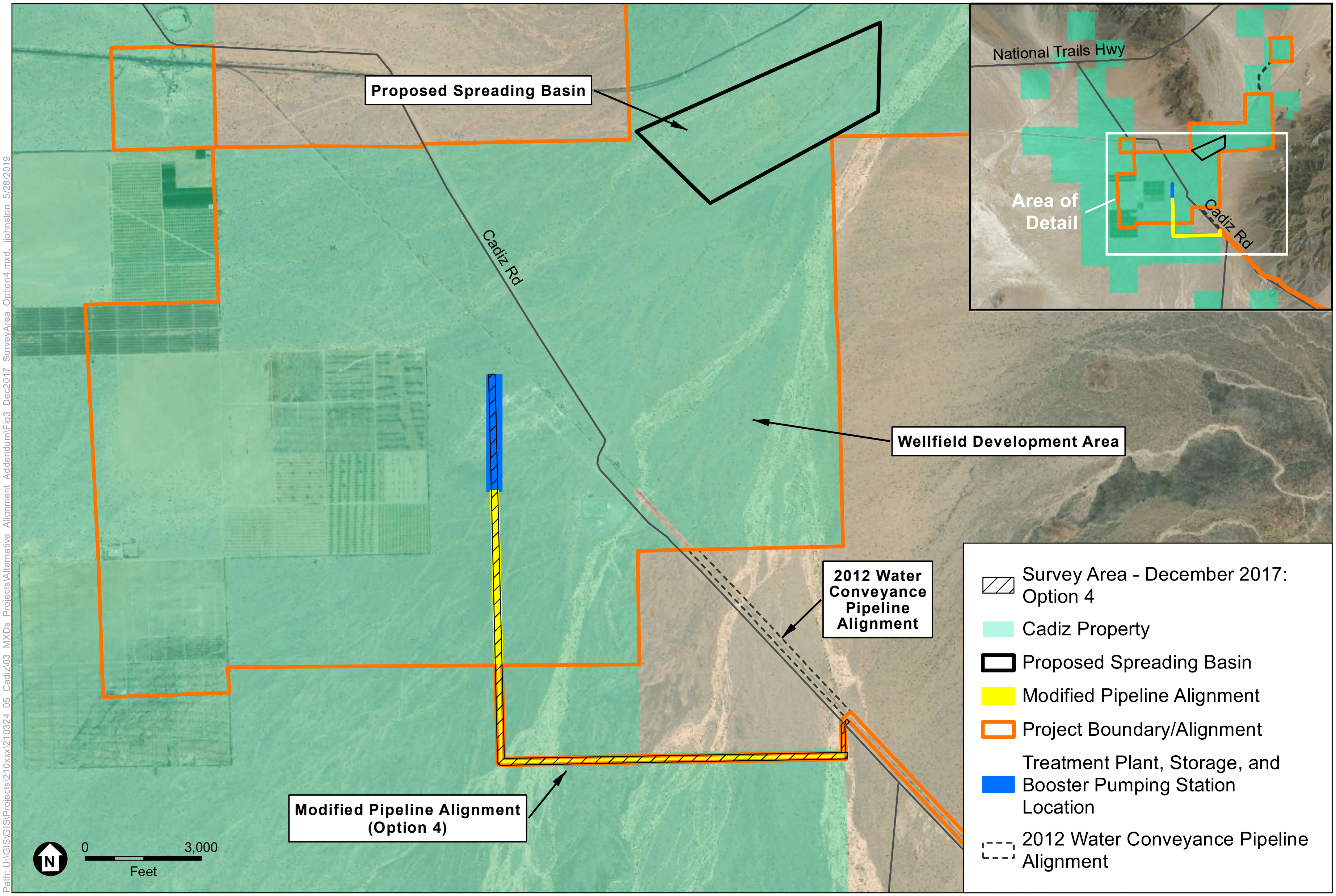
ESA



SOURCE: ESRI

Cadiz Groundwater Project

Figure 2
Survey Areas, December 2017



SOURCE: ESRI

Cadiz Groundwater Project

Figure 3
Survey Area, December 2017: Option 4

ESA

Preliminary Jurisdictional Drainage Map of Revised Pipeline Alignment Segment

SOURCE: ESRI

Cadiz Groundwater Project

Figure 1
Modified Pipeline Alignment – Potential Jurisdictional Waters
Map Page 1

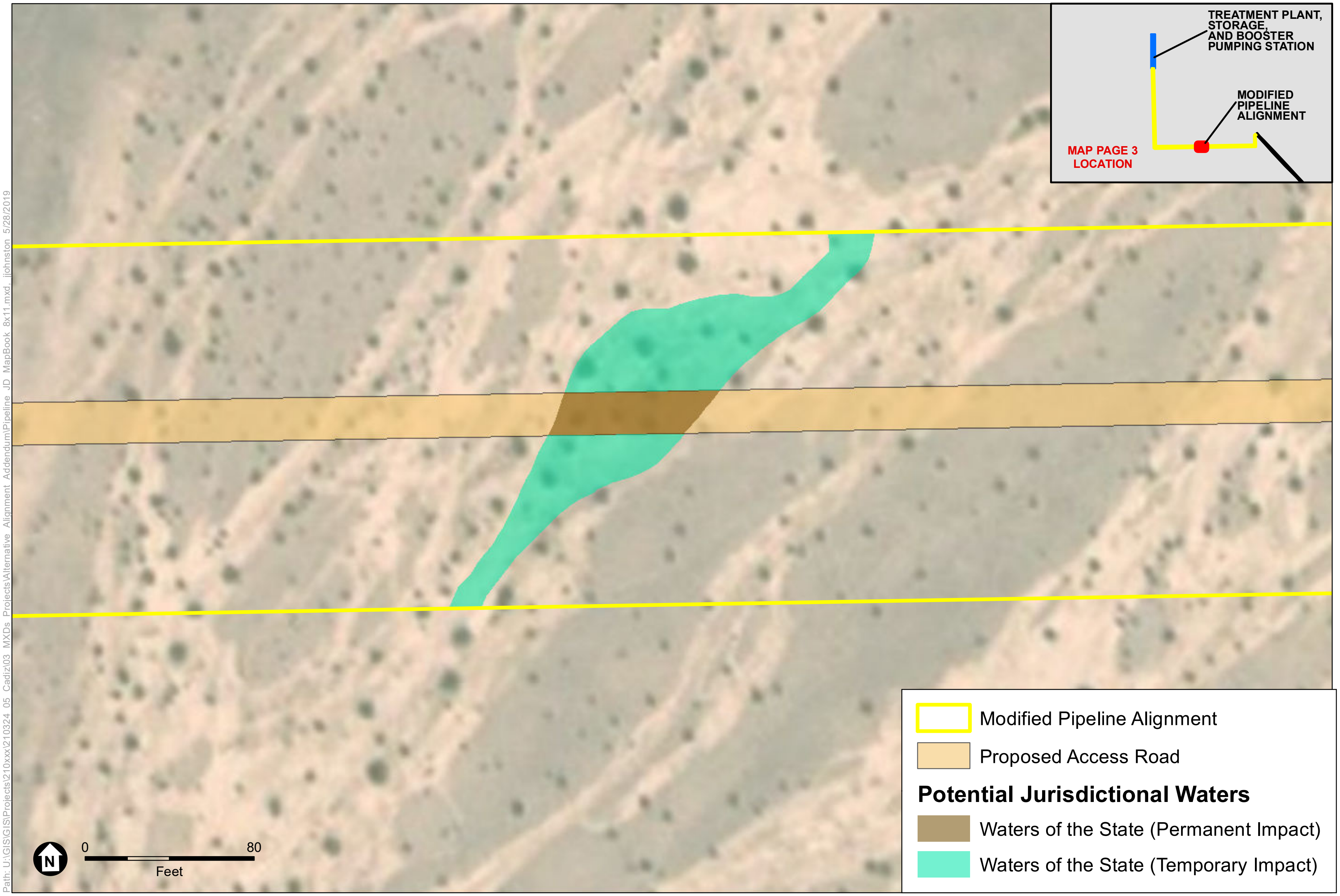
ESA

SOURCE: ESRI

Cadiz Groundwater Project

Figure 2
Modified Pipeline Alignment – Potential Jurisdictional Waters
Map Page 2

ESA

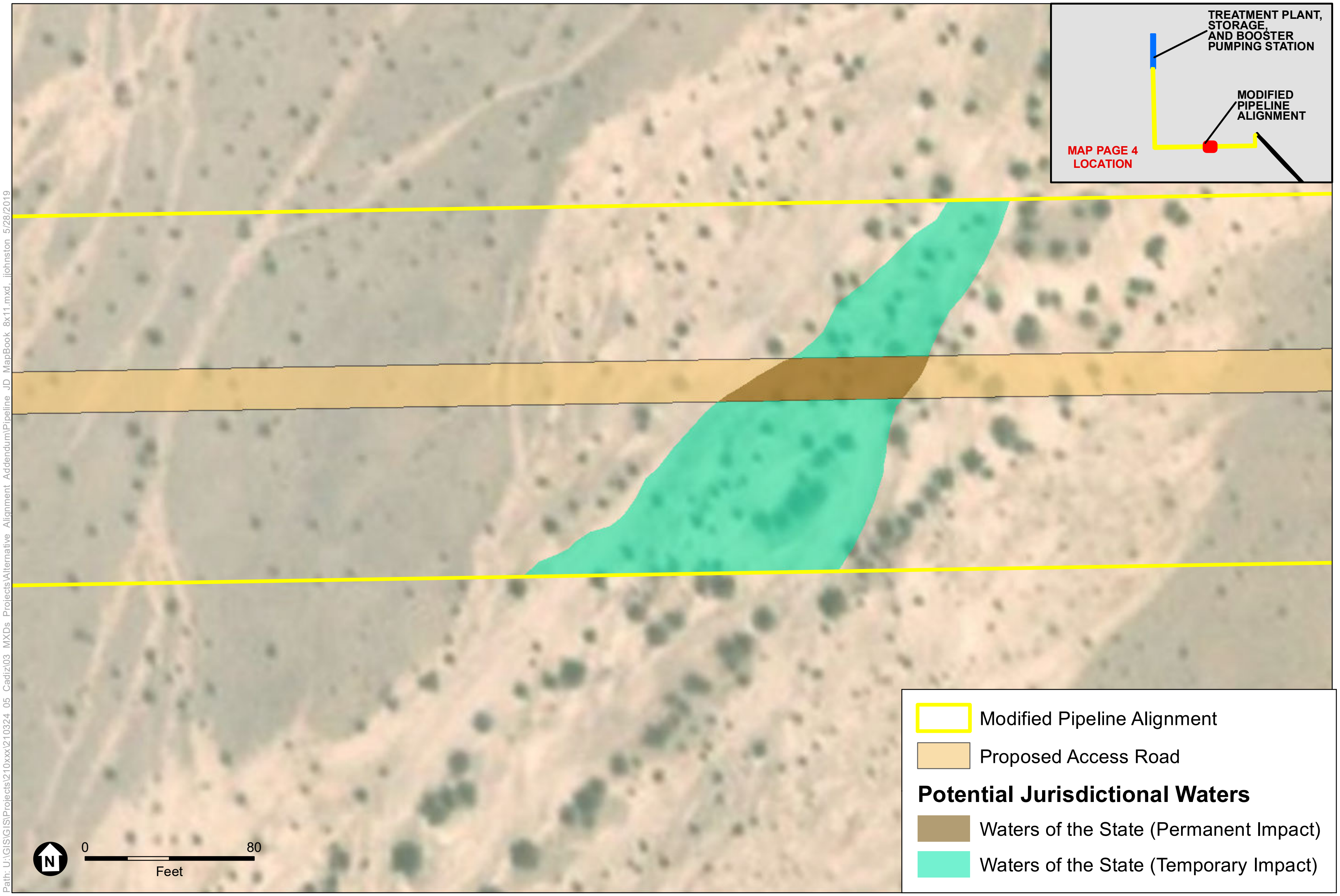


SOURCE: ESRI

Cadiz Groundwater Project

Figure 3
Modified Pipeline Alignment – Potential Jurisdictional Waters
Map Page 3

ESA



SOURCE: ESRI

Cadiz Groundwater Project

Figure 4
Modified Pipeline Alignment – Potential Jurisdictional Waters
Map Page 4

ESA

SOURCE: ESRI

Cadiz Groundwater Project

Figure 5
Modified Pipeline Alignment – Potential Jurisdictional Waters
Map Page 5

ESA

Path: U:\GIS\GIS\Projects\210xxx\210324 05 Cadiz\03 MXDs Projects\Alternative Alignment Addendum\Pipeline JD MapBook 8x11.mxd, jjohnston 5/28/2019

SOURCE: ESRI

Cadiz Groundwater Project

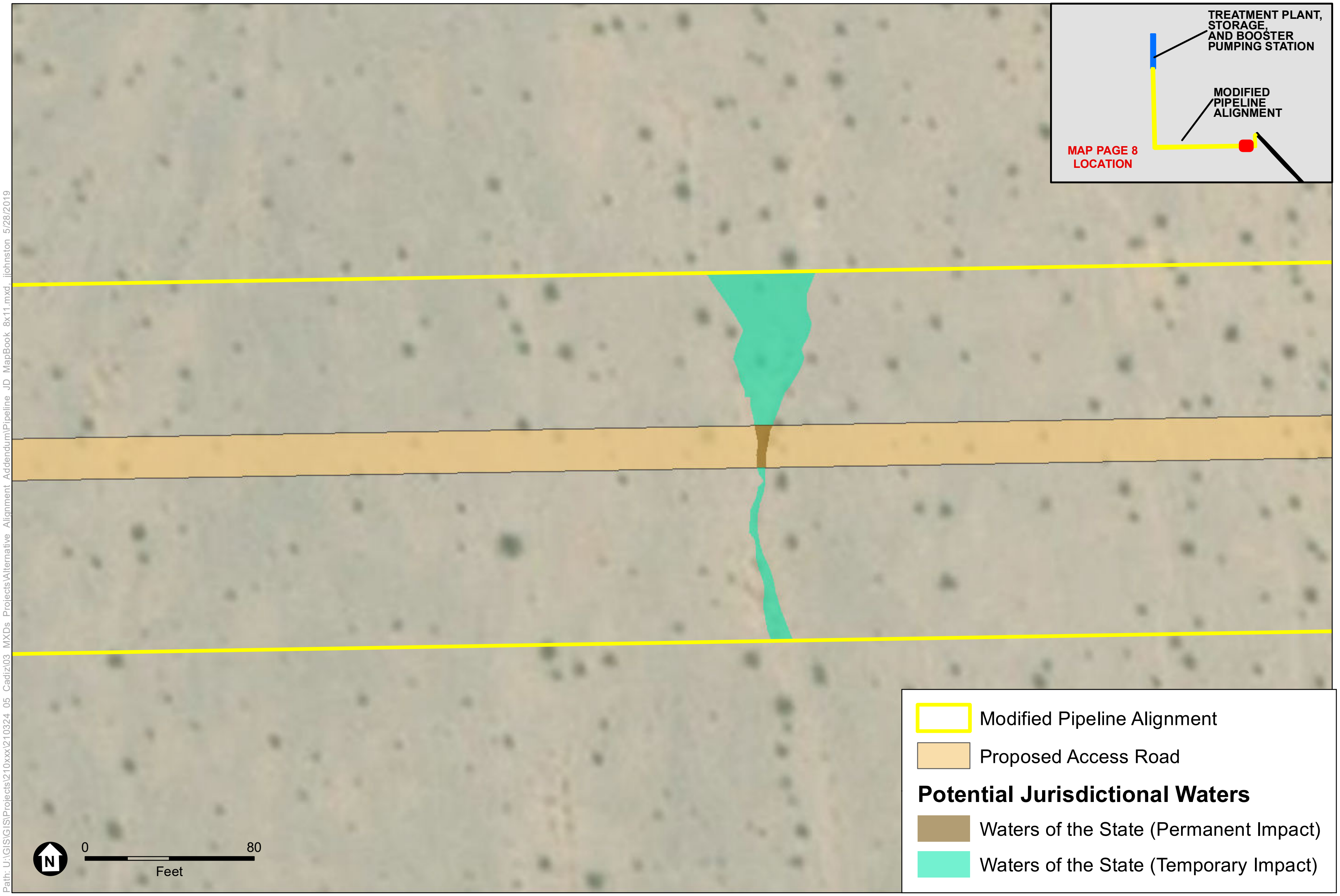
Figure 6
Modified Pipeline Alignment – Potential Jurisdictional Waters
Map Page 6

ESA

SOURCE: ESRI

Cadiz Groundwater Project

Figure 7
Modified Pipeline Alignment – Potential Jurisdictional Waters
Map Page 7

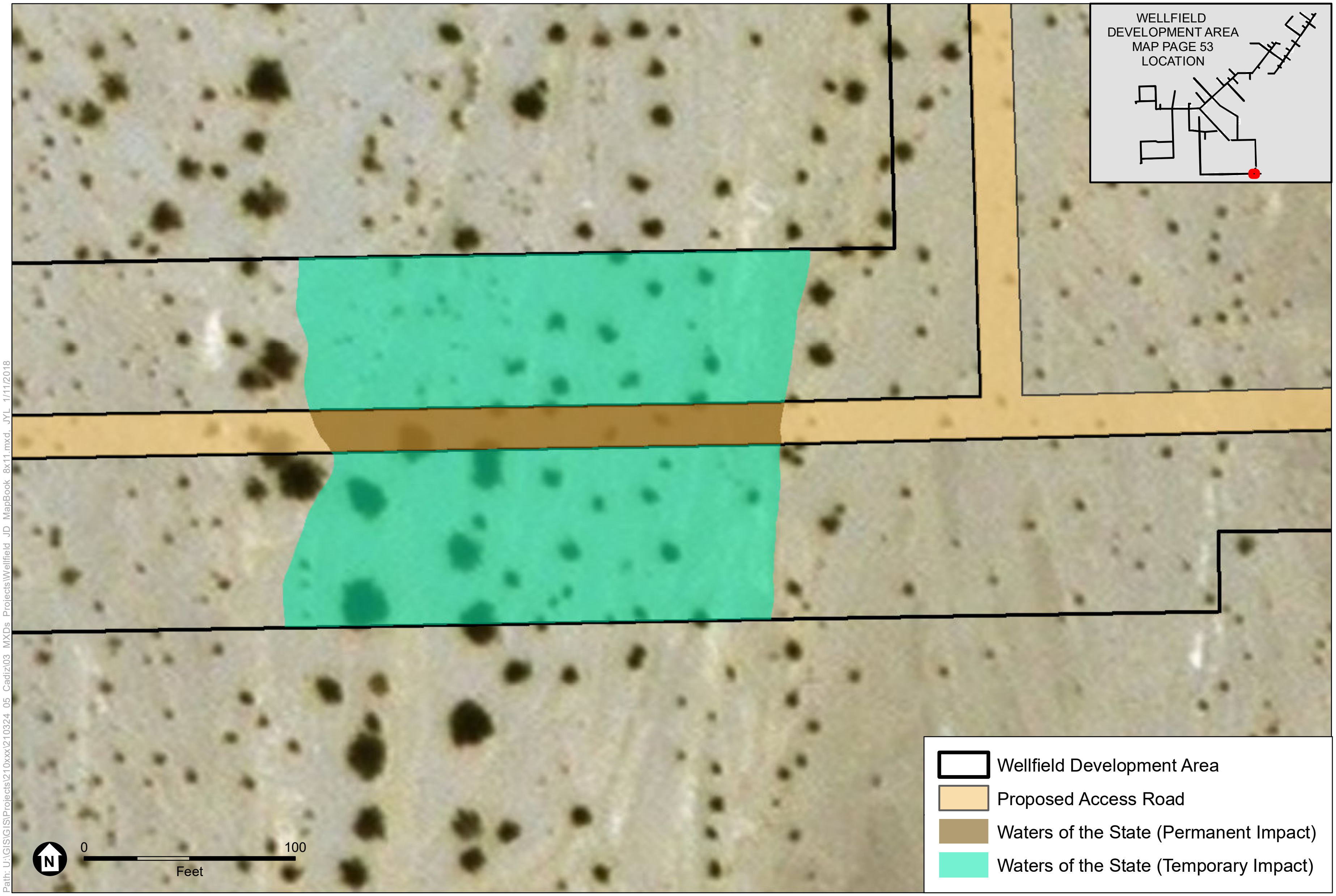


SOURCE: ESRI

Cadiz Groundwater Project

Figure 8
Modified Pipeline Alignment – Potential Jurisdictional Waters
Map Page 8

ESA



SOURCE: ESRI

Cadiz Groundwater Project

Figure 9
Modified Pipeline Alignment – Potential Jurisdictional Waters
Map Page 9

ESA

Appendix D
Natural Springs Reports

ENVIRONMENTAL FORENSICS, 2018
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Understanding the source of water for selected springs within Mojave Trails National Monument, California

Andy Zdon, PG, CHg, CEG[a], M. Lee Davisson, PG[b] and Adam H. Love, Ph.D.[c]

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ABSTRACT

While water sources that sustain many of the springs in the Mojave Desert have been poorly understood, the desert ecosystem can be highly dependent on such resources. This evaluation updates the water resource forensics of Bonanza Spring, the largest spring in the southeastern Mojave Desert. The source of spring flow at Bonanza Spring was evaluated through an integration of published geologic maps, measured groundwater levels, water quality chemistry, and isotope data compiled from both published sources and new samples collected for water chemistry and isotopic composition. The results indicate that Bonanza Spring has a regional water source, in hydraulic communication with basin fill aquifer systems. Neighboring Lower Bonanza Spring appears to primarily be a downstream manifestation of surfacing water originally discharged from the Bonanza Spring source. Whereas other springs in the area, Hummingbird, Chuckwalla, and Teresa Springs, each appear to be locally sourced as "perched" springs. These conclusions have important implications for managing activities that have the potential to impact the desert ecosystem.

KEYWORDS

Water resources; clipper mountains; bonanza spring; groundwater; forensics; isotopes

Introduction

General information and data regarding springs in the Mojave Desert are sparse, and many of these springs are not well understood. Bonanza Spring rises in the Clipper Mountains within the newly established Mojave Trails National Monument, San Bernardino County, California (Figure 1). Bonanza Spring is within the southeastern Mojave Desert, a sparsely populated area, and has generally been assumed to be a perched spring disconnected from the basin-fill aquifer system. Rapid growth and competition for water resources in the Mojave Desert is an ongoing issue and results in the need for a balancing of competing uses and priorities. These include providing water to an expanding population, preserving water-dependent ecological resources, and expanding needs of water for commercial development including alternative energy generation facilities.

In the case of Bonanza Spring, substantial groundwater development is proposed for export out of the region. Proposed groundwater development in this area is anticipated to be in excess of the groundwater recharge to the basin, resulting in basin aquifer drawdown from pumping with upgradient impacts to groundwater elevations above Bonanza Spring. Identification of future impacts from water resource utilization becomes problematic if initial baseline conditions are unknown or poorly understood. This analysis was performed with the intent to better understand the water source that sustains Bonanza Spring, neighboring Lower Bonanza Spring, and the desert ecosystem that is dependent on those resources. Bonanza Spring is the largest spring in the southeastern Mojave Desert. Despite its large size relative to other springs, Bonanza Spring is a fifth–sixth magnitude spring (Kresic, 2010), with its surface flow, not inclusive of evapotranspiration, varying around 10 gallons per minute. Small springs such as those identified in this investigation, frequently get overlooked in hydrologic investigations since their discharges are commonly inconsequential to the overall water budget of the area being studied. Such oversight is problematic when evaluating the sensitivity of critically important resources for vegetation and wildlife, both resident and migratory. Bonanza spring supports a substantial riparian area that belies its relatively small surface expression of water flow (Figure 2). That the spring is perennial is indicated by the presence of freshwater snails (*Physidae* sp.) that are

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Color versions of one or more of the figures in the article can be found online at www.tandfonline.com/uenf.

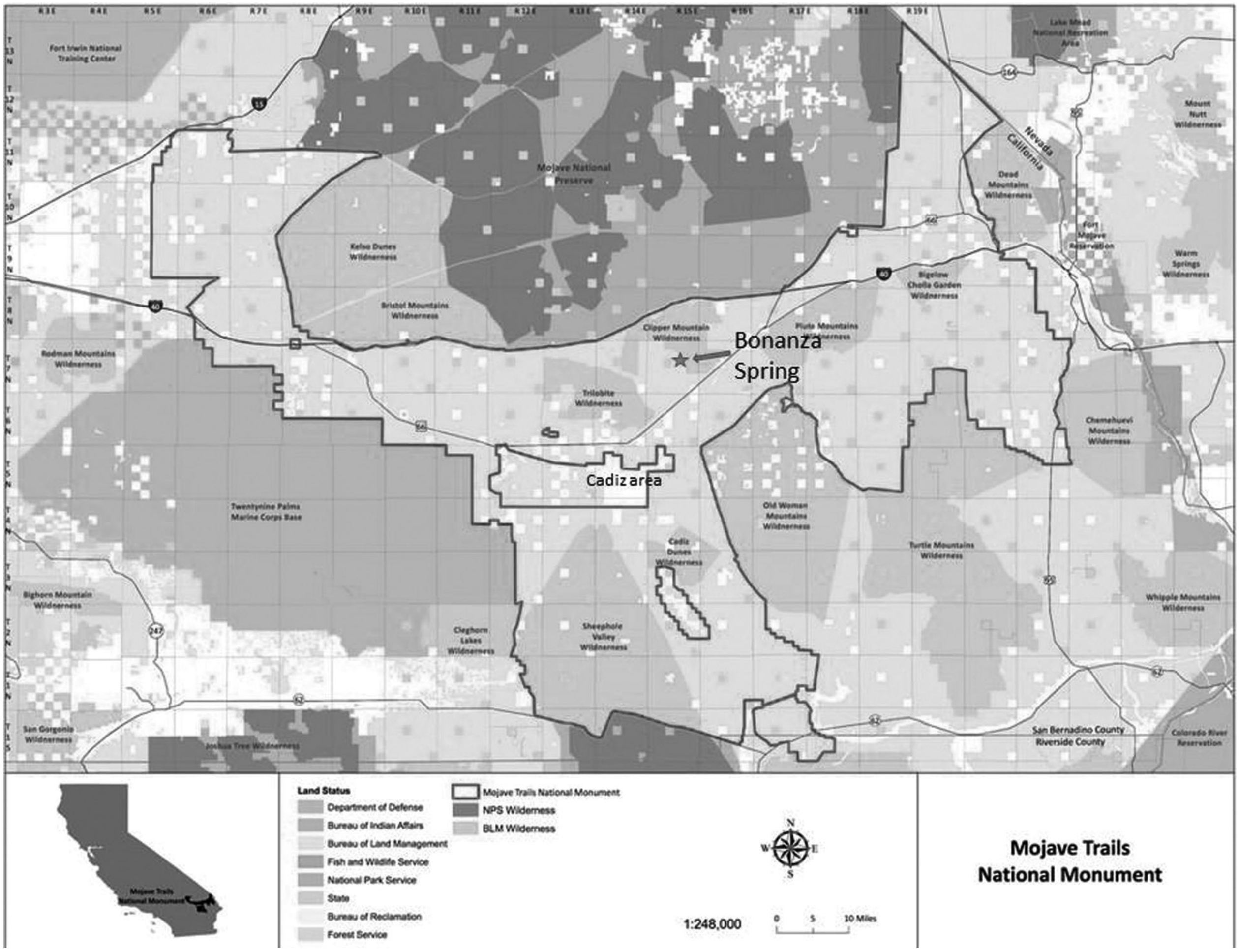

Figure 1. Location of Bonanza Spring within Mojave Trails National Monument (adapted from Wilderness Society, 2017).

reliant on fresh water to survive. These invertebrates are currently being identified to species level (Parker, 2017, pers. comm.) as many of these invertebrates can be endemic to the springs they live in.

While detailed regional hydrogeologic investigations in the Mojave region are typically sparse, the exception to this is in the area southwest of Bonanza Spring. This area of the Mojave has received attention because of the proposed Cadiz groundwater storage and recovery project (e.g., Metropolitan Water District of Southern California, 2001; Davisson, 2000; Davisson and Rose, 2000; CH2M Hill, 2011; and Geoscience Support Services, 2011). More recently, a Mojave Desert-wide spring survey (Andy Zdon & Associates, 2016) was completed on lands managed by the U.S. Bureau of Land Management (BLM) that included springs in the Clipper Mountains (Bonanza Spring, Lower Bonanza Spring, Hummingbird Spring, Lost Dutch Oven Spring, Falls Spring, Burnt Spring, and Chuckwalla Spring). Other springs of interest in the area include Vernandyles and Theresa Springs in the Marble Mountains, and the numerous springs in the Old Woman Mountains. These springs have been assumed in the past to be local springs – perched springs that rise as a result of surfacing of water that is recharged within its local watershed and not in communication with aquifers of more regional extent. The areas of the local watersheds for each of the key springs evaluated for this investigation are

Figure 2. Photograph of Bonanza Spring.

approximately 50 acres for Bonanza Spring (and Lower Bonanza Spring), 147 acres for Hummingbird Spring, 25 acres for Teresa Spring, and 20 acres for Chuckwalla Spring.

Due to the striking differences in physical character between Bonanza Spring and other springs in the Clipper Mountains, this study sought a greater understanding of Bonanza Spring and the causes for its physical differences.

Previous studies

Hydrologic investigations in the California desert have generally been focused on answering inquiries regarding a specific need. In the Bonanza Spring area (southeastern Mojave Desert), there have been three phases of investigation, as follows: 1) an early reconnaissance phase during the early decades of the 20th century, conducted to identify presence or absence of available water at springs and other desert waterholes to facilitate safe travel, and to identify potential bases of operation for more detailed scientific investigations in the region (Zdon, 2013); 2) investigations related to development of a water resource available for export (what is today known as the Cadiz Project). Investigations related to the Cadiz project have focused on the wellfield production and potential impacts to the alluvial aquifer in the Fenner Valley Groundwater Basin and surrounding hydrologically-linked groundwater basins; and 3) a recent effort to comprehensively document and understand individual springs on public lands throughout the region.

The early reconnaissance phase investigations in this area were conducted by Mendenhall (1909) and Thompson (1921, 1929). Mendenhall described the presence of Bonanza Spring in general terms and noted that the spring was in use by prospectors at that time. Thompson (1929) noted the presence of Bonanza Spring as a spring that yielded about 10 gallons per minute (similar to what it produces currently) that was piped to the community of Danby for use at the railroad. Thompson also noted the presence of other springs along the southern front of the Clipper Mountains including one spring near the Tom Reed Mine (likely what is known today as Burnt Spring) and another spring which may be what is known today as the perennial "Hummingbird Spring." Moyle (1967) and Freiwald (1984) provided general descriptions of the regional geologic and hydrologic conditions in the project area.

Hydrogeological investigations associated with the Cadiz groundwater development project have been summarized in the environmental impact reports (e.g., Santa Margarita Water District, 2012; Metropolitan Water District of Southern California, 2001) that have been prepared for the proposed project and attached technical reports and documents. These investigations have occurred over several decades and the project-specific literature is substantial. Of principal note related to the current project are geochemical and recharge-estimation investigations by Lawrence Livermore Laboratory (Davisson and Rose, 2000), a limited field spring survey conducted in the Marble Mountains to support the draft environmental impact report (Kenney Geoscience, 2011) and an assessment associated with potential project-related impacts to springs (CH2M Hill, 2011). The field activities associated with these groundwater development related investigations were on a reconnaissance level and few springs in the Clipper Mountains, and neither of the springs in the Marble Mountains (Theresa and Vernandyles), were identified.

During 2015 and 2016, a spring survey was conducted (Andy Zdon & Associates, 2016) for U.S. BLM lands in their Needles, Barstow, and Ridgecrest Districts (Bonanza Spring is within their Needles District). Information regarding the location and physical characteristics of the springs in this study was found in the files of the Needles District of the BLM (U.S. Bureau of Land Management [BLM], 2015). For the purposes of that investigation, 436 springs were identified of which 312 were inspected during the period from September 2015 through February 2016. Of that number, two springs were identified in the Marble Mountains (one spring, Theresa Spring has had surface flow on two visits with substantial signs of Desert Bighorn Sheep activity and wildlife-watering infrastructure present) and seven springs were identified in the Clipper Mountains (including Bonanza Spring and Lower Bonanza Spring), shown in Figure 3.

Data collected at springs visited during the 2015–16 spring survey included measurement of field water quality parameters and sampling for stable isotope analysis on all springs where surface water was present. Surface water was present at Bonanza, Lower Bonanza, Hummingbird, and Chuckwalla Springs in the Clipper Mountains, and Theresa Spring in the Marble Mountains. These springs with surface water present are investigated in more detail in the current investigation. Surface water presence has also been documented at Vernandyles Spring in the Marble Mountains and the remaining springs noted in the Clipper Mountains. Several of these springs were not visited during the spring survey but were described based on BLM file records (U.S. BLM, 2015) and remote imagery.

Geologic framework

Bonanza Spring is located at an elevation of 2,105 feet above mean sea level. Average annual temperatures at the

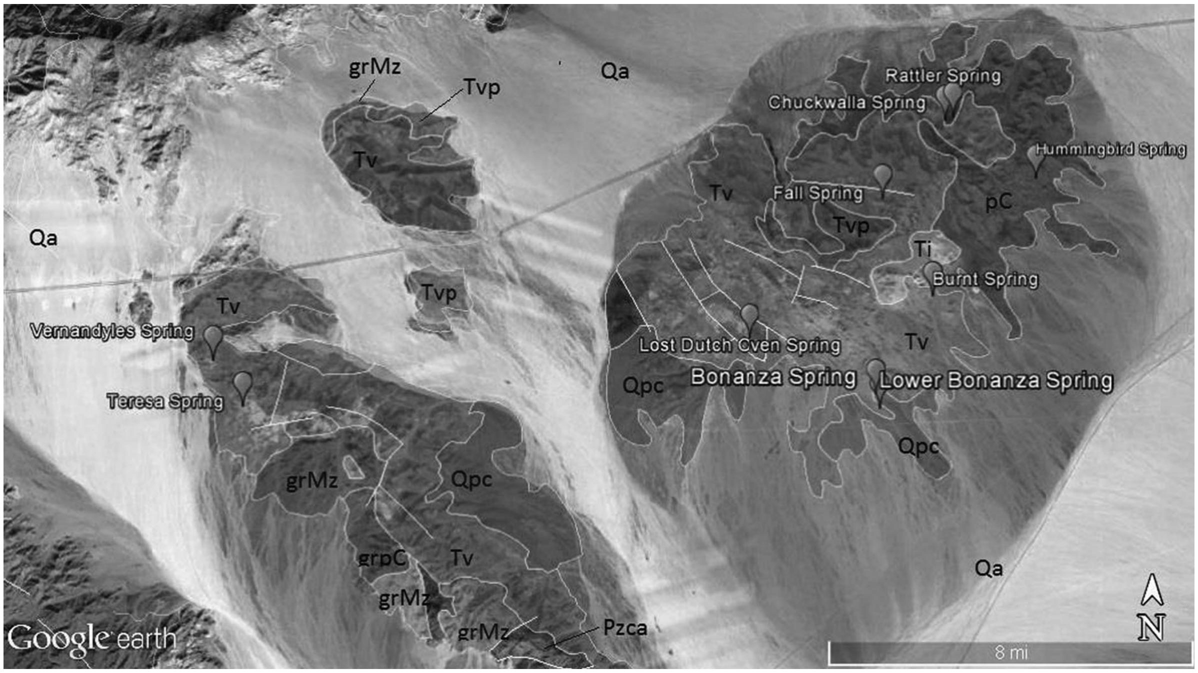

Figure 3. Geologic map and spring locations (adapted from California Department of Conservation, 2017) Qa Quaternary-aged alluvium (unconsolidated basin fill) Qpc Quaternary-aged older alluvium (sandstone, conglomerate) Tv Tertiary-aged volcanic rocks (rhyolite, basalt) Tvp Tertiary-aged volcanic rocks (rhyolite, dacite) Ti Tertiary-aged hypabyssal rocks grMz Mesozoic-aged granitic rocks Pzca Paleozoic-aged carbonate rocks pC Precambrian-aged metamorphic rocks grpC Precambrian-aged granitic rocks *Faults presented as white lines on map.

closest nearby meteorological stations with long-term records are 17.1°C (62.8°F based on a record from 1958 to 2011) at Mitchell Caverns in the Providence Mountains (elevation 4,350 feet above mean sea level), and 23.1°C (73.6°F based on a record from 1941 through 2016) at Needles in the Colorado River Valley to the east (elevation 890 feet above mean sea level). Since Bonanza Spring lies at an intermediate elevation to these two stations, an average annual temperature at Bonanza Spring of 21.0°C (69.8°F) is estimated for the purposes of comparing average ambient temperature to spring temperature.

Regionally, there is a northwest trending fault zone with a secondary east to west trend also present, all parallel to the prevailing structural regime. The geologic units in the region are very diverse, ranging from Precambrian metamorphic rocks to Tertiary-aged volcanic rocks and playa and alluvial deposits in the valley floors (Figure 3).

In the Clipper Mountains, the principal rock types present are Tertiary volcanic rocks consisting of rhyolite, andesite, basalt, and other pyroclastic rocks. These rocks comprise the bulk of the range including the highest elevations. They are the only outcropping rock unit comprising the western half of the Clipper Mountains. Elsewhere in the Clipper Mountains, Precambrian granitic and gneissic rocks outcrop (generally in the eastern third of the Clipper Mountains, and are present immediately below Hummingbird Spring serving as a restriction to flow forcing water to the surface). A small area of Tertiary-aged intrusive hypabyssal rhyolite and andesite is also present near Hummingbird Spring (Bishop, 1963). Hypabyssal rocks are intrusive rocks, emplaced at shallow to medium depth, having characteristics more like their extrusive, volcanic counterpart.

The rocks in the Clipper Mountains are cut by a series of roughly parallel, northwest trending faults. Due to the level of geologic mapping (only in rock units), the faults are mapped as ending at the alluvial interface, although it is likely they extend further. One of these faults trends southeast toward Bonanza Spring and extends northwest toward Clipper Valley.

The Clipper Mountains are surrounded by the broad desert valleys consisting of Fenner Valley to the south and east, the Clipper and Lanfair Valleys to the north, and the Cut Wash valley area that separates the Clipper Mountains from the Marble Mountains to the west. The valley areas are covered by coalescing alluvial fans forming broad slopes between surrounding mountains and the valley floors. The surrounding mountain ranges generally consist of the Marble Mountains to the west comprised of Tertiary-aged volcanic rocks and Lower Cambrian sedimentary rocks; the Providence Mountains comprised of diverse rock types to the northwest, the primarily granitic New York Mountains to the north, the

Piute Mountains to the east that are comprised of Precambrian igneous and metamorphic, and Tertiary-aged volcanic rocks, and the Old Woman Mountains to the south that are comprised largely of Precambrian igneous and metamorphic rocks (Bishop, 1963).

Hydrogeology

The principal surface water bodies in the Bonanza Spring area (primarily Clipper and Marble Mountains) are the springs in the region (Figure 3) and the playas in the vicinity of Cadiz Valley to the southwest that receive water during occasional summer and winter precipitation events that eventually evaporates. Generally, most of the springs in the Mojave Desert are "local" or "perched" springs that are the result of precipitation in their local watershed that percolates into the ground, only to reach the surface where bedrock restrictions to underflow force water to the surface. They are typically in wash bottoms, or may form small, intermittent seeps on hillsides. These local springs are wholly dependent on flow within their respective watershed. Generally, there will be no planar, perched groundwater-table that extends across ridges and valleys in these desert ranges. Larger, perennial springs may be observed along geologic structures or along geologic contacts and are in hydraulic communication with regional aquifer systems including basin-fill aquifers.

The direction of groundwater movement usually parallels the slope of the ground surface, from points of recharge in the higher elevations to points of discharge such as springs, or evapotranspiration from the salt-encrusted playas. In the Bonanza Spring area, groundwater underflow moves southward from the New York and Providence Mountains generally at elevations above the Bonanza Spring (Geoscience Support Services, 2011), southward toward Fenner Valley then southwest to Cadiz Valley. Davisson and Rose (2000) described the New York and Providence Mountains as a source of recharge to the Fenner Valley and beyond. Precipitation and periodic snowmelt runoff from the higher surrounding mountains recharge the basin alluvium.

In the Clipper Mountains, sparse water runoff from the south slope will flow toward Fenner Valley where it will either percolate back into the subsurface, evaporate, or in larger runoff events such as flash floods resulting from summer monsoonal rainfall events, reach the Fenner Valley floor and continue southwest toward the playa in Cadiz Valley. Most springs in the Clipper Mountains are located on the south-facing slopes (including Bonanza Spring). Sparse runoff on the north side of the Clipper Mountains will flow northward toward Clipper Valley, and then eventually southward around the east or west ends of the range.

Based on the field reconnaissance activities that have been conducted for this investigation and those previously (Andy Zdon & Associates, 2016), it appears that the springs in the Clipper Mountains emanate from multiple sources. These sources include independent locally perched, and regional basin systems. In the case of Bonanza Spring, field reconnaissance suggests a more complex sourcing.

Bonanza Spring rises along a structural trend at the interface of volcanic rocks and older basin fill deposits along the south side of the Clipper Mountains. The spring is within the low foothills of the southwest margin of the Clipper Mountains. The principal massif of the Clipper Mountains lies to the east, with drainage from substantially higher elevations and of larger topographic extent. Springs along this more mountainous area are of substantially smaller size than Bonanza Spring (with flow typically less than one gallon per minute). Downgradient from Bonanza Spring is Lower Bonanza Spring. This is likely a resurfacing of flow from Bonanza Spring along with possible additional seepage from the underlying formations. There is a substantial riparian area covering more than five acres for the spring complex that is anomalous given the limited watershed/catchment for the spring (approximately 50 acres) and is indicative of a regional source. In comparison, Hummingbird Spring to the east has a much larger catchment extending to near the crest of the range, and with a more substantial bedrock restriction to flow, but with much less flow suggestive of a local source. Additionally, Bonanza Spring has exhibited a relatively steady flow that has been noted back to that reported by Thompson in 1929, which contrasts with other area springs with more seasonal flow. A spring flow system that is more regional in nature would leave Bonanza Spring potentially more susceptible to regional pumping impacts than springs such as Hummingbird.

Methods

For this analysis, water samples collected from Bonanza Spring, Lower Bonanza Spring, Hummingbird Spring, and Teresa Spring were analyzed for general minerals, trace metals (conducted by Alpha Analytical, Inc., in Sacramento, California) and stable isotope, and tritium (conducted by Isotech Analytical Laboratories, Inc., in Champaign, Illinois).

Samples for general minerals analysis were collected in 1-L high-density polyethylene (HDPE) sample bottles provided by the laboratory (no preservative was used). Samples for trace metals were collected in 250-mL

HDPE sample bottles provided by the laboratory (nitric acid preservative was used). Samples were maintained on ice and shipped to the laboratory in proper holding times (with the exception for nitrate).

Samples for oxygen and hydrogen isotopes were collected in 1-L HDPE sample bottles provided by the laboratory. Samples were shipped to Isotech Laboratories in Champaign, Illinois where the $^{18}O/^{16}O$ and D/H ratios were measured as a gas using standardized mass spectrometry methods. Tritium (^{3}H) analysis was conducted using the tritium enhanced enrichment (TEE) method to obtain lower reporting limits. Tritium can be used qualitatively for dating groundwater as substantial increases in atmospheric ^{3}H was produced as a result of nuclear bomb testing beginning in the late 1940's and early 1950's. The presence of ^{3}H in groundwater is then indicative of the modernity of that water. Tritium is expressed in absolute concentration using tritium units (TU).

As is standard, the oxygen and hydrogen isotope results are reported as normalization to Standard Mean Ocean Water (SMOW), which is an internationally recognized standard in stable isotope analysis, and expressed in δ ("del") notation following its convention. Values for "del" are typically reported as negative numbers where lighter isotopic compositions have larger "del" values.

During site visits, field water quality parameters of temperature, pH, electrical conductivity, and dissolved oxygen were measured at the sources of the springs. Field instruments were checked for calibration daily, if not at higher frequencies.

Results

Geochemistry

Groundwater quality in the Clipper Mountains area tends toward moderate total dissolved solids contributed by appreciable levels of sulfate and bicarbonate. To place this water quality in context, more regional data were compiled from Andy Zdon & Associates (2016), U.S. Geological Survey (2017), Metropolitan Water District of Southern California (2001), and Davisson (2000). A piper diagram of Bonanza Spring waters and regional waters are provided in Figure 4.

Spring water at Bonanza Spring is a Na-HCO_3 type (this is consistent with water at Lower Bonanza Spring as well). This is similar to most waters in the region except those waters at Hummingbird Spring (Ca-HCO3 type). The total dissolved solids concentration in water from Lower Bonanza Spring was nearly three times that of that from the Bonanza Spring source and likely indicates that Lower Bonanza Spring is a more evaporated form of Bonanza Spring water that is present as spring outflow resurfaces downstream of the spring source. Of note is that while Hummingbird Spring appears to be a local spring, located within the same geologic units from which Bonanza Spring resides, Hummingbird Spring's water are different in chemical character (greater relative calcium abundance).

The Bonanza Spring water is also similar in type to waters from the basin fill in the Fenner and Cadiz Valleys (Mathaney et al., 2012; Metropolitan Water District of Southern California, 2001). Water from Teresa Spring in the Marble Mountains was also noted to be a Na-HCO_3 type. Field water quality parameters noted for Bonanza Spring were a temperature of 27.5°C, or 81.5°F, with a pH of 7.83, and electrical conductivity of 675 μS. Of note is the temperature of the water being considerably higher than that measured during the same sampling event at Lower Bonanza Spring (24.5°C or 76.1°F), Hummingbird Spring (23.8°C or 74.8°F), and Teresa Spring in the Marble Mountains (19.2°C or 66.6°F). Shallow groundwater temperatures will typically mimic the average annual ambient air temperature at that location. For Bonanza Spring, the water directly at the source location is 6.5°C warmer than the average annual temperature. This indicates that the water at Bonanza Spring has been at significant depth below ground surface during its history. Subsurface temperatures are affected by climatic conditions to depths of about 100 feet below surface. As has been reported in Nevada (but is likely comparable at this location), below 100 feet, normally temperatures increase about 1°F every 55 feet (Garside and Schilling, 1979). This indicates that the water issuing from Bonanza Spring has been at a depth of at least 750 feet below ground surface. This would be a low estimate of depth below ground surface as it can be assumed that some cooling of the water would have occurred as it reached the surface where the water temperature was measured. It is unclear how groundwater in an unconfined, perched setting could fall as precipitation, reach the local groundwater surface at depths more than 750 below the source of Bonanza Spring, only to rise to ground surface and discharge to the surface, all in such a limited area of approximately 50 acres.

Of note is that Davisson and Rose (2000) assumed the local catchment for Bonanza Spring as being the whole of the Clipper Mountains although this is very unlikely as it would require substantial volumes of water to flow laterally across the distant range-front of the Clipper Mountains and across several geologic northwest-trending geologic structures, instead of following the path of least resistance down-slope toward the basin fill.

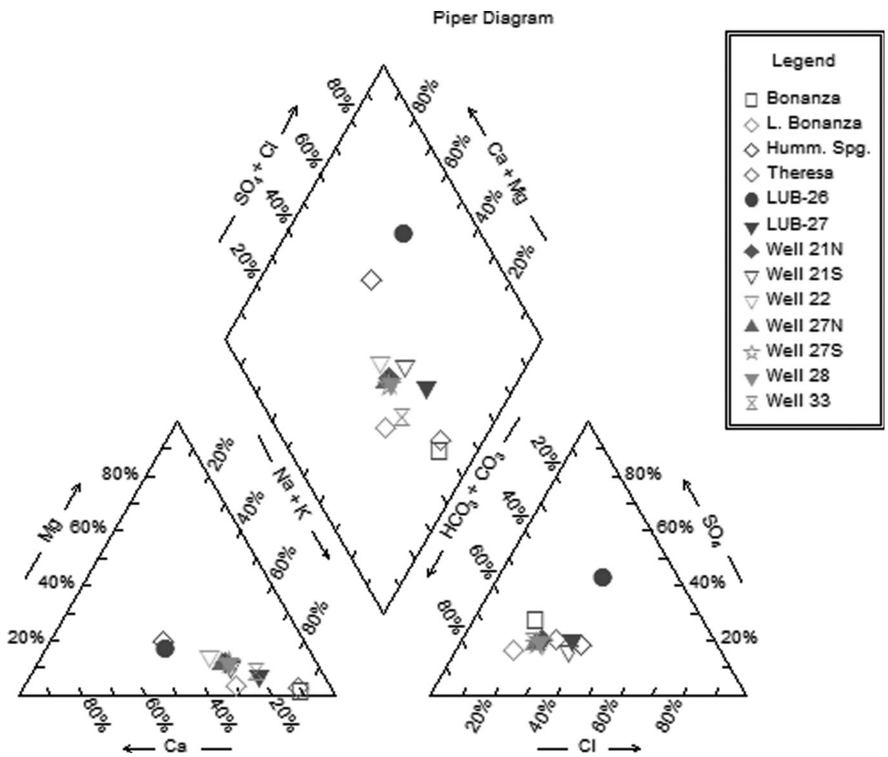

Figure 4. Piper diagram of waters in the region. Includes springs, Cadiz wells (numbered wells 21N through 33; USGS GAMA Wells LUB-26 in Mojave National Preserve south of New York Mountains and LUB-27 (Chambless, CA).

Isotopic composition

The $\delta^{18}O$ and δD abundances in precipitation systematically vary with increasing latitude and elevation. This results in lower $\delta^{18}O$ and δD isotope values at higher elevations and further distance inland in general. Additionally, this results in lower $\delta^{18}O$ and δD values in groundwater from north to south from central Nevada to southeastern California (Davisson et al., 1999). There is also a regional effect where monsoonal precipitation occurs in areas north of the Gulf of California, causing precipitation in higher elevation areas of the Mojave Desert. This summer monsoonal rain has higher isotope values than winter season equivalents because of warmer temperatures (Zdon et al., 2015). These same effects provide a means to use these patterns to potentially derive recharge sources of groundwater in the Bonanza Spring area. This methodology has been used previously in the area (Davisson, 2000) to evaluate source areas for groundwater in the Fenner Valley.

Andy Zdon & Associates (2. 6) sampled waters from springs for $\delta^{18}O$ and δD in the Clipper Mountains, Piute Mountains, Old Woman Mountains and Marble Mountains as part of their Mojave Desert-wide spring survey. That work provided a previously-lacking regional stable isotope dataset that assists in looking at individual locations in more detail. As part of this investigation, Bonanza Spring, Lower Bonanza Spring, Hummingbird Spring and Teresa Spring were sampled and also analyzed for other constituents including ^3H.

Overall, the variable precipitation sources yield a systematic difference in δD and $\delta^{18}O$ abundance in accumulated precipitation in the Mojave Desert. This has been demonstrated in previous work on multi-year annual precipitation collection throughout the Mojave (Friedman et al., 1992). In the work by Friedman and others, over seven years of annual precipitation was collected at 32 different sites ranging from approximately −200 to 7,500 feet elevation, as far north as the Owens Valley and south to the United States–Mexico border. Systematic variations were shown to exist in δD and $\delta^{18}O$ for annualized, wintertime, and summertime accumulations, consistent with the regional precipitation sources and elevation effects (Friedman et al., 1992).

Illustrated in Figure 5 is the contoured pattern of δD variations in wintertime precipitation from this previous work. Also mapped are spring locations where stable isotopes and their corresponding δD values were measured. Topographic effects on the δD values are seen in the contoured patterns where low δD values in precipitation occur north of the Transverse Ranges. Also δD values are low in the northern Mojave associated with northern winter storm tracks causing precipitation in areas such as Owens Valley. Furthermore, inspection of the

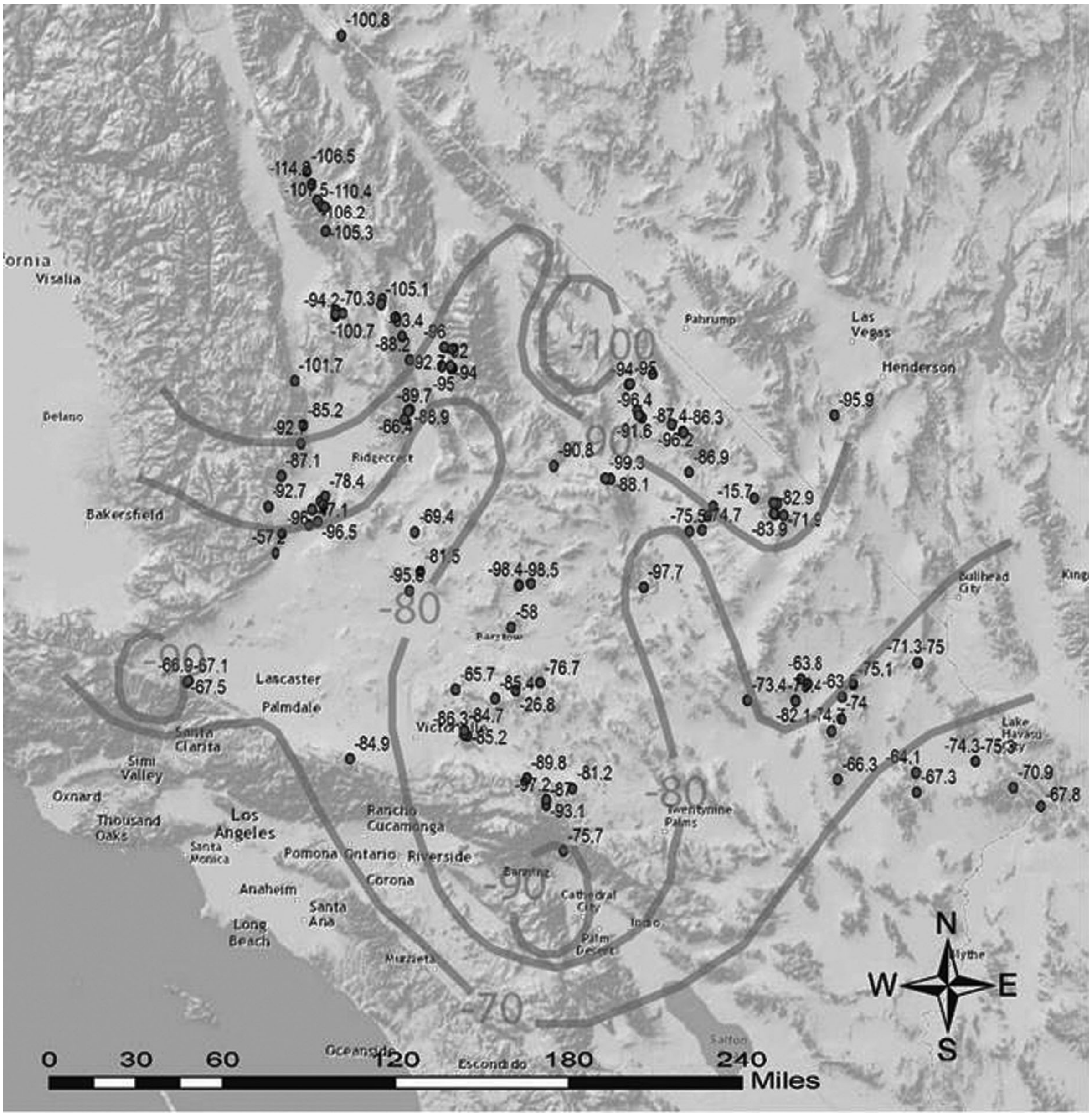

Figure 5. Contoured δD values of wintertime precipitation (orange lines) and compared to spring water δD values (red points). There is general correlation in regional isotopic values between wintertime precipitation and spring water abundance with the exception being where spring water is extensively evaporated or local topographic high elevation areas.

variation of springs' δD values plotted in Figure 5 shows a general correlation with these wintertime isotope precipitation patterns. Exceptions are where spring waters are extensively evaporated and caused enrichment of the isotope abundance (such as is frequently found in "local" springs, or in localized high elevation areas with lower δD values). Nevertheless, low δD values in both precipitation and spring water are prevalent in the northern Mojave Desert and high in the southeastern Mojave, suggesting spring water variations at this geographic scale are controlled by geographic position (Andy Zdon & Associates, 2016).

Friedman et al. (1992) also produced similar contour plots of summertime precipitation and mean annual precipitation isotope values. In both of these cases the general correlation with spring water isotope values is poor. Accordingly, the implication is that spring water sources in the Mojave reflect less of a mean annual precipitation source, but rather wintertime precipitation having the greater influence overall.

Andy Zdon & Associates (2016) illustrated the geographic dependence of isotope abundances in Mojave spring water by dividing the study region of that spring survey into four quadrants as shown in Figure 6.

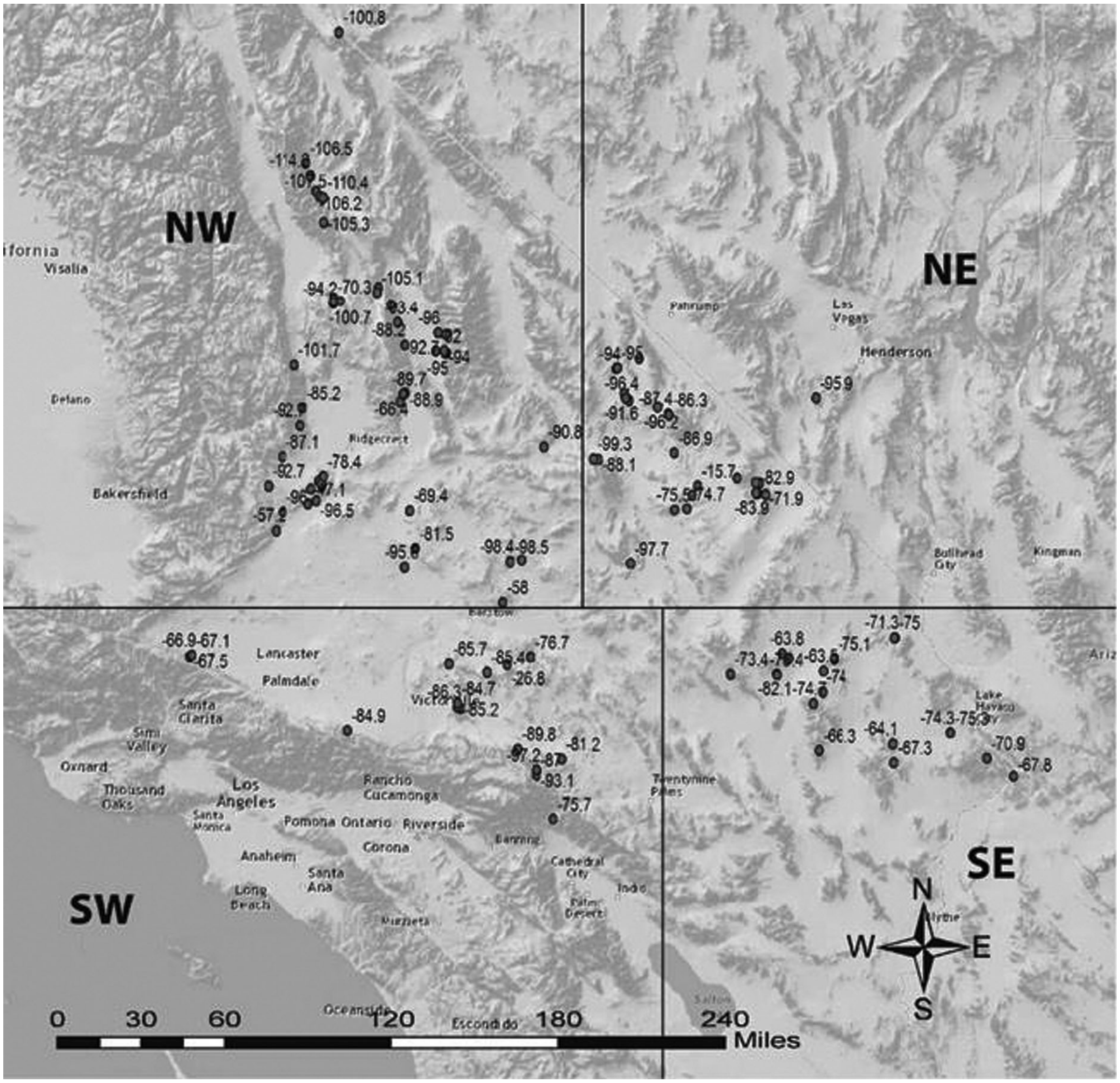

Figure 6. Mojave spring sample locations are separated into quadrants to cluster regional differences in precipitation sources.

Northwest, northeast, southwest, and southeast quadrants were defined that separate groups of springs as they might be influenced by summer monsoonal versus winter maritime precipitation sources. The quadrants presented are based on field measured stable isotope values from Mojave Desert springs and from precipitation patterns as described earlier.

Further in Figure 7, the values of δD and $\delta^{18}O$ in each quadrant are plotted compared to the Global Meteoric Water Line (GMWL). It is readily noted that the southern quadrants have higher δD and $\delta^{18}O$ values than the northern (Andy Zdon & Associates, 2016). Computed average δD values for each quadrant are shown in the list below and indicate that isotope values increase in spring water from the northwestern Mojave toward the southeast:

Quadrant average	δD
Northwest	−91.6
Northeast	−86.4
Southwest	−77.7
Southeast	−71.6

It can also be observed that most springs samples plot somewhat to the right of the GMWL, suggesting most have experienced some extent of evaporative enrichment of their isotope values. Stable isotope results for springs in the Clipper Mountain area are presented in Figure 8.

The Bonanza Spring δD value is of note in that it is closer to the northeast quadrant springs as described

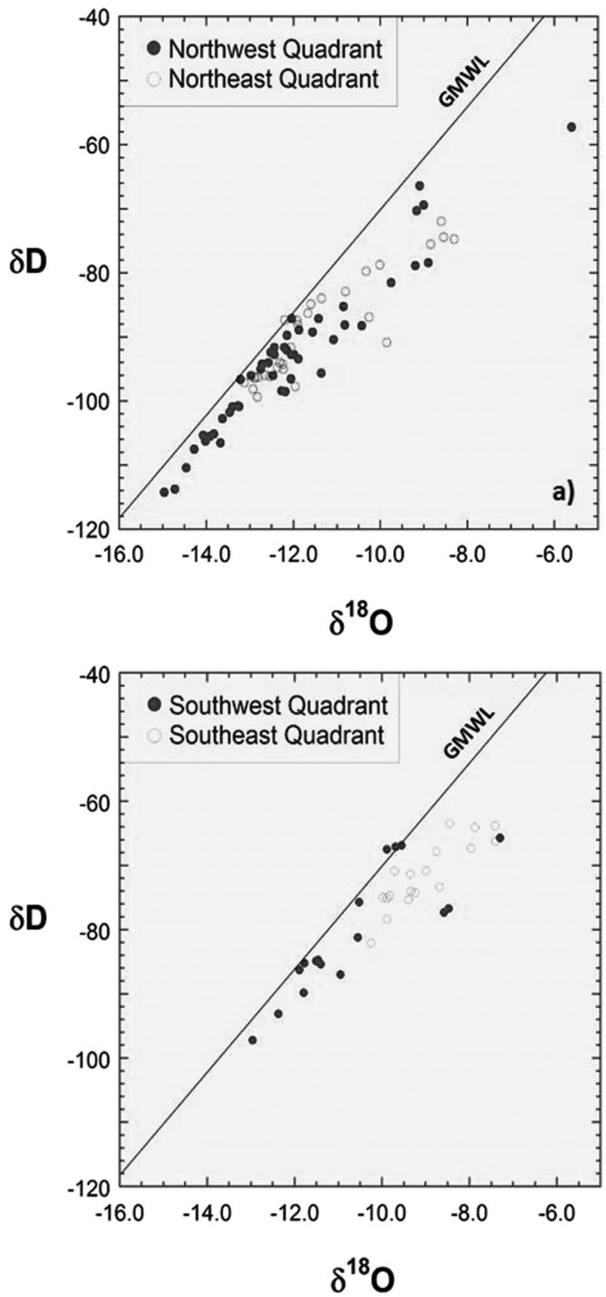

Figure 7. Distribution of δD and δ^{18}O values for spring water relative to Global Meteoric Water Line (GMWL). Note northern waters generally have lower δD and δ^{18}O values than their southern counterparts.

above than the southeast quadrant springs such as neighboring Hummingbird, Chuckwalla, and Teresa Springs. Indeed, the stable isotope values for Bonanza Spring are more typical of values measured in spring water samples in the area of the Mescal Range and Ivanpah Mountains to the north (Andy Zdon & Associates, 2016). Additionally, as reported by Rose (2017), the volumetric average isotopic signature of precipitation collected on the Clipper Mountains is much higher than the isotopic signature at Bonanza Spring. This is indicative of a recharge area north of the Clipper Mountains such as the New York and Providence Mountains and is consistent with a substantial portion of the assumed recharge area for Fenner Valley. As part of this investigation, springs in the New York Mountains and Providence Mountains (within Mojave National Preserve) were not surveyed in the Mojave Desert-wide survey as the work was conducted solely on lands managed by the BLM, but these results are also consistent with results from prior sampling within the Mojave National Preserve (e.g. Davisson and Rose, 2000).

In order to qualitatively evaluate ages of spring water from Bonanza, Hummingbird, and Teresa Springs, water samples were collected from those springs and analyzed for ^{3}H. In evaluating the ^{3}H data, the values are indicative of average values. For example, a spring with multiple sources (such as a more regional old source and from recent precipitation) will result in a composite ^{3}H value. ^{3}H was not detected at reporting limits of 0.56 TU in the water samples from Bonanza (and Lower Bonanza) and Hummingbird Springs. This indicates that the water is primarily submodern or older in age, having been recharged prior to 1952 (Clark and Fritz, 1999).

In the case of Bonanza Spring, the assumption of local recharge is problematic in that this model requires very slow movement of groundwater from the point of recharge to the spring given the small watershed. For example, the distance from the crest of the watershed to the source is approximately 1,000 feet. Assuming that precipitation recharged a local perched aquifer zone that fed the spring (if it existed), it would require very low permeability earth materials (hydraulic conductivity of substantially less than approximately 0.04 feet per day), which is improbable given that these low permeability materials would otherwise inhibit groundwater recharge and promote direct runoff from precipitation events and promote seepage in the overlying coarse-grained, higher-permeability overburden The hydraulic conductivity would have to be much lower than that used in the scenario described above as based on the spring water temperatures present, this travel path does not account for the requirement that the water reach substantial depth as described earlier, only to resurface in a very short distance. This appears to be contradicted by existing field conditions.

At Hummingbird Spring, ^{3}H was not identified in the spring sample collected indicating that it is water primarily of pre-1952 origin. Beyond this, the scale of age difference in waters of Bonanza Spring and Hummingbird Spring is not known. Given the substantially larger watershed for Hummingbird Spring, the smaller size of the spring (as compared to Bonanza Spring), and the

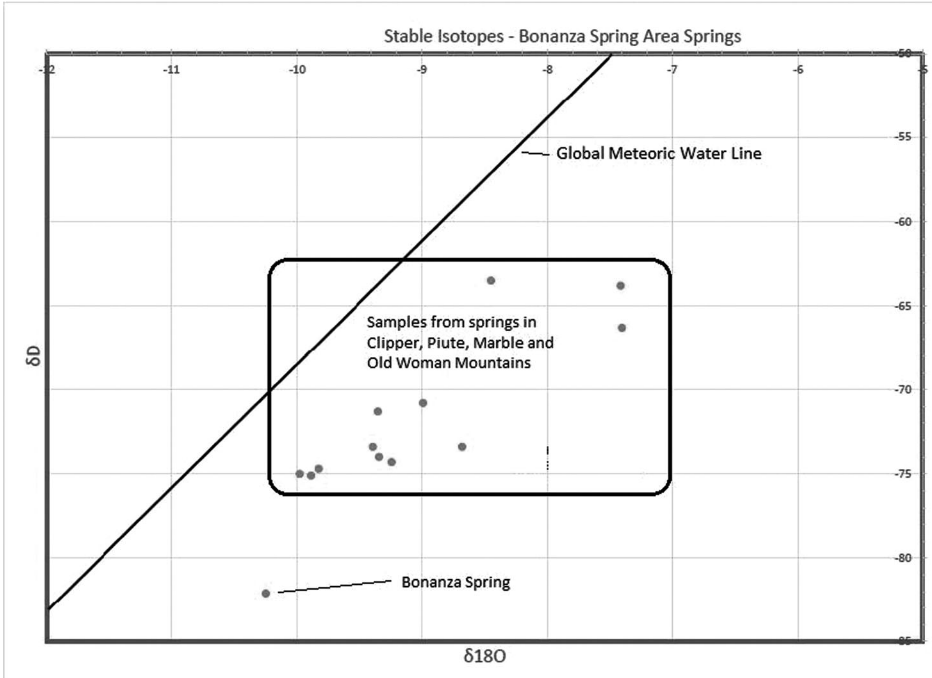

Figure 8. δD and δ^{18}O value for Bonanza Spring relative to all other waters in the region.

same source area geologic unit as at Bonanza Spring further highlights the anomalous nature of increased flow at Bonanza Spring if it were a local spring.

The geomorphology of the respective watersheds above Bonanza and Hummingbird Springs are substantially different. Watershed topography above Hummingbird Spring is more variable over a larger area, than that for Bonanza Spring. The Hummingbird Spring watershed includes cliff-forming rock units and relatively flat, sandy washes. The uncertainty of how and where in the watershed recharge would occur makes comparing estimated maximum flow velocities problematic between Bonanza Spring and Hummingbird Spring.

Tritium was identified in the water sample collected from Teresa Spring at a concentration of 1.38 $\pm$ 0.29 TU. Water from Teresa Spring therefore is either of younger origin (post-1952) or a mixture of mostly younger (local) with older (local and or more regional) waters. When combined with the results from the stable isotope analysis, the source is most likely exclusively locally sourced.

Summary/Conclusions

Based on the analysis and integration of the new and historic data collected within the geologic and hydrogeologic framework of the region, the sources of the springs evaluated appear to be as follows:

1. Bonanza Spring – water within Bonanza Spring is from a basin-fill water source, deriving its water from recharge north of the Clipper Mountains, such as the Providence and New York Mountains, and could be impacted if groundwater levels decrease at, or near, the spring (as estimated in Santa Margarita Water District (2012). Groundwater from these northern regional sources (such as the New York and Providence Mountains) moves southward toward Fenner Valley, generally around the Clipper Mountains, but also seeping through the subsurface within the volcanic rocks of the range, only to resurface at the spring. This conclusion is based on the following data:

a. groundwater elevations in the basin-fill north of the Clipper Mountains is at higher elevations than Bonanza Spring (Geoscience Support Services, 2011);
b. isotopic signatures consistent with past studies (e.g., Davisson (2000)) of waters in Fenner Valley and Mojave National Preserve indicating waters derived from sources north of the Clipper Mountains such as the New York Mountains or Providence Mountains;
c. isotopic signatures of precipitation collected in the Clipper Mountains are much higher than those at Bonanza Spring (Rose, 2017);
d. site field conditions related to large size of the spring and associated small watershed size indicate that the spring flow observed is not

compatible with its watershed and the low volume of precipitation anticipated in that watershed;

e. absence of ^3H indicating that the spring water has a composite age greater than 65 years old despite the limited size of the watershed;

f. Bonanza Spring flow has been consistent for more than 100 years despite multi-year wet periods and longer periods of drought (as indicated by the literature), and

g. Bonanza Spring water temperature is indicative of waters that have been at depths of greater than 750 feet below the spring vent and risen to groundwater surface despite being in such a small catchment.

2. Lower Bonanza Spring –Evaporated waters from Bonanza Spring with some potential for the inclusion of additional inflow from the underlying formations indicated by cooler water temperatures, same water-type with higher dissolved solids concentrations due to evaporation; and stable isotope results indicative of having undergone greater evaporation; and,
3. Hummingbird, Teresa, and Chuckwalla Springs – local, perched springs based on limited flow relative to spring watershed size, stable isotope signals, and in the case of Teresa Spring, presence of ^3H indicative of a component of younger recharge.

Based on the results of this investigation, recommendations for future groundwater management in this region include the following:

- Future groundwater development in the region, should it occur, should be cognizant of the likelihood of a hydraulic connection between the recharge area for Fenner Valley, and Fenner Valley itself with Bonanza Spring. Based on the existing source characterization of Bonanza Spring, a reduction in groundwater level could result in an uncertain, but potentially substantial decrease in free-flowing water from the spring source.
- Numerical modeling in the area (e.g., as presented in Santa Margarita Water District (2012)) indicates that expansion of a cone of depression in areas of substantial pumping, and limited recharge, can occur for periods long after pumping ceases (100 years or more). This is due to the continued drawing in of more distant groundwater to infill the recovering cone of depression. Therefore, if future groundwater development occurs that puts substantial stresses on the aquifer system, future groundwater-level monitoring protective of Bonanza Spring should be designed to obtain sufficient early warning of potentially damaging groundwater level decline to allow for changes in effective groundwater management protective of the spring resource.

In addition to the recommendations listed above, long-term monitoring of the spring will be important for future groundwater management and resource protection. This monitoring should include evaluations of additional water development in the area to assess possible impacts to both baseline spring flow and groundwater level records. Currently, there are no groundwater monitoring wells between the location of proposed groundwater development in Fenner Valley and Bonanza Spring. Additional monitoring wells between a proposed well field in Fenner Valley and the spring would provide a means to identify early changes to the groundwater system indicative of future impacts on Bonanza Spring. Additionally, reliance on observable changes at the spring as a trigger for changes in groundwater management or usage will not be an effective protective measure due to the delays in groundwater changes described above.

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Evaluation of "Understanding the source of water for selected springs within Mojave Trails National Monument, California" by Andy Zdon, M. Lee Davisson and Adam H. Love

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This is an external peer review and evaluation of the publication by Andy Zdon, M. Lee Davisson and Adam H. Love (2018), "Understanding the source of water for selected springs within Mojave Trails National Monument, California," published in Environmental Forensics, 19:2, 99-111, DOI: 10.1080/15275922.2018.1448909. Throughout this review the publication will be referred to as Zdon et al. (2018).

In preparing this review and evaluation, information was considered which appears in the references at the end of this report. Further, on June 1, 2018, a field study of Upper and Lower Bonanza Spring, identified in Zdon et al. (2018), and its watershed and surrounding area was conducted.

Generally, Zdon et al. (2018) contains information pertaining to water quality and isotopic relationships for springs, wells and groundwater in the southeast Mojave Desert. This information, however, is poorly referenced and the conclusions drawn in Zdon et al. (2018), particularly with respect to the purported connection between Bonanza Spring and the Fenner and Cadiz Basins which are unsupported by the evidence cited. In fact, there is disagreement between the data presented in Zdon et al. (2018) and data published elsewhere. Whether these conflicts arise from reporting errors in the manuscript, or from the presentation of selective information from a larger data set, cannot be determined. In sum, a complete interpretation of all available data supports completely different and sometimes opposite conclusions reached in Zdon et al. (2018).

The Journal

The manuscript is published in the journal Environmental Forensics.[1] The publishers of the journal Environmental Forensics make the following statement: "*Taylor & Francis, our agents, and our licensors make no representations or warranties whatsoever as to the accuracy, completeness, or suitability for any purpose of the Content. Any opinions and views expressed in this publication are the opinions and views of the authors, and are not the views of or endorsed by Taylor & Francis. The accuracy of the Content should not be relied upon and should be independently verified with primary sources of information.*" Of the 27 references listed in Zdon et al. (2018), many are reports, some unpublished, which have not gone through documented

[1] This journal has a relatively low impact factor of 0.850 (2016), and a 5-year impact factor of 0.845. Impact factor is a measure of the frequency with which the average article in a journal has been cited in a particular year, and is used to measure the importance or rank of a journal. (For comparison, the journals "Science" and "Nature" have Impact Factors of 37.205 and 40.137, respectively).

external peer review. Included in the references are a personal communication, general subject area book chapters, an oral presentation by one of the authors, 6 self-citations, reports and manuscripts from areas not in the Mojave Desert field area, and sources that do not come from refereed journals subject to peer review. Over a quarter of the references are more than 30 years old, and more current references (e.g. on recharge area estimation methods and other more recent field approaches) are not included.

Temperature

In Zdon et al. (2018), the authors reach a major conclusion, in part based on water temperature readings, that, "*water within Bonanza Spring is from a basin-fill water source, deriving its water from recharge north of the Clipper Mountains, such as the Providence and New York Mountains, and could be impacted if groundwater levels decrease at, or near, the spring.*" As supporting evidence, they further assert that, *"Bonanza Spring water temperature is indicative of waters that have been at depths of greater than 750 feet below the spring vent and risen to groundwater surface despite being in such a small catchment."* This is based on the author's reporting a temperature of 27.5 (or 81.5°F) for the water at Bonzana Spring in the manuscript, which they assume is geothermally influenced. This value, however, directly conflicts with a value of 14.2°C (57.6°F) reported by Andy Zdon and Associates (2016) for Bonanza Spring. This measured spring water temperature documented by Andy Zdon and Associates is less than the yearly average air temperature calculated by Zdon et al. (2018) at 21.0°C (69.8°F). A different value for water temperature is reported by Rose (2017) of 26.5°C (79.7°F) for the spring. It is unclear if the value reported in the Zdon et al. (2018) is a mistake, if an independent measurement was made, and/or if the spring temperature varies greatly as is indicated. Supporting information for the single value of 27.5 (or 81.5°F) is not given in the manuscript.

The date and time of year, time of day, location of the sampling point (Bonanza has a long surface flow above ground where ambient air temperatures could affect water temperatures), meteorological conditions, preceding precipitation, and many other factors associated with the temperature measurement are not reported in the manuscript, making further interpretation difficult. Ambient air temperatures in the area, reported by weatherbase.com, show that annually temperatures in the region may vary as widely as 100°F, and the average high temperatures in summer can be about 65°F different than the average low temperatures in winter. The location, altitude, and timing of water sampling can then particularly affect both aqueous temperature, and stable isotopic values whose fractionation can be strongly affected by temperature. This is particularly true of hydrogen and oxygen isotopic values referred to in the manuscript from T.P. Rose (2017) for precipitation in the "Clipper Mountains" which were measured less than a quarter mile from Bonanza Spring. The significance of the potential for isotopic variation is discussed below.

Cool water documented at the spring by Andy Zdon and Associates (2016) is inconsistent with a deep source. Giving the authors of Zdon et al. (2018) the benefit of the doubt and assuming the temperature reported in the manuscript of 81.5 °F represents a single, accurate independent measurement, but not the full range of measurements available in the literature, the spring water temperature at Bonanza Spring is at the very least must be considered variable;

again, this is inconsistent with a deep source and connection to the basin waters which are vertically far below the spring. Available data clearly demonstrate that the temperature of Bonanza Spring water varies greatly, indicating a local source. Additional data would need to be collected from a precisely documented, consistent location over time to demonstrate otherwise.

Flow of Bonanza Spring

Zdon et al. (2018) reach the conclusion, *"Bonanza Spring flow has been consistent for more than 100 years despite multi-year wet periods and longer periods of drought (as indicated by the literature).*" This is demonstrably untrue. Although the authors give no numerical values for Bonzana Spring discharge in their publication, they do state, *"Thompson (1929) noted the presence of Bonanza Spring as a spring that yielded about 10 gallons per minute (similar to what it produces currently) that was piped to the community of Danby for use at the railroad."* In Andy Zdon and Associates (2016) the flow of Bonanza Spring is recorded as less than 1 gallon per minute (gpm) - significantly less than the 1929 value. On June 1, 2018, the flow of Bonanza Spring was also estimated at less than 1 gpm. This variability does not indicate "consistent" flow. Further, Rose (2017) reports an entirely different, higher flow value for Bonanza Spring. The reported flow at Bonanza Spring varies by at least an order of magnitude. Inconstant flow (particularly coupled with inconstant temperature readings) is not compatible with an assumption of a constant, sustainable deep groundwater source which is a conclusion of Zdon et al. (2018). Additionally, the vegetation around Bonanza Spring has apparently changed in the past, sometimes dramatically, when viewing Google Earth imagery. This could be another indicator of inconstant discharge and flow at the spring, or alternatively periodic destruction of vegetation from localized flash flooding events.

Catchment Size and Water Balance for Bonanza Spring

Zdon et al. (2018) reach a conclusion regarding Bonanza Spring that, "*site field conditions related to large size of the spring and associated small watershed size indicate that the spring flow observed is not compatible with its watershed and the low volume of precipitation anticipated in that watershed.*" The authors do not present a water balance, however, to justify or illustrate this point, nor do they justify their presumption that any recharge area in the Clipper Mountains for the spring would be restricted to a small surface water catchment immediately above the spring.

Importantly, Zdon et al. (2018) do not consider a full range of recharge scenarios, and neglect to fully evaluate the most likely scenario of groundwater recharge from an extensive area of fractured and faulted volcanic geology, immediately above Bonanza Spring in the Clipper Mountains. They present only two possibilities for groundwater recharge that would supply the spring: either that recharge could only occur from a small, restricted surface water catchment immediately above the spring, or that recharge occurs over a vast area flowing down into the alluvial basin over a thousand feet below the spring (and then through some unexplained or geologically supported mechanism water rises to the spring).

A water balance calculation or water budget is an accounting of water movement into and out of, and storage change within, an aquifer surrounding a spring. Water-budget methods can be used to estimate the sum of both diffuse and focused recharge, and account for the sum of many phenomena such as preferential flow paths along faults and fractures. Accurate estimations of the components of water balance, including groundwater recharge area, are extremely important for properly understanding the source of spring flow.

Using very conservative values, a water balance may be calculated, and shows that even a very small recharge area could provide enough water to generate Bonanza Spring flow, while a more likely, larger local recharge area (not even considered in Zdon et al.) would produce much more sustainable flow observed at the spring. The worst case, conservative estimate can be carried out to determine if, by using a high value for spring discharge and a low value for catchment area and rainfall/recharge (solely to that small catchment), minimum rainwater could provide enough input to supply the spring. Zdon et al. (2018) do not quantify Bonanza Spring discharge, nor do they quantify recharge supplying the spring.

For calculating a worst case scenario for very high spring flow and low recharge area, and using a conservative (high) 10 gpm historic 1929 value that Zdon et al. (2018) state is "*similar to what it produces currently,*" the annual high flow for Bonanza Spring would be about 702,625 ft^3/yr. This yearly volume, equivalent to 10 gpm, is considered a higher, conservative value because it is a greater discharge than the sum of what is reported by Andy Zdon and Associates (2016) for both Bonanza and Lower Bonanza springs combined, and is more than ten times higher than that measured on June 1, 2018. The surface catchment according to the manuscript in Zdon et al (2018) is "approximately 50 acres" (2,178,000 ft^2), although the source of this estimate is not given, and review of topographic maps, local geology, and Google Earth Pro reveal this being an estimate of a recharge area is an underestimate; (a larger value for surface catchment area would collect more annual rainwater volume, therefore using the following 50 acre estimate for a smaller catchment area is conservative).

The annual rainfall depth versus altitude estimated by Davisson and Rose (2000) for the nearby Fenner Valley would give a value of about 110 mm for the 641 m elevation of Bonanza Spring Using 110 mm (0.36 ft) for the estimate of annual volume of water over the minimum catchment of 2,178,000 ft^2, the volume of potential annual input would be 748,080 ft^3, more than enough to supply spring flow to Bonanza. If a less conservative four year average precipitation of 130mm (5.12 inches/yr) for the Clipper Mountains near Bonanza Spring, actually measured and reported by Rose (2017), is used in the same calculation, the potential average rainfall annual input to the smaller, less likely recharge area would be about 884,095 ft^3/yr, or over 125% of what would be needed to supply high spring flow at Bonanza, and over 200% of what would be necessary to supply the lesser spring flow for **both** upper and lower Bonanza reported by Andy Zdon and Associates (2016). This measured average rainfall input would be over 12.5 times the water input necessary to supply the smaller flows observed by several researchers at Bonanza Spring, and if a more probable, larger recharge area was used for this calculation, the surplus water potentially supplied to the spring would be even greater. It should be noted that this excess in water supplied to the catchment by rainfall relative to spring flow does not account for some abstraction by evapotranspiration, which varies greatly seasonal and with elevation throughout the Mojave Desert.

Importantly, it should be noted that Zdon et al. (2018) do not robustly consider the possibility of a local recharge area including the Clipper Mountains at topographically higher elevations directly up gradient from the spring, (other than the very small, restricted area they define as the approximate 50 acre, surface water catchment area). They state, *"In the case of Bonanza Spring, the assumption of local recharge is problematic in that this model requires very slow movement of groundwater from the point of recharge to the spring given the small watershed. For example, the distance from the crest of the watershed to the source is approximately 1,000 feet."* However, it is very likely that the groundwater recharge area supplying the Bonanza Spring is much larger than the small, immediate surface watershed catchment noted in the manuscript. The fractured volcanic geology, local surface topography, and stable isotopic values suggest that this probable, potentially larger recharge zone would be topographically, directly up-gradient in the Clipper Mountains above the spring's surface catchment.

The authors of the manuscript do not rigorously address this likelihood of nearby recharge in the Clipper Mountains immediately up gradient of the Bonanza Spring surface catchment area. Their speculation that recharge occurs in the distant New York or Providence Mountains leaves only two very unlikely possibilities – that either recharge in these far flung ranges comes directly south or southeast through Lanfair and/or Clipper valley alluvium and then flows through the bulk of the Clipper Mountain massif to Bonanza Spring (a possibility which they themselves partially discount), or alternatively flows into the alluvium at the base of these distant ranges into the Fenner Valley, winding a tortuous pathway as much as 50 miles plus, and then is somehow pumped over a thousand feet vertically upward to Bonanza Spring.

Major Ions

Zdon et al. (2018) presents a Piper diagram of regional waters including selected springs, USGS wells, and Cadiz wells, showing the measured major ion aqueous chemistry of those sources. Trace element analysis of the waters was not reported. The authors state, *"Spring water at Bonanza Spring is a Na-HCO3 type (this is consistent with water at Lower Bonanza Spring as well). This is similar to most waters in the region except those waters at Hummingbird Spring (Ca-HCO3 type)."* Inspection of these data reveal that Bonanza Spring is dissimilar in its major ion chemistry from any well water sources, which primarily draw water from basin fill environments. This is particularly true with regard to major cations. The waters of Bonanza Spring are uniquely different than the surrounding regional well water with less than half the dissolved calcium of any well in the area and in some cases more than 4.5 times less. This difference is not supportive of the opinion put forth in Zdon et al. (2018) that Bonanza Spring issuance has a similar source to basin-fill well water and Cadiz wells.

The discussion in Zdon et al. (2018) on this topic includes the statement *"The Bonanza Spring water is also similar in type to waters from the basin fill in the Fenner and Cadiz Valleys...".*

The actual concentrations of major and minor constituents are not provided for the reader's review. Independent analysis of Bonanza Spring samples, collected February 2013 and March 2018 do show that the most abundant cation and anion are sodium and bicarbonate, respectively, similar to most basin fill well samples in the area. However, a sodium-bicarbonate chemistry is a generally common chemistry given the compositions of both local and regional source rocks, and therefore does not necessarily link the spring water to a regional source. Closer examination of the Bonanza Spring chemistry shows that this spring (and the associated Little Bonanza Spring) has a significantly higher sodium percentage than any of the other samples, as shown in the Piper diagram on Figure 4, and from other available well data surveyed among Fenner Valley and Cadiz Valley. The sulfate percentage for Bonanza Spring (approximately 30% of anions from Figure 4) is also higher than all nearby springs and wells.

Independent data from Bonanza Spring show the water to be undersaturated with respect to calcite, while all other regional aquifer groundwater samples from Fenner and Cadiz Valley show saturation with this common mineral. This characteristic further supports the Bonanza Spring water reflecting a more localized source, such as the calcite-poor rocks of the Clipper Mountains.

The notably high percentages of sodium and sulfate in Bonanza Spring, along with its undersaturation with calcite, suggest a more localized source rather than a regional source, since this combination of major ion chemistry does not appear in wells of the flow regime proposed by the authors.

Trace Metals

The authors mention that trace metal analysis was carried out but no results are reported. Sample preparation was made by addition of nitric acid, but sample filtration and use of ultra pure nitric acid, which is necessary for trace analysis, is not mentioned. Trace element analysis has proven useful in source analysis of springs in Death Valley (Kreamer et al. 1996). Why the results of trace analysis were left out of the Zdon et al. (2018) publication is not explained.

Stable Isotopes

Zdon et al. (2018) presents stable isotopic data showing aqueous hydrogen and oxygen at Bonanza Spring is uniquely different than any other spring they evaluate regionally (Figure 8). The isotopic signature is lighter (more negative) at Bonanza Spring (δD -82.1, δ^{18}O -10.25) which typically indicates water is sourced from a colder and/or higher elevation source. Surprisingly, the authors attribute this to a recharge source considerably distant (20 to 45 miles) to the north and northwest, the Providence and New York Mountains, and not to the surrounding Clipper Mountains where Bonanza is located. The authors do note, however, that previously a different assumption was made (including by one of the co-authors of Zdon et al. 2018): "*Of note is that Davisson and Rose (2000) assumed the local catchment for Bonanza Spring as being the whole of the Clipper Mountains although this is very unlikely as it would require substantial volumes of water to flow laterally across the distant range-front of the Clipper Mountains and across several geologic northwest-trending geologic structures, instead of following the path of least resistance down-slope toward the basin fill.*" The Clipper Mountains surround the spring rising up several thousand feet higher to the north (with the spring downslope), are in close proximity and receive substantial rainfall, but the authors speculate that the spring water is sourced instead tens of miles away in more distant ranges.

The time and date of this single isotopic spring measurement in Zdon et al. (2018) was not recorded in the manuscript, nor is there any mention of the number of duplicate samples, traveling spiked standard samples or field (trip) blanks. The exact location of the sampling point is not mentioned (fractionation could occur along the long surface flow between Bonanza Spring and lower Bonanza Spring), preceding precipitation is not mentioned, and many other factors associated with the stable isotopic measurement are not reported in the manuscript, making further interpretation difficult. Of note is some supportive evidence - Bonanza Spring was also sampled by T.P. Rose (2017) on 2/2/2000, finding stable isotopic values of δD -83.1, δ^{18}O -10.65, similar to those reported by Zdon et al. in their present publication.

Without discussion or justification Zdon et al. (2018) state, *"isotopic signatures of precipitation collected in the Clipper Mountains are much higher than those at Bonanza Spring (Rose, 2017)."* The authors use this statement as part of a justification to exclude the adjacent, upgradient Clipper Mountains as potential recharge areas contributing to Bonanza Spring discharge. Inspection of the data from Rose (2017) does not support the authors' assertion.

The authors state that precipitation measurement in the Clipper Mountains are isotopically heavier and infer that this invalidates these surrounding mountains as a recharge source, supplying the Bonanza Spring. As noted in Zdon et al. (2018), these same stable isotopes of hydrogen and oxygen were measured in precipitation near Bonanza Spring from 2001 to 2005 by T.P. Rose (2017) (labeled "Clipper Mountains"). According to the latitude and longitude given, the sampling point was approximately 1000 ft north of the spring and about 300 ft higher in elevation. The "winter" (October to April) precipitation measured by Rose accounted for about 79% of the yearly rainfall summed over those years and ranged in isotopic values from δD -59.3 to δD -91.0, and from δ^{18}O -7.2 to δ^{18}O -12.6. When these values are weighted with the seasonal rainfall for each individual year, the weighted "winter", October to April, 6 month averages are δD -77.55, and δ^{18}O -10.75. These delta values are very close to the values recorded in nearby Bonanza Spring discharge by Zdon et al. 2018 (δD -82.1, δ^{18}O -10.25), indicating that the spring could very well be in large part fed by local recharge in the Clipper Mountains.

Because winter temperatures are significantly cooler in the Mojave Desert compared to summer temperatures, evaporation from soil and transpiration rates from plants are appreciably less in the winter months, and a larger proportion of the precipitation is available in the winter for aquifer recharge compared with summer. According to Neff et al. (2017), *"Contributions of winter precipitation to annual recharge vary from 69% ± 41% in the southernmost Río San Miguel Basin in Sonora, Mexico, to 100% ± 36% in the westernmost Mojave Desert of California."* According to these authors winter precipitation makes up the majority of annual recharge throughout the region, and North American Monsoon (NAM) precipitation has a disproportionately weak impact on recharge. Zdon et al. (2018) apparently agree, citing studies by Freidman et al. (1992) and stating: "*Accordingly, the implication is that spring water sources in the Mojave reflect less of a mean annual precipitation source, but rather wintertime precipitation having the greater influence overall."*

The less effectual "summer" (April to October) precipitation measured by Rose over those years accounted for about 19% of the yearly summed rainfall over that time, not counting abstraction during the hotter months through evapotranspiration. As could be expected, “summer” precipitation values were heavier during the months of April to October, and ranged from δD 5.3 to δD -51.0, and from $\delta^{18}O$ 9.3 to $\delta^{18}O$ -7.2. The heaviest isotopic values were observed in the extremely dry 6-month “summer” period of 2002. In that year the location only received 0.23 inches of rain over the 6 months of April to October. Conversely, the lightest isotopic values occurred in the 6 month “summer” period that received the most rain (2.99 inches) in 2004. When these values are weighted with the seasonal rainfall for each year, the weighted average “summer” averages were δD -37.9, and $\delta^{18}O$ -4.7. These “summer” values probably have de minimis effect on groundwater, as recharge is likely dominated by winter precipitation which has stable isotopic delta deuterium and delta oxygen-18 values very similar to water issuing from Bonanza Spring, indicating that the Clipper Mountains are a likely recharge source.

Zdon et al. (2018 state, *“isotopic signatures consistent with past studies…indicating waters derived from sources north of the Clipper Mountains such as the New York Mountains or Providence Mountains”* Similarity of two deuterium samples from Bonanza Spring to those of selected well samples from regional fill aquifers several miles to the north does not constitute proof of the spring having a regional source. This must be supported by hydraulic evidence and a more complete isotopic data set that accounts for seasonality and spatial distribution of rainfall.

Tritium (^3H)

Tritium Analysis was conducted on selected samples in Zdon et al. (2018) and the manuscript states, *“Tritium (^3H) analysis was conducted using the tritium enhanced enrichment (TEE) method to obtain lower reporting limits.”* The authors also state that, “*^3H was not detected at reporting limits of 0.56 TU in the water samples from Bonanza (and Lower Bonanza) and Hummingbird Springs*.” The only laboratory for isotopic analysis mentioned in the manuscript is Isotech Laboratories for stable isotopic analysis. On the Isotech website, it is reported that they conduct liquid scintillation counting with or without electrolytic enrichment, having a detection limit of 1 Tritium Unit (TU), not 0.56 TU. Tritium electrolytic enrichment available at Isotech Laboratories, called “enhanced enrichment (TEE)” in the manuscript, allows lower reporting limits. Because the laboratory for tritium analysis was not specified in Zdon et al. (2018) and because of the discrepancy in detection limits, it is slightly unclear which laboratory was used for tritium analysis, nor is the number of duplicates, spiked samples, field or laboratory controls, or chain of custody procedures specified in the publication. Sampling dates, times, exact locations, antecedent rainfall are also not specified in the manuscript.

The lack of detection of ^3H in Bonanza and Lower Bonanza Spring indicates that the average residence time for groundwater emerging at the springs is more than 65 years. These data are not incompatible with flow from fractured Tertiary volcanic rocks immediately upgradient of the surface water catchment for these springs, in the Clipper Mountains. Flow through fractured rock can include not only fracture flow, but matrix flow which has much longer average residence time. A combination of slow flow through the vadose zone, and consequent imbibition of water into the rock matrix during groundwater flow can extend average groundwater travel and residence time, and is consistent with the geological materials upgradient of the catchment area of the springs in question. Geologic data indicate that the recharge area for the spring is much larger than the topographic surface drainage area. Tritium ages exceeding 65 years are common in saturated fractured media, which contains a mixture of transmissive fractures and very narrow micro-fracture networks that can have very slow transport velocities.

Conclusions

The publication by Andy Zdon, M. Lee Davisson and Adam H. Love (2018), "Understanding the source of water for selected springs within Mojave Trails National Monument, California," published in Environmental Forensics, 19:2, 99-111, is an interesting study of selected spring flow in the Mojave Desert, but suffers from critical weaknesses which undercut and invalidate some of the conclusions of the paper. The Zdon et al, (2018) publication speculates that, , "*Future groundwater development in the region, should it occur, should be cognizant of the likelihood of a hydraulic connection between recharge in the Fenner Valley, and Fenner Valley itself with Bonanza Spring. Based on the existing source characterization of Bonanza Spring, a reduction in groundwater level could result in an uncertain, but potentially substantial decrease in free-flowing water from the spring source*." This statement is directly contradicted by available spring temperature and flow data, the concentration of major ions in spring water, stable isotopic data, and the geological environment surrounding the spring. Zdon, Davisson, and Love do not deal with or present any physical hydrogeology (numerical modeling, geologic cross sections etc.) to demonstrate there is any hydraulic connection between the alluvial aquifer and the spring, and the data indicate otherwise.

In particular, the publication only makes general statements on the geological setting, location of faults, and the hydrogeologic environment, without complete referencing or justification. The exact sample locations, times, dates, number of samples, measurement error bars, ambient air temperatures, antecedent rainfall, and other important factors which could influence results are not documented in the publication. The number of duplicates, spiked samples, field or laboratory controls, or the chain of custody procedures are not specified. Incomplete data on water temperature and spring discharge is presented, whereas on the other hand, more complete data sets available elsewhere are inconsistent with the authors' conclusions. The stable isotopic precipitation values from the "Clipper Mountains" in a previous study are mischaracterized in this publication as "high" which is key in the authors' misinterpretation of groundwater recharge potential in the Clipper Mountains. Some data, such as trace metals which were collected and analyzed, are not reported. Divalent calcium cation concentrations, and sodium and sulfate concentrations, which exhibit significantly different values between Bonanza Spring and other springs and well water, are not addressed or explained by the authors.

Bonanza Spring is clearly a precious resource in the region and must be protected. However, the omission of data, and misinterpretation of hydrogeology based on selective information, lead the authors of the manuscript to dubiously ascribe groundwater recharge which sustains this spring to far-flung areas. The questionable speculation in the Zdon et al. (2018) manuscript, that recharge occurs in the distant New York or Providence Mountains, then moves tens of miles through basin alluvium and perhaps the whole of the Clipper Mountain massif, and then perhaps resurges upward over a thousand feet through undefined mechanisms, is inconsistent and incompatible with the field evidence. They do not rigorously address the likelihood of nearby recharge in the Clipper Mountains immediately upgradient of the Bonanza Spring surface catchment area. These closer, sustainable recharge sources for Bonanza Spring in the Clipper Mountains are the most probable explanation of subsurface flow and is consistent with published, investigatory results. The nearby upgradient recharge sources in the Clipper Mountains that supply the spring would, in all likelihood, be unaffected by pumping activity in wellfields screened in basin fill sediments thousands of feet lower and many miles away. Recharge sources in close proximity to the spring catchment and upgradient are the most credible hydrogeologic interpretation within a reasonable degree of scientific certainty.

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hydrology

Article

Use of Radiocarbon Ages to Narrow Groundwater Recharge Estimates in the Southeastern Mojave Desert, USA

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Abstract: Estimating groundwater recharge in arid or semiarid regions can be a difficult and complex task, since it is dependent on a highly variable set of spatial and temporal hydrologic parameters and processes that are dependent on the local climate, the land surface properties, and subsurface characteristics. As a result, traditional methods for estimating the recharge can result in a wide range of derived values. This is evident in the southeastern Mojave Desert, where calculated recharge estimates by previous investigators that range over an order of magnitude (from ~2500 to ~37,000 acre feet per year) are reported. To narrow down this large span of recharge estimates to narrower and more plausible values, this study evaluates the previous recharge estimates in this region, to examine the sources of variability in the reported results and to constrain the recharge estimates based on the hydrologic conditions and the radiocarbon age-dating of spring flows—even without knowledge of the precise subsurface hydrology. The groundwater age and perennial flow characteristics of springs in this study could not be derived from waters sourced solely from local recharge. Therefore, the springs in this study require a significant groundwater contribution to their overall discharge. A previously described conceptual site model in the region established that Bonanza Spring is similarly hydrologically connected to the regional basin-fill aquifer, based on geologic and geochemical/isotopic analyses, and this conceptual site model for where perennial spring water is sourced should readily be extended to these other perennial springs in this region.

Keywords: water resources; Mojave Trails National Monument; Mojave Desert; Bonanza Spring; forensics; isotopes

1. Introduction

Estimating groundwater recharge in arid or semiarid regions can be a difficult and complex task. Groundwater recharge in arid and semi-arid areas is dependent on a complex set of spatial and temporal hydrologic parameters and processes dependent on local climate, land surface properties and subsurface characteristics that are extremely difficult to quantify by using conventional methods of analysis [1]. These difficulties are especially increased in the southeastern Mojave Desert, due to the sparse amount of data that is available in much of this generally undeveloped and expansive region, where large extrapolations are necessary between sparse locations where data are available. The lack of a detailed delineation of subsurface flow pathways is further complicated by the extensive faulting in the region. As such, groundwater recharge estimates for the hydrologic system have varied by more than an order of magnitude between different researchers, highlighting the current uncertainty attached to an important water resource parameter for this arid or semiarid region.

The estimated volume of recharge is a key component in water resources and aquifer management when evaluating the potential impacts of water extraction and recovery in groundwater systems and hydrologically-connected springs. The water in both groundwater and spring flow are controlled by a water balance simply shown by the following equation:

$$\text{Water Inflow} - \text{Water Outflow} = \text{Change in Water Stored} \quad (1)$$

For groundwater, when outflow exceeds inflow, groundwater in storage decreases and groundwater elevations decrease. When inflow exceeds outflow, the reverse is true. When the system is in equilibrium, groundwater levels will generally remain constant. Similarly for spring systems, when outflow exceeds inflow, the spring draws down the source of water and spring flow decreases. When inflow exceeds outflow, the reverse is true for springs also. When spring systems are in equilibrium, spring flow will generally remain constant. Thus, for springs sourced primarily by local recharge, spring flows are temporally well-correlated with precipitation and evapotranspiration patterns.

Thus, for regions such as the southeastern Mojave Desert, where there is a high degree of spatial variability in recharge, the characteristic of a basin being generally in hydrologic balance enables an easier approach to estimating the regional average recharge conditions based on estimating the hydrologic discharge. When using discharge, the components are generally more accurately quantifiable and thus they provide a more reliable assessment of the overall average recharge across the region, based on the ability to reflect the integrated recharge of a larger area, compared to local precipitation gauges and evapotranspiration stations.

This study focuses on a review of the past recharge estimates and associated uncertainties for the southeastern Mojave region, and it considers the results of the observed flow patterns of the springs and recent radiocarbon analyses on selected spring waters, to narrow the range of plausible estimates. The implications of a narrowed set of plausible recharge rates is then discussed in the context of the sustainability of spring flow in this region. Rapid growth and competition for water resources in the Mojave Desert is an ongoing issue and, as with other locations of water resource limitations, this results in a need to balance competing uses and priorities. These include providing water to an expanding population, preserving water-dependent ecological resources, and supplying the expanding water demands of commercial and industrial development, including alternative energy generation facilities.

1.1. Site Description

In general, information and data regarding recharge and spring flow in the Mojave Desert is sparse, and the details of the subsurface hydrology of these springs is typically not well understood. The springs considered in this analysis are: Bonanza Spring, Burnt Spring, Hummingbird Spring rise in the Clipper Mountains, and Vernandyles Spring and Theresa Spring rise in the Marble Mountains within the newly established Mojave Trails National Monument, San Bernardino County, California (Figure 1 and Table 1).

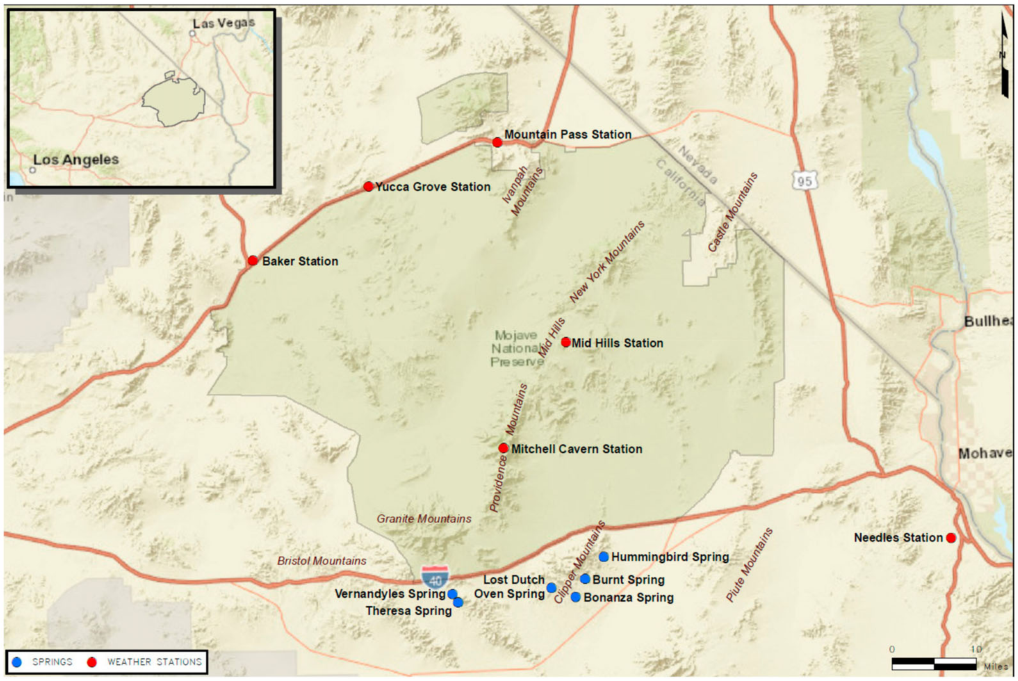

Figure 1. Location of the springs investigated within the Mojave Trails National Monument. Also shown are the location of the closest weather stations where local precipitation has been recorded.

Table 1. Spring locations and elevation.

Springs	Latitude	Longitude	Elevation
Bonanza Spring	34.68513	−115.405	2105
Burnt Spring	34.71591	−115.384	2497
Hummingbird Spring	34.75338	−115.344	2326
Vernandyles Spring	34.69516	−115.661	2562
Theresa Spring	34.68073	−115.65	2456
Lost Dutch Oven Spring	34.70255	−115.455	2633

1.2. Geologic and Hydrogeologic Setting

The area covered in this study spans a substantial portion of the Mojave Desert, a region of isolated mountain ranges separated by expanses of desert plains. Overall, the Mojave Desert forms a wedge-shaped area bounded by the Garlock Fault on the north, the San Andreas Fault (and the north slope of San Bernardino Mountains) on the south, and the Colorado River to the east. The southern edge of the Mojave Desert bounds the Transverse Ranges, an east-west trending series of mountain ranges extending from the Pacific coast to the south-central portion of the Mojave Desert. North of the Garlock Fault, the region is considered to be within the Basin and Range geomorphic province. The Basin and Range is characterized by a roughly linear pattern of north-northwest trending ranges and intervening alluvial valleys, resulting from range-front normal faults and with internal drainage.

The portion of the Mojave Desert covered in this study includes parts of the east and southeastern Mojave Desert, and a portion of the Colorado Desert in the southeast corner of the study area. This is a geologically diverse area and it falls within the Eastern California Shear Zone, an area of fault-rotated bedrock mountain ranges, elongated along variable orientations, and surrounded by broad alluvial valleys with internal drainage (Figure 2). The easternmost portion of the study area has drainage to the Colorado River which then flows south toward Mexico. Rock types are variable, with some mountain ranges dominated by intrusive igneous rocks (e.g., Granite Mountains, Old Woman Mountains, Chemehuevi Mountains); and volcanic rocks (e.g., Clipper Mountains), while other ranges are variable in lithology (e.g., the Marble Mountains, which are primarily comprised of volcanic rocks on the north and carbonate sedimentary rocks on the south).

The principal surface water bodies throughout the region include scattered springs and the normally dry playas on the valley floors, which receive water during occasional summer and winter precipitation events that eventually evaporate. Generally, most of the springs in the Mojave Desert are "local" or "perched" springs that are the result of precipitation in their local watershed that percolates into the ground, only to reach the surface where bedrock restrictions to underflow force water to the surface. They are typically located in wash bottoms, or they may form small, intermittent seeps on hillsides. These local springs are wholly dependent on flow within their respective watersheds. There is no recognized planar, perched groundwater-table that extends across ridges and valleys in these desert ranges. Larger, perennial springs may be observed along geologic structures or contacts that are hydrologically connected with regional groundwater systems, including basin-fill aquifers (Figure 3).

The direction of the groundwater movement usually parallels the slope of the ground surface, from points of recharge in the higher elevations to points of discharge such as springs, or evapotranspiration from the salt-encrusted playas.

The surface catchment areas of the local watersheds for each of the key springs were evaluated by delineating the topographic ridgelines using Google Earth, and using the Google Earth area tool to calculate the bounded catchment area. The associated surface catchment areas for the springs in this study are approximately 50 acres for Bonanza Spring (and Lower Bonanza Spring), 147 acres for Hummingbird Spring, 963 acres for Burnt Spring, 39 acres for Vernandyles Spring, and 25 acres for Theresa Spring. These spring all are similar in that they are perennial, with Bonanza, Hummingbird, and Burnt Springs lying within the Fenner Valley Groundwater Basin, and Vernandyles and Theresa Springs within the neighboring Bristol Valley Groundwater Basin (Figure 4). They all have relatively small catchment areas, relative to the broad extent of the larger groundwater basins. Bonanza Spring has previously been identified as being in hydraulic communication with the basin-fill aquifer system surrounding the Clipper Mountains [2].

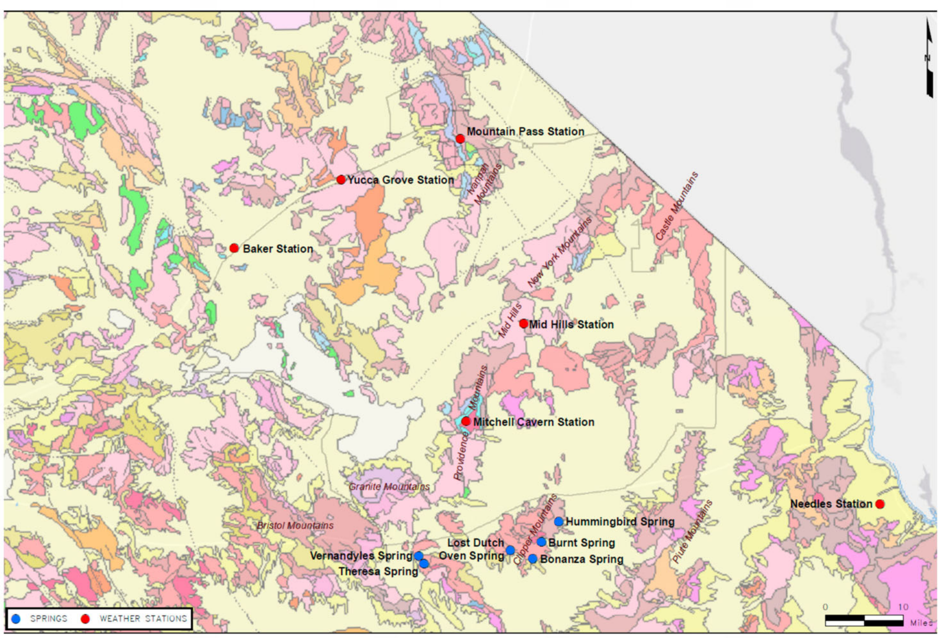

Figure 2. Geologic map [3] with the location of springs and weather stations investigated within Mojave Trails National Monument. A detailed description of map units and symbols are found at https://maps.conservation.ca.gov/cgs/gmc/.

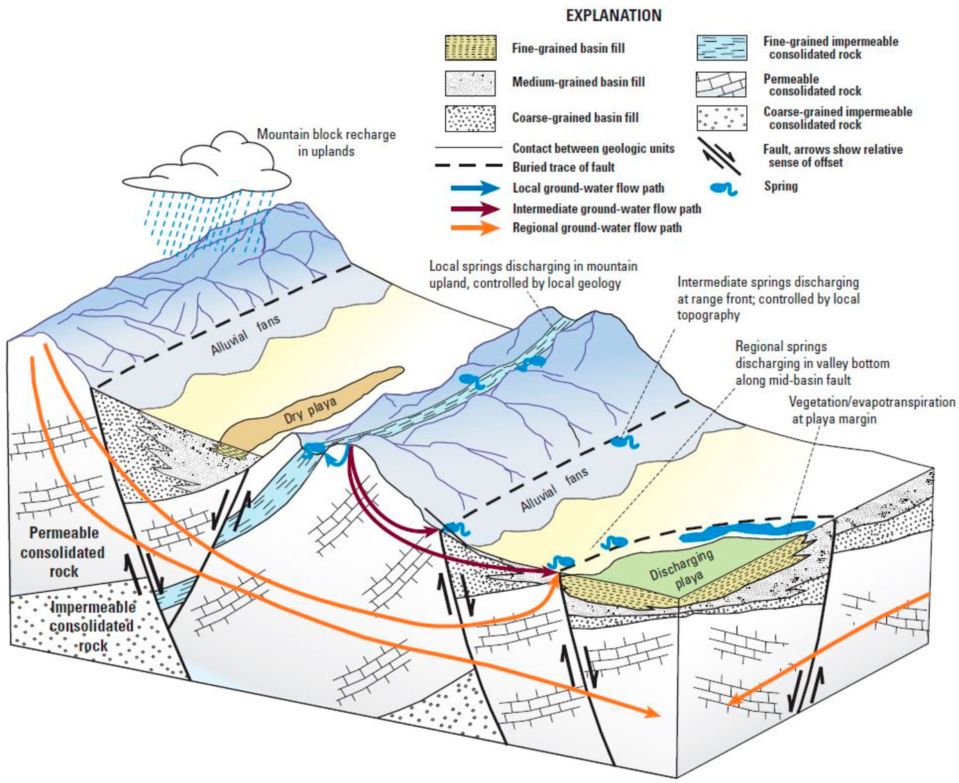

Figure 3. Cross-section of the conceptual model for the hydrology of perennial springs in this region where local and intermediate recharges from precipitation mix with the regional groundwater flow [4].

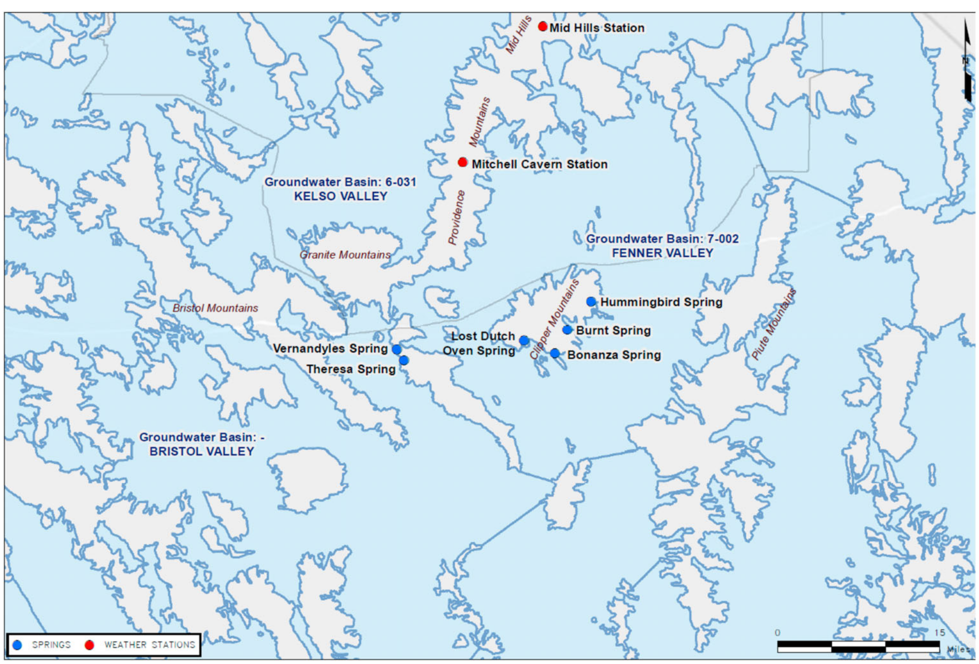

Figure 4. Groundwater basin map [5] with the location of the springs and weather stations investigated within the Mojave Trails National Monument. Solid blue lines divide the groundwater basins. Springs in this study are all within the Bristol Valley and Fenner Valley groundwater basins.

2. Materials and Methods

Field samples of spring discharges were collected for this evaluation, to supplement the analyses, to further refine and provide bounds on plausible recharge rates with new data. Water samples were collected from these perennial springs of the region: Bonanza Spring on 3 October 2017; Burnt Spring, and Hummingbird Springs on 7 November 2017; and Vernandyles and Theresa Springs on 22–23 May 2018 (respectively). Another perennial spring in the region, the Lost Dutch Oven Spring, was visited in the field on 3 October 2017 but it was found to have insufficient water/moisture to obtain a representative sample. The samples were collected in 1 L volume high density polyethylene (HDPE) sample bottles and shipped in a chilled cooler. Field water quality parameters of temperature, pH, electrical conductivity, and dissolved oxygen were measured at the sources of the springs. Field instruments were checked at least daily for calibration.

Analytical Procedures

The collected water samples were analyzed by Isotech Analytical Laboratories, Inc., (Champaign, IL, USA) for radiocarbon at all springs. In addition, tritium was analyzed for Burnt Spring, Vernandyles Spring, and Theresa Springs, as Bonanza Spring and Hummingbird Spring were previously analyzed for tritium [2]. The carbon isotope analyses involved the acidification of water to convert dissolved inorganic carbon (DIC) to carbon dioxide (CO_2), which was then extracted, purified, and analyzed by isotope ratio mass spectrometry for $\delta^{13}C$ and accelerator mass spectrometry for ^{14}C. Tritium analysis was conducted using tritium electrolytic enrichment of the sample to obtain lower reporting limits and liquid scintillation spectrometry analysis.

The $\delta^{13}C$ results are reported as a normalization to the Vienna Pee Dee Belemnite (VPDB), an internationally recognized standard in $\delta^{13}C$ analysis. The ^{14}C content of DIC is reported as a percentage of modern carbon (pmc), and it has been corrected for the ^{13}C content in each sample based on Stuiver and Polach (1977) [6]. The tritium content is reported in tritium units (TU). See Table 2.

Table 2. Carbon isotope and tritium results for each of the sampled springs.

Location	$\delta^{13}C$ of DIC Relative to VPDB	$\delta^{13}C$ Corrected ^{14}C	Tritium Content
Bonanza Spring	−9.7‰	15.5 pMC	<0.56 TU
Hummingbird Spring	−12.1‰	74.9 pMC	<0.56 TU
Burnt Spring	−13.4‰	80.4 pMC	<0.66 TU
Vernandyles Spring	−8.0‰	57.8 pMC	<0.60 TU
Theresa Springs	−15.2‰	65.9 pMC	<0.55 TU

^{14}C decays at a steady rate with a half-life of 5730 years. Therefore, waters with 50% modern carbon would have an apparent age of 5730 years, and waters with 25% modern carbon would have an apparent age of 11,460 years and so on [7].

3. Results

This study evaluates five relatively recent efforts to estimate the recharge in this area: Geoscience Support Services (1999) [8], U.S. Geological Survey (2000) [9], Lawrence Livermore National Laboratory (2000) [10], CH2M Hill (2011) [11], and Johnson Wright Inc. (2012) [12]. Older published recharge estimates (greater than 30 years old) were excluded based on the absence of key meteorological stations at the time of their development.

The review of groundwater recharge estimates focused on two key elements: The quality of the precipitation record used in the recharge analyses, and the various recharge estimation methods. Precipitation data records for meteorological stations [13] within the following climate data networks were reviewed:

- Remote Automatic Weather Stations (RAWS)

- National Weather Service Coop (NWS Coop)
- Natural Resources Conservation Service Snotel (Snotel)
- California Data Exchange Center (CDEC)
- International Civil Aviation Organization (ICAO)
- Desert Research Institute (DRI)
- California Irrigation Management Information System (CIMIS)

Based on that review, meteorological data was used for six stations within, or adjacent to the study area. These included the Mitchell Caverns, Mid-Hills, Yucca Grove, Mountain Pass, and Baker and Needles stations (see precipitation record for each station shown in Figure 5). Of these, only Needles and Mid-Hills reported precipitation data from recent years.

3.1. Evaluation of the Historical Precipitation Record

The precipitation record in this arid region general exhibits bi-modal, winter/summer precipitation seasons, noted by multi-decade wet and dry periods—with the period 1976 through to 1998 being the wettest in the Mojave Desert during the 20th century [14]. Tagestad, et al. (2016) [15] evaluated the long-term precipitation record for the Mojave Desert as a whole, and statistically identified 30- to 40-year long wet/dry cycles throughout the record. These included an early-century wet period (1905–1946); and mid-century drought (1947–1975); and a later-century wet period (1975–2010). Annual precipitation has generally been below the 1975–2010 average since 2010 (Figure 5).

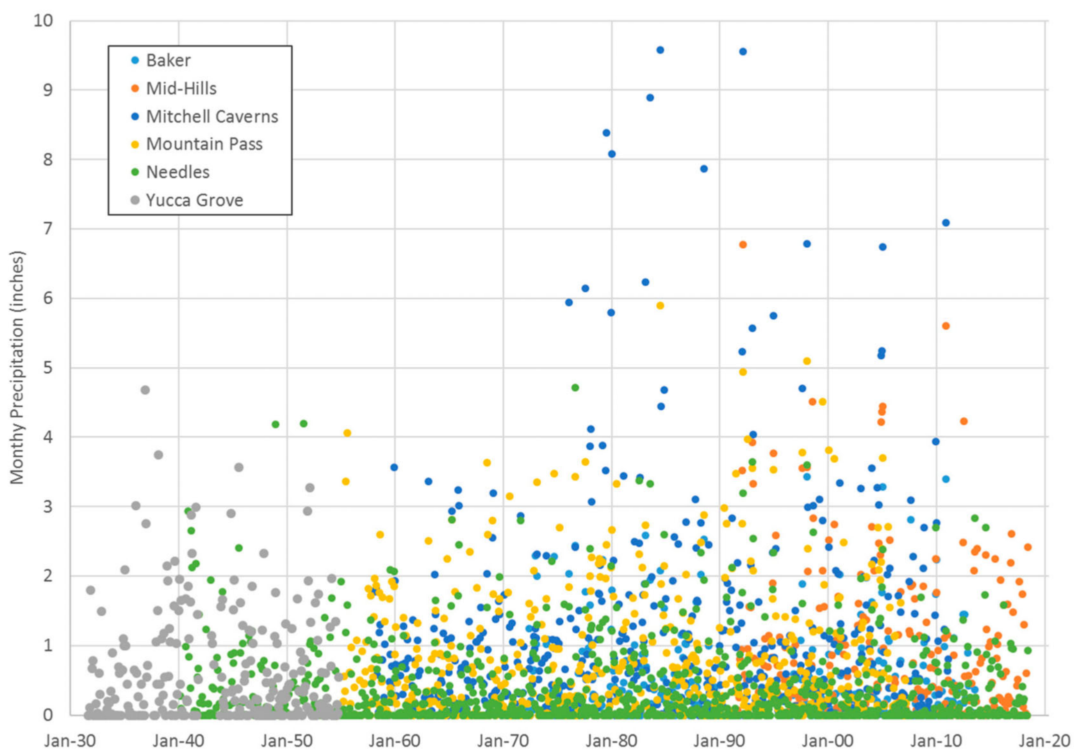

Figure 5. Monthly precipitation records for the Baker, Mid-Hills, Mitchell Caverns, Mountain Pass, Needles, and Yucca Grove Stations. Precipitation data included in Supplementary Materials.

Of the networks reviewed, Mitchell Caverns has been the principal station that is used in evaluating precipitation and associated recharge estimates. Mid-Hills Station, which is located approximately 15 miles northeast of the Mitchell Caverns Station, between the Providence Mountains and the New York Mountains, has also been extensively used. It is important to note that the Mid-Hills

Station is more than 1000 feet higher in elevation than the Mitchell Caverns Station. Comparing the precipitation records shows that annual precipitation and sub-annual precipitation durations at Mid-Hills Station are less than that at Mitchell Caverns, despite its higher elevation.

At least part of this precipitation vs. elevation difference observed between Mitchell Caverns Station and Mid-Hills Station can be attributed to the isolated nature of heavy monsoonal storms during the summer and early fall, and the effect that topographic relief plays on convection and thunderstorm development. [16]. Nonetheless, elevation alone does not result in increased precipitations, as the more prominent the mountain mass is above the surrounding plains, the greater the updrafts, and the associated convection in the storm cells result in more precipitation.

As an example of this isolated nature of summer storms, during August 2005, the Mitchell Caverns Station had a total monthly precipitation of more than three inches, while the higher Mid-Hills Station had less than one inch of precipitation. In the case of the Mid-Hills Station the topographic relief of the higher summits are substantially less than at the mountains (Edgar Peak and Clark Mountain) in the Providence—New York Mountains, and Clark Mountains respectively. Precipitation in this region is not only related to elevation but also to topographical relief, hence the inverse precipitation-elevation relationship between the Mitchell Caverns and Mid-Hills stations. This results in a more complex precipitation patterns and relationships than what was previously assumed in most of the previous study's recharge estimates. This pattern was also discussed by the U.S. Geological Survey in their evaluation of regional recharge [9].

Additionally, while this region is currently experiencing a new, post-2010 dry period, future climate change in the Mojave region is anticipated to result in hotter and drier conditions [17], which are expected to have long-term recharge impacts to this region.

3.2. Evaluation of Recharge Estimate Methodologies

A comparison of the recharge estimates resulting from each of the five studies is shown in Figure 6. While numerical groundwater models are ideal tools to evaluate transient, three-dimensional groundwater issues in that the complexities of the groundwater system can be evaluated in detail, and assumptions of how the groundwater system works can be tested for internal consistency, a brief summary and evaluation of each study's methodology and result is provided below.

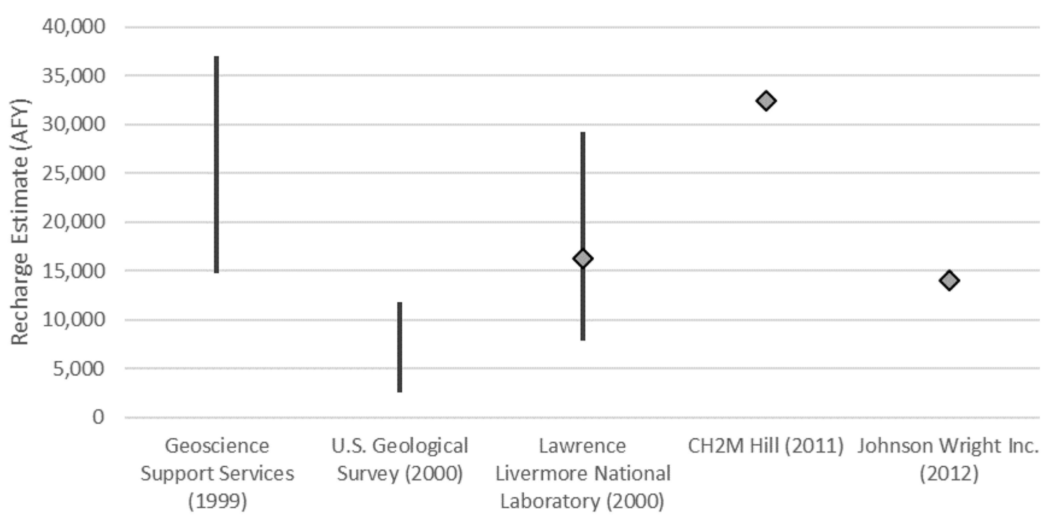

Figure 6. Comparison of the recharge estimates in the region of each of the previous studies [8–12].

3.2.1. Geoscience Support Services (1999)

Geoscience Support Services, Inc., (GSS) developed a comprehensive watershed model to evaluate recharge within the Bristol, Cadiz and Fenner Watersheds [8]. The watershed model estimated the groundwater recharge (called recoverable water in the report) as ranging from 14,800 to 37,000 acre-feet per year (AFY). The watershed model was developed based on guidance from the San Bernardino County Hydrology Manual [18], and by using the construction of an isohyetal map with the inclusion of precipitation records at Mitchell Caverns, Amboy, Needles, Yucca Grove, Kelso, Twentynine Palms, and Mountain Pass. Although GSS did not explicitly note the period of records that were used for each station, the hydrologic analysis within the report used precipitation data from 1975 to 1997, which is entirely within a wet cycle of regional precipitation [15]. GSS reported that adjustments were made to the precipitation intensity and other site-specific parameters, but the specifics were not detailed.

The GSS watershed model development also required numerous field parameters and these had many assumptions and simplifications, such as: (1) soil characteristics that assumed infiltration characteristics (soil thickness, field capacity, apparent specific gravity, and soil curve number; (2) daily evapotranspiration rate, vegetation density, vegetation interception, and the initial moisture content of the soil. The reports note that these parameters were estimated by field observations, and the model was highly sensitive to field capacity and soil thickness. Although some factors assumed (such as initial soil moisture) can typically vary widely and result in substantial effects in the analysis, few measurements of field indices were detailed.

While desert pavement (wind-polished, closely packed rock fragments that cover a desert surface where wind has removed fine-grained particles, protecting the underlying materials) substantially limits infiltration where it is present [19] and in the project area provides a surface veneer to alluvial terraces, little discussion of such surfaces were included in the GSS report.

Given the large region of interest in the model and the high spatial variability in these parameters that exists that the model does not attempt to capture, considerable uncertainty is expected for the resulting recharge estimate. A chloride mass balance approach to estimating recharge was used to validate the watershed model; however, multiple assumptions required for a valid analysis (e.g., that the chloride in the groundwater originates solely from precipitation directly on the aquifer, and there is no recycling or concentration of chloride within the aquifer) were known to be violated [8].

3.2.2. U.S. Geological Survey (2000)

The U.S. Geological Survey (USGS) prepared a preliminary estimate of groundwater recharge using the Maxey–Eakin Method [9], a commonly used recharge estimation method for the Basin and Range and Mojave Desert regions. The U.S. Geological Survey used two different scales to estimate recharge. The first model used a wide-ranging precipitation model extending far beyond the Bonanza Spring area. The second model focused on area-specific precipitation stations/records. As described above, the period of record for key stations, such as Mitchell Caverns, suffer from both a period of record entirely within a multi-decade wet period, but also from topographic effects on precipitation totals.

The first model (with wide-ranging data) is limited by its inclusion of datasets that are atypical of project area conditions [10]. The second model reflects the wet period dominant record [15] given the stations used and that the estimated precipitation vs. elevation relationships are skewed high, largely due to the Mitchell Caverns station, which has received more precipitation than the higher elevation stations (as discussed in Evaluation of Precipitation Record section above).

The first model's derived recharge estimate to the Fenner, Bristol and Cadiz basins was 2547 AFY. The second model's estimated recharge estimate to the Fenner, Bristol and Cadiz basins was 11,807 AFY, and given the period of record for the stations used, and the increased precipitation measured at Mitchell Caverns relative to the stations at similar or higher elevations, the long-term recharge is likely less than 11,807 AFY, using this method.

3.2.3. Lawrence Livermore National Laboratory (2000)

Davisson and Rose (2000) [10] presented a range of groundwater recharge estimates ranging between 7864 AFY to 29,185 AFY. Personal communications [20] indicate that a best estimate of groundwater recharge based on their work would be an estimate that is closer to their regional precipitation-elevation curve of 16,214 AFY. The 29,185 AFY estimate was a maximum estimate (upper error bound).

As with the USGS recharge evaluation, the Maxey–Eakin analysis conducted by Davisson and Rose was based on a data record during a wetter-than-average period [15]. Again, based on a long-term average annual precipitation trends, the recharge could be anticipated to be less than predicted. The inclusion of the most recent precipitation data, including those from the Mid-Hills station has the effect of raising the elevation for the 8-inch precipitation contour, which in turn reduces the recharge area and volume of the groundwater recharge to lower than that predicted by both Davisson and Rose [10] and the U.S. Geological Survey [9].

3.2.4. CH2M Hill (2011)

A CH2M Hill (2011) Report [11] included an update of work performed by Geoscience Support Services using the U.S. Geological Survey programs INFIL3.0 and MODFLOW to re-evaluate the estimated groundwater recharge that was previously estimated by Geoscience Support Services (1999). Based on these efforts, the average annual "recoverable" water quantities for the Fenner Watershed area are estimated at 30,191 AFY and 2256 AFY for Orange Blossom Wash (32,447 AFY combined).

CH2M Hill's report includes a INFIL3.0 model that represents large areas in the region (in the hundreds of square miles) to have identical characteristics. Given the local landscape and the high special variability of surface soil conditions, this assumption does not reflect the realities of the physical conditions, and it thus incorporates substantial generalization and uncertainty to the model results, similar to the previous GSS [8] analysis. Also, as did the GSS [8], USGS [9], and LLNL [10] recharge estimates, the CH2M Hill [11] report uses precipitation records from periods that were wetter than the long-term average conditions [15].

CH2M Hill reported the attempted use of these derived recharge rates in numerical groundwater flow modeling of the region [21]. The evapotranspiration rate was a calibrated parameter in the reported model, and it allowed for the evapotranspiration rate to vary substantially between recharge scenarios, even though evapotranspiration would be unlikely to change, given that the playa soils would remain unchanged, the climate factors would be unchanged, and assuming that the groundwater levels would be above the extinction depth, allowing evapotranspiration to take place. A more reliable test of the recharge estimate using the numerical model would have been to use a published evapotranspiration rate from salt-encrusted dry lakes, and to calibrate to the recharge.

However, their modeling resulted in the required acceptance of high evapotranspiration rates to calibrate the model. High evapotranspiration rates were necessary in the model to allow for the amount of water to discharge from the Bristol and Cadiz Playas to accommodate the high estimated recharge rate [12]. CH2M Hill reported the use of evapotranspiration rates greater than 50 ft/year for Cadiz Dry Lake and 20 ft/year for Bristol Dry Lake. These rates are substantially above the pan evaporation rate (nearly five times the pan evapotranspiration rate for Cadiz Dry Lake, and approximately 10 times the U.S. Geological Survey's evapotranspiration rate from playa soils in Death Valley), and they are unreasonable, which suggests that other model parameters (such as recharge) are also not accurate.

3.2.5. Johnson Wright Inc. (2012)

Johnson Wright Inc. (JWI) (2012) [12] used a discharge evaluation that was based on more recent evapotranspiration data than what was used in the CH2M Hill analysis. Continuous micrometeorological data collected over a four-year period in Death Valley were used to estimate evapotranspiration rates over the area evaluated [22]. The JWI analysis resulted in more consistent and generally improved estimates of groundwater discharge than in previous studies [22]. DeMeo's resulting midpoint evapotranspiration rate estimates were 0.13 feet per year (ft/yr) for salt-encrusted playa, and 0.15 ft/yr for bare-soil playa. JWI assumed the 0.15 ft/yr evapotranspiration rate resulting in 8947 AFY of evapotranspiration losses from the Bristol and

Cadiz playas (based on the area in which evapotranspiration takes place in the CH2M Hill model). Further, adding the estimated annual pumping from the basin of approximately 5000 AFY [11] and assuming that the basin is in hydrologic balance or that inflow equals outflow, an estimated recharge of approximately 14,000 AFY can be inferred (plus the volume of spring discharge which is likely small in comparison to the total recharge estimate and within the error of the estimate). However, the JWI analysis also should be considered to have a high estimate of recharge, due to the use of a surface evapotranspiration estimate that does not account for the extinction depth and the existing depth to groundwater beneath the playas. Thus, JWI's high estimated recharge of approximately 14,000 AFY plus spring discharge is similar to the best estimate of Davisson [9,20], as calculated from above average periods of precipitation.

3.3. Isotopic Characterisitics of Spring Water at Selected Springs

The recharge estimates can be further assessed based on the radiocarbon characteristics of these perennial springs in the study area. While tritium was not detected in any of the water collected from these perennial springs in the sampling events indicated, which would have been expected if the water was sourced by a recent recharge, a previous sampling collected from Theresa Spring had detectable levels of tritium (1.38 TU). The detection of tritium suggests that, on occasion, Theresa Spring includes a significant amount of source water from more recent recharge, but the recent absence shows that the inclusion of local recharge is likely to be highly seasonal. Based on the results of the ^{14}C analysis, the following apparent water ages (corrected for δ^{13}C results) were identified (Table 3):

Table 3. Apparent water age for each of the sampled springs.

Location	Apparent Radiocarbon Water Age
Bonanza Spring	15,500 years
Hummingbird Spring	2400 years
Burnt Spring	1800 years
Vernandyles Spring	4400 years
Theresa Springs	3400 years

These radiocarbon results are similar to the radiocarbon results in groundwater in the area presented by Rose [23] and is consistent with the result of groundwater aging in the Fenner Valley basin-fill aquifer by Davisson [24]. Radiocarbon ages of water are considered "apparent ages" since waters can dissolve and mix additional radiocarbon-free carbon by chemical reactions with aquifer materials producing a dilution of the original radiocarbon content that results in ages that may be older than actual. Additionally, older waters can mix with more recent recharge and reflect more recent radiocarbon ages compared to the age of some of the source water. Nevertheless, the radiocarbon ages of these perennial spring waters reflect that a substantial portion is sourced from water of the older basin-fill regional groundwater and not recent, local seasonal recharge.

4. Discussion

Given the high degree of spatial and temporal variability, and the vast distances without data, precipitation-driven recharge estimation in the study area are subject to substantial uncertainty resulting from:

- Issues associated with the precipitation record, both in the period of the record (higher than average period), and incomplete records;
- Local topographic effects on precipitation patterns;
- Substantial spatial variability of surface soil and rock characteristics that are not considered in the analyses, which include the data input for those characteristics.

These large uncertainties in the derived recharge values hinder the ability to appropriately assess and manage the water resources in the region.

Alternatively, a more reliable method to evaluate the basin integrated recharge in the Fenner, Cadiz, and Bristol basins based on a numerical groundwater flow model is hampered by the lack of site-specific parameters calibrate to recharge, and the expectation that given the size and complexity of the basin modeling, the results are unlikely to have a single unique solution. A modeling effort with the purpose of estimating recharge would require a detailed sensitivity analysis, and the consideration of potentially multiple conceptual site models to determine a more reliable range of plausible recharge estimates. Such a basin scale hydrologic analysis would benefit from the incorporation of the flows from perennial spring in the model hydrodynamics to evaluate the role of groundwater versus local recharge on flow dynamics. CH2M Hill reported that using a simplistic analytical model for evaluating the connection between the basin-fill aquifer and Bonanza Spring, approximately eight feet of groundwater drawdown appeared to eliminate the surface flow that currently occurs at a relatively constant rate, and which would also be reasonably expected to result in a substantial reduction in the vegetation cover in the riparian area [11].

The ages derived from the perennial springs in the Fenner and Bristol groundwater basin water are consistent with the sourcing work conducted previously [1,24], and the regional nature of groundwater flow discharging at Bonanza Spring. Even without knowing the specific hydrologic pathway, with respect to Burnt Spring, Hummingbird Spring, Vernandyles Spring, and Theresa Spring, this analysis suggests that those waters derive from one of the three following potential sources:

1. recharge in the upper elevations of the Clipper Mountains which takes approximately 2000–4000 years for that water to reach spring discharge locations;
2. from a similar basin-fill aquifer source to Bonanza Spring, but with a less tortuous/more permeable path that allows it to travel to the discharge location thousands of years faster;
3. a mixture of water from the basin-fill aquifer source to the north, and more recent recharge that results in the tritium content being diluted to non-detectable concentrations, and where the radiocarbon ages are composite ages that reflect the apparent age result from the mixing of two distinct sources.

For Scenario 1, the necessary travel times are unreasonably slow. For example, for Bonanza Spring, given the apparent age of 15,500 years, and the short travel path within the catchment area (approximately 1400 ft), the apparent groundwater velocity would be on the order of 10^{-4} ft/day. This rate would not be sufficient to sustain the spring flow.

For Scenario 2, the discharge from these other perennial springs is lower than would be expected, given Bonanza Spring's flow rate if they were solely sources from a comparable groundwater formation.

Therefore, the more complex Scenario 3 appears to be most plausible. The age of the water discharged from Bonanza Spring and considering the small catchment area (50 acres) precludes this water from being sourced within that catchment. First, the Maxey-Eakin analysis conducted by Lawrence Livermore Laboratory [20] indicates that for the mid-elevations of the small catchment above Bonanza Spring (e.g., at an elevation of approximately 680 m or 2230 feet above mean sea level), the recharge rate for the Bonanza Spring catchment would be 0.010 ft/yr. Given that the catchment is volcanic rock and that the Maxey-Eakin Method does not consider surficial soil or rock conditions, and this would result in the same recharge rate for more permeable sandy alluvium present in the area, this recharge rate on a local basis would likely be high. Nevertheless, this recharge rate would only provide a maximum of approximately one-third of the water to account for the discharge at the spring (approximately 10 gallons per minute or 15 AFY). Further, to maintain constant flow would also indicate that recharge remains constant and would not account for the widely varying precipitation seasonally and annually that is measured in the area. As described in the report by Kenny (2018) [25], the storage in that system conceptualization could only maintain constant flow in the order of a couple of decades during extended dry periods, and thus it cannot account for the approximately 100-year record indicating that such spring flows have minimal observed seasonal changes.

There are springs to the north (up-gradient) of Vernandyles and Theresa Springs at elevations that are higher than either of these springs within the Mojave National Preserve, indicating that Vernandyles and Theresa Springs discharge at elevations that could be fed from a more distant alluvial source that encounters the volcanic rocks from which both Vernandyles and Theresa Springs discharge. The same can be said of the springs in the Clipper Mountains (Bonanza, Burnt and Hummingbird).

Given the existing uncertainties in specific hydrologic flow paths and the recharge estimation, the degree of hydraulic connection between the basin-fill aquifer and these perennial springs, and the expectation of a hotter and dryer climate in this region for the foreseeable future, water resource management would need to use recharge estimates in the basin within the 4000 to 12,000 AFY range (consistent with the range of U.S. Geological Survey [9] estimates and the lower-end of estimates by LLNL [10], but lower than the estimates by GSS [8], CH2M Hill [11], and JWI [12]) in order to protect the water resources in the region, until more refined recharge estimates can be determined using the detailed and site-specific modeling approaches described above.

While there are springs observed in this region that are seasonal and that appear to source from local precipitation-driven recharge, the perennial flow and older radiocarbon characteristics of Bonanza Spring, Hummingbird Spring, Burnt Spring, Vernandyles Spring, and Theresa Springs indicate that they are not exclusively sourced from local recharge. Thus, these spring flows, and the ecological community that depends on such flows, are inseparably connected to the regional groundwater and any groundwater management decisions that can impact on this resource.

Supplementary Materials: The following are available online at http://www.mdpi.com/2306-5338/5/3/51/s1, Precipitation data used to construct Figure 5. Love and Zdon-2018 Hydrology-Precip records Mojave.xlsx.

Author Contributions: A.H.L. contributed conceptualization, methodology, formal analysis, validation, writing—original draft preparation, writing—review and editing, and visualization. A.Z. contributed conceptualization, methodology, formal analysis, investigation, supervision, writing—original draft, project administration, and funding acquisition.

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Memorandum

DATE: January 2, 2019

TO: Fenner Valley Water Authority
Santa Margarita Water District

FROM: David K. Kreamer, Ph. D.

RE: Review of September 2018 Love and Zdon publication. Enclosed are my findings.

Review of *"Use of Radiocarbon Ages to Narrow Groundwater Recharge Estimates in the Southeastern Mojave Desert, USA"* by Adam H. Love and Andy Zdon in Hydrology MDPI[1]

By
David K. Kreamer, Ph.D.

In the publication, Love and Zdon 2018, the authors attempt to critically review and improve and constrain estimates of groundwater recharge in the Southeastern Mojave Desert by use of radiocarbon dating. The conclusions reached in this paper rely on previous published work in non-journal publications, and one round of radiochemical measurements made at five (5) selected springs.

Understanding groundwater recharge, subsurface water balance volumes, and average groundwater residence time is a crucial aspect in defining the sustainability of springs throughout the world, and particularly in the Mojave Desert. Springs in arid lands are precious and are the focus of ecologic system health, cultural heritage, drinking water supply, and regional stability, and therefore have attracted much scientific study (LaMoreaux et all 2001; Chapelle et al. 1997; Manga 2001; Kreamer et al. 2015; Meinzer 1927; Kreamer and Springer 2008). Environmental studies in this sensitive, vulnerable region need to be robust, based on solid literature, and quantitatively define uncertainties in their conclusions and interpretation.

While the publication by Love and Zdon in Hydrology MDPI adds data to study of springs in the Mojave Desert, the conclusions reached by the authors are seriously flawed, contain both citations and self-citations from non-refereed work, do not adequately describe limitations or uncertainties

[1] https://www.mdpi.com/2306-5338/5/3/51.

in their work, fail in some cases to consider the possibility of local spring recharge beyond surface catchments, use different areas and basins for their comparison of annual recharge volumes, and neglect the incorporation of standard methodologies to interpret their data.

The conclusions articulated by the authors are tenuous at best. Problems with the publication's format, methodologies, omissions, and interpretations, (many of them major flaws), include:

1. Springs are very poor locations to attempt to calculate average groundwater residence time.
2. The authors, Love and Zdon, confuse the concept of the generally accepted "*average groundwater residence time*" with their use of the more misleading term "*apparent groundwater age.*"
3. The paper's "*Site Description" and "Geologic and Hydrogeologic Setting*" sections contain no citations of literature, except a self-citation addressing their previous characterization of the source of Bonanza Spring.
4. The paper does not adequately map or quantitatively define "*Southeastern Mojave Desert*" in the article's title and appears to use different, non-equivalent areas and basins when comparing annual recharge volumes.
5. The work compares five annual recharge estimates, with three estimates from Technical Memoranda or Reports. Two other estimates are veiled, apparently not externally refereed, self-citations in letter and report form, and in one instance is self-congratulatory. This is generally considered a poor practice in cited literature. Memoranda and Reports are often not readily available for external review, and the rigor of their peer review is not always apparent. The obfuscation exhibited by unclear referencing exhibited in the self-cited work is also considered a poor practice in cited literature**.**
6. The publication does not indicate correction of tritium values with helium-3 analysis.
7. The authors do not use any of the standard methodologies to correct carbon-14 values for interaction with "dead" geologic inorganic carbon, not atmospherically derived.
8. The publication does not consider the effect of groundwater's interaction with organic carbon.
9. Concerning Love and Zdon's (2018) tritium and ^{14}C analyses of spring water, the authors fail to report duplicate or replicate analyses critical to establishing the limits of uncertainty in their findings.
10. For their tritium and ^{14}C analyses of spring water, there is poor reporting of the sampling date, exact location of the sampling points, ambient air temperatures and other meteorological conditions, antecedent precipitation, and many other factors which could influence radiological measurements – these are not detailed in the manuscript.
11. The authors do not report additional sampling or results from local wells or springs to support their findings.
12. Other indicators of average groundwater travel time to springs and recharge (e.g. chloride mass balance studies, chloroflourocarbons (CFCs), trace elements) are not fully investigated.

13. The authors make a refutable, *a priori* presumption that Bonanza Spring is "in hydraulic communication with the basin-fill aquifer system surrounding the Clipper Mountains".
14. The publication does not consider or analyze the possibility of fracture flow.
15. The publication lacks an associated quantitative groundwater transport model.

These weaknesses in the publication are elaborated below.

1. **Springs are poor locations to attempt to calculate average groundwater residence time.**

According to the International Atomic Energy Agency's (IAEA) "Isotope Methods for Dating Old Groundwater" (2013), "*Springs probably are the least desirable sources for sampling 'old' groundwater because their discharge can represent a mixture of many waters of generally unknown origin (and age).*" Wells are considered far superior. This is a caution about over interpretation of estimates of average groundwater residence time for spring flow.

2. **The authors confuse the concept of the generally accepted "*average groundwater residence time*" with their use of the misleading term "*apparent groundwater age*".**

Groundwater scientists have generally agreed for many years that the concept of "groundwater age" is flawed. Fontes (1983) notes *"Owing to dispersion, the 'age' of a groundwater sample corresponds generally to a time distribution of many elementary flows. Thus, except in the theoretical case of a pure piston flow system, or of stationary waters entrapped in a geological formation, the concept of groundwater age has little significance."*

3. **The paper's "*Site Description" and "Geologic and Hydrogeologic Setting*" sections contain no citations of literature, except a self-citation addressing their previous characterization of the source of Bonanza Spring.**

It is typical in publications to do comprehensive literature searches, from extensive source material. Love and Zdon (2018) describe the region's geologic and hydrogeologic features in detail without citation of a single source. However, notable is an absence of specific description of geologic structures, exact locations of faults, orientation of geologic contacts, rock porosities and permeabilities, and other characteristics crucial to interpretation of spring flow.

Three figures are shown in this section with sources cited in the captions; one figure is a small portion of a much larger, generic map of California's surface geology from a State government website (Geological Map of California. California Geological Survey, Geologic Data Map No. 2. 2010. Available online: https://maps.conservation.ca.gov/cgs/gmc/). A second figure is a conceptual geologic cross-section drawn from another publication on the hydrogeology underlying White Pine County on the northern Utah-Nevada border <u>about 350 miles away and distant from the Mojave Desert</u> (U.S. Geological Survey. Water Resources of the Basin and Range Carbonate-Rock Aquifer System, White Pine County, Nevada, and Adjacent Areas in Nevada and Utah. Scientific Investigations Report 2007–5261; Welch, A.H., Bright, D.J., Knochenmus, L.A., Eds.; U.S. Geological Survey: Reston, VA, USA, 2007; Figure 16; p. 37.) The third is a small portion of a California state website map of groundwater basins (California Department of Water Resources. Groundwater Basin Boundary Assessment Tool. Division of Integrated Regional Water Management. 2018. Available online: https://gis.water.ca.gov/app/bbat/).

4. **The paper does not adequately map or quantitatively define "*Southeastern Mojave Desert*" in the article's title, and appears to use different, non-equivalent areas and basins for comparison of annual recharge volumes.**

One of the key elements of this publication is comparison of groundwater volumes in five annual recharge estimates. These values are compared in the paper's Figure 6. It is not reported, however, that the location and areal extent/ boundaries that are the basis for these recharge estimates are vaguely described and from dissimilar areas. The five recharge estimates compared in this publication are from: the Geoscience Support Services (1999), the U.S. Geological Survey (2000), the Lawrence Livermore National Laboratory which is the Davison and Love (2000) including a personal communication, CH_2M Hill (2011), and Johnson Wright Inc. (2012) by A. Zdon.

According to the publication's authors Love and Zdon, Geoscience Support Services (1999) and the USGS (2000) estimates are for the area comprised of the Bristol, Cadiz and Fenner Basins. The "Lawrence Livermore National Laboratory (2000)" (by Davisson and Love) recharge estimate contains anecdotal personal communication, with the recharge area under consideration being the Fenner Watershed. The Fenner Watershed includes the Clipper Valley according to the California Department of Water Resources. CH_2M Hill (2011) also bases its estimate on only Fenner and the Orange Blossom Wash. In the Love and Zdon (2018) publication, the Johnson Wright (by Zdon letter) recharge estimate is unclear about the area which it represents. The current publication only mentions the Bristol and Cadiz playas.

Also, some of the comparisons in Love and Zdon are between quantities of dissimilar (a.) "recoverable" water and (b.) groundwater recharge. Comparisons should be made between similar parameters and study areas.

5. **The work compares five annual recharge estimates, with three estimates from Technical Memoranda or Reports. Two other estimates are veiled, apparently not externally refereed, self-citations in letter and report form, and in one instance is self-congratulatory. This is generally considered a poor practice in cited literature. Memoranda and Reports are often not readily available for review, and the rigor of their peer review is not always apparent and often not critically externally reviewed. The obfuscation exhibited by unclear referencing exhibited in the self-cited work is also considered a poor practice in cited literature.**

The first three Technical Memoranda and Reports are from Geoscience Support Services (1999), CH_2M Hill (2011), and the USGS (2000). Of the remaining two, one of the self-citations is from a seven page government report (Davisson and Love, 2000) listed in the MDPI Hydrology publication as Lawrence Livermore National Laboratory (2000), the other from a non-refereed letter written by one of the authors (Zdon), listed as Johnson Wright Inc. (2012). The authors use anecdotal information from the first (personal communication) and self-congratulate the quality of their own recharge estimate from the second. For the latter self-citation, Love and Zdon (2018) present, without support, that Zdon's (Johnson Wright Inc.) non-refereed recharge estimate, "*resulted in more consistent and generally improved estimates of groundwater discharge than in previous studies*". It should be noted that the Johnson Wright Inc. (2012) letter by Zdon only suggests a single value with no error bars in Figure 6, not a range of values, and Zdon's letter based evaporation estimates on interpretation of data from the topographically lower, hotter Death Valley, CA and may not represent all evaporation values for the study area near the Cadiz, Bristol basins.

In fairness to the authors, there are not an abundance of recharge estimates in the Eastern Mojave Desert, and their choices for comparison are limited. Even so, annual groundwater recharge comparisons should normalize to equivalent areas, self-citation should be made more transparent, and it is suggested that authors should refrain from self-promotion.

6. The publication does not indicate correction of tritium values with helium-3 analysis.

Tritium was measured in this study at five springs and used to represent apparent groundwater age. There are natural limits to this method because the atmospheric tritium bomb pulse caused by nuclear testing and associated tritium in the atmosphere, precipitation, infiltrating waters, and groundwater has been greatly reduced in recent decades because of: (a.) lower amounts of tritium in precipitation in the Mojave Desert relative to points further inland and other locations in California (Stewart and Farnsworth 1968; Harms 2015), (b.) tritium decay, which has brought tritium levels in precipitation close to pre-bomb levels for several decades, and (c.) dispersion and mixing of groundwater of different ages. Because of tritium's short half-life it has been increasingly difficult to identify a "bomb peak" in groundwater and distinguish between pre-bomb pulse and post-bomb pulse waters. These challenges can be overcome by measuring tritium concentrations in concert with its decay product helium-three or ^3He ($^3He_{trit}$) as first suggested by Tolstykhin and Kamensky (1969) and experimentally confirmed by Torgersen et al. (1979). Measuring tritium and tritiogenic ^3He together supports identification of the tritium peak as the sum of tritium and ($^3He_{trit}$), even if most of the tritium has decayed. It also allows direct calculation of average groundwater residence time from the mother/daughter ratio (tritium/^3He). This is advantageous because it removes the requirement to ascertain the exact time-dependent tritium delivery to the aquifer (Clark et al. 1976). $^3H/^3He$ analysis can also be compared to studies of chlourofluorocarbons and krypton-85. ^3He analysis was not presented in the current paper by Love and Zdon.

Through radioactive decay, post bomb pulse tritium levels in precipitation have approached pre-bomb levels since the 1980s around the world, and the mean tritium concentration in California precipitation is 11.4 pCi/L, or 3.5 Tritium Units (TU) (Harms 2015). With even lower than average tritium in the precipitation in Mojave Desert relative to inland and mountainous areas in California and on the West Coast, for as much as approximately 35 years or almost 3 half-lives, some groundwater which originated as post-bomb precipitation contains tritium concentrations now approaching detection limits of analytical equipment. This diminishment reduces the strength of conclusions in Love and Zdon (2018) based on single measurements of tritium alone.

Without helium-three analysis the tritium result of Love and Zdon (2018) are less useful. Also, there is only one value of tritium measurement for each spring listed in the Hydrology MDPI publication. This lack of confirmatory replicate sampling will be discussed further below.

7. **The authors do not use any of the standard methodologies to correct carbon-14 values for interaction with "dead" geologic inorganic carbon, not atmospherically derived.**

Probably one of the greatest flaws is the radioactive carbon-14 (^{14}C) "age dating" work by Love and Zdon (2018) and their inadequate discussion of, and correction for, groundwater interaction with carbonate geologic materials. These carbonate rocks have been in the ground millennia and have totally depleted ^{14}C (sometimes referred to as "dead" carbon), thus reducing the radioactive carbon signal in the adjacent and interacting groundwater and producing a false indication of a lengthy average groundwater travel time to a spring.

According to Phillips and Castro (2003), "*Natural radiocarbon was first detected by Libby in the mid-1940s (Arnold and Libby, 1949; Libby, 1946), but the first applications to subsurface hydrology were not attempted for another decade (Hanshaw et al., 1965; Munnich, 1957; Pearson, 1966). These early investigators discovered that radiocarbon shows clear and systematic decreases with flow distance that can be attributed to radiodecay, but also exhibits the effects of carbonate mineral dissolution and precipitation reactions.* ***Quantification of residence time is not possible without correction for additions of nonatmospheric carbon***." (My emphasis).

It is a major error in the Hydrology MDPI manuscript that the authors do not adequately correct their data for interaction with "dead" carbonate species. These adjustments can be major. From IAEA (2013), "*the extent to which recharge waters evolve in isotopic equilibrium with soil gas (open system evolution) or react with carbonates following recharge (closed system evolution) (Clark and Fritz 1997; Deines et al. 1974) can lead to uncertainties in 14C model age of old groundwater.*" Love and Zdon do not include uncertainty analysis in their publication.

Not only do Love and Zdon (2018) not adjust for non-atmospheric carbon, they make no distinction between dissolved inorganic carbon (DIC) and dissolved organic carbon (DOC) or address other complicating factors. Along these lines the International Atomic Energy Agency describes inorganic carbon and its effects, "*The two most significant geochemical processes are dilution of dissolved inorganic 14C (DI^{14}C) from dissolution of carbonates and formation of DIC from microbial degradation of old organic carbon within the aquifer. Thomas et al. (2001) found unadjusted ^{14}C model ages of DIC in groundwater from Nevada as much as 20 ka, that, when corrected on the basis of δ13C for carbonate rock recrystallization in this tectonically active aquifer, were in the range of 1–7 ka and similar to ^{14}C model ages of DOC in the aquifer.*"

Other typical chemical reactions, such as de-dolomitization (Plummer et al. 1990) or weathering of feldspars, cause chemical precipitation of calcium carbonate which leads to an isotopic fractionation influencing the concentrations of both ^{13}C and ^{14}C. Also, noted by IAEA (2013), "*uptake of magnesium and/or calcium on exchangers, such as clay minerals, permits additional dissolution of carbonate minerals (calcite and/or dolomite), which dilutes the ^{14}C reservoir in groundwater. If not corrected for cation exchange, the 'adjusted' C model age is too old*." Love and Zdon make no such correction.

It is clear that calcium carbonate exists in rocks, fractures and groundwater in the study area. In the upgradient Clipper Mountains Mine, according to Minedata.org, the rock contains "small, thin lenses of limestone in the schist" and "limestone near the quartz diorite contains small, discontinuous bodies of friable, granite-rich tactite." Limestone is largely calcium carbonate rock in which ^{14}C is absent, and whose interaction with groundwater would artificially increase the apparent average groundwater travel time – "apparent age". There are also documented calcium mine prospects in the study area (e.g. Unnamed Prospect at 34° 48' 8" North , 115° 22' 25" West). Importantly, Zdon et al. (2018) in major ion analysis show 30% to 70% carbonate and bicarbonate species in water from many springs and wells in and around the study area. The serious omission of ^{14}C adjustment for non-atmospheric carbon in Love and Zdon (2018) is unexplained.

8. The publication does not consider the effect of groundwater's interaction with organic carbon.

Love and Zdon (2018) do not make clear distinctions between the impact of inorganic carbon and organic carbon, or many of the other complicating factors in ^{14}C analysis of groundwater. Although organic material is sparse in the present Mojave Desert, past climate supported abundant plant life which could be incorporated into the study site's subsurface. Discussing the impact of DOC on ^{14}C in groundwater, IAEA (2013) notes, "*Owing to the many geochemical interactions that can lower the 14C content of DIC and, if not quantified, limit the usefulness of radiocarbon dating of DIC in groundwater, the feasibility of radiocarbon dating of DOC in groundwater was investigated in a series of studies (Drimmie et al. 1991; Hendry and Wassenaar 2005; Long et al. 1992; Murphy et al. 1989; Murphy et al. 1989; Purdy et al. 1992; Tullborg and Gustafsson 1999; Wassenaar et al. 1989; Wassenaar et al. 1991)."*

IAEA (2013) continues, *"Many more geochemical and isotopic reactions occur in groundwater systems that are not considered by any of the traditional adjustment models. The most important of these pertain to the presence of organic carbon",* and "*old organic carbon is oxidized in the aquifer, which dilutes the ^{14}C reservoir, and if not accounted for, the adjusted age is too old*." IAEA concludes. "*There are two main sources of DOC in groundwater: (i) particulate organic carbon (POC) in the soil zone and unsaturated zone that can have radiocarbon ages of zero to at least several thousand years; and (ii) sedimentary organic matter (SOM) such as lignite, peat or other forms of POC buried with the aquifer sediment that typically is radiocarbon-'dead'. Both sources of DOC can dilute the ^{14}C content of DOC in an aquifer."*

The net result of decades of research and study on the use of dissolved ^{14}C to assess average groundwater residence time is that adjustments must be made to any calculation of "apparent age" for the contribution of non-atmospheric carbon. These indispensable and fundamental adjustments are not included in Love and Zdon (2018). Love and Zdon acknowledge these possible complications but take no steps to correct their data.

9. **Concerning Love and Zdon's (2018) tritium and ^{14}C analyses of spring water, the authors fail to report duplicate or replicate analyses critical to establishing the limits of uncertainty in their findings.**

An essential element of almost all scientific studies is to evaluate the representativeness of sampling, the extent of uncertainties in results and conclusions (error bars), and to identify and quantify sensitivities in parameters used for calculation. Core to this are duplicate and replicate analyses, to determine the accuracy and precision of measurements. These standard methods were not reported by Love and Zdon, and goodness and validity of their "one shot" tritium and ^{14}C analyses remain in question.

10. **For their tritium and ^{14}C analyses of spring water, there is poor reporting of the sampling time of day, exact location of the sampling points, ambient air temperatures and other meteorological conditions, antecedent precipitation, and many other factors which could influence radiological measurements – these are not detailed in the manuscript.**

For an external reviewer to determine the representativeness of a sampling regimen, important information, such as ambient and preceding meteorological conditions, aids in interpretation. The authors briefly describe their sampling and analytical methodologies, but leave out important details on the actual field sampling, chain-of-custody protocols, exact location of sampling, and other important details. The exact location of sampling is important in this case as Bonanza Spring is actually two springs, Upper and Lower, and has a long surface flow above ground in between where ambient air temperatures could affect water temperatures and chemistry. The "one shot" nature of the sampling, coupled with a paucity of field information make further interpretation of seasonal or diurnal variation particularly difficult. The authors speculate on seasonal variability for Theresa Spring, but provide no overwhelming evidence of temporal variation. It should be noted that the study/sampling area receive scant to no rain in the many months preceding sampling.

This problem could be easily resolved. Attendant field information could be made available in either an Appendix or via a publicly accessible URL.

11. **The authors do not report additional sampling or results from local wells or springs to support their findings.**

Zdon et al. (2018) and other literature sources provide hydrochemical information from many wells and springs in the same study area as this publication, but Love and Zdon (2018) make very few, and in some instances, no comparisons with this available water quality information. For example, trace elements, measured by the authors previously for this study's five springs, are not reported or interpreted. Also, as mentioned above, the past information on the carbonate concentrations in the five springs sampled in the current publication are directly relevant to interpretation of ^{14}C, and many other parameters are germane. Past spring water temperatures, major ions, stable isotope similarities between spring water and precipitation all are applicable to current interpretation. The lack of complete and holistic treatment of available data can lead to erroneous interpretations, if they are just based on the small body of field measurements presented in Love and Zdon (2018).

12. **Other indicators of average groundwater travel time to springs and recharge (e.g. chloride mass balance studies, chloroflourocarbons (CFCs), trace elements) are not fully investigated.**

There are many other ways to ascertain groundwater recharge volumes and average groundwater travel time to springs. These include many environmental tracers in soil and groundwater. Some of these proven methodologies include chloride mass balance techniques, measurement of chlorofluorocarbons (e.g. Freon CFC-12, SF6, Halon 1301, CFC-11, CDC-113) and sulfur hexafluoride (SF_6), trace element analysis, and other indicators. Multivariate analysis of these many parameters, including techniques like Principal Component Analysis (PCA) serial correlation, are often fundamental in interpretation.

Several authors stress the importance of using more than one approach for estimating recharge, and underscore the need to employ various techniques (Scanlon et al. 2002). Concerning the use of chloride balance in arid lands IAEA notes that, "*In semi-arid to arid regions, the distribution of recharge is usually quite heterogeneous, occurring mainly in the mountains or along mountain fronts or ephemeral streams during intermittent runoff events. Local measurement techniques can be useful in areas of focused recharge. In broad areas between mountain ranges or away from streams, recharge can be nearly zero or essentially zero, as can be determined by the accumulation of solute tracers within the unsaturated zone which occurs through continued conditions where evaporation removes the water but not the solutes. The chloride mass balance technique (Wood and Sanford 1995) is one method that has proven useful under such conditions.*"

Use of CFCs, SF_6, ^{85}Kr, and $^{3}H/^{3}He$ to date and track subsurface fluid flow has proven valuable in many studies (Busenberg and Plummer, 1992; Dunkle et al, 1993; Kreamer et al. 1988; Busenberg et al., 1993; Plummer et al., 1993; Ekwurzel et al., 1994; Reilly et al., 1994; Katz et al., 1995; Cook et al., 1995, 1996; Cook and Solomon, 1995, 1997; Szabo et al., 1996; Oster et al., 1996; Johnston et al., 1998; Plummer et al., 1998 a,b). The U.S. Geological Survey (2018) notes, "*The feasibility of using CFCs as tracers of recent recharge and indicators of groundwater age was first recognized in the 1970s (Thompson et al., 1974; Schultz et al., 1976; Randall and Schultz, 1976; Thompson, 1976; Hayes and Thompson, 1977; Randall et al., 1977; Thompson and Hayes, 1979; Schultz, 1979*)." Love and Zdon (2018) did not investigate these approaches.

The use of trace elements, rare earth element, and statistical analytical interpretation (including multivariate analysis) has also been used to great advantage to understand groundwater flow and recharge, including in the desert Southwest (Kreamer et al 1996; Johannessonn et al. 1997; Asante et al. 2018; Asante and Kreamer 2018; Asante and Kreamer 2015). Multivariate analysis was not included in the Love and Zdon (2018) publication.

13. **The authors make a refutable *a priori* presumption that Bonanza Spring is "in hydraulic communication with the basin-fill aquifer system surrounding the Clipper Mountains."**

Love and Zdon (2018) state that Bonanza Spring is sourced from regional groundwater distantly sourced and in direct connection with basin groundwater that, immediately below, is over one thousand feet lower than the elevation of the spring's issuance. The basis for this assertion, that Bonanza "*has previously been identified as being in hydraulic communication with the basin-fill aquifer system surrounding the Clipper Mountains [2]"* is a self-citation (Zdon et al 2018). This speculative assertion by the authors is unlikely and refutable based on field measurements, some made by the authors themselves. Love and Zdon (2018) rule out the possibility that recharge to the spring could be locally sourced from higher elevations in the Clipper Mountains themselves, and assert that any local recharge contribution to spring flow could only come from a small surface water catchment immediately above the spring.

The authors acknowledge that recharge to springs can come from areas outside surface water catchment basins but assume *a priori* that Bonanza Spring is sourced from deep subsurface basin water, derived from alluvial fill thousands of feet lower. The authors never explain the mechanism that raises water from depth. They assume that local recharge contribution to the spring could only come from its relatively small surface catchment, rather than the simpler, more likely explanation that the bulk of the recharge to Bonanza Spring flows from the fractured rocks and higher elevations in the Clipper Mountains immediately above the spring. The reasons for this assumption by Love and Zdon are articulated in Zdon et al. (2018) but are refutable.

The reasons given in Zdon et al (2018) include Bonanza Spring's temperature, discharge, major ion concentrations, trace metal concentrations, stable isotopes of hydrogen and oxygen, and one, single tritium value. These interpretations by the collective authors have other different explanations and conclusions.

Temperature

One reason the authors (Zdon et al 2018; Love and Zdon 2018) assume Bonanza spring water is sourced from deep basin fill water (and not the upgradient Clipper Mountains directly above the spring) is the water's temperature. Zdon et al. (2018) state that *"Bonanza Spring water temperature is indicative of waters that have been at depths of greater than 750 feet below the spring vent and risen to groundwater surface despite being in such a small catchment."* This is based on the author's reporting a temperature of 27.5 (or 81.5°F) for the water at Bonanza Spring in the manuscript, which they assume is geothermally influenced. This value, however, directly conflicts with a value of 14.2°C (57.6°F) reported by Andy Zdon and Associates (2016) for Bonanza Spring. This measured spring water temperature documented by Andy Zdon and Associates is less than the yearly average air temperature calculated by Zdon et al. (2018) at 21.0°C (69.8°F). Cool water documented at the spring by Andy Zdon and Associates (2016) is inconsistent with a deep source; rather this variation is indicative of a more local source, influenced by seasonal or diurnal variation.

Discharge

Another reason the authors (Zdon et al 2018; Love and Zdon 2018) give for the assumption of a deep, consistent groundwater source is their assertion of stability of spring discharge and flow. Zdon et al. (2018) reached the conclusion, *"Bonanza Spring flow has been consistent for more* *than 100 years despite multi-year wet periods and longer periods of drought (as indicated by the literature).*" This is demonstrably untrue. Although Zdon et al (2018) give no numerical values for Bonanza Spring discharge in their publication, they do state, *"Thompson (1929) noted the presence of Bonanza Spring as a spring that yielded about 10 gallons per minute (similar to what it produces currently) that was piped to the community of Danby for use at the railroad."* In Andy Zdon and Associates (2016) the flow of Bonanza Spring is recorded as less than 1 gallon per minute (gpm) - significantly less than the 1929 value. On June 1, 2018, the flow of Bonanza Spring was also estimated at less than 1 gpm. This variability does not indicate "consistent" flow. Further, Rose (2017) reports an entirely different, higher flow value for Bonanza Spring. The reported flow at Bonanza Spring varies by at least an order of magnitude. Inconstant flow (particularly coupled with inconstant temperature readings) is not compatible with an assumption of a constant, sustainable deep groundwater source which is a conclusion of both Zdon et al. (2018) and Love and Zdon (2018). Additionally, the vegetation around Bonanza Spring has apparently changed in the past, sometimes dramatically, when viewing Google Earth imagery or from on the ground observations at the spring. This could be another indicator of inconstant discharge and flow at the spring, or alternatively periodic destruction of vegetation from localized flash flooding events.

Major Ions

Zdon et al. (2018) presents a Piper diagram of regional waters including selected springs, USGS wells, and Cadiz wells, showing the measured major ion aqueous chemistry of those sources. Trace element analysis of the waters was not reported. The authors state, *"Spring water at Bonanza Spring is a Na-HCO3 type (this is consistent with water at Lower Bonanza Spring as well). This is similar to most waters in the region except those waters at Hummingbird Spring (Ca-HCO3 type)."* Inspection of these data reveals that Bonanza Spring is dissimilar in its major ion chemistry from any well water sources, which primarily draw water from basin fill environments. This is particularly true with regard to major cations. The waters of Bonanza Spring are uniquely different than the surrounding regional well water with less than half the dissolved calcium of any well in the area and in some cases more than 4.5 times less. This difference is not supportive of the opinion put forth in Zdon et al. (2018) that Bonanza Spring issuance has a similar source to basin-fill well water and Cadiz wells. The discussion in Zdon et al. (2018) on this topic includes the statement *"The Bonanza Spring water is also similar in type to waters from the basin fill in the Fenner and Cadiz Valleys..."*.

Independent analysis of Bonanza Spring samples, collected February 2013 and March 2018 do show that the most abundant cation and anion are sodium and bicarbonate, respectively, similar to most basin fill well samples in the area. However, a sodium-bicarbonate chemistry is a generally common chemistry given the compositions of both local and regional source rocks, and therefore does not necessarily link the spring water to a regional source. Closer examination of the Bonanza Spring chemistry shows that this spring (and the associated Little Bonanza Spring) has a significantly higher sodium percentage than any of the other samples, as shown in the Piper diagram on Figure 4 in Zdon et al. (2018), and from other available well data surveyed among Fenner Valley and Cadiz Valley. The sulfate percentage for Bonanza Spring (approximately 30% of anions from Figure 4) is also higher than all nearby springs and wells.

Independent data from Bonanza Spring show the water to be undersaturated with respect to calcite, while all other regional aquifer groundwater samples from Fenner and Cadiz Valley show saturation with this common mineral. This characteristic further supports the Bonanza Spring water reflecting a more localized source, such as the more calcite-poor rocks of the Clipper Mountains. The notably high percentages of sodium and sulfate in Bonanza Spring, along with its undersaturation with calcite, suggest a more localized source rather than a regional source, since this combination of major ion chemistry does not appear in wells of the flow regime proposed by the authors.

Trace Metals

The authors mention that trace metal analysis was carried out but no results are reported. Sample preparation was made by addition of nitric acid, but sample filtration and use of ultra pure nitric acid, which is necessary for trace analysis, is not mentioned. Trace element analysis has proven useful in source analysis of springs in Death Valley (Kreamer et al. 1996). Why the results of trace analysis were left out of the Zdon et al. (2018) publication is not explained.

Stable Isotopes

Zdon et al. (2018) presents stable isotopic data showing aqueous hydrogen and oxygen at Bonanza Spring is uniquely different than any other spring they evaluate regionally (their Figure 8). The isotopic signature is lighter (more negative) at Bonanza Spring (δD -82.1, δ_{18}O -10.25) which typically indicates water is sourced from a colder and/or higher elevation source. Surprisingly, the authors attribute this to a recharge source considerably distant (20 to 45 miles) to the north and northwest, the Providence and New York Mountains, and not to the surrounding Clipper Mountains where Bonanza is located. The authors do note, however, that previously a different assumption was made (including by one of the co-authors of Zdon et al. 2018): "*Of note is that Davisson and Rose (2000) assumed the local catchment for Bonanza Spring as being the whole of the Clipper Mountains …"*. The Clipper Mountains surround the spring rising up several thousand feet higher to the north (with the spring downslope), are in close proximity and receive substantial rainfall, but the authors speculate that the spring water is sourced instead tens of miles away in more distant ranges. Without discussion or justification Zdon et al. (2018) state, *"isotopic signatures of precipitation collected in the Clipper Mountains are much higher than those at Bonanza Spring (Rose, 2017)."* The authors use this statement as part of a justification to exclude the adjacent, upgradient Clipper Mountains as potential recharge areas contributing to Bonanza Spring discharge. Inspection of the data from Rose (2017) does not support the authors' assertion.

The authors state that precipitation measurement in the Clipper Mountains are isotopically heavier and infer that this invalidates these surrounding mountains as a recharge source, supplying the Bonanza Spring. As noted in Zdon et al. (2018), these same stable isotopes of hydrogen and oxygen were measured in precipitation near Bonanza Spring from 2001 to 2005 by T.P. Rose (2017) (labeled "Clipper Mountains"). According to the latitude and longitude given, the sampling point was approximately 1000 ft north of the spring and about 300 ft higher in elevation. The "winter" (October to April) precipitation measured by Rose accounted for about 79% of the yearly rainfall summed over those years and ranged in isotopic values from δD -59.3 to δD -91.0, and from δ^{18}O -7.2 to δ^{18}O -12.6. When these values are weighted with the seasonal rainfall for each individual year, the weighted "winter", October to April, 6 month averages are δD -77.55, and δ^{18}O -10.75. These delta values are very close to the values recorded in nearby Bonanza Spring discharge by Zdon et al. 2018 (δD -82.1, $\delta^{18}O$ -10.25), indicating that the spring could very well be in large part fed by local recharge in the Clipper Mountains.

Tritium

Tritium analysis reported in Love and Zdon (2018) for Bonanza Spring is apparently the same information reported information published on selected samples in Zdon et al. (2018). Zdon et al. states, *"Tritium (3H) analysis was conducted using the tritium enhanced enrichment (TEE) method to obtain lower reporting limits."* The authors also state that, "3*H was not detected at reporting limits of 0.56 TU in the water samples from Bonanza (and Lower Bonanza) and Hummingbird Springs*." The only laboratory for isotopic analysis mentioned in the manuscript is Isotech Laboratories for stable isotopic analysis. On the Isotech website, it is reported that they conduct liquid scintillation counting with or without electrolytic enrichment, having a detection limit of 1 Tritium Unit (TU), not 0.56 TU. Tritium electrolytic enrichment available at Isotech Laboratories, called "enhanced enrichment (TEE)" in the manuscript, allows lower reporting limits. Because the laboratory for tritium analysis was not specified in Zdon et al. (2018) and because of the discrepancy in detection limits, it is slightly unclear which laboratory was used for tritium analysis, nor are the number of duplicates, spiked samples, field or laboratory controls, or chain of custody procedures specified in the publication. Sampling dates, times, exact locations, antecedent rainfall are also not specified in the manuscript.

If one assumes the lack of detection of ^{3}H in the single, "one shot" sample taken Bonanza and Lower Bonanza Spring, without ^{3}He comparison (Zdon et al 2018; Love and Zdon 2018), is a valid value and does not have a post bomb pulse component, this would support the authors' contention that the average residence time for groundwater emerging at the springs is more than 65 years. However, these data are not incompatible with flow from fractured Tertiary volcanic rocks immediately upgradient of the surface water catchment for these springs, in the Clipper Mountains. Flow through fractured rock can include not only fracture flow, but matrix flow which has much longer average residence time. A combination of slow flow through the vadose zone, and consequent imbibition of water into the rock matrix during groundwater flow can extend average groundwater travel and residence time, and is consistent with the geological materials upgradient of the catchment area of the springs in question. Geologic data indicate that the recharge area for the spring is much larger than the topographic surface drainage area. Tritium ages exceeding 65 years are common in saturated fractured media, which contains a mixture of transmissive fractures and very narrow micro-fracture networks that can have very slow transport velocities.

14. The manuscript does not consider or analyze the possibility of fracture flow.

As stated above, a likely source for groundwater supply to springs on mountain slopes in arid regions is precipitation, infiltration and recharge in the mountains immediately above the springs and gravity fed flow downward to the spring. This would require subsurface fracture flow through the hard rocks above the spring. (Note that even in Love and Zdon's (2018) presumption that Bonanza Spring is not fed from mountain recharge immediately above, but fed from groundwater in the alluvial fill basin up to and over 1000 feet below, constrained fracture flow would likely be required or there would be many springs along the mountain front of the Clipper

Mountains). But fracture flow is not addressed by the authors, nor tectonic structural analysis of study area conducted.

^{14}C analysis can be mathematically analyzed in fracture flow systems, but was not presented by Love and Zdon. These analyses consider both fracture flow, and flow within the rock matrix for calculation of average groundwater residence time. Several authors have modeled radiocarbon fate and transport in fractured systems, correcting for diffusion in carbon-14 dating of groundwater. For simulation of fracture flow with matrix effects work has been done by Neretnieks (1980); Neretnieks (1981); and Tang et al. (1981), then for transport through a parallel set of fractures with transverse diffusion into the intervening rock matrix Sudicky and Frind (1982); and Sudicky and Frind (1984). Also, as noted by IAEA (2013), "*A more general 3-D analysis for fractured rock media was provided by Therrien and Sudicky (1996). Although Tang et al. (1981) recognized early on the application of their analytical solution to radiocarbon dating of groundwater in a thin aquifer bounded by thick confining beds, Sanford (1997) provided an elegant analytical derivation and solution for a parallel series of stagnant and flow zones, applicable either for porous or fractured rock media.*"

15. The study lacks an associated quantitative groundwater transport model.

Many representations of groundwater flow in arid regions are supported by robust numerical modeling (Belcher et al. 2017). Love and Zdon (2018) present no mathematical modeling effort to support their conclusions.

Conclusions

The publication by Adam H. Love and Andy Zdon (2018), *"Use of Radiocarbon Ages to Narrow Groundwater Recharge Estimates in the Southeastern Mojave Desert, USA"* published in Hydrology MDPI, is an interesting study of groundwater recharge and selected spring radiocarbon analyses in the Mojave Desert, but suffers from critical weaknesses which undercut and invalidate some of the conclusions of the paper. The publication only makes general statements on the geological setting, location of faults, and the hydrogeologic environment, without complete referencing or justification. Annual recharge is compared from apparently dissimilar geographical areas with dissimilar data sets. The exact sample times, number of samples, measurement error bars, ambient air temperatures, antecedent rainfall, spring discharge and other important factors which could influence results are not documented in the publication. The number of duplicates, spiked samples, field or laboratory controls, or the chain of custody procedures are not specified.

Springs in the Mojave Desert are clearly a precious resource in the region and must be protected, and estimates of groundwater recharge are important factors in predicting their sustainability. Conceptual models which support recharge estimates and help populate water balance calculations must consider all alternative explanations. However, the omission of data and misinterpretation of hydrogeology based on selective information, lead the authors of this manuscript to dubiously ascribe groundwater recharge that sustains some of these springs to far-flung areas.

The questionable speculation in the Zdon et al. (2018) manuscript supported by Love and Zdon (2018), that recharge for springs like Bonanza occurs in the distant New York or Providence

Mountains, then moves tens of miles through basin alluvium and then resurges upward over a thousand feet through undefined mechanisms, is inconsistent and incompatible with the field evidence. In the Bonanza Spring example, they do not rigorously address the likelihood of nearby recharge in the Clipper Mountains immediately upgradient of the spring surface catchment area. These closer, sustainable recharge sources for Bonanza Spring and other springs in the Clipper Mountains are the most probable explanation of subsurface flow to springs and are consistent with published, investigatory results.

Importantly, Love and Zdon (2018) contains serious methodological omissions in interpretation of recharge and average groundwater residence time, which ultimately influence their interpretation for the hydrogeology of the study area.

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February 5, 2019

Matthew H. Litchfield, P.E.
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Three Valleys Municipal Water District
1021 E. Miramar Avenue
Claremont, CA 91711-2052

sent via email to:
mlitchfield@tvmwd.com

Re.: Report of the Independent Peer Review Panel for the Groundwater Monitoring, Management, and Mitigation Plan (GMMMP) for the Cadiz Project

Dear Mr. Litchfield:

The report of the Independent Peer Review Panel ("the Panel") for the Groundwater Monitoring, Management, and Mitigation Plan (GMMMP) for the Cadiz Project accompanies this letter.

The Panel appreciates the opportunity to submit this report to Three Valleys Municipal Water District (TVMWD) and Jurupa Community Services District (JCSD). Should you have any questions, please do not hesitate to contact me at (949) 939-7160.

Sincerely,

aquilogic, Inc.

Anthony Brown
CEO and Principal Hydrologist

Wildermuth Environmental, Inc.

Mark Wildermuth, P.E.
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REPORT OF THE INDEPENDENT PEER REVIEW PANEL FOR THE GROUNDWATER MANAGEMENT, MONITORING, AND MITIGATION PLAN (GMMMP) FOR THE CADIZ VALLEY GROUNDWATER CONSERVATION, RECOVERY AND STORAGE PROJECT San Bernardino County, California

Prepared for:
Three Valleys Municipal Water District (TVMWD)
1021 E. Miramar Avenue
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Prepared by:
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Anthony Brown, **aquilogic**
Mark Wildermuth, **Wildermuth Environmental**
Dave Romero, **Balleau Groundwater**
Tim Parker, **Parker Groundwater**

February 5, 2019

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ACRONYMS AND ABBREVIATIONS

Note: acronyms and abbreviations are spelled out in both the Executive Summary, which may be read independently, and the body of the report starting at Section 2.0: Introduction

A	cross-sectional area
ARZC	Arizona and California Railroad
AF	acre-feet
AFY	acre-feet per year
b	aquifer thickness
bgs	below ground surface
cm	centimeters
Cadiz	Cadiz, Inc.
Cadiz Project	Cadiz Valley Water Conservation, Recovery, and Storage Project
CEQA	California Environmental Quality Act
d	day
DRI	Desert Research Institute
E	modules of elasticity
Et	evapotranspiration
°F	degrees Fahrenheit
FEIR	Final Environmental Impact Report
ft	feet
gpm	gallons per minute
GMMMP	Groundwater Management, Monitoring, and Mitigation Plan
Panel	Panel
K	hydraulic conductivity
Km	kilometer
i	hydraulic gradient
L	liter
m	meter
MAF	million acre-feet
mg/L	milligrams per liter
mi	mile
MSL	mean sea level
N	porosity
n_e	effective porosity
Ppt	precipitation
Pi1	intergranular soil pressure prior to pumping
Pi2	intergranular soil pressure at maximum drawdown
ppb	parts per billion
Q	flow rate (quantity of water per time)
S	storativity
SMWD	Santa Margarita Water District
Su	compression of aquifer
SWP	State Water Project
T	transmissivity

TDS	total dissolved solids
USA	United States of America
USGS	United States Geological Survey
V	velocity (distance per time)
W	aquifer unit width
yr	year
Z	thickness of aquifer layer

1.0 EXECUTIVE SUMMARY

1.1 Introduction

An Independent Peer Review Panel ("Panel") was retained by Three Valleys Municipal Water District (TVMWD) and Jurupa Community Services District (JCSD) to conduct an impartial, objective, third-party review ("Review") of the Groundwater Management, Monitoring, and Mitigation Plan (GMMMP) for the Cadiz Valley Water Conservation, Recovery, and Storage Project (the Cadiz Project) and associated documentation. The Review was conducted in light of continuing study and reports that have been generated for, or pertinent to, the Cadiz Project after the certification of the Final Impact Report ("FEIR") for the Cadiz Project (ESA, 2012a) and the adoption of the GMMMP by the County of San Bernardino (ESA, 2012b).

The Panel consisted of the following groundwater professionals not previously employed by Cadiz: Anthony Brown of Aquilogic, Inc. (**aquilogic**), Tim Parker of Parker Groundwater - Technology, Innovation, Management, Inc. (**Parker Groundwater**), Mark Wildermuth of Wildermuth Environmental, Inc. (**WEI**), and Dave Romero of Balleau Groundwater Inc. (**BGW**) (see **Appendix A**).

1.1.1 Cadiz Project

The Cadiz Project is located at the confluence of the Fenner, Orange Blossom Wash, Bristol and Cadiz watersheds in eastern San Bernardino County (see **Figure 1** and **Appendix B**). Within this closed basin system, groundwater percolates and migrates downward from the higher elevations and eventually flows to Bristol and Cadiz dry lakes where it evaporates after mixing with the highly saline groundwater zone under the dry lakes. The portion that evaporates is lost from the groundwater basin and is unable to support beneficial uses. The fundamental purpose of the Cadiz Project is to conserve the substantial quantities of groundwater that are presently wasted and lost to evaporation to create a local water supply alternative for Southern California. Under the conservation and recovery component of the Cadiz Project, an average of 50,000 acre-feet per year (AFY) of groundwater would be pumped from the basin over a 50-year period.

1.1.2 Panel Objectives

The focus of the Review was to evaluate whether the GMMMP was sufficient to ensure that the proposed pumping at the Cadiz Project would not result in Potential Significant Adverse Impacts to Critical Resources ("Undesirable Results") that could not be effectively mitigated. The objectives of the Panel were to assess whether the GMMMP (ESA, 2012b):

- Provided sufficient management and monitoring to identify any Undesirable Results that could occur in response to proposed groundwater pumping as part of the Cadiz Project

- Provided effective Corrective Measures (i.e., mitigation) to address any Undesirable Results that do occur

In addition, where deemed necessary, the Panel has provided recommendations for management, monitoring, and mitigation procedures, and recommend additional work to improve the understanding of the hydrology of the Cadiz Project area. It should be noted that none of these recommendations are associated with a failure of the GMMMP to provide sufficient management, monitoring, and mitigation of Undesirable Results.

1.2 Groundwater Management, Monitoring, and Mitigation Plan

The GMMMP (ESA, 2012b) was developed to guide the long-term groundwater management of the groundwater basins tributary to the Cadiz Project. The GMMMP was a component of the FEIR for the Cadiz Project (ESA, 2012a), completed in accordance with the California Environmental Quality Act (CEQA) Guidelines Sections 15161 and 15378(a).

The success or failure of the GMMMP to manage and mitigate potential harm to Critical Resources will determine whether Undesirable Results actually occur. It should be noted that not all impacts from the proposed pumping at the Cadiz Project are deemed "significant and unreasonable"; that is, not all impacts are an Undesirable Result. Certain impacts may be less than significant but would still be monitored and managed in accordance with the GMMMP (ESA, 2012b). Other impacts may be deemed significant but the GMMMP provides Corrective Measures to reduce the impacts so they are no longer significant. The adaptive management approach within the GMMMP allows the plan to adapt to new data, new concerns, new technologies, etc. to ensure that either no Undesirable Results occur or, if they occur, they can be effectively mitigated. The following six Critical Resources were identified in the GMMMP (ESA, 2012b):

1. Basin Aquifers
2. Springs within the Fenner Watershed
3. Brine Resources at Bristol and Cadiz dry lakes
4. Air Quality
5. Project Area Vegetation
6. Colorado River and its Tributary Sources of Water

The GMMMP includes monitoring of spring flows, spring flow quality, vegetation, groundwater levels, groundwater quality, ground surface subsidence, migration of the saline-fresh water interface, brine resources, air quality, and soil conditions. In general, the monitoring in the GMMMP is appropriate to identify potential Undesirable Results. In addition, the monitoring thresholds that trigger mitigation are appropriate. Together, the monitoring and trigger thresholds are protective of Critical Resources.

The GMMMP (ESA, 2012b) also proposes Corrective Measures that have an effect throughout the watersheds (e.g., modification or cessation of pumping at the Cadiz Project well-field). Where such Corrective Measures will not prevent an ongoing impact, or will not alleviate an impact in a reasonable period of time, the GMMMP proposes resource-specific measures to address an Undesirable Result at a Critical Resource. In general, the mitigation in the GMMMP is practical and appropriate.

While the monitoring, management, and mitigation in the GMMMP is appropriate, the Panel has provided recommendations to supplement the GMMMP (see **Sections 1.3 and 7**).

1.2.1 Potential Impacts to Aquifers

The response of the aquifer system to the proposed pumping at the Cadiz Project was evaluated using numerical groundwater modeling (GSSI, 2011). In response to the cessation of pumping, an immediate aquifer water-level recovery is observed proximate to the Cadiz Project well-field. However, at some distance from the well-field, groundwater levels continued to decline. Under such circumstances, an Undesirable Result may occur many years after the implementation of a mitigation action (e.g., the cessation of pumping). Given the propagation of the cone of depression after pumping stops, continued monitoring of groundwater conditions proximate to Critical Resources will continue after mitigation is implemented, as proposed in the GMMMP (ESA, 2012b, Section 6.4.3).

It is noted that the GMMMP (ESA, 2012b) and FEIR (ESA, 2012a) considered the delay in the propagation of the cone of depression by evaluating potential Undesirable Results over a 100-year period. No Undesirable Results were identified in the FEIR that could not be mitigated, considering the drawdown that would result over 100 years using various recharge rates as low as 5,000 AFY.

Despite the fact that no un-mitigatable Undesirable Results were identified in the FEIR (ESA, 2012a), monitoring of overall groundwater conditions in the watersheds tributary to the Cadiz project was proposed in the GMMMP (ESA, 2012b). This monitoring is appropriate and protective of overall aquifer conditions.

A groundwater level drawdown threshold (80 feet) is proposed in the GMMMP (ESA, 2012b) for a distance of two miles from the center of the Cadiz Project well-field. This threshold is intended to provide a management “floor” below which mitigation actions would be triggered. Such a floor was selected as it lessens the need for resource-specific mitigation actions at individual Critical Resources, and it provides a proactive Corrective Measure that would prevent significant impact.

1.2.2 Potential Impacts to Springs within the Fenner Watershed

Opponents to the Cadiz Project have expressed concerns that the proposed pumping at the Cadiz Project might lower groundwater elevations in the fractured bedrock watershed that supports flow at Bonanza Spring. As the FEIR found (ESA, 2012a), and studies subsequent to the approval of the GMMMP (ESA, 2012b) conclude (Kenney and TLF, 2018), the weight of credible data obtained to date demonstrates there is no direct hydraulic connection between the springs and a regional groundwater table in the alluvial aquifer. However, the impact analysis in the FEIR (2012a), in an abundance of caution, assumed there was a direct hydraulic connection.

Assuming that a direct hydraulic connection between Bonanza Spring and the alluvial aquifer exists, the results of numerical groundwater modeling (GSSI, 2011; CH2M.Hill, 2012) suggested that a ten-foot decline in groundwater levels in the alluvial aquifer in the Fenner Valley below Bonanza Spring could result in a maximum drawdown at Bonanza Spring of about six to seven feet after hundreds of years. These drawdowns in groundwater elevation were deemed to be within the range of the historic groundwater level fluctuations resulting from natural climatic conditions (ESA, 2012a). Therefore, the impacts were considered to be, not only remote and unlikely, but also insignificant (ESA, 2012a).

In performing our Review, the Panel has considered the potential for an Undesirable Result assuming that a direct hydraulic connection exists, and the possible need for mitigation. With respect to potential impacts to springs, the GMMMP proposes spring flow and spring water quality monitoring, along with vegetation monitoring. This monitoring is appropriate and protective of this Critical Resource.

Aside from the management floor and modifications to pumping at the Cadiz Project well-field, resource-specific measures were considered for potential Undesirable Results at Bonanza Spring. These included the possible construction of a horizontal well to maintain spring flows. The proposed spring flow Corrective Measures in the GMMMP are practical and appropriate.

1.2.3 Potential Impacts to Brine Resources at Bristol and Cadiz Dry Lakes

The hyper-saline groundwater beneath the Bristol and Cadiz dry lakes supports two existing mineral strip-mining operations. Numerical groundwater modeling (GSSI, 2011) shows that between 30 and 65 feet of drawdown will occur beneath Bristol Dry Lake. Once groundwater levels beneath Bristol Dry Lake decline below 12 feet below ground surface (bgs), the trenches used to evaporate groundwater and recover precipitated salts will be dry, curtailing some mineral strip-mining operations.

With respect to potential impacts to Brine Resources, the GMMMP proposes groundwater level and groundwater quality monitoring at cluster wells at the dry lakes. This monitoring is appropriate, although groundwater level declines beneath the dry lakes are anticipated.

If numerical groundwater modeling predictions of groundwater levels beneath the dry lakes come to pass, it is likely that Corrective Measures will need to be implemented, as outlined in the GMMMP (Section 6.2.3, ESA, 2012b). These Corrective Measures include possible installation of injection and/or extraction well(s), a mitigation agreement, and/or modification of Cadiz Project operations to allow the strip-mining operations to continue. These Corrective Measures place the entire burden of the mitigation on the Cadiz Project and will not result in a disruption of the existing strip-mining operations. Thus, the mitigation actions proposed in the GMMMP are practical and appropriate.

1.2.4 Potential Impacts to the Saline-Fresh Water Interface

There is currently an established transitional interface between saline groundwater in the vicinity of Bristol and Cadiz dry lakes and freshwater moving towards the dry lakes from the Fenner Valley and other up-stream watersheds. The proposed pumping at the Cadiz Project will reverse groundwater flow between the Cadiz Project well-field and the dry lakes, causing the saline-fresh water interface to migrate towards the Cadiz Project well-field. However, some movement of the interface is an environmentally insignificant and reasonable consequence of the Cadiz Project's ability to conserve millions of gallons of fresh water (ESA, 2012a).

With respect to potential impacts to the saline-fresh water interface, the GMMMP proposes groundwater level and groundwater quality monitoring at cluster wells. This monitoring is appropriate, although some migration of the interface is anticipated.

A threshold perimeter distance of 6,000 feet for the potential movement of the saline-fresh water interface was specified by the County in the GMMMP (ESA, 2012b) and deemed insignificant in the FEIR (ESA, 2012a). If the interface migrates to the perimeter distance, Corrective Measures may be required to prevent further migration. These Corrective Measures include installing brackish water extraction or fresh water injection wells at the saline-fresh water interface. Such Corrective Measures are practical and appropriate.

1.2.5 Potential Impacts to Ground Surface Levels in the Watershed

The FEIR (ESA, 2012a) identified that aquifer and aquitard compaction could cause temporary and permanent subsidence at locations proximate to the Cadiz Project. However, significant subsidence across a wide area resulting from the proposed pumping at the Cadiz Project is not anticipated.

The GMMMP (ESA, 2012b; Section 6.3) proposes a monitoring program that includes land surveys, InSAR satellite data, and extensometers. This monitoring is appropriate.

In the event that significant subsidence is observed, the GMMMP (ESA, 2012b; Section 6.3.4) proposed Corrective Measures that include repairs to damaged structures, a potential mitigation agreement, and possible modification of Cadiz Project well-field operations to arrest subsidence. Such mitigation actions are practical and appropriate.

1.2.6 Other Potential Impacts

There are three other Critical Resources identified in the GMMMP: Air Quality, Project Area Vegetation, and the Colorado River and its Tributary Sources of Water. In general, the Panel concurs with the GMMMP proposed monitoring to evaluate whether any of these potential Undesirable Results occur. The Panel also concurs with the Corrective Measures, if required, proposed in the GMMMP (ESA, 2012b) and agrees that they are reasonably sufficient to avoid any Undesirable Results.

1.3 Recommendations

As noted, the monitoring, management, and mitigation approach proposed in the GMMMP (ESA, 2012b) is appropriate, as was previously determined by the Groundwater Stewardship Committee (2011). After careful review and consideration of the FEIR, GMMMP, and more recent technical reports, this Panel has recommended a number of complementary additions that could be made to the GMMMP, if feasible. Collectively these recommendations are intended to allay any concerns that opponents to the Cadiz Project may still have, improve public confidence in the Cadiz Project, and are provided in an abundance of caution. The recommendations are not intended to alter the analyses or findings regarding the environmental impacts of the Cadiz Project described in the FEIR (ESA, 2012a), or contain any significant new information. In addition, none of the recommendations are associated with a failure of the GMMMP to provide sufficient management, monitoring, and mitigation of Undesirable Results. However, the Panel strongly believes that the recommendations provide helpful direction in the ongoing monitoring, mitigation and management of the Cadiz Project. The recommended supplemental monitoring will produce additional information to assist with the following:

- Identifying and quantifying any Undesirable Results
- Further assessing the degree of hydraulic connection, if any, between Bonanza Spring and the alluvial aquifer in Fenner Valley below
- Monitoring brine water conditions beneath Bristol and Cadiz dry lakes
- Mapping the migration of the saline-fresh water interface over time
- Identifying changes in vegetation in riparian habitats below springs
- Evaluating the cause of any impacts (e.g., the proposed pumping at the Cadiz Project, climatic conditions, other factors)
- Determining the type, nature, magnitude, and duration of Corrective Measures that could be implemented
- Assessing the effects of any implemented mitigation

1.3.1 Detailed Plans

It is recommended that, at least one year prior to the commencement of the proposed pumping at the Cadiz Project, a more detail monitoring plan be prepared to document all aspects of data collection related to the Cadiz Project. A detailed Quality Assurance Project Plan (QAPP) should also be prepared. In addition, a formal data management system (DMS) should be developed for the Cadiz Project. Finally, an online repository should be developed to host all technical reports as they are finalized and delivered to the County as required by the GMMMP.

1.3.2 Geological Understanding

To provide additional information on the geologic structure and hydrogeology in the vicinity of Bonanza Spring, it is recommended that geophysical mapping be conducted in the area immediately above and for some distance below the spring. The objectives of the geophysical surveys would be to delineate structural features (i.e., faults) and other structural deformation, identify potential fracture lineaments with increased facture aperture and density (i.e., groundwater bearing potential), map the bedrock surface below the unconsolidated deposits south of the spring, and map the groundwater surface above and below the spring.

To provide additional information on the geologic structure and hydrogeology in the Fenner Gap, it is recommended that geophysical mapping be conducted in this area. The objectives of the geophysical surveys would be to delineate structural features (i.e., faults) and other structural deformation, identify the location and thickness of carbonate formations, identify potential karstic features (e.g., caves) and fracture lineaments with increased facture aperture and density (i.e., groundwater bearing potential), and map the groundwater surface.

1.3.3 Hydrogeologic Understanding

To provide additional information on hydrogeologic conditions between Bonanza Spring and the alluvial aquifer in the Fenner Valley below, it is recommended that additional monitoring wells be installed: (1) immediately below the spring (i.e., within 100 yards) with casings discretely screened in unconsolidated deposits beneath and adjacent to the stream fed by the spring, if they contain groundwater, and in the fractured bedrock beneath these deposits; and (2) at the limits of the alluvial aquifer (e.g., one mile southeast of Bonanza Spring).

1.3.4 Weather Conditions

It is recommended that a weather station, or at least a rain gauge, be installed in the bedrock watershed that supports flow at Bonanza Spring. This will assist in evaluating the relationship between precipitation, recharge, and spring flow.

1.3.5 Spring Monitoring

The potential for Undesirable Results to springs, notably Bonanza Spring, appears to be the most contentious issue related to the Cadiz Project. It is recommended that more frequent monitoring be conducted at the Bonanza, Whiskey, and Vontrigger springs using transducers and dataloggers. In addition, it is recommended that the exact geographic location and elevation of the spring emergence be mapped using a global positioning system (GPS) annually or after a change in location is observed during other monitoring activities.

1.3.6 Vegetation Monitoring

It is recommended that a terrestrial ecologist be retained to develop a scientifically appropriate, standardized methodology to monitor vegetation below the springs. Such a standardized methodology will allow changes in vegetation to be tracked over time.

1.3.7 Groundwater Monitoring

In general, the number and location of wells used to monitor regional groundwater conditions appear adequate. However, the Panel recommends that, in some cases, the frequency of groundwater monitoring be modified slightly (see **Section 7.10**). Monitoring groundwater levels at a higher frequency will better establish baseline conditions. It will also allow the response of the hydrologic system to increased pumping to be evaluated, including information on hydrogeologic structure within the watersheds, an improved understanding of hydraulic parameters (e.g., hydraulic conductivity and storativity), and identification of possible data gaps that may need to be filled. In addition, the increased monitoring frequency will assist in the assessment of potential Undesirable Results from the proposed pumping at the Cadiz Project. In doing so, it will also allow pumping operations to be optimized (e.g., well cycling, pumping rates) to maintain production while preventing Undesirable Results.

1.3.8 Third-Party Wells in Fenner Valley

There are no potable third party wells in the Cadiz Project area. However, it is recommended that transducers be installed during the pre-operational period in any third-party well that could be materially impacted by the proposed pumping at the Cadiz Project. This data will establish baseline groundwater conditions at the third-party wells, and allow for groundwater level and quality changes to be monitored during the proposed pumping at the Cadiz Project. Higher frequency data will assist in determining whether any observed impact results from the proposed pumping at the Cadiz Project or other factors, such as climatic variability.

1.3.9 Saline Migration

There is currently an established transitional interface between saline groundwater in the vicinity of Bristol and Cadiz dry lakes and freshwater moving towards the dry lakes from the

Fenner Valley and other up-stream watersheds. The saline–fresh water interface will migrate along areas of preferentially higher hydraulic conductivity. Such irregular migration may not be detected by just four well clusters (three at Bristol Dry Lake and one at Cadiz Dry Lake). Therefore, it is recommended that the location of the interface be mapped spatially and at depth using geophysical techniques prior to the commencement of pumping at the Cadiz Project. The results of this geophysical mapping can be used to locate the proposed cluster wells, and select the screened depths at each cluster. It is further recommended that the geophysical mapping be repeated every five years after the proposed pumping at the Cadiz Project is initiated. This will allow the migration of the saline-fresh water interface to be mapped in three-dimensions over time.

1.3.10 Subsidence

In the current GMMMP, the proposed land surface monitoring consists of conducting ground-level surveys, acquiring InSAR imagery, installing extensometers, and reviewing this information at various frequencies during pre-operational, operational, and post-operational periods. The Panel recommends that the InSAR data analysis be increased (see **Section 7.13**).

In the GMMMP (ESA, 2012b), it is proposed that three extensometers be placed in strategic locations with the highest probability of land subsidence proximate to the Cadiz Project well-field (ESA, 2012b). It is recommended that only one extensometer be installed during the pre-operational period. The installation of the two additional extensometers could be deferred until a temporal and more spatially extensive dataset on land subsidence is available (i.e., InSAR data and lithology data obtained from new production and monitor wells).

1.3.11 Groundwater Modeling

Numerical groundwater flow models have already been developed for the Cadiz Project (GSSI, 2011; CH2M.Hill, 2011). These numerical models present a reasonable representation of groundwater conditions for most areas of the watersheds tributary to the Cadiz project; however, they were based on a limited data-set and include significant assumptions and hydrogeologic judgement. The Panel recommends that numerical groundwater modeling be updated on a periodic basis (see **Section 7.14**) and, as part of defined updates, the model should also be recalibrated.

After the updates and recalibration, the numerical groundwater modeling can then be used to further evaluate potential Undesirable Results that may be caused by the proposed pumping at the Cadiz Project. The modeling should also be used to assess the effectiveness of the mitigation actions proposed in the GMMMP (ESA, 2012b).

1.3.12 Mitigation Actions

The County of San Bernardino imposed a requirement under the GMMMP that limited the aquifer drawdown to 80 feet within two miles of the center of the Cadiz Project well-field in the first 15 years of operation and 100 feet over the life of the Cadiz Project. The most common Corrective Measure in the GMMMP (ESA, 2012b) to prevent or alleviate Undesirable Results is to reduce or modify pumping at the Cadiz Project well-field (e.g., well cycling, individual pump rate adjustments). Such an action, as a stand-alone Corrective Measure, will likely be effective in the long-term; however, it may not alleviate certain impacts in a reasonable timeframe due to the response lag in the hydrologic system (e.g., groundwater levels would continue to decline at locations distant from the well-field for decades after pumping ceased). Therefore, the GMMMP included the following resource-specific measures that would either prevent ongoing impact or alleviate impact in a reasonable time frame:

- Bonanza Spring – the installation of a possible horizontal well immediately above Bonanza Spring, as provided in the FEIR (ESA, 2012a)
- Brine Resources – the installation of one or more brine extraction wells at the dry lakes to maintain mineral strip-mining operations, as proposed in the GMMMP (ESA, 2012b)
- Saline Intrusion – the extraction of brackish groundwater or injection of fresh water along the saline-fresh water interface, as proposed in the GMMMP (ESA, 2012b)

More details regarding these resource-specific measures needs to be developed. In addition, additional evaluation of these potential resource-specific measures is recommended, including analysis using an updated numerical groundwater flow model.

In addition to these resource-specific measures, it is recommended that the following additional Corrective Measures be evaluated:

- Bonanza Spring – The injection of water at the edge of the alluvial aquifer in Fenner Valley below Bonanza Spring to "cut-off" the propagation of the cone of depression at the edge of the alluvial aquifer in Fenner Valley below Bonanza Spring
- Bonanza Spring – The injection of water into water-bearing fractures immediately above Bonanza Spring to maintain groundwater levels in the watershed that support spring flow
- Bonanza Spring – the temporary provision of water for flow and habitat maintenance (e.g., a water tank and pipe to the spring head)
- Brine Resources – the injection of water at the saline-fresh water interface to "cut-off" the propagation of the cone of depression beyond the injection area (this injection could also halt the migration of the saline-fresh water interface)
- Air quality – the spraying of water on areas prone to dust generation

More details regarding these potential alternative mitigation measures need to be developed. Their feasibility (effectiveness, implementability, and cost) should be evaluated, including analysis using numerical groundwater modeling. Their effectiveness should examine both short-term effectiveness in preventing continued adverse impacts, and their long-term effectiveness at alleviating impacts in a reasonable period of time.

1.4 Conclusions

The GMMMP provides appropriate and sufficient management and monitoring to identify Undesirable Results that could occur in response to proposed pumping as part of the Cadiz Project. The Panel has recommended a number of complementary additions that could be made to the GMMMP, where such additions are feasible.

The GMMMP provides effective Corrective Measures to address any Undesirable Results in the long-term. Due to the response lag time in the hydrologic system, the modification or cessation of pumping at the Cadiz Project may not prevent ongoing impacts to certain Critical Resources. In addition, for the same reason, in some instances, the mitigation may not alleviate certain impacts in a reasonable period of time. Where the cessation or reduction of pumping at the Cadiz Project will not prevent or alleviate impacts, alternate resource-specific measures have been proposed in the GMMMP and/or FEIR to mitigate impacts. The Panel has also identified some additional measures that should be considered.

2.0 INTRODUCTION

An Independent Peer Review Panel ("Panel") was retained by Three Valleys Municipal Water District (TVMWD) and Jurupa Community Services District (JCSD) to conduct an impartial, objective, third-party review ("Review") of the Groundwater Management, Monitoring, and Mitigation Plan (GMMMP) for the Cadiz Valley Water Conservation, Recovery, and Storage Project (the Cadiz Project) and associated documentation. The Review was conducted in light of continuing study and reports that have been generated for, or pertinent to, the Cadiz Project after the certification of the Final Impact Report ("FEIR") for the Cadiz Project (ESA, 2012a) and the adoption of the GMMMP by the County of San Bernardino (ESA, 2012b). TVMWD and JCSD hold options to acquire water from the Cadiz Project and requested this Review of the GMMMP.

The focus of the Review was to evaluate whether the GMMMP was sufficient to ensure that the proposed pumping at the Cadiz Project would not result in Potential Significant Adverse Impacts to Critical Resources ("Undesirable Results") that could not be effectively mitigated (see **Section 2.1**).

The Panel consisted of the following groundwater professionals not previously employed by Cadiz:

- Anthony Brown of Aquilogic, Inc. (**aquilogic**)
- Tim Parker of Parker Groundwater - Technology, Innovation, Management, Inc. (**Parker Groundwater**)
- Mark Wildermuth of Wildermuth Environmental, Inc. (**WEI**)
- Dave Romero of Balleau Groundwater Inc. (**BGW**)

Biographical sketches for each member of the Independent Review Panel are provided in **Appendix A**.

Each of the above parties, except **aquilogic**, prepared an independent technical memorandum documenting their own review. During the Review process, the Panel met on five occasions via tele-conference to discuss aspects of the Review. In addition, the Panel had one lengthy tele-conference meeting with Geoscience Support Services, Inc. (GSSI) to discuss the numerical groundwater flow model developed for the Cadiz Project (GSSI, 2011).

Aquilogic was tasked with incorporating key elements of the memoranda prepared by individual members of the Panel, the discussions during tele-conferences, and their own review in this "Consensus Report". The Consensus Report has been reviewed by all members of the Panel, and all agree with the content herein.

As part of this work, the Panel was given unrestricted access to the Cadiz Project area, existing hydrogeologic and engineering consultants working on the Cadiz Project, and any documentation generated as part of, or pertinent to, the Cadiz Project. All members of the Panel have visited the Cadiz Project location, including Bonanza Spring, which has been the subject of recent studies.

2.1 Project Understanding

For readers unfamiliar with the Cadiz Project, a project overview is provided in **Appendix B**. Information in the overview and this sub-section is taken directly from aquilogic (2013) and the FEIR (ESA, 2012a) for the Cadiz Project. More detailed information about the project can be found within the FEIR. The following sections of the FEIR are particularly pertinent to the groundwater hydrology:

- Section 2: Project Background
- Section 3: Project Description
- Section 4.6: Geology and Soils
- Section 4.9: Hydrology and Water Quality
- Section 5.3.6: Geology and Soils (under Cumulative Impacts)
- Section 5.3.9: Hydrology and Water Quality
- Appendix B: GMMMP (ESA, 2012b), as further modified and adopted by the County of San Bernardino on October 1, 2012.
- Appendix H: Hydrology Reports

2.1.1 Background

Cadiz Inc. (Cadiz) is a private corporation that owns approximately 34,000 mostly contiguous acres in the Cadiz and Fenner Valleys (Cadiz Property), which are located in the Mojave Desert portion of eastern San Bernardino County, California (see **Figure 1**).

Cadiz, in collaboration with Santa Margarita Water District (SMWD) and other water providers participating in the Cadiz Project (Project Participants), developed the Cadiz Project to implement a comprehensive, long-term groundwater management program for the closed groundwater basin underlying its property. The program would allow for both the beneficial use of some of the groundwater, and future storage of imported surface water in the groundwater basin (**Figure 2**).

Underlying the Cadiz, Fenner, and Bristol Valleys is a vast groundwater basin that holds an estimated 17 to 34 million acre-feet (MAF) of fresh groundwater. The Cadiz Project, which would be sited on Cadiz Property, is located at the confluence of the Fenner, Orange Blossom Wash, Bristol and Cadiz Watersheds (watersheds), which span over 2,700 square miles.

Within this closed basin system, groundwater percolates and migrates downward from the higher elevations in the watersheds and eventually flows to Bristol and Cadiz dry lakes. The dry lakes represent the low point in this closed hydrologic system, meaning that all surface and groundwater within the surrounding watersheds eventually flows down-gradient to these dry lakes and not beyond. Once the fresh groundwater reaches the dry lakes, it evaporates, first mixing with the highly saline groundwater zone under the dry lakes and getting trapped in the salt sink, no longer fresh, suitable, or available to support freshwater beneficial uses. The portion that evaporates is lost from the groundwater basin and is not available for beneficial uses.

2.1.2 Project Purpose

Under Article X, Section 2 of the California Constitution, waters of the State must be put to maximum reasonable and beneficial use and should not be wasted. The fundamental purpose of the Cadiz Project is to save substantial quantities of groundwater that are presently wasted and lost to evaporation by natural processes. In the absence of the Cadiz Project, approximately three million acre-feet (MAF) of groundwater presently held in storage between the proposed wellfield and the dry lakes would become saline and evaporate over the next 100 years. By strategically managing groundwater levels, the Cadiz Project would conserve up to 2 MAF of this water, retrieving it from storage before it is lost to evaporation. The conservation opportunity is unique and garners special emphasis. The proposed conservation is not dependent upon future rainfall, snow pack or the needs and demands of others: the groundwater is already in storage. Moreover, the conservation and resulting water supply augmentation can be achieved independently from the environmental and regulatory conditions that generally constrain the importation of water to Southern California. The geographic isolation of the groundwater makes it non-tributary to the Colorado River system, and therefore eligible for distinctive treatment under federal regulations that may unlock additional complementary storage opportunities, both within the Basin and in Lake Mead.

The Cadiz Project makes available a reliable water supply for Project Participants, to supplement or replace existing supplies and enhance dry-year supply reliability. Both the State Water Project (SWP) and Colorado River water supplies are experiencing reductions from historic deliveries. As a result, Southern California water providers are looking for new supplies to replace or augment current supplies and enhance dry-year supply reliability. The Cadiz Project would optimize the reasonable and beneficial use of water within the aquifer system in a sustainable fashion—conserving water that would otherwise be wasted—to create a local water supply alternative for Southern California water providers.

The objectives of the Cadiz Project are as follows:

- Maximize beneficial use of groundwater in the Bristol, Cadiz, and Fenner Valleys by conserving and using water that would otherwise be lost to brine and evaporation

- Improve water supply reliability for Southern California water providers by developing a long term source of water that is not significantly affected by drought
- Reduce dependence on imported water by utilizing a source of water that is not dependent upon surface water resources from the Colorado River or the Sacramento-San Joaquin Delta
- Enhance dry-year water supply reliability within the service areas of SMWD and other Project Participants
- Enhance water supply opportunities and delivery flexibility for SMWD and other Project Participants through the provision of carry-over storage and, for Phase 2, imported water storage
- Support operational water needs of the Arizona and California Railroad (ARZC) in the Cadiz Project area
- Create additional water storage capacity in Southern California to enhance water supply reliability
- Locate, design, and operate the Cadiz Project in a manner that minimizes significant environmental effects and provides for long-term sustainable operations

2.1.3 Project Components

The Cadiz Project includes the following two distinct but related components:

- Groundwater Conservation and Recovery Component
- Imported Water Storage Component

Under the Groundwater Conservation and Recovery Component, an average of 50,000 acre-feet per year (AFY) of groundwater would be pumped from the basin over a 50-year period for delivery to Project Participants in accordance with agreements with Cadiz Inc. and the GMMMP. The GMMMP (ESA, 2012b) has been developed to guide the long-term groundwater management of the basin for the Cadiz Project. The level of groundwater pumping proposed under the Groundwater Conservation and Recovery Component is designed specifically to extract and conserve groundwater that would otherwise migrate to the dry lakes, enter the brine zone, and evaporate. The Groundwater Conservation and Recovery Component was analyzed at a project level in the FEIR (ESA, 2012a) in accordance with the California Environmental Quality Act (CEQA) Guidelines Sections 15161 and 15378(a).

Figure 1: Location of the Cadiz Project (aquilogic, 2013)

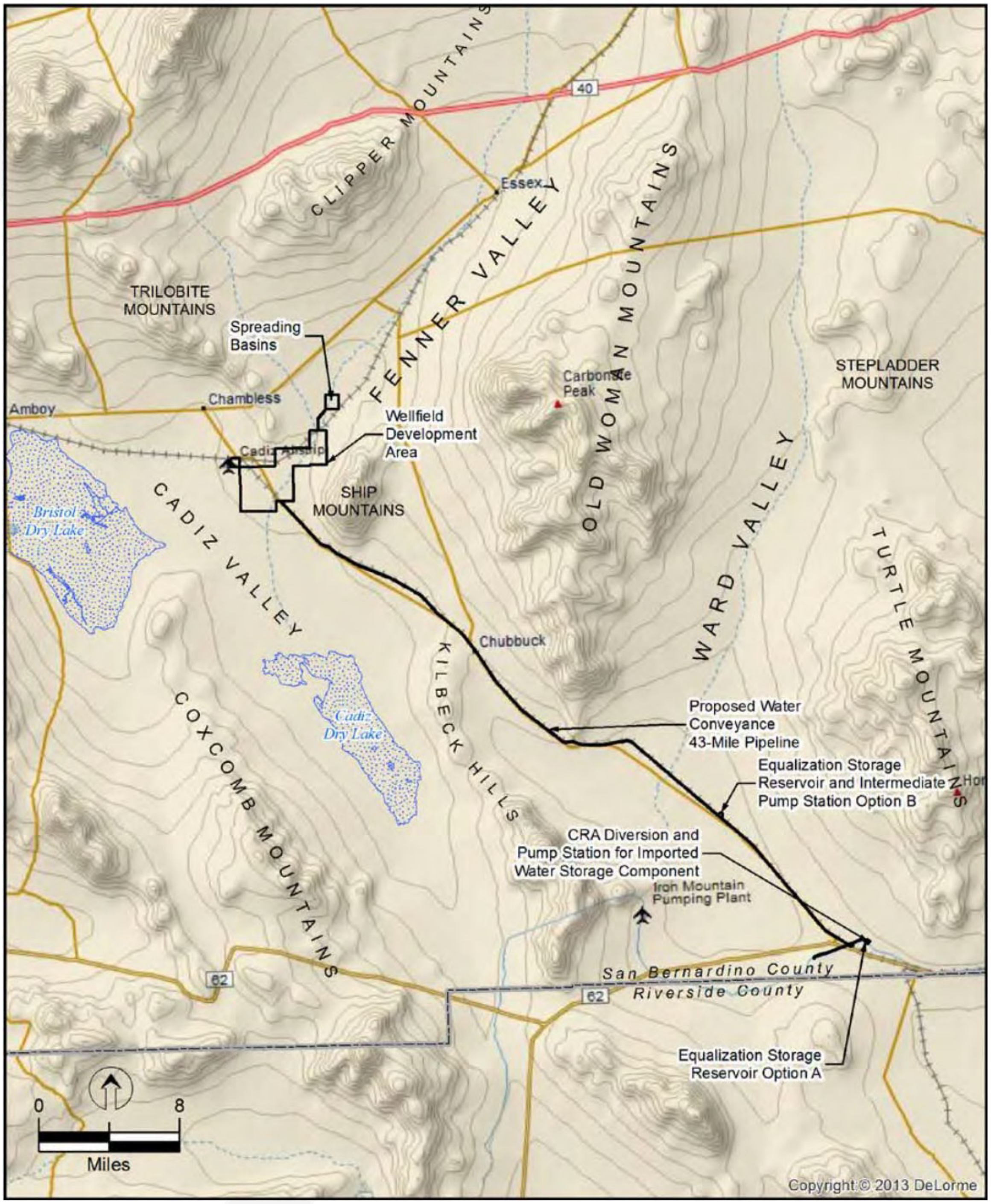

Figure 2: Cadiz Project Area Project (aquilogic, 2013)

2.2 Objectives

The objectives of the Panel were to assess whether the GMMMP (ESA, 2012b):

- Provided sufficient management and monitoring to identify any Undesirable Results that could occur in response to proposed groundwater pumping as part of the Cadiz Project
- Provided effective Corrective Measures (i.e., mitigation) to address any Undesirable Results that do occur

In addition, where deemed necessary, the Panel has provided recommendations for management, monitoring, and mitigation procedures, and recommend additional work to improve the understanding of the hydrology of the Cadiz Project. The recommendations are not intended to alter the analysis or findings regarding the environmental impacts of the Cadiz Project described in the FEIR (ESA, 2012a), or contain any significant new information. In addition, none of the recommendations are associated with a failure of the GMMMP to provide sufficient management, monitoring, and mitigation of Undesirable Results. Rather, the recommendations, if implemented, would provide the following:

- Improved overall hydrologic understanding of the Cadiz Project area
- Improved monitoring during the pre-operational (i.e., baseline), operational, and post-operational periods
- Further assurance that the Cadiz Project would not cause Undesirable Results
- Greater confidence that, if an Undesirable Result did occur, it could be mitigated effectively

2.3 Prior Reviews

The following independent technical peer reviews were previously conducted for the Cadiz Project:

1. Groundwater Stewardship Committee. October 2011 Summary of Findings and Recommendations. Cadiz Groundwater Conservation, Recovery and Storage Project (Groundwater Stewardship Committee, 2011).
2. County of San Bernardino. October 2012 review, establishment and approval of the GMMMP (County, 2012).
3. Geology and Hydrology Experts Review - 2018 Bonanza Spring Assessment. January 2018 (Geology and Hydrology Experts Review, 2018).

In addition to these independent technical peer reviews, the FEIR (ESA, 2012a), and GMMMP (ESA, 2012b) as an appendix to the FEIR, were again independently evaluated by the judiciary as part of six separate legal actions brought by opponents to the Cadiz Project. In all six actions, the courts affirmed the FEIR and GMMMP, rejecting the position taken by project opponents that these reviews and approvals, including the GMMMP and the California Environmental

Quality Act (CEQA) Mitigation Monitoring and Report Plan for the Project, were deficient. In June 2016, the California Appeals Court upheld the six trial court rulings and completed a *de novo* EIR review to validate the FEIR and GMMMP.

Aquilogic previously conducted a "Review of The Groundwater Hydrology of the Cadiz Project, San Bernardino County, California" (aquilogic, 2013). This impartial, objective, third-party review was prepared for Laborers International Union of North America ("LIUNA") pursuant to a settlement of litigation pending in Orange County Superior Court entitled "Rodrigo Briones, Lonnie Passmore, Laborers' International Union of North America Local Union No. 783 v. Santa Margarita Water District et al., Orange County Superior Court Case No. 30-2012-00620636-CU-WM-CXC (LIUNA) (Action)", between Real Parties-in-Interest, Cadiz, Inc., and Fenner Valley Mutual Water Company (Fenner), (collectively, Cadiz Parties) and, Rodrigo Briones, an individual, Lonnie Passmore, an individual, and LIUNA Local Union No. 783. Anthony Brown also sat on the review panel for the Geology and Hydrology Experts Review (2018).

Parker Groundwater. Tim Parker was an integral member of the Groundwater Stewardship Committee (2011) review. He also sat on the review panel for the Geology and Hydrology Experts Review (2018).

WEI. Mark Wildermuth sat on the review panel for the Geology and Hydrology Experts Review (2018).

Balleau has never participated in any review of, or other technical work associated with, the Cadiz Project.

2.4 Document Review

As noted, the Panel was given unrestricted access to the Cadiz Project area, existing consultants working on the Cadiz Project, and any documentation generated as part of, or pertinent to, the Cadiz Project. The Cadiz Project has been the subject of extensive technical evaluation as part of overall project development, the rigorous environmental review process under CEQA, independent analysis by the County of San Bernardino, multiple legal challenges to the FEIR (ESA, 2012a), and the overall permitting process for the project. The courts have upheld the FEIR and the findings therein, and there appear to be no legal or technical justification to prevent the project from proceeding. However, we understand that there are regulatory and political hurdles that need to be overcome for the project to proceed, and there is still opposition to the project. The opposition is principally focused on concerns that the proposed pumping at the Cadiz Project may impact springs in the mountains surrounding and above the Fenner Valley.

Given the extensive technical evaluations conducted for the Cadiz Project, there is a significant volume of documentation associated with the project. Therefore, the Panel focused their

Review on the following documents and gave specific attention to the work generated *after* the certification of the FEIR (ESA, 2012a) and the GMMMP (ESA, 2012b), notably items 7-16 below:

1. GSSI. (1999). Cadiz Groundwater Storage and Dry-Year Supply Program. Environmental Planning Technical Report. Groundwater Resources. Volume 1 and Volume 2. Report 1163. November 1999.
2. GSSI. (2011). Cadiz Groundwater Modeling and Impact Analysis, Volume 1- Report. September 1, 2011.
3. CH2M.Hill. (2011). Assessment of effects of the Cadiz Groundwater Conservation Recovery and Storage Project operation on springs. EIR Appendix H3 (see next bullet point).
4. Environmental Science Associates (ESA). (2012a). Final Environmental Impact Report (FEIR) for the Cadiz Valley Water Conservation, Recovery, and Storage Project. SCH# 2011031002. July 2011.
5. ESA. (2012b). Groundwater Management, Monitoring, and Mitigation Plan (GMMMP) for The Cadiz Valley Groundwater Conservation, Recovery and Storage Project. September.
6. Aquilogic, Inc. (2013). Review of the Groundwater Hydrology of the Cadiz Project, San Bernardino County, California. October 2013.
7. Zdon. (2016). Mojave Desert Springs and Waterholes: Results of the 2015–16 Mojave Desert Spring Survey, Inyo, Kern, San Bernardino and Los Angeles Counties, California. Andy Zdon and Associates.
8. Rose. (2017). Data Measured on Water Collected from Eastern Mojave Desert, California. Lawrence Livermore National Laboratory, LLNL-TR-737159. T.P. Rose. August 18, 2017.
9. Kenney and TLF. (2018). Updated Assessment of Cadiz Water Project's Potential Impacts to Bonanza Springs. Kenney and TLF Consulting, LLC. January 2018.
10. Love and Zdon. (2018). Use of Radiocarbon Ages to Narrow Groundwater Recharge Estimates in the Southeastern Mojave Desert, USA. A.H. Love and A. Zdon. USA Hydrology-05-00051.
11. Zdon et al. (2018). Understanding the source of water for selected springs within Mojave Trails National Monument, California. A. Zdon, M. L. Davidson, and A.H. Love. Vol. 19, No. 2, 99–111.
12. Kreamer. (2018). Evaluation of "Understanding the source of water for selected springs within Mojave Trails National Monument, California" (Zdon, 2018). Professor D. Kreamer. June 2018.
13. Schroth. (2018). Comments on "Understanding the source of water for selected springs within Mojave Trails National Monument, California" (Zdon et al, 2018). B. Schroth, Ph.D.
14. Geology and Hydrology Experts Review. (2018). Bonanza Spring Assessment. January 2018.
15. TLF. (2018). Twentieth Annual Groundwater Monitoring Report, January - December 2017. TLF Consulting LLC. December 2018.

16. Kreamer. (2019). Review of “Use of Radiocarbon Ages to Narrow Groundwater Recharge Estimates in the Southeastern Mojave Desert, USA” (Love and Zdon, 2018). Professor D. Kreamer. January 2019.

3.0 GROUNDWATER MANAGEMENT, MONITORING, AND MITIGATION PLAN

The GMMMP (ESA, 2012b) was written pursuant to an agreement between SMWD, Cadiz, and San Bernardino County, and made part of the FEIR (ESA, 2012a). The GMMMP was then independently amended by the government agency responsible for groundwater management in the project area (i.e., San Bernardino County) after the certification of the FEIR. The GMMMP provides the following:

- Description of the Cadiz Project location and objectives
- Description of physical characteristics of the groundwater basin
- Identification of the Critical Resources and assessment of potential impacts in and surrounding the Cadiz Project area due to groundwater pumping
- Description of the modeling tools that will be used to refine the monitoring network and that will be used in the future to refine impact assessments and action criteria
- Description of the monitoring network and identification of the locations of the features of the monitoring network
- Description of the monitoring, testing, and reporting procedures that will be used to collect and analyze data
- Description of the action criteria established to avoid Undesirable Results
- Description of the decision-making process to be used once the action criteria are met or when the County considers refinements to the GMMMP
- Description of “Corrective Measures” that may be implemented to minimize Undesirable Results
- Description of objectives and requirements for a Closure Plan
- Description of the TRP (Technical Review Panel) and its responsibilities and procedures

The success or failure of the GMMMP to manage and mitigate potential harm to Critical Resources will determine whether Undesirable Results actually occur. It should be noted that not all impacts from the proposed pumping at the Cadiz Project are deemed “significant and unreasonable”; that is, an impact may not be an Undesirable Result. Certain impacts may be less than significant but would still be monitored and managed in accordance with the GMMMP (ESA, 2012b). Other impacts may be deemed significant but the GMMMP provides Corrective Measures (i.e., mitigation) to reduce the impacts so they are no longer significant. It is recognized that certain impacts that are considered insignificant under CEQA may still cause concern among some constituencies. The adaptive management approach within the GMMMP allows the plan to adapt to new data, new concerns, new technologies, etc. to ensure that either no Undesirable Results occur or, if they occur, they can be effectively mitigated.

The following six Critical Resources were identified in the GMMMP (ESA, 2012b):

1. Basin Aquifers
2. Springs within the Fenner Watershed
3. Brine Resources at Bristol and Cadiz dry lakes
4. Air Quality
5. Project Area Vegetation
6. Colorado River and its Tributary Sources of Water

The first item, Potential Significant Adverse Impact to Basin Aquifers, drives the risk to the remaining potential receptors of harm. Given ongoing opposition to the Cadiz Project and concerns expressed by certain environmental groups and the ongoing brine strip-mining operations at the dry lakes, the two receptors that have been associated with most controversy are potential Undesirable Results at the springs and to Brine Resources. These, and other potential impacts, are discussed in further detail below.

3.1 Potential Impacts to Aquifers

The response of the aquifer system to the proposed pumping at the Cadiz Project was evaluated using numerical groundwater modeling (GSSI, 2011). In response to the cessation of pumping, an immediate aquifer water-level recovery is observed proximate to the Cadiz Project well-field. However, at some distance from the well-field, groundwater levels continued to decline. This results from the continued movement of groundwater toward the well-field to infill the deepest parts of the cone of depression around the well-field. Under such circumstances, an Undesirable Result may occur at a Critical Resource even many years after the implementation of a mitigation action (e.g., the cessation of pumping). Given the propagation of the cone of depression after pumping stops, continued monitoring of groundwater conditions proximate to Critical Resources will continue after mitigation is implemented, as proposed in the GMMMP (ESA, 2012b, Section 6.4.3).

It is noted that the GMMMP (ESA, 2012b) and FEIR (ESA, 2012a) considered the delay in the propagation of the cone of depression by evaluating potential Undesirable Results over a 100-year period. No Undesirable Results were identified in the FEIR that could not be mitigated, considering the drawdown that would result over 100 years using various recharge rates as low as 5,000 AFY.

Despite the fact that no un-mitigatable Undesirable Results were identified in the FEIR (ESA, 2012a), monitoring of overall groundwater conditions in the watersheds tributary to the Cadiz project was proposed in the GMMMP (ESA, 2012b).

A groundwater level drawdown threshold (80 feet) is proposed in the GMMMP (ESA, 2012b) for a distance of two miles from the center of the Cadiz Project well-field. This threshold is intended to provide a management "floor" below which mitigation actions would be triggered. Such a floor was selected as it lessens the need for resource-specific mitigation actions at individual Critical Resources, as it is believed to provide a proactive Corrective Measure that would prevent significant impact.

3.2 Potential Impacts to Springs Within the Fenner Watershed

The spring closest to the proposed Cadiz Project extraction well-field is Bonanza Spring located in the Clipper Mountains (see **Figure 3**). The Bonanza Spring is approximately 11 miles from the center of the Fenner Gap. All Fenner Watershed springs, including Bonanza Spring, are located in crystalline bedrock formations and outcrop at much higher elevations than groundwater within the "alluvial aquifer" of the Fenner Valley. **Table 1** indicates the difference in elevation between various springs and the alluvial aquifer. Bonanza Spring is located over 1000 feet above the groundwater level in the alluvial aquifer under "worst case" recharge conditions.

Spring Name	Spring Coordinates (feet)		Ground Surface Elevation (feet aMSL)	Groundwater Elevation in 5,000 AFY Recharge Scenarios (feet aMSL)		Separation Between Groundwater and Spring (feet)
	X	Y				
Bonanza	7341583	2081937	2,100	Pre-Pumping	1,090	1,010
				Post-Pumping (50 yrs)	1,087	1,013
Hummingbird	7359165	2106976	2,375	Pre-Pumping	1,450	925
				Post-Pumping (50 yrs)	1,450	925
Chuckwalla	7348897	2112708	3,018	Pre-Pumping	1,510	1,508
				Post-Pumping (50 yrs)	1,510	1,508
Willow	7409767	2040142	3,888	Pre-Pumping	1,190	2,698
				Post-Pumping (50 yrs)	1,190	2,698
Honeymoon	7415055	2057465	3,310	Pre-Pumping	1,290	2,020
				Post-Pumping (50 yrs)	1,290	2,020

Table 1. Spring Elevations Under Worst Case Recharge Scenario (i.e., 5,000 AFY) (aquilogic, 2013)

Opponents to the Cadiz Project have expressed concerns that the proposed pumping at the Cadiz Project might lower groundwater elevations in the bedrock aquifer in the watershed that supports flow at Bonanza Spring. The GMMMP presents the results of an analysis by CH2M.Hill (2011) where two conceptual models of Bonanza Spring were developed. Bonanza Spring was chosen as an appropriate indicator spring for all springs in the Fenner Watershed because it is the closest spring to the proposed Cadiz Project well-field. Therefore, this would be the most likely spring to experience any Undesirable Results from the proposed pumping at the Cadiz

Project. The Panel agrees with the selection of Bonanza Spring as an indicator spring for potential Undesirable Results.

As the FEIR found (ESA, 2012a), and studies subsequent to the approval of the GMMMP (ESA, 2012b) conclude, the weight of credible evidence obtained to date demonstrates that there is no direct hydraulic connection between Bonanza Spring and a regional groundwater table in the alluvial aquifer in Fenner Valley below. In fact, the detailed geological mapping conducted after approval of the FEIR and GMMP by Kenney and TLF (2018) provides further evidence that Bonanza Spring is not hydraulically connected to the alluvial aquifer in the Fenner Valley below (see **Figures 4 and 5**). Thus, hypothetical conceptual model #1 (“Concept-1”) reasonably assumed that no hydraulic connection existed between Bonanza Spring and the groundwater flow regime in the alluvial aquifer in Fenner Valley below. In Concept 1, the spring is supported by a watershed and groundwater system in fractured bedrock above a no-flow or low-flow boundary (e.g., fault or stratigraphic “perching” layer), as described in Scenarios 2 and 3 in aquilogic (2013), Section 6.1 (see **Figures 6 and 7**).

Recent GPS tracking of Bighorn Sheep reportedly shows that they frequent Bonanza Spring (CADFW, 2018). Anecdotal information suggests that hunters also take the view that it is important to maintain flow at Bonanza Spring. Comments received during the public review period for the FIER suggested the potential for a direct hydraulic link between Bonanza Spring and the alluvial aquifer in Fenner Valley below. Therefore, in order to address the possibility of a hydraulic connection between Bonanza Spring and the alluvial aquifer, hypothetical conceptual model #2 (“Concept-2”) assumed that a direct hydraulic connection existed between Bonanza Spring and the groundwater flow regime in the alluvial aquifer in Fenner Valley below. In Concept 2, the spring is supported by a watershed and groundwater system in fractured bedrock with no geologic boundary to flow between the fractured rock system and the adjacent alluvial aquifer, as described in Scenario 1 in aquilogic (2013), Section 6.1 (see **Figure 8**).

Some researchers (Zdon, 2016; Zdon et al., 2018; Rose, 2017) continue to assert the hypothesis of a direct hydraulic connection between Bonanza Spring and the alluvial aquifer. Their assertions are principally based on their conclusions regarding groundwater geochemistry. However, these conclusions are disputed by other researchers (Kreamer, 2018; Schroth, 2018; Kreamer, 2019). For the purposes of this Review, we have not attempted to resolve the dispute over geochemical interpretation. This was unnecessary as the impact analysis in the FEIR (2012a), in an abundance of caution, assumed there was a direct hydraulic connection.

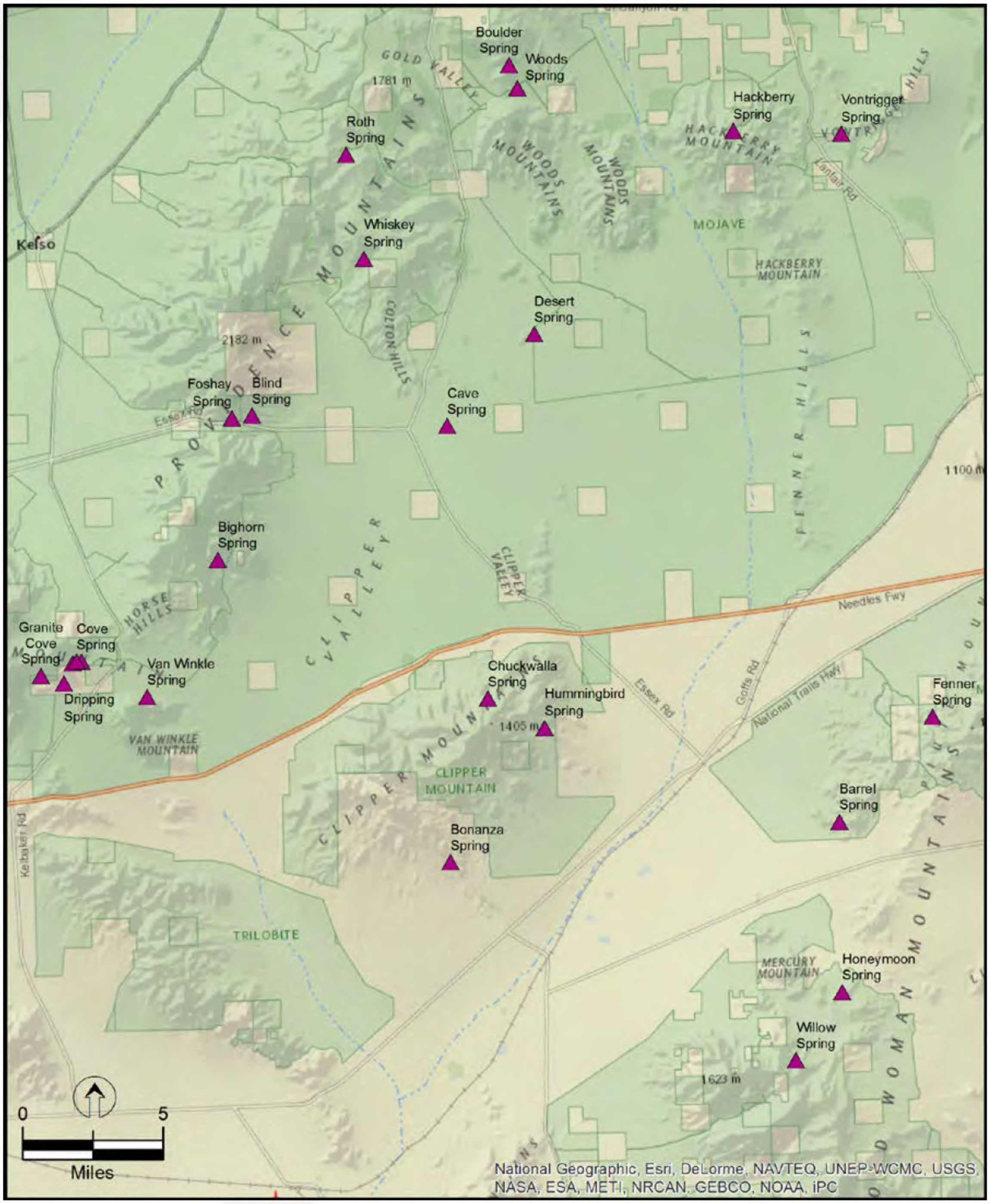

Figure 3: Springs within the Project Area (aquilogic, 2013)

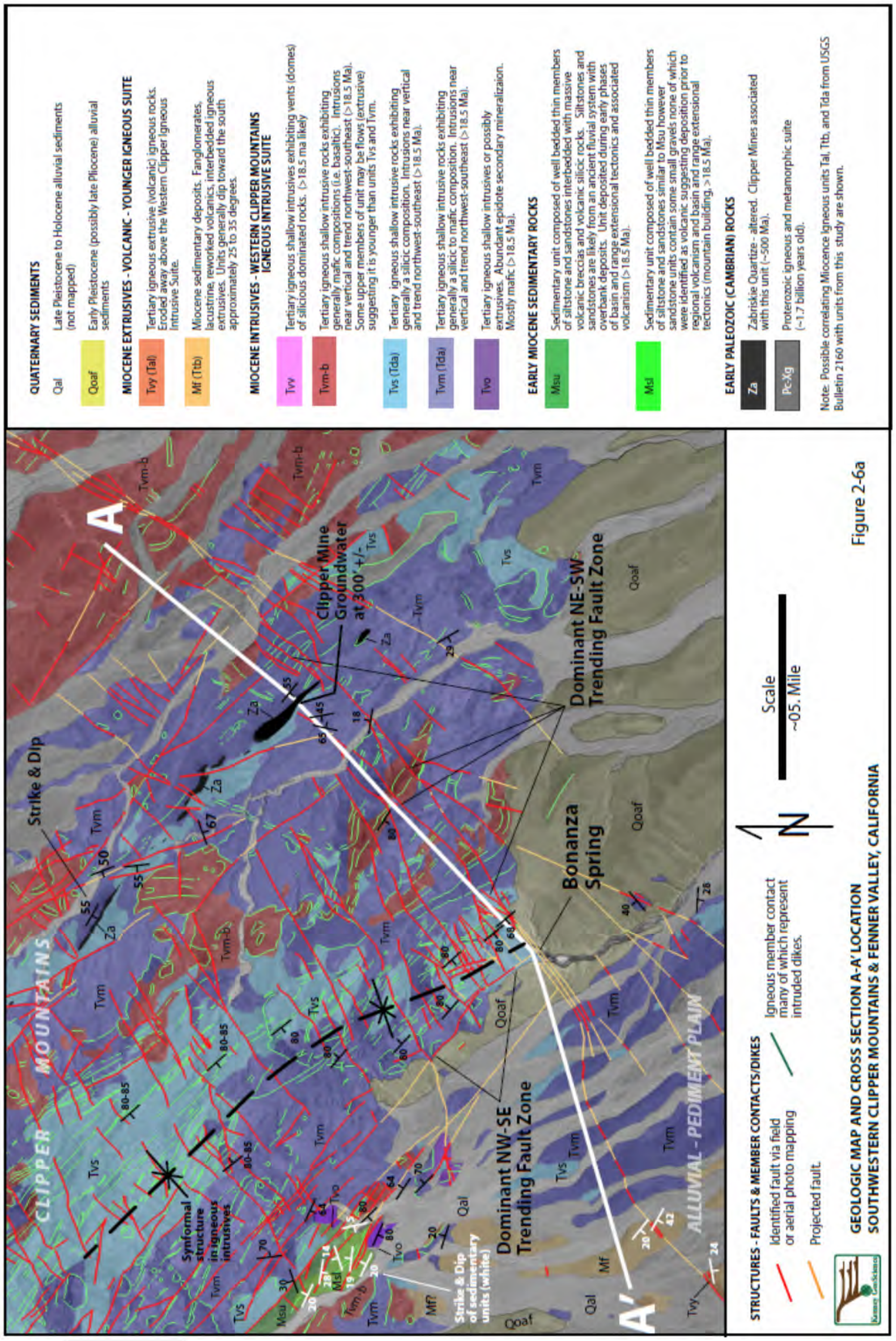

Figure 4: Geologic Map and Cross Section A-A' Location Southwestern Clipper Mountains and Fenner Valley (Kenney and TLF, 2018)

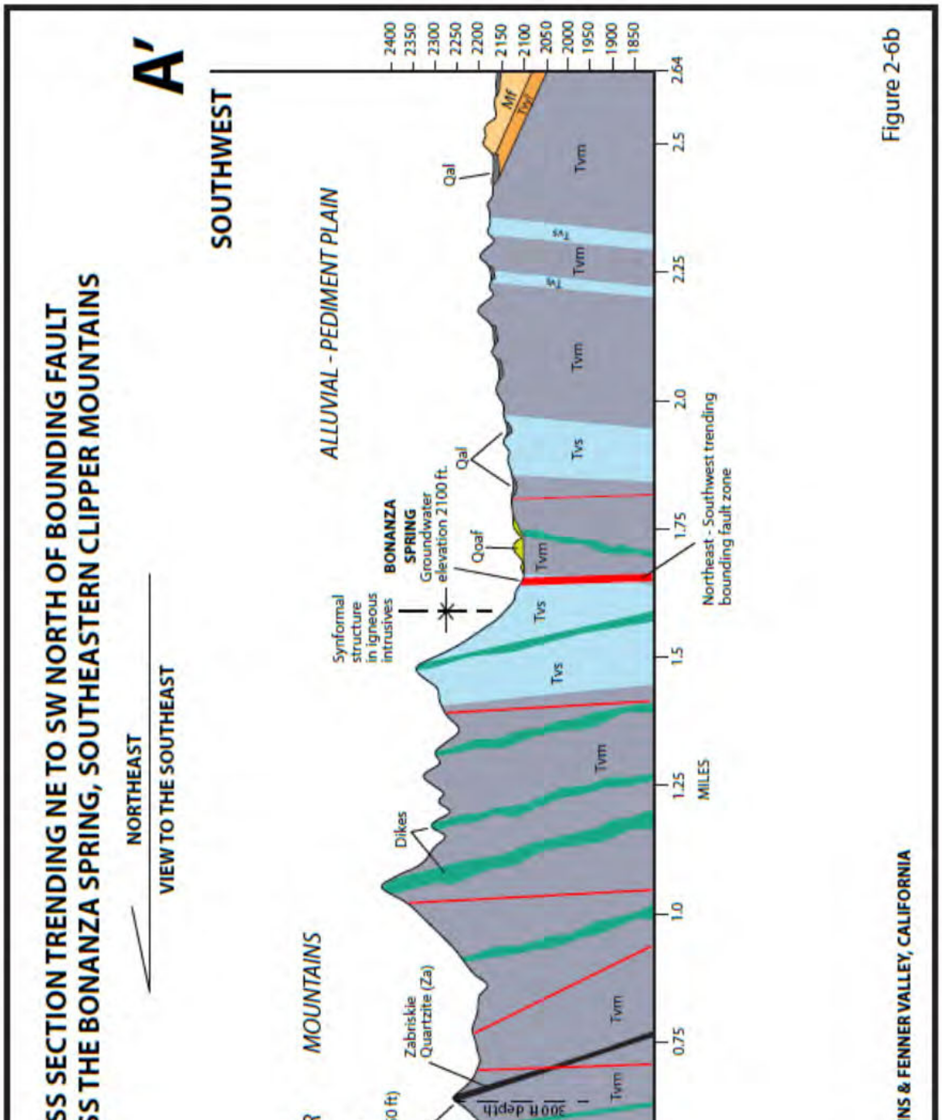

Figure 5: Geologic Cross Section A-A' Southwestern Clipper Mountains and Fenner Valley (Kenney and TLF, 2018)

Given the geological mapping of Kenney and TLF (2018), the hydrologic assessment in aquilogic (2013), and fundamental hydrogeologic concepts, the Panel has concluded that the weight of credible evidence suggests that no direct hydraulic connection exists between Bonanza Spring and the alluvial aquifer in Fenner Valley below. The evidence includes, but is not limited to, the following:

- The 11 mile distance between the proposed pumping at the Cadiz Project well-field and Bonanza Spring
- The over 1,000-foot change in elevation between groundwater in Fenner Valley and Bonanza Spring
- The hydrologic nature of the fractured bedrock watershed supporting Bonanza Spring and the alluvial deposits in Fenner Valley
- The identification of faults in the vicinity of Bonanza Spring that control spring location by Kenner and TLF (2018)
- The evaluation of groundwater geochemistry at Bonanza Spring by Kreamer (2019), notably lower water temperatures and spring flow variation
- The infiltration of stream flow supported by Bonanza Spring immediately down-stream of the spring (i.e., the presence of a vadose zone down-stream of Bonanza Spring)

Despite the weight of evidence, in performing our Review, the Panel has considered the potential for an Undesirable Result assuming that a direct hydraulic connection exists, and the possible need for mitigation.

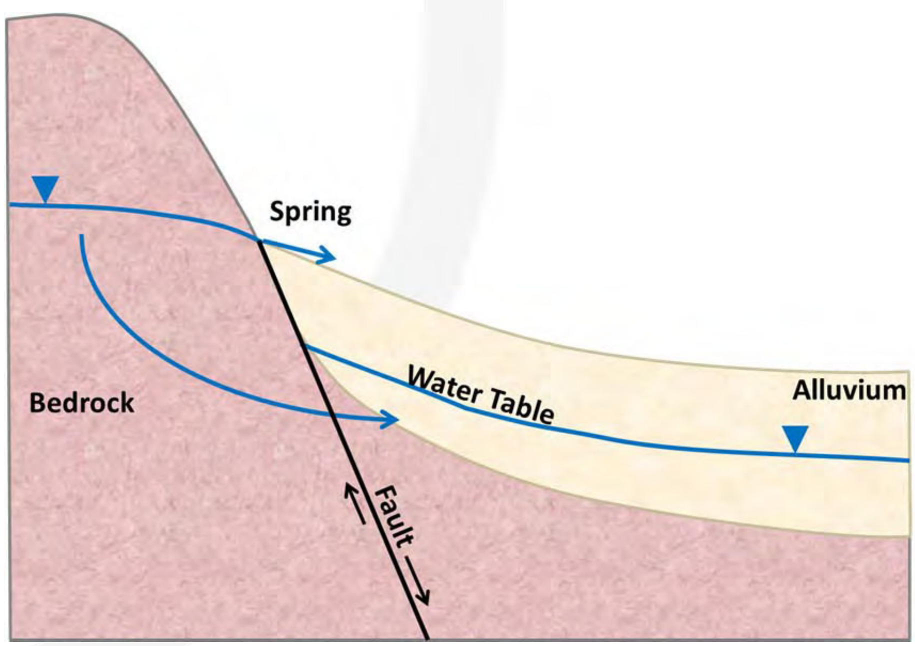

Figure 6: Scenario 2 – Fault Acts as a Partial Groundwater Flow Barrier (Groundwater in Alluvium NOT in Direct Hydraulic Communication with Spring) (aquilogic, 2013)

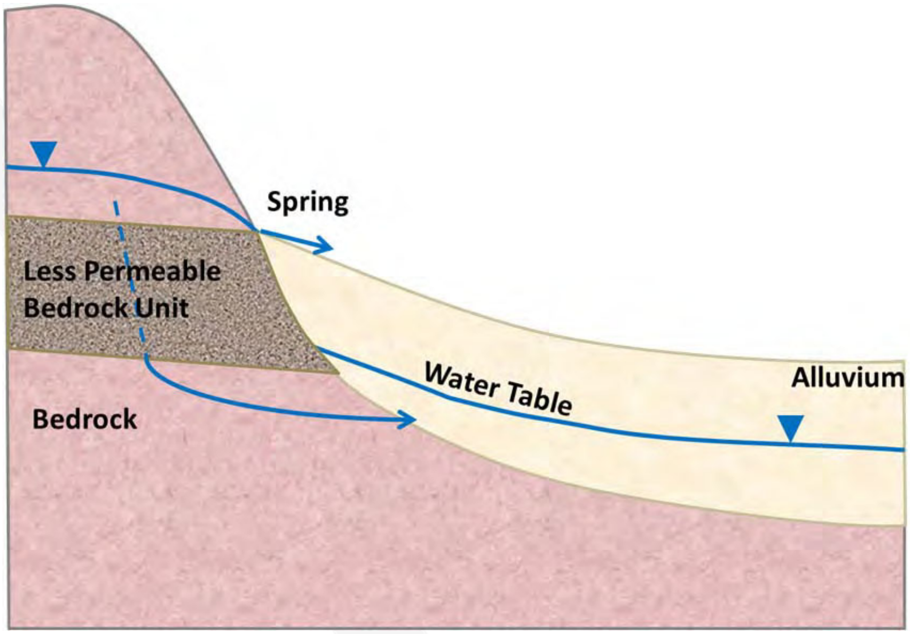

Figure 7: Scenario 3 – Stratigraphic Unit (i.e. Aquitard) Acts as a Partial Groundwater Flow Barrier (Groundwater in Alluvium NOT in Direct Hydraulic Communication with Spring) (aquilogic, 2013)

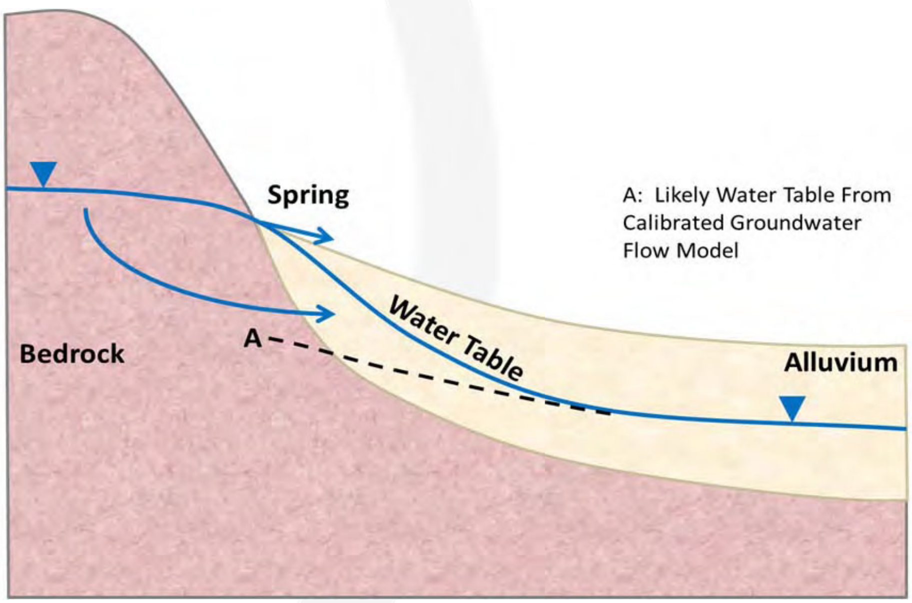

Figure 8: Scenario 1 – Groundwater in Alluvium in Direct Hydraulic Communication with (and Sustaining) Spring (aquilogic, 2013)

It has been noted in studies conducted after approval of the FEIR (ESA, 2012a) and GMMMP (ESA, 2012b) by Kenney and TLF (2018) that spring level and flow has fallen in recent years as a result of climatic conditions, and this may continue:

> *"Field mapping within the Bonanza Spring "watershed" area identified areas of very strong secondary mineralization and weathering. This was observed as chemical*

weathering of plagioclase phenocrysts in the igneous rocks, veins of quartz and iron minerals, abundant colorful (reds, orange, purple color) secondary minerals along fractures and penetrative to the rocks, and abundant liesegang banding rings. However, along the outer limits of the Bonanza Spring "watershed" area, the degree of secondary chemical weathering and mineralization dramatically decreased (Figure 2-5). Strongly altered rocks in the vicinity of the Bonanza Spring occur from the spring area to nearly the top of the local ridges toward the north, and slightly below the mountain ridges to the northeast. These observations suggest that fluids once flowed at higher elevations in the past and that the fluids preferentially may have primarily flowed from the north.

It is interesting to point out that the Tunnel Well was likely excavated not for minerals, but instead to obtain groundwater. A metal pipe is observed to have been installed into the tunnel where a mound of earth at the entrance of the tunnel allowed for ponding water to occur inside the tunnel. It can be observed today in the tunnel that the fault zone is a groundwater barrier, with rocks northeast of the fault zone that are moist and rocks with the fault gouge zone that are dry. Groundwater may have historically been higher here (a spring?) than in other locations in the Bonanza Spring cuspate valley due to the intersection of the Southwestern Boundary Fault Zone and a northeast-southwest trending smaller scale fault extending across the valley to the northeast (Figure 2-5). These data suggest that the Tunnel Well "spring" exhibits a small-scale version in terms of fault structure as that proposed for the Bonanza Spring – due to the intersection of two fault zones at high angles to one another.

An ancient abandoned channel of likely late Pleistocene age was identified less than 200 feet west of the Bonanza Spring (Figure 2-5). The abandoned channel is approximately 10 to 15 feet above the current Bonanza Spring Wash elevation and once flowed essentially due south. The significance of the abandoned wash with the Bonanza Spring is that abundant travertine deposits occur in the sediments at the base of the wash and adjacent bar deposits. The carbonate travertine deposits are over 8 feet thick and due to their elevation above the current Bonanza Spring suggest that during the Pleistocene, groundwater levels in the Bonanza cuspate valley area were higher by over 10 to 15 feet minimum. This observation is consistent with the observation of pronounced secondary weathering and mineralization of rocks at higher elevations within the Bonanza Spring cuspate valley.'

Furthermore, variation in flow at Bonanza Spring is noted by other researchers, including those that postulate a direct hydraulic connection between the spring and groundwater in the alluvial aquifer (Zdon, 2016; Zdon et al, 2018; Rose, 2017).

Concept 2 is a simple representation of a generic mountain system with similar characteristics to the Clipper Mountains and was intended to evaluate the general response of a water table in fractured bedrock of mountains under various assumptions that are specific to hydrogeologic conditions at Bonanza Spring. The results of the Concept-2 model suggested that a ten-foot decline in groundwater levels in the alluvial aquifer in the Fenner Valley below Bonanza Spring could result in about one foot of drawdown at the springs after 50 years of pumping at the Cadiz Project and six to seven feet of drawdown at Bonanza Spring after hundreds of years, assuming that the decline in the alluvial aquifer was maintained at ten feet of drawdown indefinitely. These drawdowns in groundwater elevation attributed to the proposed pumping at the Cadiz Project were deemed to be within the range of the historic groundwater level fluctuations resulting from natural climatic conditions (ESA, 2012a). Therefore, the impacts were considered to be, not only remote and unlikely, but also insignificant (ESA, 2012a).

3.3 Potential Impacts to Brine Resources at Bristol and Cadiz Dry Lakes

The hyper-saline groundwater beneath the Bristol and Cadiz dry lakes supports two existing mineral strip-mining operations. These operations evaporate the hyper-saline groundwater from beneath the dry lakes to recover the precipitated salts. The Undesirable Results to Brine Resources on Bristol and Cadiz dry lakes that could result from proposed pumping at the Cadiz Project include the following: (1) lowering of hyper-saline groundwater levels in brine recovery wells and brine supply trenches used by the mineral strip-mining operations; and (2) impacts to the geochemistry of the hyper-saline groundwater (e.g., reduced calcium chloride or sodium chloride within the brine) that impact precipitate recovery.

Numerical groundwater modeling performed by GSSI (2011) shows that, depending on the recharge amount used in the modeling, between 30 and 65 feet of drawdown will occur beneath Bristol Lake. In general, the trenches used to expose saline groundwater to evaporation and precipitate salts for mineral strip-mining operations at Bristol Dry Lake are about 12 feet deep. Therefore, once groundwater levels beneath Bristol Dry Lake decline below 12 feet below ground surface (bgs), the trenches will be dry, curtailing current mineral strip-mining operations. As noted in the FEIR (ESA, 2012a), under natural climatic conditions, groundwater levels beneath the dry lakes have declined at times and these trenches were dry.

If the groundwater level predictions from the modeling come to pass, it is likely that Corrective Measures will need to be implemented, as outlined in the GMMMP (Section 6.2.3, ESA, 2012b), to allow the strip-mining operations to continue during the proposed pumping at the Cadiz Project. These resource-specific measures include the following:

- Provision of substitute supplies, deepening of wells
- Blending well water with another source
- Constructing replacement wells
- Paying the third-party owner for any increased pumping costs, and
- Entering into a mitigation agreement with the impacted third party well owner

These Corrective Measures place the entire burden of the mitigation on the Cadiz Project and will not result in a disruption of the existing strip-mining operations. On this basis, the FEIR and the GMMMP concluded any Undesirable Results were avoidable (ESA, 2012a). The modification, reduction, or cessation of pumping, if groundwater drawdowns exceeded the 80-foot "floor" within two miles of the center of the Cadiz Project well-field (see **Section 5.1**), were not the primary mitigation measures to avoid Undesirable Results to Brine Resources.

3.4 Potential Impacts to the Saline-Fresh Water Interface

There is currently an established transitional interface between saline groundwater in the vicinity of Bristol and Cadiz dry lakes and freshwater moving towards the dry lakes from the Fenner Valley and other up-stream watersheds. The interface is maintained in place by the movement of groundwater to the dry lakes and subsequent evaporation at the dry lakes. The proposed pumping at the Cadiz Project is intended to meet the conservation objective and capture most of the groundwater flowing toward the dry lakes that would otherwise be lost to evaporation and wasted. Thus, the proposed pumping will likely reverse groundwater flow between the Cadiz Project well-field and the dry lakes; that is, flow would be from the dry lakes to the well-field. This change in groundwater flow direction is expected to cause the saline-fresh water interface to migrate away from the dry lakes towards the Cadiz Project well-field.

Once saline groundwater has migrated into what was the fresh water part of the aquifer it will be difficult to reverse the effects. Therefore, some movement of the interface has been accepted as an environmentally insignificant and reasonable consequence of the Cadiz Project's ability to conserve millions of gallons of fresh water (ESA, 2012a).

A threshold perimeter distance of 6,000 feet for the potential movement of the saline-fresh water interface was specified by the County in the GMMMP (ESA, 2012b) and deemed insignificant in the FEIR (ESA, 2012a). The GMMMP proposes the installation of cluster wells 6,000 feet from the currently mapped location of the interface. These cluster wells will monitor groundwater geochemical conditions, notably total dissolved solids (TDS) concentrations, to identify if the interface is approaching or has reached the threshold distance. If the interface reaches the cluster wells at the perimeter distance, Corrective Measures may be required to prevent further migration of the saline-fresh water interface. These resource-specific measures include installing brackish water extraction or fresh water injection wells at the saline-fresh water interface. It should be noted that there are no known existing wells used for potable supply within the 6,000-foot perimeter of the saline-fresh water interface that could be impacted.

Results of the analysis of saline water movement using the numerical groundwater model (GSSI, 2011; ESA, 2012b) indicate that migration of the saline-fresh water interface induced by the proposed pumping at the Cadiz Project ranges from 6,300 to 10,400 feet, depending on the recharge value used in the numerical groundwater model. These distances exceed the 6,000-foot perimeter distance specified in the GMMMP (see above). Consequently, the saline-fresh water interface will likely need to be actively managed when the Cadiz Project is operating. This adaptive management includes monitoring and mitigation (see above). The GMMMP (ESA, 2012b) provides that migration will be limited to 6,000 feet northeast of the dry lakes through physical measures (e.g., injection or extraction wells) or pumping restrictions if physical measures prove ineffective. Such Corrective Measures appear reasonable and should be effective, if implemented appropriately. The monitoring and mitigation proposed in the GMMMP (ESA, 2012b), complemented by additional monitoring and modeling improvements recommended herein, will ensure this potential impact remains insignificant once the Cadiz Project is operational and through the project's life.

3.5 Potential Impacts to Ground Surface Levels in the Watershed

The FEIR (ESA, 2012a) identified that aquifer and aquitard compaction (both elastic and inelastic) could cause temporary and permanent subsidence at locations proximate to the Cadiz Project – a potential Undesirable Result. The Fenner and other watersheds from which the Cadiz Project draws water have large volumes of groundwater in storage (between 17 and 34 million acre-feet [MAF]) (ESA, 2012a). These volumes greatly exceed the volumes that will be removed by the proposed pumping at the Cadiz Project after recharge has been considered: 50,000 AFY pumped for 50 years (2.5 MAF) minus 5,000 to 32,000 AFY of recharge for 50 years (0.25 to 1.6 MAF) resulting in a net loss from storage of 0.9 to 2.25 MAF. Therefore, significant subsidence across a wide area resulting from the proposed pumping at the Cadiz Project is not anticipated. However, localized subsidence may occur in areas proximate to the Cadiz Project well-field with geologic conditions that foster subsidence (e.g., areas underlain by inelastic clay layers).

The current agricultural pumping conditions (1,223 AFY in 2017) do not appear to induce subsidence and are not sufficient to allow for the identification of areas prone to localized subsidence. Such areas will only become apparent, if they exist, once the proposed pumping at the Cadiz Project has been sustained at higher volumes for an extended period. Thus, subsidence will need to be monitored during project operations.

Section 6 of aquilogic (2013) previously summarized the potential impacts to ground levels. Because no extensive building structures are proposed as part of the Cadiz Project, the region is largely undeveloped, and the Project area is underlain by predominantly coarser-grained sediments (sands and gravels), simple load compaction subsidence should not occur. It should be noted that, during the compilation of comments to the FEIR, there were no objections to the Cadiz Project raised by the two nearby railroads or the natural gas companies that have pipelines in the area. In fact, the projected subsidence impacts were determined to be within the range of published subsidence criteria.

With respect to potential carbonate cavern collapse and the railroad, the maximum allowable subsidence is 1-inch per 62-foot string of track. The example on p.57 aquilogic (2013) would result in 2.12 inches of deformation over 520 feet, or ¼ inch per 62-foot string; that is, well within the railroad tolerances. **Aquilogic** concurred with the estimates of groundwater pumping subsidence generated from the GSSI (2011) modeling. That is, maximum subsidence (2.5 to 3.13 feet) would occur beneath Bristol Dry Lake, where clay content is highest. The next highest area of subsidence (2.0 to 2.5 feet) would occur in an area within the Bristol Watershed, where clay is still present, close to the proposed Cadiz project well-field (where drawdown is greatest); that is, on Cadiz owned land. These levels of subsidence over the areas predicted are well within the railroad tolerances.

The GMMMP (ESA, 2012b; Section 6.3) proposes a monitoring program that includes land surveys, InSAR satellite data, and extensometers. In the event that significant subsidence is observed, the GMMMP (ESA, 2012b; Section 6.3.4) proposed Corrective Measures that include repairs to damaged structures, a potential mitigation agreement, and possible modification of Cadiz Project well-field operations to arrest subsidence. The GMMMP presents a reasonable approach to the monitoring and mitigation of potential subsidence. The monitoring and mitigation proposed in the GMMMP (ESA, 2012b), complemented by some slight modifications to the monitoring recommended herein, should ensure this Undesirable Result does not occur or, if it does occur, can be mitigated effectively during and after the Cadiz Project operational period.

3.6 Other Potential Impacts

There are three other potential Critical Resources identified in the GMMMP: Air Quality, Project Area Vegetation, and the Colorado River and its Tributary Sources of Water. Table 6-1 and Table 5-2 of the GMMMP (ESA, 2012b) summarize these potential impacts and the monitoring proposed to assess them:

- Air Quality Potential Impacts: Changes in air quality that exceed baseline conditions by 5 percent (%) and changes in soil conditions showing degradation of soil structure. Assessed using nephelometers.
- Project Area Vegetation. Reduction in the extent or character of Project area baseline vegetation. Assessed using vegetation monitoring.
- Colorado River and its Tributary Sources of Water. Removal of water from the Colorado watershed. The assumption that groundwater pumped at the Cadiz Project is non-tributary to the Colorado River is supported by substantial physical evidence (e.g., bedrock and groundwater divides). However, two monitoring wells (one existing and another to be installed) on property owned by Cadiz within the adjacent Piute Watershed that is tributary to the Colorado River will be monitored to assess the current interpretation.

The Panel has made some recommendations with respect to the Vegetation Monitoring at the Springs (see **Section 7.9**). However, in general, the Panel concurs with the GMMMP proposed monitoring to evaluate whether any of these potential Undesirable Results occur, and if they are caused by the proposed pumping at the Cadiz Project. The Panel also concurs with the Corrective Measures, if required, proposed in the GMMMP (ESA, 2012b) and agrees that they are reasonably sufficient to avoid any of these potential Undesirable Results.

4.0 GENERAL ASSESSMENT OF THE GMMMP

Table 6-1 in the GMMMP (ESA, 2012b) summarizes the monitoring and mitigation program for each potential Undesirable Result. For each of the Critical Resource categories, comments identified by the Panel are provided in **Table 2** below. The comments are based on whether the monitoring: (1) will identify an Undesirable Result; (2) has appropriate trigger thresholds; and (3) will be protective of Critical Resources. That is, collectively, do they avoid Undesirable Results? The Panel has concluded that, in general, the monitoring proposed in the GMMMP (ESA, 2012b) is sufficient for this purpose.

Nevertheless, some parties continue to express concerns about the Cadiz Project. Given these concerns, and the opportunity to improve the long-term efficacy of the monitoring and mitigation, the Panel has recommended the consideration and inclusion of additional monitoring, management and mitigation measures. If administratively feasible (e.g., permits and approvals to conduct certain monitoring can be obtained), these measures can be added to the GMMMP. These additional measures will provide greater assurances and greater confidence that the Cadiz Project will meet its water conservation objectives, can be implemented without causing Undesirable Results or, if they occur, any Undesirable Result can be mitigated.

The recommendations are not intended to alter the analysis or findings regarding the environmental impacts of the Cadiz Project described in the FEIR (ESA, 2012a), or contain any significant new information. Rather, the recommendations presented below are designed to:

- Improve the robustness of the GMMMP
- Broaden hydrogeologic knowledge of the Cadiz Project area
- Increase public confidence by providing additional monitoring, management and mitigation measures to further reduce the unlikely risk of Undesirable Results and are presented in an abundance of caution

Table 2. Monitoring and Trigger Threshold Summary with Panel Comments

Potential Impact	Monitoring Summary	Trigger Summary	Review Panel Comment
Springs	Visual observation and flow measurements at three springs (Bonanza, Whiskey, and Vontrigger) in accordance with the guidance document prepared by Desert Research Institute (DRI)	Reduction in average annual or seasonal flow or degradation in characteristics as correlated to precipitation	1. The GMMMP monitoring is appropriate to identify impacts. The understanding of the localized groundwater system proximate to Bonanza Spring could be improved with additional monitoring (i.e., additional monitoring wells, higher frequency monitoring). In addition, more defined vegetation monitoring is recommended (see below). 2. The proposed trigger thresholds are appropriate. For the avoidance of doubt, the GMMMP should evaluate threshold groundwater level declines in nearby wells (existing and recommended) that could be used as an early-warning of possible impacts to spring flow. Monitoring of these groundwater levels once the Project has commenced would be helpful and add to overall knowledge of the aquifer system. 3. The GMMMP monitoring and thresholds are protective of this Critical Resource. However, for the avoidance of doubt, and to address lingering concerns about impacts on the springs post-FEIR, we recommend that the GMMMP incorporate: (a) higher frequency spring flow monitoring; (b) additional localized groundwater monitoring; (c) more defined vegetation monitoring; (d) monitoring and other investigations (e.g., geophysical surveys) to confirm the conceptual model of spring flow; and e) considering new data collected before and after the initiation of pumping at the Cadiz Project, the hydrologic system at Bonanza Spring should be evaluated further with numerical groundwater modeling. The GMMMP contemplates a reassessment of monitoring every five years and this recommendation is not inconsistent with that requirement. Note: Cadiz has previously initiated monitoring of Bonanza and Vontrigger Springs; however, it has been denied access to Whiskey Spring.

Land Subsidence	Benchmark stations; InSAR; extensometers	Land surface decline of > 0.3 ft. A declining trend that would impact infrastructure	1. The GMMMP monitoring is appropriate to identify impacts. Although there have been no objections raised to this methodology, additional monitoring may be helpful. For the avoidance of doubt, we recommend: (a) additional InSAR analyses be performed; (b) only one initial extensometer be installed; and (c) the location and design of the additional extensometers be based on the InSAR data analyses. 2. The GMMMP trigger thresholds are appropriate. 3. The GMMMP monitoring and thresholds are protective of this Critical Resource. For the avoidance of doubt, we recommend: (a) more frequent InSAR data are analyzed; and (b) considering new data collected before and after the initiation of pumping at the Cadiz Project, the potential land subsidence should be evaluated using numerical groundwater modeling. The GMMMP contemplates a reassessment of monitoring every five years and this recommendation is not inconsistent with that requirement.
Saline Migration	Cluster wells between the dry lakes and Cadiz Project well-field	Total dissolved solids (TDS) concentrations increase >600 milligrams per liter (mg/L or ppm) at cluster wells ~6,000 feet from the current saline-fresh water interface.	1. The GMMMP monitoring is appropriate to identify impacts. Additional complementary measures could be considered by the Technical Review Panel, including conducting Electro-magnetic (EM) mapping of the saline-fresh water interface prior to pumping at the Cadiz Project during project operation, and post-operation. 2. The GMMMP trigger threshold is appropriate. 3. The GMMMP monitoring and thresholds are protective of this Critical Resource. For the avoidance of doubt, we recommend: (a) monitoring be supplemented with geophysics, and (b) considering new data collected before and after the initiation of pumping at the Cadiz Project, the migration of the interface should be evaluated using numerical groundwater modeling. The GMMMP contemplates a reassessment of monitoring every five years and this recommendation is not inconsistent with that requirement.

Brine Resources at Bristol and Cadiz dry lakes	Observation and cluster wells at dry lakes	Changes in brine water levels of >50% in the water column above of the mineral strip-mining company's pump intake	1. The GMMMP monitoring is appropriate to identify impacts. 2. The GMMMP trigger threshold is appropriate. 3. The GMMMP monitoring and thresholds are protective of this Critical Resource. For the avoidance of doubt, considering new data collected before and after the initiation of pumping at the Cadiz Project, brine water levels beneath the dry lakes should be evaluated further using numerical groundwater modeling. The GMMMP contemplates a reassessment of monitoring every five years and this recommendation is not inconsistent with that requirement.
Management of Overall Groundwater Drawdown	Monitoring within a 2-mile radius of the center of the Cadiz Project well-field	Groundwater decline of >80 feet at this distance (a groundwater management "floor")	1. The GMMMP monitoring is appropriate to identify impacts. However, for the avoidance of doubt, it is recommended that: (a) additional monitoring wells be installed proximate to Bonanza Spring; and (b) the frequency of monitoring be increased. 2. The proposed trigger threshold is appropriate. 3. The proposed monitoring and thresholds are protective of this Critical Resource. For the avoidance of doubt, we recommend: (a) additional groundwater monitoring be conducted; and (b) considering new data collected before and after the initiation of pumping at the Cadiz Project, the overall hydrologic conditions in the watersheds tributary to the Cadiz Project should be evaluated further with numerical groundwater modeling. The GMMMP contemplates a reassessment of monitoring every five years and this recommendation is not inconsistent with that requirement.

Third Party Wells	Groundwater observation wells	More than twenty (20) feet decline in static water levels	1. The proposed monitoring is appropriate to identify impacts. There is no evidence of wells withdrawing potable water within the Cadiz Project area. However, to improve understanding of the extent of potential drawdown (with the consent of the non-potable water users), it is recommended that transducers and data-loggers be installed at third-party wells where potential impacts appear most likely (i.e., third-party wells closest to the Cadiz Project well-field). The transducers should be maintained in these third-party wells for the pre-operational period and first five years of operations. 2. The proposed trigger threshold is appropriate. 3. The proposed monitoring and trigger threshold are protective of this Critical Resource. For the avoidance of doubt, we recommend: (a) increased frequency of monitoring at select third-party wells, and (b) considering new data collected before and after the initiation of pumping at the Cadiz Project, groundwater levels at third-party wells should be evaluated further using numerical groundwater modeling. The GMMMP contemplates a reassessment of monitoring every five years and this recommendation is not inconsistent with that requirement.
Adjacent Groundwater Basins	Groundwater observation wells	No action criteria necessary	1. The GMMMP is appropriate to identify impacts. 2. Trigger thresholds might be established in the unlikely event that adverse impacts from proposed pumping at the Cadiz Project are observed. 3. The GMMMP monitoring is protective of this Critical Resource.
Air Quality	Nephelometers, Soil testing	Changes in air quality that exceed baseline conditions by 5% and changes in soil conditions showing a degradation of soil structure	1. The GMMMP monitoring is appropriate to identify impacts. 2. The GMMMP trigger thresholds are appropriate. 3. The GMMMP monitoring and thresholds are protective of this Critical Resource.

Vegetation	Visual observation and correlation with groundwater levels	Reduction in the extent or character of Project area baseline vegetation	1. The GMMMP monitoring is appropriate to identify impacts. Aside from areas proximate to the springs, no groundwater dependent flora or fauna were identified in the FEIR. The weight of credible evidence indicates there is no direct hydraulic connection between Bonanza Spring and the alluvial aquifer in Fenner Valley below. Nevertheless, to address ongoing concern regarding the Bonanza Spring, and for the avoidance of doubt, it is recommended that further details and definition on vegetation mapping of Bonanza, Vontrigger, and Whiskey springs be provided. 2. The GMMMP proposed trigger thresholds can be refined in a more detailed vegetation monitoring plan. 3. The GMMMP monitoring and thresholds are protective of this Critical Resource. Nevertheless, for the avoidance of doubt, greater detail on the vegetation monitoring at springs should be provided, including more defined trigger thresholds. The GMMMP contemplates a reassessment of monitoring every five years and this recommendation is not inconsistent with that requirement.

The Corrective Measures for each Undesirable Result are presented in Table 6-1 in the GMMMP (ESA, 2012b, p. 120) and summarized in **Table 3** below, along with comments from the Panel. These comments are discussed further in later sections of this Consensus Report. The comments are provided in the context of whether the mitigation: (1) is practical (feasible and implementable) and appropriate; (2) will prevent an Undesirable Result; and/or (3) will alleviate an Undesirable Result, if it occurs, in a reasonable period of time.

Table 3. Mitigation Summary with Panel Comments

Potential Impact	**Corrective Measures**	**Comment**
Springs	Modification of Project operations to re-establish baseline flow and spring characteristics.	1. The GMMMP mitigation is practical and appropriate. 2. Based upon current evidence and analyses presented in this report, it is unlikely that there is a direct hydraulic connection between Bonanza Spring and the alluvial aquifer. To the extent there is a direct hydraulic connection, the FEIR concluded that the impact was not significant as the expected change, even after 100 years, was within the natural historic variation in water levels at Bonanza Spring. However, given the elevated concerns that continue to surround this specific resource, and for the avoidance of doubt, we recommend that additional mitigation measures be evaluated to prevent adverse impact (e.g.,

		aquifer recharge, temporary replacement water). A commitment to provide water for aquifer recharge or temporary replacement water appears feasible and sufficient to offset any observed impact at Bonanza Spring. The FEIR did propose the construction of a horizontal well to fulfill the same purpose. However, implementing this alternative mitigation may be difficult due to permitting issues. 3. Even if a direct hydraulic connection is assumed, the proposed mitigation will alleviate adverse impact. Alternative mitigation measures noted above should be evaluated to alleviate any impact in a more expeditious period of time.
Land Subsidence	Repair damaged structures. Enter into a mitigation agreement. Modification of Project well-field operations to arrest subsidence	1. The GMMMP mitigation is practical and appropriate. 2. The GMMMP mitigation may not prevent impact; however, the impacts may not be significant, and the potential impacts are not considered a threat to railroad and pipeline infrastructure. For the avoidance of doubt, the proposed monitoring program and thresholds (see **Table 2**) should be sufficient to trigger mitigation before an Undesirable Results occurs. 3. The proposed mitigation will alleviate impact in a reasonable period of time.
Saline Migration	Compensation. Installation of injection and/or extraction well(s) to maintain interface within its 6,000-foot limit. Modification of Project well-field operations	1. The GMMMP mitigation is practical and appropriate; 2. The GMMMP mitigation, notably injection/extraction wells, should prevent further migration of the interface. The recommended geophysical mapping (see **Table 2**) will allow for the pro-active design and installation of such wells, and earlier adjustments to Cadiz Project well-field operations. 3. The proposed mitigation will alleviate the migration in a reasonable period of time. It is unlikely that they will restore groundwater between the current interface and the 6,000-foot limit to its pre-impact condition. However, no potable water supplies will be impacted and restoration of the current interface does not appear to have any beneficial purpose.
Brine Resources at Bristol and Cadiz dry lakes	Compensation. Installation of injection and/or extraction well(s). Enter into a mitigation agreement. Modification of Project operations to maintain beneficial use	1. The GMMMP mitigation is practical and appropriate. 2. The proposed mitigation may prevent further impact to brine resources. The cost of installing and operating extraction wells will be borne by the Cadiz Project. While the impact may continue after mitigation due to the response lag time in the hydrologic system, the installation of injection wells is unlikely to prevent further impact. A mitigation agreement that includes the installation of brine extraction wells will allow mineral strip-mining operations to continue.

		3. The GMMMP mitigation can alleviate the impact to brine resources but it is unlikely that brine resources will be restored to their condition prior to pumping at the Cadiz Project for many decades, irrespective of the mitigation. Consequently, the mitigation agreement provides for the installation of brine extraction wells to allow mineral strip-mining operations to continue with no additional expense to the strip-miners.
Management of Overall Groundwater Drawdown	Modification of Project operations to avoid impact	1. The GMMMP mitigation is practical and appropriate. 2. The GMMMP mitigation may not prevent further impact due to the response lag time in the hydrologic system. However, the proposed monitoring program (see **Table 2**) can be used to trigger mitigation before Undesirable Results occur. 3. The GMMMP mitigation will alleviate impact in reasonable period of time proximate to the Cadiz Project well-field. The restoration of groundwater conditions further from the well-field will take many decades due to the response lag time. However, the lag-time response was analyzed under the FEIR over a 50-year post-pumping period, and Corrective Measures reflect this analysis.
Third Party Wells	Continued provision of substitute water supplies. Deepen or otherwise improve efficiency of impacted well(s). Blend impacted well water with another source. Construct replacement well(s). Compensation. Enter into a mitigation agreement. Modification of Project well-field operations	1. The GMMMP mitigation is practical and appropriate. 2. There are no third-party potable wells within the Cadiz Project area. The GMMMP mitigation will not prevent further impact to groundwater levels at non-potable third-party wells. However, it will provide a non-potable supply of water to impacted parties. 3. While the proposed mitigation will not alleviate the impact to groundwater levels at third party wells in a reasonable period of time, it will alleviate the impact to those third-party wells by providing an alternate water supply.
Adjacent Groundwater Basins	None	There are no anticipated impacts in adjacent basins. If information is developed to suggest there are impacts, the GMMMP monitoring program (see **Table 2**) should identify whether mitigation actions are needed.
Air Quality	Modification of Project operations to re-establish baseline air quality levels	1. The GMMMP mitigation is practical and appropriate. 2. The Cadiz and Bristol dry-lakes were identified as potential sources of air-quality impacts. However, due to the soil composition (high concentration of Calcium Chloride) at the dry-lakes, it is unlikely that air quality impacts will occur as a result of a reduction of moisture. In the unlikely event that significant air quality impacts are observed, the proposed mitigation may not

		prevent further impact due to the response time in the hydrologic system. Even with changes in Cadiz Project operations, brine water levels may not recover for many years. Therefore, in the unlikely event that significant air quality impacts occur, alternative mitigation measures should be evaluated (e.g., surface spraying in areas prone to dust generation). 3. The proposed mitigation will alleviate impact, but not in a reasonable period of time due to the response time in the hydrologic system. Therefore, in the unlikely event that significant air quality impacts occur, alternative mitigation measures should be evaluated.
Vegetation	Modification of Project operations to re-establish baseline vegetation	1. The GMMMP mitigation is practical and appropriate. 2. Aside from areas proximate to the springs, no groundwater dependent flora or fauna were identified in the FEIR. However, there is no credible evidence of a direct hydraulic connection between Bonanza Spring and the alluvial aquifer in Fenner Valley below. Nevertheless, for the avoidance of doubt, if it is assumed that a direct hydraulic connection exists and a significant impact is observed, the proposed mitigation may not prevent further impact due to the response lag time in the hydrologic system. Therefore, in the unlikely event that a significant impact to vegetation at springs associated with Cadiz Project operations occurs, alternative mitigation measures should be evaluated (e.g., temporary watering of vegetation). The FEIR did propose the construction of a horizontal well to fulfill the same purpose; however, trucking water may be easier, more practical, and more expeditious to implement. 3. The proposed mitigation will alleviate impact, but not in a reasonable period of time (see comment above). Therefore, in the unlikely event that a significant impact to vegetation at springs associated with Cadiz Project operations occurs, alternative mitigation measures should be evaluated.

5.0 ANALYSIS OF MONITORING AND MITIGATION

The GMMMP (ESA, 2012b) includes an assessment of Undesirable Results using numerical groundwater modeling to understand the potential hydrologic effects of the proposed pumping at the Cadiz Project. The Panel was provided access to the numerical model (GSSI, 2011) and reviewed various model simulations to gain perspectives on the potential hydrologic effects of the Cadiz Project.

The Cadiz Project will conserve water by capturing groundwater that would otherwise be wasted through evaporation from Bristol and Cadiz dry lakes. To achieve this, groundwater pumping will lower groundwater levels within the Fenner, Bristol Dry-Lake, Cadiz Dry-lake, and Orange Blossom Wash watersheds. For a project that involves the drawdown of aquifer water levels across a wide geographic area, the dynamics of groundwater storage changes related to the propagation of the cone of depression may be an important management factor. In particular, the lag time between groundwater level response distant from the pumping and the actual pumping activities (i.e., starting, continued pumping, modified pumping, and cessation) should be understood and considered).

For example, if an Undesirable Result is observed (e.g., reduced spring flows related to the proposed pumping at the Cadiz Project), then mitigation may include reduction or cessation of pumping at the Cadiz Project. However, even after the cessation of pumping, groundwater levels distant from the pumping may continue to decline for some period of time in response to prior pumping as a result of the response lag time. To provide context, a preliminary analysis using the numerical groundwater model for this example (i.e., potential hydrologic effects associated with the cessation of pumping at the Cadiz Project) is presented below

5.1 Aquifer Response to Pumping at the Cadiz Project

As an example[1], a scenario of pumping at the Cadiz Project using the GSSI (2011) model was run for 25 years. It was assumed that, in year 25, a threshold for an Undesirable Result was “triggered” at a monitoring point. This indicates that an impact may occur (e.g., reduced spring flow related to pumping at the Cadiz Project). It was then assumed that, as mitigation for this potential impact, pumping was terminated at the beginning of year 26. The continued aquifer response for several years after the cessation of pumping was analyzed using numerical groundwater model simulations with a recharge rate of 16,000 AFY.

[1] GSSI ran three model versions with different natural recharge rates to characterize a range of possible basin natural recharge (Project Scenario: 32,000 AF/Y, Sensitivity 1: 16,000 AF/Y and Sensitivity 2: 5,000 AF/Y). The example described herein is with the mid-range 16,000 AF/Y natural recharge version.

For this model simulation, in response to the cessation of pumping, an immediate aquifer water-level recovery is observed proximate to the Cadiz Project well-field (i.e., groundwater levels rise as groundwater infills the cone of depression around the well-field). However, at some distance from the well-field, groundwater levels continued to decline. This results from the continued movement of groundwater toward the well-field to infill the deepest parts of the cone of depression around the well-field. These distant locations could be coincident with a monitoring point being used to assess the effect of the proposed pumping at the Cadiz Project on a Critical Resource.

An illustration of the drawdown response in this model simulation is shown on **Figure 9**. The red dashed line (contour) indicates the location of 10 feet of drawdown after 25 years of pumping at the Cadiz Project. At the beginning of the 26th year when pumping stops, the blue lines illustrate the expansion of the 10-foot drawdown contour outward for the next 10, 20 and 30 years after pumping stops. That is, drawdown exceeds 10 feet for many years after that mitigation has been implemented – the cessation of pumping. Under such circumstances, an Undesirable Result may occur at a Critical Resource even many years after the implementation of the mitigation action (i.e., the cessation of pumping).

Given the propagation of the cone of depression after pumping stops, continued monitoring of groundwater conditions proximate to Critical Resources should continue after mitigation is implemented, as proposed in the GMMMP (ESA, 2012b, Section 6.4.3).

It is noted that the FEIR (ESA, 2012a) considered the delay in the propagation of the cone of depression by evaluating potential Undesirable Results over a 100-year period - 50 years of pumping 50,000 AFY and 50 years after pumping. No Undesirable Results were identified in the FEIR that could not be mitigated, considering the drawdown that would result over 100 years using various recharge rates as low as 5,000 AFY.

This model simulation is presented for illustrative purposes and further model simulations could be run to assess groundwater level responses to the mitigation actions proposed in the GMMMP once the Cadiz Project becomes operational, new data are collected, and the groundwater model is updated. In particular, simulations should examine whether a trigger threshold should be adjusted to account for the time lag between an action and the response at a monitoring point being used to assess Undesirable Results. Trigger thresholds for drawdown tied to several defined periods of time for a particular Critical Resource should also be evaluated. In addition, alternative mitigation actions that do not have time lag response issues (e.g., recharging the aquifer proximate to the Critical Resource) should be evaluated.

A groundwater level drawdown threshold (80 feet) is proposed in the GMMMP for a distance of two miles from the center of the Cadiz Project well-field. This threshold is intended to provide a management "floor" below which mitigation actions would be triggered. Such a floor was selected as it lessens the need for resource-specific mitigation actions at individual Critical Resources, as it is believed to provide a proactive Corrective Measure that would prevent significant impact.

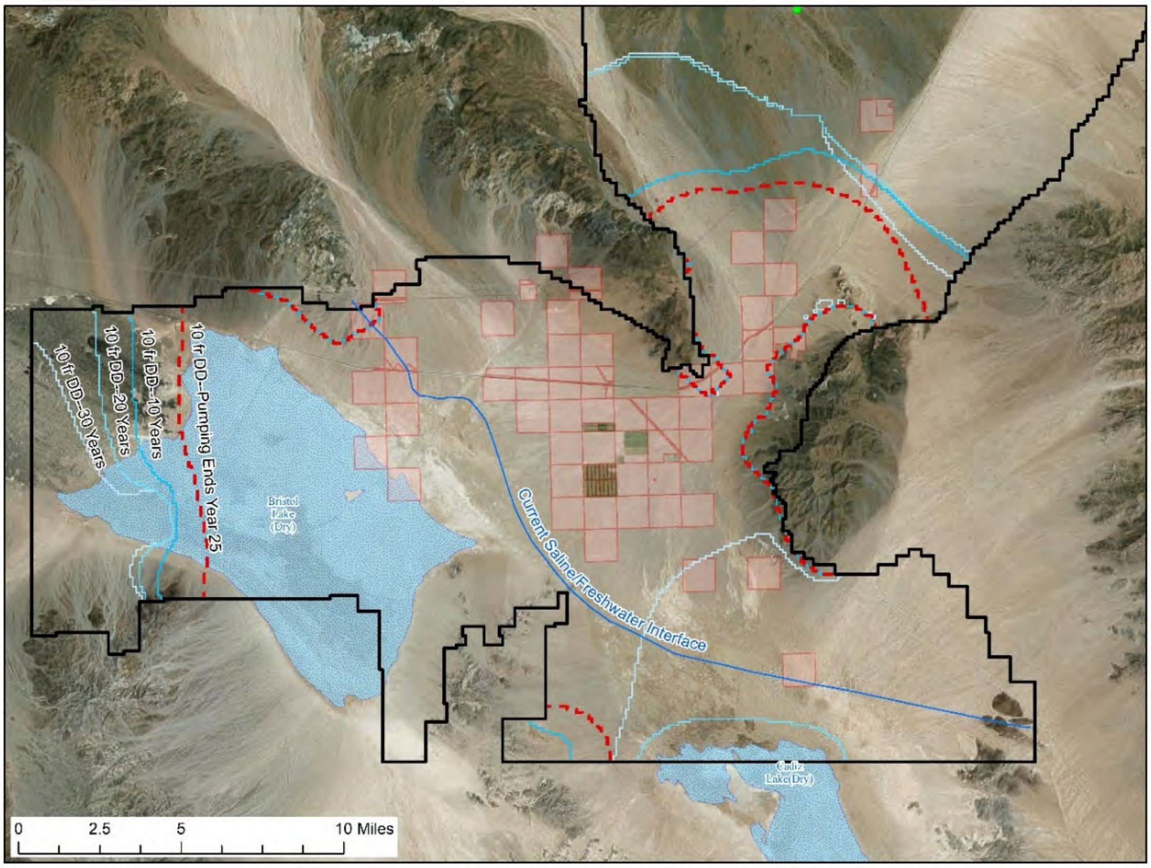

Figure 9: Lag in drawdown response related to the cessation of pumping at the Cadiz Project

It should be noted that the drawdown threshold two miles from the center of the Cadiz Project well-field may trigger mitigation when none is actually required. For example, if the 80-foot threshold is triggered, but unacceptable groundwater level declines are not observed closer to the springs (e.g., at monitoring well 6N15E1) or brine resources, no mitigation should be required. Conversely, if the 80-foot drawdown threshold is not triggered, but groundwater level declines observed closer to Critical Resources suggest an Undesirable Result could occur, then mitigation may be required. For these reasons, adequate monitoring is needed as close as reasonably possible to the Critical Resources. If monitoring closer to the Critical Resources indicates that an Undesirable Result could occur, then mitigation can be implemented.

The GMMMP (ESA, 2012b) discusses updating the numerical groundwater model(s) as information is collected during project operations. It is anticipated that subsequent modeling analysis will provide information that guides the "Decision-Making Process" (ESA, 2012b) associated with potential Corrective Measures for each identified Critical Resource. It is recommended that the numerical groundwater model be recalibrated after the installation and testing of new pumping wells at the Cadiz Project well-field, and this recalibration completed within a year. The model should then be recalibrated again after one year of pumping at higher flow rates (i.e., up to 50,000 AFY), and this recalibration completed within the second year of pumping. The recalibrated numerical groundwater model would then be used for the additional analyses recommended in this Consensus Report. The model should then be recalibrated again after five years of pumping and the collection of additional monitoring data for groundwater levels, groundwater geochemistry, spring flows, and land subsidence, etc. Again, this recalibration should be completed within a year.

5.2 Springs within Fenner Watershed

The FEIR (ESA, 2012a) and GMMMP (ESA, 2012b) concluded that it was very unlikely that a direct hydraulic connection existed between Bonanza Springs and the alluvial aquifer in Fenner Valley below. It further concluded that, even if there was a direct hydraulic connection, any impact would be within the natural historical variations in spring flow. Nevertheless, certain opponents to the Cadiz Project continue to express concerns about possible impact to the springs.

Subsequent to the finalization of the FEIR, detailed geologic mapping and hydrogeologic analyses conducted at Bonanza Spring (Kenney and TLF, 2018) conclude that there is no direct hydraulic connection between Bonanza Spring and the alluvial aquifer. However, some researchers (Zdon, 2016; Zdon et al., 2018; Rose, 2017) assert the hypothesis of a direct hydraulic connection between Bonanza Spring and the alluvial aquifer. Their assertions are principally based on their findings regarding groundwater geochemistry. These findings are disputed by other researchers (Kreamer, 2018; Schroth, 2018; Kreamer, 2019).

Irrespective of the dispute over groundwater geochemistry, given the geological mapping of Kenney and TLF (2018), the hydrologic assessment in aquilogic (2013), and fundamental hydrogeologic concepts, the Panel has concluded that the weight of credible evidence suggests that there is no direct hydraulic connection between Bonanza Spring and the alluvial aquifer in Fenner Valley below. The evidence includes, but is not limited to, the following:

- The 11 mile distance between the proposed pumping at the Cadiz Project well-field and Bonanza Spring
- The over 1,000-foot change in elevation between groundwater in Fenner Valley and Bonanza Spring

- The hydrologic nature of the fractured bedrock watershed supporting Bonanza Spring and the alluvial deposits in Fenner Valley
- The identification of faults in the vicinity of Bonanza Spring that control spring location by Kenner and TLF (2018)
- The evaluation of groundwater geochemistry at Bonanza Spring by Kreamer (2019), notably lower water temperatures and spring flow variation
- The infiltration of stream flow supported by Bonanza Spring immediately down-stream of the spring (i.e., the presence of a vadose zone down-stream of Bonanza Spring)

Despite the weight of evidence, for the purposes of this Review, we have not attempted to resolve the dispute over geochemical interpretation. The impact analysis in the FEIR (2012a), in an abundance of caution, assumed there was a direct hydraulic connection. Further, in performing our Review, the Panel has considered the potential for an Undesirable Result assuming, in an abundance of caution, that a direct hydraulic connection exists.

5.2.1 Geophysical Mapping

As noted, the Panel has concluded that the weight of credible evidence suggests that there is no direct hydraulic connection between Bonanza Spring and the alluvial aquifer in Fenner Valley below. However, in order to provide additional information on the geologic structure and hydrogeology in the vicinity of Bonanza Spring, it is recommended that geophysical mapping be conducted in the area immediately above, and for some distance below, the spring. The objectives of the geophysical surveys would be to delineate structural features (i.e., faults) and other structural deformation, identify potential fracture lineaments with increased facture aperture and density (i.e., groundwater bearing potential), map the bedrock surface below the unconsolidated deposits south of the spring, and map the groundwater surface above and below the spring. A geophysical contractor should be retained to plan and implement the geophysical mapping. If feasible, the mapping may include shallow seismic surveys, surface electro-magnetics (EM), time-domain EM (TDEM), and electrical resistance tomography (ERT).

5.2.2 Spring Flow Monitoring

The GMMMP provides for quarterly monitoring of flow at the Bonanza Spring. The Whiskey and Vontrigger springs will also be monitored quarterly, even though these springs are located beyond the projected drawdown in groundwater levels in the alluvial aquifers that results from the proposed pumping at the Cadiz Project. As such, the monitoring at Whiskey and Vontrigger springs will serve as background monitoring. This will allow any significant variations in flow at Bonanza Spring that result from pumping at the Cadiz Project to be isolated from variations that result from other factors (e.g., drought) that are observed at Whiskey and Vontrigger springs.

Given the smaller scale of the bedrock watershed that supports Bonanza Spring (Kenney and TLF, 2018), a change in recharge should have a rapid effect on hydraulic head within the groundwater in the bedrock watershed. Bonanza Spring would respond much more rapidly to this change in hydraulic head. That is, for example, with declining recharge, hydraulic heads within the watershed that supports Bonanza Spring will decline and flows at Bonanza Spring (and possibly its elevation) may also decline. As noted, in the past it appears that Bonanza Spring itself has moved downslope in response to the historic lowering of the groundwater elevations in the watershed that supports the spring (Kenney, 2018; Zdon et al., 2018). This lowering may occur in the future should current drought conditions persist or reoccur.

If it is assumed that there is a hydraulic connection between Bonanza Spring and the groundwater in the alluvial aquifer, the temporal response at Bonanza Spring to the proposed pumping at the Cadiz Project must be considered. The proposed pumping will occur 11 miles away from Bonanza Spring and at an elevation more than 1000 feet lower. Therefore, it will take many years for the cone of depression caused by the proposed pumping to propagate out to the edge of the alluvium within the Fenner Valley below Bonanza Spring (GSSI, 2011; CH2M.Hill, 2011). Thus, any Undesirable Results from the proposed pumping at the Cadiz Project may take many years to appear at Bonanza Spring, in the unlikely event they do ever occur. In addition, if the proposed pumping were to be lowered or stopped (e.g., as a mitigation measure), groundwater levels proximate to the pumping would rebound. Given this, should pumping be reduced or ceased, monitoring of the springs and groundwater levels would need to continue for some period until stable or recovering hydrologic conditions were observed.

In the current GMMMP (ESA, 2012b) no new monitoring facilities will be constructed. *In-situ* measurements will be made at the Bonanza, Whiskey and Vontrigger springs. The general assumption made in the GMMMP is that the nearest spring, Bonanza Spring, would be impacted by the proposed pumping at the Cadiz Project before any more distant spring, if such impact were to occur. That is, Bonanza Spring should be monitored and, if no adverse impact is observed, the other springs should not be impacted. As noted, background monitoring would be conducted at Whiskey and Vontrigger springs. The following measurements will be made at Bonanza, Whiskey, and Vontrigger springs: depth of ponded water, flow rates, electrical conductivity (EC), pH, temperature, any colorations of water, and general type and extent of adjacent vegetation. These measurements will be made quarterly prior to the proposed pumping at the Cadiz Project and during project operations, and annually in the post-operational period. The GMMMP (ESA, 2012b) proposes quarterly monitoring of three springs. However, the responses at these springs to individual hydrologic events (e.g., precipitation) are generally observed over time frames much shorter than three months. For example, one large storm in such an arid setting may only elicit a response at the springs that lasts a few days or weeks, and the nature of the response (e.g., increase and subsequent declines in flows over time) may only be evident with high-frequency data. These short-term responses are also valuable in assessing responses to longer-term hydrologic events (e.g., seasonal precipitation, climatic changes, sustained pumping), and the impact these can have on future spring flows.

Therefore, it is recommended that more frequent monitoring be conducted at the Bonanza, Whiskey, and Vontrigger springs. Ideally, this should include transducers and a data-logger to monitor ponded water depth at reasonable, higher-frequency intervals. A multi-parameter probe could be used to monitor depth/flow, EC, and temperature at the same frequency. Alternatively, EC and temperature could be manually monitored on a monthly basis for at least one year prior to the proposed pumping at the Cadiz Project, and during the first year of project operations. After that, manual monitoring could be conducted quarterly. Data-loggers would be downloaded during manual monitoring events. Other parameters, such as pH, water coloration, and observations of riparian vegetation, could be conducted quarterly. In addition, it is recommended that the exact geographic location and elevation of the spring emergence be mapped using a global positioning system (GPS) annually or after a change in location is observed during other monitoring activities.

It should be noted that additional monitoring recommended in this Consensus Report (e.g., spring flow monitoring, monitoring wells below Bonanza Spring) will require approvals from government agencies. The monitoring proposed in the GMMMP (ESA, 2012b) is sufficient to ensure that no Undesirable Results will occur, or can be mitigated. However, the additional monitoring recommended herein will assist in the overall understanding of the hydrology of the Cadiz Project area, notably at Bonanza Spring, and improved monitoring of possible Undesirable Results at Critical Resources. Therefore, given the value of such monitoring, it is hoped that such approvals will be forthcoming. If permission to install the transducers and data-loggers is not given, then ponded water depth and spring flow should be monitored on the same frequency as manual monitoring of EC and temperature.

Prior to any monitoring of spring flows, including manual monitoring, a correlation between ponded water depth and flow will need to be developed. This is normally done for a location immediately downstream of the spring where the stream profile is defined and constrained (e.g., where it crosses bedrock) or where the profile can be artificially constrained (e.g., construction of a v-notch weir). A location with a naturally confined profile should be identified. Ponded water depth and flow measurements should be taken at that location on several occasions during different flow conditions (e.g., low-flow, regular flow, storm-flow) to develop the correlation. The transducer or multi-probe would then be installed at that location.

The exact scientific method as to how the “general type and extent of adjacent vegetation” will be monitored was not specifically described in the GMMMP. It is recommended that a terrestrial ecologist be retained to develop a scientifically appropriate methodology to monitor vegetation at the three springs at least one year prior to the commencement of the proposed pumping at the Cadiz Project, during the operational period, and for some period after pumping has ceased. This might include defined transects across the stream below the springs, and identification and quantification of species at points along the transects over time. Such a standardized methodology will allow changes in vegetation to be tracked over time.

It is important that at least one year of higher-frequency data on spring conditions be obtained prior to the proposed pumping at the Cadiz Project. In particular, this monitoring will provide a baseline for Bonanza Spring that can compared to data collected after the pumping at the Cadiz Project is initiated. This baseline comparison will supplement and/or complement the comparison of data for Bonanza Spring to the time-contemporaneous data collected at the Whiskey and Vontrigger springs. That is, how does any change in conditions at Bonanza Soring compare to other springs, based on time-contemporaneous data, and how does it compare to conditions at Bonanza Spring prior to the proposed pumping at the Cadiz Project. Such comparisons will assist in evaluating whether any change at Bonanza Spring is the result of the proposed pumping at the Cadiz Project, climatic variability, and/or other factors.

Finally, we recommend that more detailed quality assurance and quality control (QA/QC) procedures be developed, described, implemented, and documented for the collection and analysis of all data pertinent to the springs. A detailed quality assurance project plan (QAPP) should be prepared to describe the QA/QC procedures. In fact, the QAPP should describe QA/QC procedures for the collection and analysis of all data pertinent to the Cadiz Project.

Although it appears unlikely that a direct hydraulic connection exists between Bonanza Spring and the alluvial aquifer in Fenner Valley below, the additional monitoring recommended herein will produce scientifically defensible information to assist with the following:

- Characterizing the degree, if any, of hydraulic communication between Bonanza Spring and the alluvial aquifer in the Fenner Valley
- Identifying and quantifying any Undesirable Results at Bonanza Spring
- Evaluating the cause of any such impacts (e.g., the proposed pumping at the Cadiz Project, climatic conditions, other factors)
- Determining the type, nature, magnitude, and duration of mitigation actions that could be implemented

5.2.3 Spring Flow Mitigation

As noted, the analyses presented in the FEIR (ESA, 2012a), aquilogic (2013), and Kenney and TLF (2018), indicates that there is likely no direct hydraulic connection between Bonanza Spring and the alluvial aquifer in Fenner Valley below. Therefore, without such a connection, the proposed pumping at the Cadiz Project will have no impact on Bonanza Spring (or other springs for that matter), and there would be no need for Corrective Measures. Even if there is a direct hydraulic connection, the FEIR concluded that the proposed pumping at the Cadiz Project would have no significant impact on Bonanza Spring, as any impact would be within historical variations observed at the spring. Therefore, given the lack of an Undesirable Result, there would be no need for mitigation.

The GMMMP still proposes potential Corrective Measures in the unlikely event that an Undesirable Result occurs at the springs (ESA, 2012a, Section 6.4.3). These measures include modification or cessation of pumping at the Cadiz Project well-field. However, as noted (See **Section 5.1**), due to the response lag time in the hydrologic system, such measures are reactive and would not prevent impact or alleviate impact in a reasonable period of time. The FEIR did assess the construction of a horizontal well just above Bonanza Spring to maintain spring flow (ESA, 2012a, Section 6.4.3). Such a Corrective Measure would prevent further impact and alleviate impact in a reasonable period of time. However, implementing such mitigation would require approvals from government agencies. Alternatively, an injection well could be installed either at the edge of the alluvial aquifer in Fenner Valley or above Bonanza Spring.

Injection of water at the edge of the alluvial aquifer would “cut-off” the propagation of the cone of depression caused by the proposed pumping at the Cadiz Project. Injection of water above Bonanza Spring would maintain groundwater levels in the fractured bedrock watershed that supports spring flow. Given the very low effective fracture porosity, only small volumes of water are anticipated to be needed for injection into water-bearing fractures. Such injection programs, if implemented proactively, could actually prevent impact to Bonanza Spring and, even if implemented reactively, would prevent further impact and alleviate the impact in a reasonable period of time. Like the horizontal well proposed in the FEIR (ESA, 2012a), implementing such injection would require approvals from government agencies.

Finally, flow at Bonanza Spring has been estimated to be about 10 gallons per minute (gpm) (Thompson, 1929). Even in the unlikely event that the proposed pumping at the Cadiz Project reduced flows at Bonanza Spring, water could be delivered to a temporary storage tank above the spring. Water from this tank could then be discharged to Bonanza Spring to maintain spring flows. The provision of supplemental water, if implemented reactively, would prevent further impact and alleviate the impact in a reasonable period of time. Like the horizontal well proposed in the FEIR (ESA, 2012a), implementing such a mitigation action would require approvals from government agencies.

5.3 Groundwater Monitoring

The GMMMP (ESA, 2012b) includes groundwater monitoring requirements, such as monitoring locations, monitoring type, monitoring frequency, monitoring parameters. The locations of monitoring points pertinent to Bonanza Spring and the Brine Resources are presented in **Figure 10** (an excerpt from Figure 5-1: Monitoring Features of the GMMMP [ESA, 2012b]).

The perimeter of the green area on **Figure 10** indicates the maximum extent of 20 feet of drawdown in the alluvial aquifer resulting from the proposed pumping at the Cadiz Project, with the numerical groundwater model calibrated to recharge of 32,000 AFY. The maximum extent of 20 feet of drawdown extends to the contact between the alluvium and the bedrock of the Clipper Mountains south of Bonanza Spring. It also extends beyond the mineral strip-mining operations at Bristol Dry Lake.

In the GMMMP (ESA, 2012b), it is proposed that groundwater conditions be monitored at wells 6N15E1 and 6N15E29 (see **Figure 10**) to observe the propagation of the cone of depression outward from the proposed pumping at the Cadiz Project toward Bonanza Spring. These wells would serve as sentry wells – providing an early indication of potential Undesirable Results at Bonanza Spring, assuming there is a direct hydraulic connection between the spring and the alluvial aquifer.

In the GMMMP, there is no threshold groundwater level decline at monitoring well 6N15E1 that would trigger mitigation. This is because no actual link, as opposed to a hypothetical link, between the alluvial aquifer and Bonanza Spring has been established. The credible evidence (Kenney and TLF, 2018) indicates that there is no hydraulic connection, and the analyses presented in the FEIR (ESA, 2012a) indicates that, even with an assumed hydraulic connection, the proposed pumping at the Cadiz Project would have a negligible impact on spring flows. Therefore, no such threshold at monitoring well 6N15E1 is warranted.

Despite the credible evidence, to assuage concerns and improve public confidence that the Cadiz Project can be operated without causing Undesirable Results, the Panel recommends that additional groundwater monitoring be conducted proximate to Bonanza Spring.

Monitoring well 6N15E1 is screened within the alluvial sediments of the Fenner Valley (Kenney, 2018, Figure 17 and Figure2-7b). The well is located approximately 1.5 miles southeast of the contact between alluvial deposits (Qoaf) and the Clipper Mountains. This well will be useful in identifying the propagation of potential drawdown in the alluvial aquifer of the Fenner Valley resulting from the proposed pumping at the Cadiz Project.

Monitoring well 6N15E1 is located approximately 3.5 miles southeast of Bonanza Spring. Ideally, a monitoring well should be placed closer to Bonanza Spring to monitor groundwater level conditions at the contact between the alluvial deposits and the Clipper Mountains (e.g., one mile southeast of Bonanza Spring). In addition, the well will not provide data on groundwater conditions within the fanglomerates and other unconsolidated deposits on the side slopes of the Clipper Mountains (if they contain groundwater). It will also not provide data on groundwater conditions in the fractured bedrock either below Bonanza Spring or in the watershed above Bonanza Spring that supports spring flow. Ideally, to more effectively monitor potential Undesirable Results at Bonanza Spring and evaluate the possible cause of the impact, monitoring wells could be placed in the following locations:

- Immediately below the spring (i.e., within 100 yards) with separate casings discretely screened in unconsolidated deposits beneath and adjacent to the stream fed by the spring, if they contain groundwater, and in the fractured bedrock beneath these deposits
- Below Bonanza Spring at the limits of the alluvial aquifer (e.g., one mile southeast)
- Immediately above the spring (i.e., within 50 yards) in the fractured bedrock watershed that supports spring flow

The monitoring of spring flow itself (see **Section 5.2.2**) negates the need for the latter monitoring well. That is, the spring itself serves as a groundwater monitoring point for the bedrock watershed that supports spring flow. The second monitoring well would provide a second, but not duplicative, groundwater data point within the alluvial aquifer in Fenner Valley. The first set of monitoring wells in the unconsolidated deposits and fractured bedrock below Bonanza Spring would provide data that could not be obtained from any currently existing monitoring wells. Therefore, this set of wells is the most important additional monitoring wells needed to evaluate groundwater conditions in relation to potential Undesirable Results at Bonanza Spring. These monitoring wells (outlined in Recommendations, Section 7) would provide a more definitive data set to monitor and evaluate potential Undesirable Results at Bonanza Spring. For example, if groundwater levels decline in 6N15E1, but not in the additional monitoring wells installed between Bonanza Spring and well 6N15E1, then it is unlikely that an Undesirable Result will occur at Bonanza Spring. As another example, if groundwater levels are stable at a new monitoring well one mile southeast of Bonanza Spring but declining in a monitoring well within the fractured bedrock, and flows at Bonanza Spring are impacted, the impact cannot be from the proposed pumping at the Cadiz Project, but rather a climatic or other effect within the watershed above the spring. As a third example, if groundwater levels are declining in all monitoring wells, and flows at Bonanza Spring are impacted, then the impact could be from the proposed pumping at the Cadiz Project, and Corrective Measures would need to be taken.

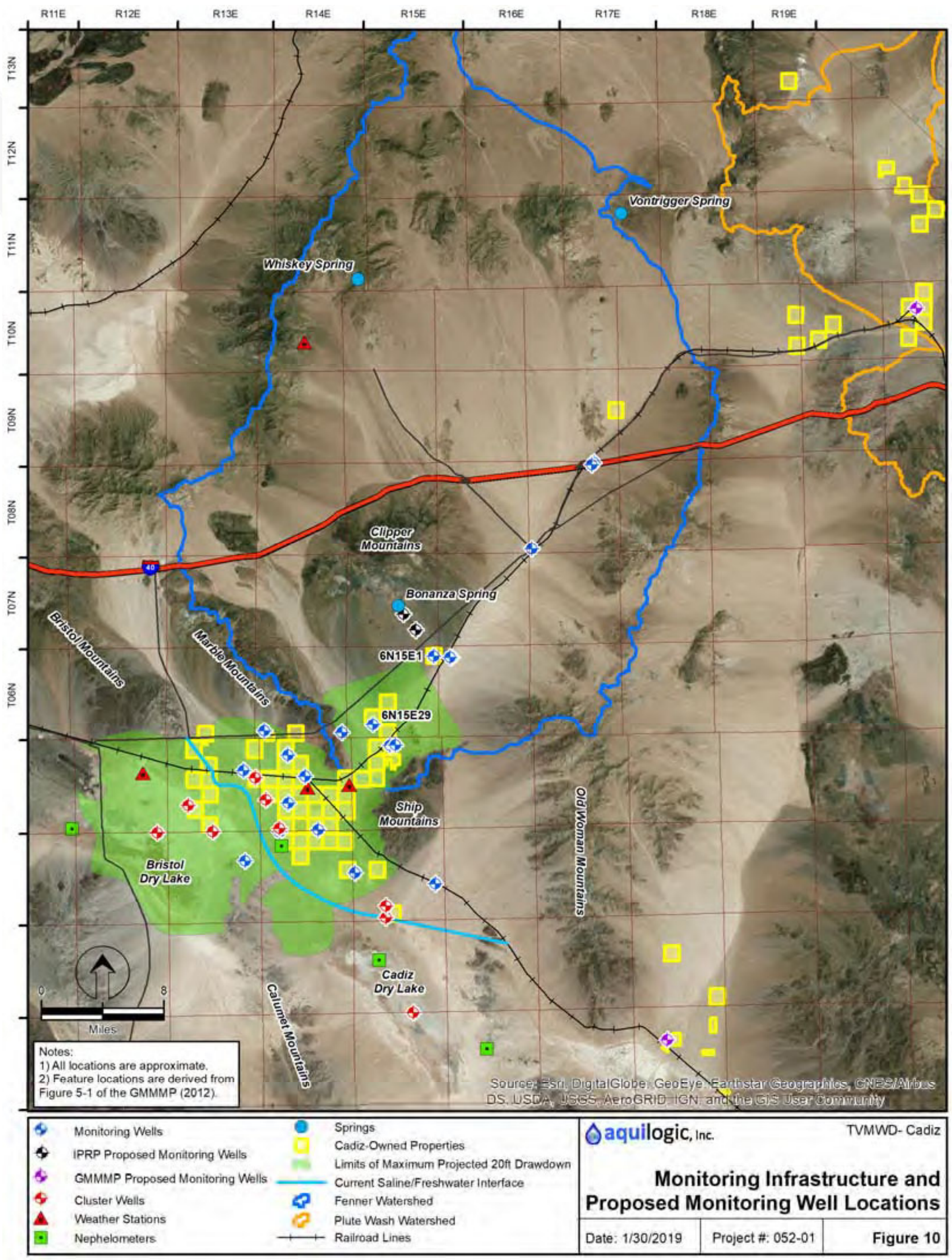

Figure 10: Excerpt of Monitoring Features from Figure 5-1 of the GMMMP (ESA, 2012b)

In the current GMMMP (ESA, 2012b, see Figure 5-1, p. 64), groundwater levels and water quality will be monitored in the Fenner Valley at 14 existing monitoring wells plus two proposed monitoring wells (Danby-1 located between Chubbuck and Rice; and Piute-1 located east of Goffs). It is proposed in Appendix B of the GMMMP (ESA, 2012b, p. 122) that groundwater level measurements be taken at various frequencies depending on well and operating period. In the pre-operational period, transducers will be used to collect high frequency groundwater level measurements at six existing monitoring wells (5N14E5F1, 6N15E01H, 6N15E29P1, 4N14E13J1, 5N14E24D2, 5N14E16H1); whereas, groundwater levels at the other ten wells will be measured manually on a monthly basis. In the GMMMP, it is proposed that groundwater level measurements be taken semi-annually during the operation period and annually during the post-operational period. During the pre-operational period, groundwater quality samples will be collected quarterly at five monitoring wells and annually at nine wells. During the operational and post-operational periods, groundwater will be sampled annually at the five wells previously sampled quarterly.

In general, the number and location of wells used to monitor regional groundwater conditions appear appropriate. Cadiz has prepared Annual Agricultural Monitoring Reports (CH2M.Hill, 2018) for two decades, as required under its permitted agricultural use. The data in these reports indicates that groundwater levels have not materially changed over the last twenty year period. However, when the Cadiz Project begins operation, the hydrologic system will be subject to annual pumping much higher than previously seen. This pumping will be maintained for up to 50 years. Given the increased pumping and concerns expressed by some project opponents, the Panel recommends that the frequency of groundwater monitoring be modified slightly.

The groundwater monitoring program proposed in the GMMMP (ESA, 2012b) may not provide the temporal resolution needed to establish baseline conditions immediately prior to the proposed pumping at the Cadiz Project or to evaluate the hydrologic response to the pumping of 50,000 AFY during the first few years of operation. Monitoring groundwater levels at a higher frequency will better establish baseline conditions. It will also allow the response of the hydrologic system to increased pumping to be evaluated, including information on hydrogeologic structure within the watersheds, an improved understanding of hydraulic parameters (e.g., hydraulic conductivity and storativity), and identification of possible data gaps that may need to be filled. In addition, the increased monitoring frequency will assist in the assessment of Undesirable Results (e.g., Bonanza Spring, Brine Resources) from the proposed pumping at the Cadiz Project. In doing so, it will also allow pumping operations to be optimized (e.g., well cycling, pumping rates) to maintain production while preventing Undesirable Results. Therefore, it is recommended that the following modified groundwater monitoring and sampling program be implemented concurrent with commencement of the Cadiz Project:

- Pre-operational (for at least one year) – transducers be placed in all 16 monitoring wells, plus the proposed monitoring wells adjacent to Bonanza Spring and brine migration cluster wells, to collect groundwater level readings (perhaps hourly basis), and the data-loggers downloaded quarterly.

- The groundwater quality sampling program proposed in the GMMMP (ESA, 2012b) is acceptable. The new monitoring wells proximate to Bonanza Spring proposed herein and any new brine migration cluster wells should be sampled quarterly.
- First year of operation – the pre-operational monitoring and sampling program recommended above should be maintained.
- Years 2-5 of operation – transducers should be maintained in the monitoring wells, and the data-loggers downloaded annually. Groundwater quality samples should be collected at all monitoring wells, including any newly installed monitoring wells, annually.
- Years 6-50 of operation – the groundwater monitoring and sampling program proposed in the GMMMP (ESA, 2012b) is acceptable. For any newly installed monitoring wells, groundwater levels should be monitored semi-annually and sampled annually for groundwater quality analyses. It should be noted that, under the adaptive management approach in the GMMMP, analysis of the data collected may require that the proposed monitoring program be modified for these later year of operation and the post-operational period.
- First post-operations year – the pre-operational monitoring and sampling program recommended above should be implemented during this period of rapid groundwater recovery.
- Years 2-5 post-operations – the monitoring and sampling program implemented in years 2-5 of operations should be implemented during this period of rapid groundwater recovery.
- Subsequent post-operations years - the groundwater monitoring and sampling program proposed in the GMMMP (ESA, 2012b) is acceptable.

5.4 Brine Resources Underlying Bristol and Cadiz Dry Lakes

The hydrograph below in **Figure 11** (GSSI, 2011) shows the projected drawdown of groundwater levels beneath the Bristol Dry Lake during the proposed pumping at the Cadiz Project. The hydrograph was produced from numerical groundwater modeling performed by GSSI (2011). It shows that, depending on the recharge amount used in the modeling, between 30 and 65 feet of drawdown will occur beneath Bristol Dry Lake. In general, the trenches used to expose saline groundwater to evaporation and precipitate salts for mineral strip-mining operations at Bristol Dry Lake are about 12 feet deep, and the two existing strip-mining operators utilize approximately 750 AFY of brine water. Therefore, once groundwater levels beneath Bristol Dry Lake decline below 12 feet bgs, the trenches will be dry, curtailing some strip-mining operations and processes. However, it is understood that the strip-mining operations already pump groundwater from existing wells into the trenches. In addition, under natural climatic conditions, groundwater levels beneath the dry lakes decline at times, and the trenches are then dry.

Viewed strictly from the standpoint of whether the project is causing a physical change in the environment, and if there were a need for a "physical solution" if the groundwater level predictions from the modeling come to pass, it is likely that Corrective Measures will need to be implemented as outlined in the GMMMP (ESA, 2012b) to mitigate impacts on the strip-mining businesses. These Corrective Measures include operational modifications and/or negotiation of a compensation or mitigation agreement with mineral strip-mining operator(s). Such an agreement would require that Cadiz bear all of the costs of drilling wells to pump the brine, as the strip-mining operators do presently in some locations, rather than rely on the high groundwater table to fill evaporation/precipitation trenches. For example, brine extraction wells deeper than 70 feet bgs could be installed to maintain mineral strip-mining at Bristol Dry Lake.

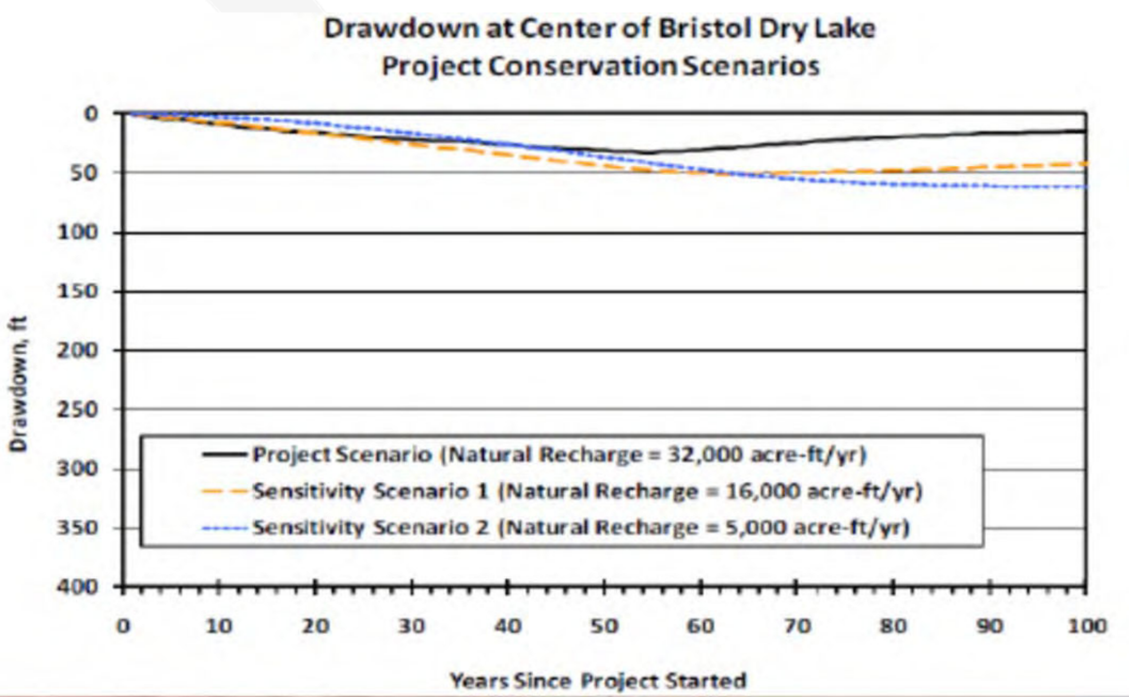

Figure 11: Drawdown Beneath Bristol Lake Under Three Recharge Scenarios (GSSI, 2011)

In Section 5.8 (p. 63) of the GMMMP (ESA, 2012b) it states that "*An additional well cluster will be installed on the Bristol Dry Lake playa to monitor brine levels and chemistry at different depths beneath the Dry Lake surface. This well cluster will be positioned in relation to the well clusters at the margin of the Dry Lake so as to provide optimum data for the variable density transport model*" (ESA, 2012b). The well clusters on Figure 5-1 (p.64) of the GMMMP are not labeled. However, there appears to be only one cluster in the middle of the Bristol Dry Lake (see **Figure 10**). It is also proposed in the GMMMP that a well cluster be installed at the middle of Cadiz Dry Lake (see **Figure 10**). It is recommended that these well clusters be added to the groundwater monitoring and sampling program after installation (see **Section 5.3**). In addition, it is recommended that groundwater samples collected at the well clusters be analyzed for lithium concentrations. This data may assist in the design and construction of any brine extraction wells that have to be installed to maintain mineral strip-mining operations.

GSSI (2011) analyzed hydrologic effects at the dry lakes using a numerical groundwater flow and transport model. The numerical model represents evapotranspiration (Et) from the dry lakes using a technique that involves specification of surficial elevations based on USGS 15-minute topographic quadrangles (Cadiz, Danby, Bristol Lake and Cadiz Lake) and an Et extinction depth below that surface reasonably assumed to be 15 feet bgs (GSSI, 2011, p. 36 - 37). The numerical model simulates direct Et from the saturated groundwater regime (water table) beneath the Bristol and Cadiz dry lakes. As the groundwater levels decline below the dry lakes in response to pumping at the Cadiz Project, the Et rate decreases. Eventually, when groundwater levels decline below the extinction depth, simulated Et stops.

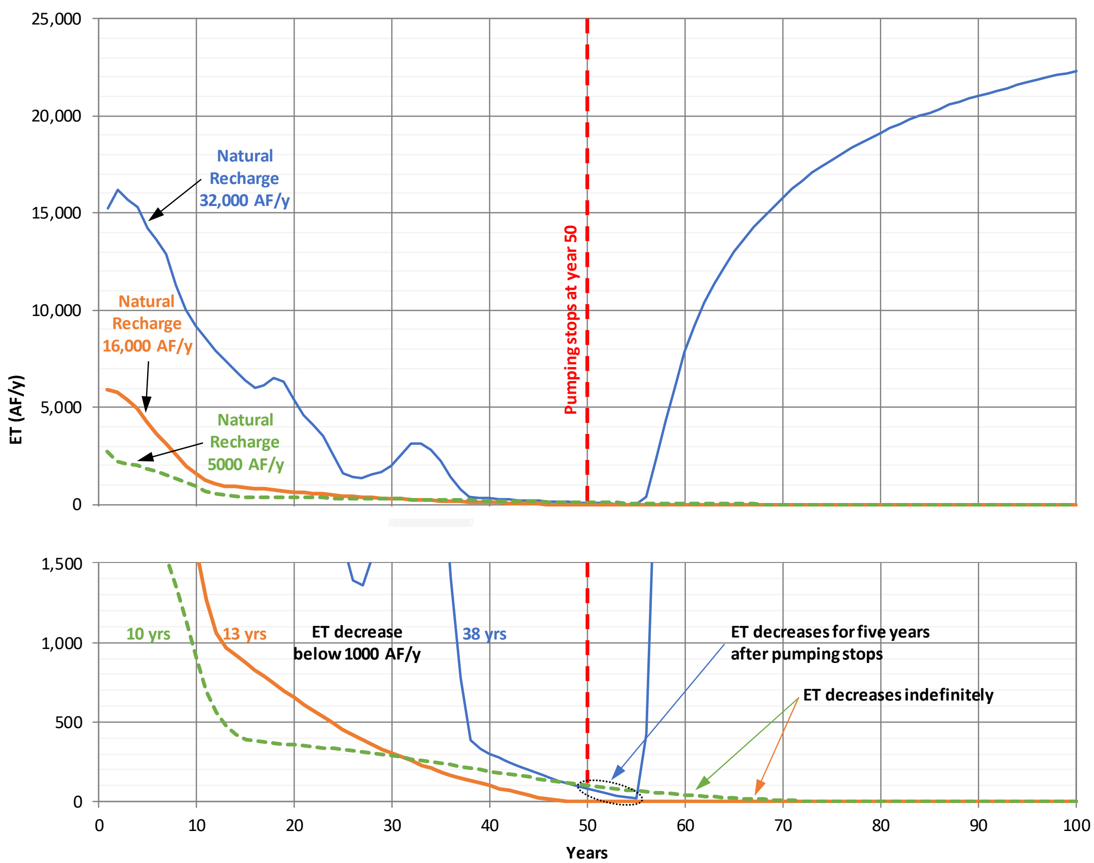

Figure 12: Simulated Et for Three Recharge Scenarios (lower chart is an expansion of the bottom 1,500 AFY of the upper chart)**.**

GSSI (2011, Tables 2, 3 and 4) ran three model simulations to provide water budget tables that include total Et for three project scenarios with different recharge rates (Project scenario: 32,000 AFY, Sensitivity 1: 16,000 AFY and Sensitivity 2: 5,000 AFY - GMMMP, p. 41 - 42). **Figure**

12 below shows the Et quantities reported from the GSSI (2011) water budget tables indicating the change in Et over time for each simulation.

Two important observations are apparent in **Figure 12:**

- First, with the proposed pumping at the Cadiz Project, Et lowers to small quantities (< 1,000 AFY) in each scenario (38 years in the Project Scenario, 13 years in Sensitivity 1, and 10 years in Sensitivity 2). This small volume of Et indicates that shallow groundwater levels below most of the dry lakes have been lowered below 15 feet bgs. With such groundwater level declines, the brine supply trenches would likely be dry and shallow brine recovery wells may have reduced yields.
- Second, Et continues to decrease after pumping at the Cadiz Project ceases in year 50. The continued decline in Et (and associated decline in groundwater levels) results from the time lag discussed previously in this Consensus Report (see **Section 5.1**). In the Project Scenario (32,000 AFY recharge), Et decreases for another five years after pumping at the Cadiz Project stops. In the Project Scenario, Et then recovers and exceeds 1,000 AFY seven years after pumping ceases. However, in Sensitivity Scenarios 1 and 2 (16,000 and 5,000 AFY, respectively), Et decreases indefinitely and shows no recovery for the 50-year period after pumping ceases. This indicates that shallow (high salt) groundwater levels at the dry lakes may not recover to within 15 feet of the land surface within the duration of this model simulation (i.e., 50 years after pumping ceases).

Lowering the groundwater table beneath Cadiz and Bristol dry lakes is a physical change necessary to achieve the conservation objectives of the Cadiz Project. Such a change is approved as part of the approach to optimally manage the basin under the GMMMP (ESA, 2012b). The above results indicate that simply stopping pumping at the Cadiz Project may not mitigate Undesirable Results to Brine Resources. However, such a cessation or modification of pumping was never intended to be the sole Corrective Measure for impacts to Brine Resources. As set forth in the GMMMP (ESA, 2012b, Section 6.2.3), alternative mitigation for loss of production at the mineral strip-mining operations will be needed (e.g., drilling new, deeper brine recovery wells). Careful logging and depth discreet sampling of any new brine recovery wells may allow the wells to be constructed to optimize recovery of select minerals (e.g., lithium).

5.5 Saline–Fresh Water Interface Migration

As noted in **Section 3.4** in this Consensus Report, there is currently an established transitional interface between saline groundwater in the vicinity of Bristol and Cadiz dry lakes and freshwater moving towards the dry lakes from the Fenner Valley and other up-stream watersheds. The proposed pumping will likely reverse groundwater flow between the Cadiz Project well-field and the dry lakes; that is, flow would be from the dry lakes to the well-field.

This change in groundwater flow direction will cause the saline-fresh water interface to migrate away from the dry lakes towards the Cadiz Project well-field. Results of the analysis of saline water movement using the numerical groundwater model (GSSI, 2011; ESA, 2012b, p. 52) indicate that migration of the saline-fresh water interface induced by the proposed pumping at the Cadiz Project ranges from 6,300 to 10,400 feet, depending on the recharge value used in the numerical groundwater model.

The GMMMP (ESA, 2012b) proposes the installation of nine cluster wells to monitor saline groundwater conditions and/or the potential migration of the saline–fresh water interface (see **Figure 10**) (ESA, 2012b). As noted above (**Section 5.4**), cluster wells will be installed in the middle of Bristol and Cadiz dry lakes. Two cluster wells will be installed between Bristol Dry Lake and the current location of the saline fresh water interface. Three cluster wells will be installed between the current location of the interface and the Cadiz Project well-field. One well will be installed at the interface to the north of Cadiz Dry Lake, and the final cluster will be installed between Cadiz Dry Lake and the Cadiz Project well-field, just north of the interface.

As per Page 68 of the GMMMP (ESA, 2012b), "*These new well clusters are set forth in Features 3, 8 and 9 and are depicted in Figures 5-1 and 5-2 as Proposed Induced Flow and Brine Migration Cluster Wells*." Unfortunately, the "features" are not numbered on Figures 5-1 or 5-2.

The installation of cluster wells proposed in the GMMMP is an appropriate approach to monitoring a saline–fresh water interface. Such wells have been used in other areas experiencing saline intrusion (e.g., West Basin of Los Angeles County, Orange County Groundwater Basin, Seaside Basin). However, the saline–fresh water interface will not migrate in a uniform regular fashion, either spatially or at depth. The migration will occur along areas of preferentially higher hydraulic conductivity, either spatially or vertically. That is, once the interface begins to migrate, it may do so in an irregular pattern of "saline fingers" as opposed to a uniform "saline front". These fingers will also vary with depth. Such irregular migration may not be detected by just four well clusters (three at Bristol Dry Lake and one at Cadiz Dry Lake).

Given the above, it is recommended that the location of the saline-fresh water interface be mapped spatially and at depth using geophysical techniques prior to the proposed pumping at the Cadiz Project. Given the relative homogeneity of the alluvial deposits and known groundwater depth, EM techniques will be effective at mapping the mineralization of groundwater (i.e., TDS content). Different EM tools can be used to spatially map groundwater mineralization at various depths. ERT can also be used to map vertical profiles of groundwater mineralization along cross-section lines. The outputs from the spatial EM mapping and ERT can be combined to create a three-dimensional visualization of the saline-fresh water interface. The results of this geophysical mapping can be used to locate the proposed cluster wells, and select the screened depths at each cluster. It is further recommended that the geophysical mapping be repeated every five years after the proposed pumping at the Cadiz Project is initiated. This will allow the migration of the saline-fresh water interface to be mapped in three-dimensions over time. An understanding of the migration of the saline-fresh water interface will allow any potential mitigation actions to be optimized (e.g., recharge of fresh water in areas and depths of preferential migration).

5.6 Potential Subsidence

In the current GMMMP (ESA, 2012b; Section 6.3, and Table 6-1), the proposed land surface monitoring consists of ground-level surveys, InSAR imagery, extensometers, and reviewing this information at various frequencies during pre-operational, operational, and post-operational periods. In the GMMMP, it is proposed that ground-level surveys be conducted on an annual basis for the pre-operational, operational and post operational periods. This methodology and frequency proposed in the GMMMP (ESA, 2012b) are appropriate.

The current GMMMP proposes to acquire InSAR imagery once during the pre-operational period, once every five years during the operational period, and twice at five-year intervals during the post operational period. InSAR is a powerful tool that cost-efficiently measures ground surface deformation throughout an area of interest. Thus, the Panel agrees with the selection of this technology in the GMMMP and recommends the following:

- The availability of historical InSAR imagery in the Project area should be investigated and, if available, acquired and processed to obtain a pre-operational assessments of land subsidence
- InSAR imagery should be acquired and processed every year during the first ten years of the operational period
- InSAR imagery should be acquired and processed every five years for years 11 through 50 of the operational period
- InSAR imagery should be acquired and processed every year for years 1 through 5 of the post-operational period
- InSAR imagery should be acquired and processed every five years thereafter during the post-operational period

In conjunction with groundwater monitoring data, InSAR analysis has the potential to indicate the presence and location of groundwater barriers. In addition, InSAR data in the early years of the proposed pumping at the Cadiz Project is especially important because most of the drawdown proximate to the Cadiz Project well-field (i.e., areas prone to land subsidence) will occur in these early years.

In the GMMMP (ESA, 2012b; Figure 5-2), it is proposed that three borehole extensometers be placed in strategic locations with the highest probability of land subsidence proximate to the Cadiz Project well-field. Borehole extensometers measure the continuous change in vertical distance between the land surface and a subsurface reference point in a borehole, where an anchor is placed. No information is provided on how the extensometers will be constructed (e.g., whether pipe, cable, rods, or how many anchor points will be constructed at each extensometer site). It is assumed that extensometers would be constructed during the pre-operational period. Deformation observations will be recorded daily during the operational period. The observational frequency is not stated for the post-operational period.

It is recommended that the expected number of anchor points at each extensometer site be defined. A general description of extensometer construction and instrumentation, and a recommended post-operational period measurement rate should also be specified. Data storage, QA/QC procedures, and the methods used to analyze data should be developed and documented prior to extensometer installation. Extensometer data can be compared to inter-ferograms of two temporally-adjacent InSAR images to provide greater confidence in the regional estimates of ground level displacements from InSAR.

It is extremely costly to install extensometers and they only provide point source data. That is, only three measurements of land subsidence would be provided for the entire project area. Therefore, it is recommended that only one extensometer be installed during the pre-operational period. The installation of the two additional extensometers could be deferred until a temporal and more spatially extensive dataset on land subsidence is available (i.e., InSAR data). If the InSAR data indicates that land subsidence is an Undesirable Result, then the additional extensometers would be installed. The InSAR data coupled with the lithologic information from new production and monitoring wells would be used to help locate these extensometers.

6.0 GMMMP CLARIFICATION REQUESTS

The GMMMP (ESA, 2012b) was developed to describe how the Cadiz Project could be operated to avoid Undesirable Results through monitoring and adaptive management. Based on current knowledge, in general, the current GMMMP presents the following:

- A thorough description of the Undesirable Results
- A rigorous and appropriate monitoring program (that can be supplemented by recommendations presented herein)
- Practical, effective, and appropriate management and mitigation actions (which, can be supplemented, if feasible, by recommendations presented herein)

The monitoring program in the GMMMP will generate new information that, over time, will improve the understanding of the hydrologic system tributary to the Cadiz Project. This new data should be considered in the development of updated, calibrated, numerical groundwater modeling efforts. The GMMMP will need to be updated periodically in light of new data, modeling, and overall improved understanding. This may result in refinements to the monitoring, management and mitigation actions over time.

After reviewing the GMMMP, the Panel has presented certain recommendations (see **Sections 4 and 7**). In addition, the Panel has specific clarification requests with respect to certain statements or sections in the GMMMP.

6.1 Chapter 1

Comment 1. Section 1.1, Page 8. "*spreading basins*". **Comment:** Spreading basins may incur evaporative losses. It should be noted if injection wells have been considered.

Comment 2. Section 1.4.1, Page 14. "*SMWD will be the public agency carrying out the Project and will also be the public agency with the greatest responsibility for supervising the Project*." **Comment**: An organizational flow chart would help the reader to understand who is responsible for operational decisions, mitigation decisions, operational oversight, and overall control of the Cadiz Project.

Comment 3. Section 1.4.4, Page 16. "FVMWC will lease all Project facilities and control and operate the Project during its entire duration". **Comment**: Section 1.4.1 says SMWD will fulfill this role.

Comment 4. Section 1.5.1, Page 18. "*Extraction in any given year may range from 25,000 to 75,000 afy to accommodate carryover, but shall not exceed more than an average of 50,000 afy measured over a 10-year period, inclusive of agricultural production by Cadiz. Project participants can carry over their annual allocations by storing their water in the basin for later* *extraction and delivery during drought or emergency conditions within the 50-year operation period'*. **Comment:** Whether the second sentence carries precedence over the first requires clarification (e.g., if in the first ten years a participant builds up some carry over, can they cause the 50,000 AFY 10 year rolling average to be exceeded in any of the subsequent 10 years?). This requires clarification.

Comment 5. Section 1.6, Page 19. "*ARZC*". **Comment:** This acronym should be spelled out as follows, Arizona and California Railroad.

Comment 6. Section 1.7, Page 20. "*Regardless of any phasing, the average annual extraction over the 50 years of Project operations will not exceed 50,000 afy from all combined Cadiz Agricultural Program and Project pumping*". **Comment: The phrase** "measured over a 10 year averaging period" should be added.

6.2 Chapter 3

Comment 7. Footnote 8 Page, 34. "*The 100-year time frame assumes no Project pumping during years 51 through 10*". **Comment:** This explanation should be placed before the table as this is the first time this concept is introduced.

Comment 8. Chapter 3 Page 35. "*allow for the carryover of native water in storage*". **Comment:** This concept needs to be better explained.

6.3 Chapter 4

Comment 9. Table 4-2. Page 42. Column 3, Row 5 in the lowest recharge scenario "*0 – 80 Drawdown at Bristol Dry Lake (feet)*". **Comment:** The noting that the least drawdown at this receptor is associated with the lowest recharge is counter-intuitive. This could only be correct if the reader understands that, to calibrate the groundwater model with the lowest recharge (Scenario 2), the hydraulic conductivities used in this model were also the lowest.

Comment 10. Figure 4-7 Page 48. The 0-foot contour in Layer 2 is closer to the Cadiz Project well-field under low recharge conditions. This is counter-intuitive, unless the reader understands that to calibrate the groundwater model with the lowest recharge (Scenario 2), the hydraulic conductivities used in this model were also the lowest (Same as comment 9).

Comment 11. Section 4.2.1.5 Page 52. "*Results of the modeling indicate that the saline-freshwater interface in the Bristol Dry Lake area would move up to 10,400 feet northeast during Years 1 to 50 under the Project Scenario, up to 9,700 feet under Sensitivity Scenario 1, and up to 6,300 feet under Sensitivity Scenario 2*." The GMMMP needs to explain why the interface does not move as far under reduced recharge conditions because this concept is counter-intuitive. The reader needs to understand that to calibrate the groundwater model with the lowest recharge (Scenario 2), the hydraulic conductivities used in this model were also the lowest (Same as comment 9).

Comment 12. Section 4.2.1.5 Page 52. *"As a precautionary measure to limit the migration of hyper-saline groundwater and protect the health of the aquifer under the County Ordinance, the saline-freshwater boundary shall be monitored and its migration limited to 6,000 ft northeast of the dry lakes through physical measures (e.g., injection or extraction wells) or pumping restrictions if physical measures prove ineffective"*. **Comment:** Pumping restrictions may be a least preferred mitigation method in terms of the rapidity and targeted nature of a required response (see **Sections 4 and 7**).

6.4 Chapter 5

Comment 13. Chapter 5 Page 63. *"A total of thirteen different types of monitoring features have been identified for assessing potential impacts to critical resources during the term of the Project, as identified in Chapter 4. A summary of these thirteen types of monitoring features, as well as monitoring frequencies and parameters to be monitored, is provided in Tables 5-1 and 5-2. Locations are shown in Figures 5-1 and 5-2."* **Comment:** The "features" are not identifiable on Figures 5-1 or 5-2, and are not labeled with identifiers. Larger copies of Figures 5-1 and 5-2 should be provided.

Comment 14. Section 5.8 Page 73. *"A typical observation well cluster completion is illustrated on Figure 5-5."* **Comment:** It would be useful to know which Formations will be targeted – hydro-stratigraphic units (HSUs) in the upper alluvial and/or carbonate formations.

6.5 Chapter 6

Comment 15. Page 77. Section 6. Review of Monitoring and Mitigation of Significant Adverse Impacts to Critical Resources (Action Criteria, Decision-Making Process and Corrective Measures). The first paragraph of this section of the GMMMP contains a concise description of the process to identify the need for corrective action. It states:

> *"This Management Plan identifies specific quantitative criteria or trends (action criteria) that will "trigger" review and corrective actions where necessary to protect critical resources or otherwise avoid Undesirable Results. When action criterion are triggered, a review of the triggering event will be conducted to determine whether the event is attributable to or exacerbated by Project operations, and if so, which specific corrective measures should be implemented to avoid adverse impacts to critical resources or Undesirable Results. It is the intent of this Management Plan to identify deviations from baseline conditions, along with deviations from groundwater model Projections, at monitoring features as early as possible in order to identify and prevent the occurrence of adverse impacts to critical resources or Undesirable Results as a result of Project*

> *operations. Triggering events may, in some circumstances, necessitate immediate corrective actions and subsequent review to ensure that the triggering event resulted from Project operations."*

The decision-making process contained in the GMMMP describes the process to be followed in the event an action criterion is triggered, as well as changes to the GMMMP. The second sentence in the first full paragraph is presumptive and states:

> *"FVMWC may propose refinements to the action criteria and monitoring network after additional data has been accumulated which indicates that the monitoring is unnecessary."*

We recommend that the text be rewritten to state:

"FVMWC may propose refinements to the action criteria and monitoring network after additional data has been accumulated and thoroughly reviewed."

The decision process is described as follows:

- Initial notification – FVMWC will provide written notice of a triggering event with 10 days of its occurrence. To accomplish this within ten days assumes that the FVMWC can promptly review and assess the monitoring data, make technical findings, and issue notices. We recommend that the FVMWC refine this part of the process description to describe its internal review practices that will enable it to meet the ten-day notice requirement.

- Initial assessment and notification – Within 60 calendar days of issuing notice that an action criterion is triggered. The GMMMP states:

  "FVMWC will undertake a three-step assessment process. First, FVMWC will assess whether the triggering of any action criterion is attributable to Project operations. Second, for any triggering of an action criterion attributable to Project operations, FVMWC will assess whether the triggering of the action criterion constitutes a potential adverse impact. Third, for any triggering of an action criterion that is attributable to the Project and constitutes a potential adverse impact, FVMWC will assess, recommend, and implement corrective measure(s) (including refinements in monitoring or to this Management Plan) necessary to avoid or mitigate the potential adverse impact or Undesirable Result.

  FVMWC shall provide its written assessment and recommendation, along with supporting data, to SMWD, the County Representative, and the members of TRP within the sixty (60) day assessment period."

The 60-day period may not be long enough to determine attribution, the material significance of the triggering response, and to subsequently and thoughtfully "*assess, recommend, and*

implement corrective measure(s) (including refinements in monitoring or to this Management Plan) necessary to avoid or mitigate the potential adverse impact or Undesirable Result."
Comment: We recommend that the FVMWC refine this part of the process description to describe its internal review practices that will enable it to meet the 60-day reporting requirement, or extend the reporting requirement timeframe.

Comment 16. Technical Review Panel (TRP) Review and Recommendation – Within 90 days of receiving FVMWC written assessment. The GMMMP states:

> *"Upon receiving FVMWC's written assessment and recommendation, the TRP will have ninety (90) calendar days to determine whether it concurs with the assessment and recommendation (including but not limited to modifications to the monitoring network, corrective actions, etc.). During the TRP review period, the TRP may request additional data and analysis from FVMWC and will have access to all monitoring data. Within the ninety (90)-day TRP review period, the TRP will issue a written report of its review of FVMWC's assessment and recommendation, including whether it concurs with the assessment and recommendation, to the County Representative, FVMWC, and SMWD, and if it does not concur, the basis of its disagreement and any alternative recommended actions. The TRP's written report shall state whether or not the report reflects a consensus of the TRP members. If the TRP members cannot reach a consensus, the members' differing opinions and recommendations shall be set forth in the written report.'*

The proposed scope and schedule of the TRP effort is conditioned on the thoroughness and technical backup of the FVMWC assessment report. The cumulative review time, assuming the FVMWC and TRP stay within the time frames allocated in the GMMMP, could run up to 150 days or five months. This may be too long to determine a response to an Undesirable Result.

- County and SMWD Review and Documentation – no time schedule to complete. **Comment:** The decision-making process is adequate although the time frame is indefinite.

Comment 17. Page 86. There is an apparent inconsistency among the text on page 86 and Table 5-1: the text states that the groundwater levels *"will be monitored on a continuous basis throughout the operational and post-operational terms of the Project*." Table 5-1 states that groundwater levels will be monitored continuously during the pre-operational and operational periods, and perhaps continuously during the post-operational period. **Comment:** This apparent inconsistency should be cleared up. The Panel recommends that the observation well clusters be constructed, and monitoring initiated, in advance of the proposed pumping at the Cadiz Project . The relationship between groundwater levels at the observation well clusters and the mineral strip-mining operator wells and brine supply trenches should be determined prior to Cadiz Project startup.

Comment 18. Section 6.4.1 Page 87. *"Of the monitoring well network, SCE Well no. 5 and SCE Well no. 11, along with other newly installed well clusters located between the interface and the Project well-field will be located such that that they are appropriate to serve as "sentinel" wells to determine whether there is a progressive migration of the saline-freshwater interface."* **Comment:** It would be useful to know the well cluster locations beforehand and whether groundwater level drawdown is expected at these locations. This should ensure that there is sufficient time for mitigation to be in place before any adverse impact occurs should drawdown be greater than expected.

Comment 19. Section 6.4.3 Page 87. *"If the action criterion is triggered, the decision-making process will include: Assessment of whether the increased TDS concentration or migration of the saline-freshwater interface is attributable to Project operations*;". **Comment.** An additional, first bullet might be to increase monitoring frequency to determine any rate of change.

Comment 20. Section 6.4.4 Page 88. "*Installing one or more extraction well(s) or injection well(s) at the northeastern edge of Bristol Playa and/or north of Cadiz Playa where the salt mining source wells are located to maintain the saline freshwater interface within its 6,000-foot limit <u>subject to the same mitigation measures imposed on the Project well-field as set forth in the SMWD Mitigation Monitoring and Reporting Program (see Figures 5-1 and 5-2)</u>'"* **Comment:** Clarification is required as to why certain text was underlined and what the underlined text means.

Comment 21. Management of the groundwater floor. This feature of the GMMMP is described as follows:

> *"The Project may drawdown the aquifer in the center of the Project well-field area to a maximum drawdown level (the "floor") of elevation 530 feet (80 feet below baseline elevations). The floor will be calculated as an average groundwater elevation over a 2-mile radius from the center of the Project well-field area. Once the floor is reached, and absent approval of a new floor by the County, pumping must be reduced to a quantity at or below the amount that will maintain water levels at or above the 80-foot floor."*

This groundwater floor management scheme includes an adaptive management component to drop the floor from 80 to 100 feet provided that the change is supported by sufficient operational data, the change will increase conservation, and the change will not cause undesirable results. The action criterion proposed for the management of the groundwater floor is stated in the GMMMP as follows.

> *"The decision-making process will be initiated if the action criteria are triggered. The action criteria are trends in groundwater levels that demonstrate that the*

> *designated floor elevation will be exceeded within 10 years. If such changes are measured, the decision-making process will be initiated."*

Comment: The last sentence of the action criterion cited above should be clarified. We understand it to mean that if such trends in groundwater levels occur, the decision-making process will be initiated. Our monitoring recommendations should serve to address all remaining doubt and that the adaptive management plan will result in reasonable decision-making and mitigation approaches.

Comment 22. Section 6.5.3, Page 90. "*Installing one or more brine extraction well(s) and/or injection well(s) where the salt mining source wells are located <u>subject to the same mitigation measures imposed on the Project well-field as set forth in the SMWD Mitigation Monitoring and Reporting Program (see Figure 5-1)</u>.'*" **Comment:** Clarification is required as to why certain text was underlined and what the underlined text means.

6.6 Chapter 7

Comment 23. Section 7.2, Page 100. "*To ensure that the Closure Plan can be fully implemented, FVMWC will establish and maintain an escrow account or other equivalent financial assurances mechanism for post-closure operations*." **Comment:** When will the escrow account be set up - before 5 - 15 years of operation, before operation? Clarification on the timeframe is required.

Comment 24. Table 5-1 Page 112. Final row, 10th column "Bristol and Cadiz dry lakes" "Semi-annually". **Comment:** Depending on how far sentinel wells are from 6,000-foot perimeter, this frequency may be insufficient to be able to react to rapid changes in drawdown (see Recommendations in **Section 7**).

7.0 RECOMMENDATIONS

The monitoring, management, and mitigation approach proposed in the GMMMP (ESA, 2012b) is appropriate, as was previously determined by the Groundwater Stewardship Committee (2011). Such a determination was made prior to the imposition of the County's oversight and additional conditions imposed on the Cadiz Project. These conditions, among others, included the 80-foot floor on groundwater elevations two miles from the center of the Cadiz Project well-field, and the ability to modify or curtail pumping if the proposed pumping at the Cadiz Project causes an Undesirable Result.

After careful review and consideration of the FEIR, GMMMP, and more recent technical reports, this Panel has recommended a number of complementary additions that could be made to the GMMMP, if feasible (ESA, 2012b). Collectively these recommendations are intended to allay any concerns that opponents to the Cadiz Project may still have, improve public confidence in the Cadiz Project, and are provided in an abundance of caution.

The recommendations are not intended to alter the analysis or findings regarding the environmental impacts of the Cadiz Project described in the FEIR (ESA, 2012a), or contain any significant new information. In addition, none of the recommendations are associated with a failure of the GMMMP to provide sufficient management, monitoring, and mitigation of Undesirable Results. However, the Panel strongly believes that the recommendations provide helpful direction in the ongoing monitoring, mitigation and management of the Cadiz Project. The recommended supplemental monitoring will produce additional information to assist with the following:

- Identifying and quantifying any Undesirable Results
- Further assessing the degree of hydraulic connection, if any, between Bonanza Spring and the alluvial aquifer in Fenner Valley below
- Monitoring brine water conditions beneath Bristol and Cadiz dry lakes
- Mapping the migration of the saline-fresh water interface over time
- Identifying changes in vegetation in riparian habitats below springs
- Evaluating the cause of any impacts (e.g., the proposed pumping at the Cadiz Project, climatic conditions, other factors)
- Determining the type, nature, magnitude, and duration of Corrective Measures that could be implemented
- Assessing the effects of any implemented mitigation

7.1 Detailed Monitoring Plan

It is recommended that, at least one year prior to the commencement of the proposed pumping at the Cadiz Project, a more detail monitoring plan be prepared to document all aspects of data collection related to the Cadiz Project. The plan should also address data management, analyses, and interpretation. If a dispute arises over Undesirable Results, it is critical that data collection, management, analyses, and interpretation have been conducted in general accordance with a detailed monitoring plan. The plan should cover the pre-operational, operational, and post-operational periods. The plan should be a “living document” and should be updated periodically (e.g., every five years) as data collection and analysis techniques improve, and data requirements for the Cadiz Project change.

7.2 Quality Assurance

It is recommended that, at least one year prior to the commencement of the proposed pumping at the Cadiz Project, more detailed QA/QC procedures be developed, described, implemented, and documented for the collection and analysis of all data pertinent to the Cadiz Project. A detailed QAPP should be prepared to describe the QA/QC procedures for the collection and analysis of all data pertinent to the Cadiz Project.

7.3 Data Management System

It is recommended that, at least one year prior to the commencement of the proposed pumping at the Cadiz Project, a formal data management system (DMS) be developed for the Cadiz Project. The DMS should contain all data collected as part of the Cadiz Project. The data should be categorized by type, location, and date, as well as other data-pertinent fields. While a project-specific DMS can be developed, it is recommended that off-the-self software be used as the platform for the DMS for the Cadiz Project. The DMS should have a graphical user interface (GUI) that operates within a geographic information system (GIS) platform (e.g., ArcGIS). This will facilitate data input, data mapping, and data interpretation (e.g., by SpatialAnalyst).

7.4 Document Repository

The Cadiz Project will be implemented in an area with a very limited human population. However, some opponents to the Cadiz Project continue to distrust the conclusions reached in the FEIR, the County’s adoption of the GMMMP, and the Court’s review of the Cadiz Project. It is important that stakeholders have access to all documents pertinent to the Cadiz Project, regardless of whether they support or oppose the project. Therefore, it is recommended that an online repository be developed to host all technical reports as they are finalized and delivered to the County as required by the GMMMP.

7.5 Geological Understanding

It is recommended that, within one year of the commencement of the proposed pumping at the Cadiz Project, geophysical surveys be completed in two areas to assist in assessing geologic conditions (areas 1 and 2 on **Figure 13**):

- At Bonanza Spring
- In the Fenner Gap

To provide additional information on the geologic structure and hydrogeology in the vicinity of Bonanza Spring, it is recommended that geophysical mapping be conducted in the area immediately above, and for some distance below, the spring. The objectives of the geophysical surveys would be to delineate structural features (i.e., faults) and other structural deformation, identify potential fracture lineaments with increased facture aperture and density (i.e., groundwater bearing potential), map the bedrock surface below the unconsolidated deposits south of the spring, and map the groundwater surface above and below the spring. A geophysical contractor should be retained to plan and implement the geophysical mapping. The mapping may include shallow seismic surveys, surface EM, TDEM, and ERT.

To provide additional information on the geologic structure and hydrogeology in the Fenner Gap, it is recommended that geophysical mapping be conducted in this area. The objectives of the geophysical survey would be to delineate structural features (i.e., faults) and other structural deformation, identify the location and thickness of carbonate formations, identify potential karstic features (e.g., caves) and fracture lineaments with increased facture aperture and density (i.e., groundwater bearing potential) in the carbonates, and map the groundwater surface. A geophysical contractor should be retained to plan and implement the geophysical mapping. The mapping may include shallow seismic surveys, TDEM, and ERT.

Whatever geophysical techniques are recommended by the contractor, it is important to have control points to help interpret the geophysical data. Borehole logs and down-hole geophysical logs (i.e., eLogs) for existing wells will provide this control. If wells proximate to the geophysical surveys do not have geophysical logs but have poly-vinyl chloride (PVC) casing, then they can be logged using EM, natural gamma, temperature, and EC down-hole tools. If these wells have steel casing, then down-hole logging will be limited to gamma, temperature, and EC. The existing geological mapping (Kenney and TLF, 2018) will also provide some control for the geophysical survey at Bonanza Spring.

To provide additional data on hydrogeologic conditions proximate to Bonanza Spring, it is recommended that the geophysical survey be conducted within one year of the commencement of pumping at the Cadiz Project.

As noted, the recommended geophysical surveys, like other recommendations presented herein (e.g., spring flow monitoring, new monitoring wells), are located on Federal lands. Thus, it may be difficult to obtain approvals from government agencies to install the wells. Given the value of such monitoring, it is hoped that such approvals will be forthcoming.

7.6 Hydrogeologic Understanding

To provide additional information on hydrogeologic conditions between Bonanza Spring and the alluvial aquifer in the Fenner Valley below, it is recommended that the following additional monitoring wells be installed (see **Figure 13**):

- Immediately below the spring (i.e., within 100 yards) with casings discretely screened in unconsolidated deposits beneath and adjacent to the stream fed by the spring, if they contain groundwater, and in the fractured bedrock beneath these deposits
- At the limits of the alluvial aquifer (e.g., one mile southeast of Bonanza Spring)

The first set of monitoring wells in the unconsolidated deposits and fractured bedrock below Bonanza Spring would provide data that could not be obtained from any currently existing monitoring wells. Therefore, this set of wells is the most important additional monitoring wells needed to evaluate groundwater conditions in relation to potential Undesirable Results at Bonanza Spring. In addition, in the unlikely event that a direct hydraulic connection between Bonanza Spring and the alluvial aquifer exists, groundwater declines at these new wells may provide an "early warning" of potential Undesirable Results at Bonanza Spring.

To provide baseline data on groundwater conditions proximate to Bonanza Spring, it is recommended that, if feasible, the new monitoring wells be installed at least one year prior to the initiation of pumping at the Cadiz Project.

7.7 Weather Conditions

It is recommended that a weather station, or at least a rain gauge, be installed in the bedrock watershed that supports flow at Bonanza Spring. This will assist in evaluating the relationship between precipitation, recharge, and spring flow. To provide baseline data on precipitation and its impact on flows at Bonanza Spring, if feasible, it is recommended that the weather station be installed as soon as possible.

7.8 Spring Monitoring

The potential for Undesirable Results to springs, notably Bonanza Spring, appears to be the most contentious issue related to the Cadiz Project. The GMMMP provides for quarterly monitoring of flow at the Bonanza, Whiskey and Vontrigger springs during the pre-operational and operations periods, and annually post-operations. The proposed monitoring of the Bonanza Spring and other springs is important to evaluate the effect of regional climatic trends. However, given the smaller scale of the bedrock watershed that supports Bonanza Spring (Kenney and TLF, 2018), the responses at these springs to individual hydrologic events (e.g., precipitation) are generally observed over time frames much shorter than three months. These short-term responses are also valuable in assessing responses to longer-term hydrologic events (e.g., seasonal precipitation, climatic changes, sustained pumping), and the impact these can have on future spring flows.

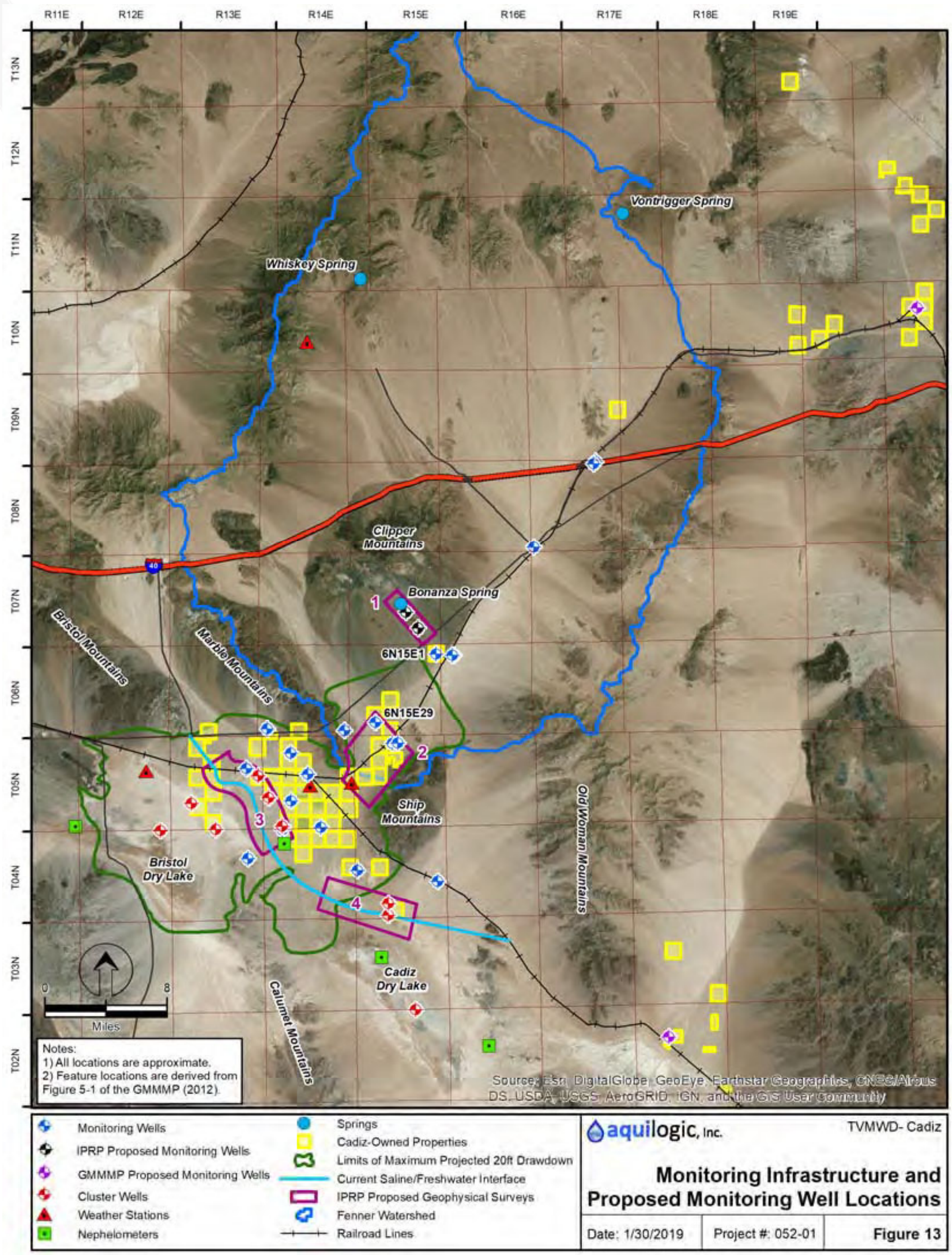

Figure 13: Potential Geophysical Survey Areas

It is recommended that more frequent monitoring be conducted at the Bonanza, Whiskey, and Vontrigger springs to obtain a baseline. This should include transducers and a data-logger to monitor ponded water depth at frequent intervals. A multi-parameter probe could be used to monitor depth/flow, EC, and temperature at the same frequency. Alternatively, EC and temperature could be manually monitored on a monthly basis for at least one year prior to the proposed pumping at the Cadiz Project, and during the first year of project operations. After that, manual monitoring could be conducted quarterly. Data-loggers would be downloaded during manual monitoring events. Other parameters, such as pH, water coloration, and observations of riparian vegetation, could be conducted quarterly. In addition, it is recommended that the exact geographic location and elevation of the spring emergence be mapped using a GPS annually or after a change in location is observed during other monitoring activities.

Prior to any monitoring of spring flows, including manual monitoring, a correlation between ponded water depth and flow will need to be developed. This is normally done for a location immediately downstream of the spring where the stream profile is defined and constrained (e.g., where it crosses bedrock) or where the profile can be artificially constrained (e.g., construction of a v-notch weir). A location with a naturally confined profile should be identified. Ponded water depth and flow measurements should be taken at that location on several occasions during different flow conditions (e.g., low-flow, regular flow, storm-flow) to develop the correlation. The transducer or multi-probe would then be installed at that location.

To provide baseline data on spring flow conditions at springs, if feasible, it is recommended that the transducers be installed at least one year prior to the initiation of pumping at the Cadiz Project.

It is important that, if consent to conduct the monitoring can be secured, at least one year of high-frequency data on spring conditions be obtained prior to the proposed pumping at the Cadiz Project. In particular, this monitoring will provide a baseline for Bonanza Spring that can compared to data collected after the pumping at the Cadiz Project is initiated. This baseline comparison will supplement and/or complement the comparison of data for Bonanza Spring to the time-contemporaneous data collected at the Whiskey and Vontrigger springs. That is, how does any change in conditions at Bonanza Spring compare to other springs, based on time-contemporaneous data, and how does it compare to conditions at Bonanza Spring prior to the proposed pumping at the Cadiz Project. Such comparisons will assist in evaluating whether any change at Bonanza Spring is the result of the proposed pumping at the Cadiz Project, climatic variability, and/or other factors.

7.9 Vegetation Monitoring

The exact scientific method as to how the "general type and extent of adjacent vegetation" will be monitored at the springs and elsewhere in the watersheds was not described in the GMMMP. It is recommended that a terrestrial ecologist be retained to develop a scientifically appropriate, standardized methodology to monitor vegetation below the springs. This might include defined transects across the stream below the springs, and identification and quantification of species at points along the transects over time. Such a standardized methodology will allow changes in vegetation to be tracked over time.

To provide baseline data on vegetation conditions within the watersheds tributary to the Cadiz Project, it is recommended that vegetation mapping be initiated at least one year prior to the initiation of pumping at the Cadiz Project.

7.10 Groundwater Monitoring

The GMMMP includes groundwater monitoring requirements, such as monitoring locations, monitoring type, monitoring frequency, monitoring parameters. The locations of monitoring points are presented in **Figure 10** (an excerpt from Figure 5-1: Monitoring Features of the GMMMP [ESA, 2012b]). It is proposed in Appendix B of the GMMMP (ESA, 2012b) that groundwater level measurements be taken at various frequencies depending on well and operating period. In the pre-operational period, transducers will be used to collect high frequency groundwater level measurements at six existing monitoring wells (5N14E5F1, 6N15E01H, 6N15E29P1, 4N14E13J1, 5N14E24D2, 5N14E16H1); whereas, groundwater levels at the other ten wells will be measured manually on a monthly basis. In the GMMMP, it is proposed that groundwater level measurements be taken semi-annually during the operation period and annually during the post-operational period. During the pre-operational period, groundwater quality samples will be collected quarterly at five monitoring wells and annually at nine wells. During the operational and post-operational periods, groundwater samples will be sampled annually at the five wells previously sampled quarterly.

In general, the number and location of wells used to monitor regional groundwater conditions appear adequate. However, the Panel recommends that, in some cases, the frequency of groundwater monitoring be modified slightly. When the Cadiz Project begins operation, the hydrologic system will be subject to annual pumping higher than previously seen. This pumping will be maintained for up to 50 years.

The groundwater monitoring program proposed in the GMMMP (ESA, 2012b) will establish baseline conditions immediately prior to the proposed pumping at the Cadiz Project. However, to better evaluate the hydrologic response to the pumping of 50,000 AFY during the first few years of operation, monitoring groundwater levels at a higher frequency is recommended to provide an improved understanding of baseline conditions. Higher frequency monitoring when pumping is initiated at the Cadiz Project will also allow the response of the hydrologic system to increased pumping to be evaluated, including information on hydrogeologic structure within the watersheds, an improved understanding of hydraulic parameters (e.g., hydraulic conductivity and storativity), and identification of possible data gaps that may need to be filled. In addition, the increased monitoring frequency will assist in the assessment of potential Undesirable Results from the proposed pumping at the Cadiz Project. In doing so, it will also allow pumping operations to be optimized (e.g., well cycling, pumping rates) to maintain production while preventing Undesirable Results. Therefore, it is recommended that the following groundwater monitoring and sampling program be initiated at least one year prior to the commencement of pumping at the Cadiz Project:

- Pre-operational – transducers be placed in all 16 monitoring wells, plus the proposed monitoring wells adjacent to Bonanza Spring and brine migration cluster wells, to collect groundwater level readings on an hourly basis, and the data-loggers downloaded quarterly.
- The groundwater quality sampling program proposed in the GMMMP (ESA, 2012b) is acceptable. The new monitoring wells proximate to Bonanza Spring proposed herein and any new brine migration cluster wells should be sampled quarterly.
- First year of operation – the pre-operational monitoring and sampling program recommended above should be maintained.
- Years 2-5 of operation – transducers should be maintained in the monitoring wells, and the data-loggers downloaded annually. Groundwater quality samples should be collected at all monitoring wells, including any newly installed monitoring wells, annually.
- Years 6-50 of operation – the groundwater monitoring and sampling program proposed in the GMMMP (ESA, 2012b) is acceptable. For any newly installed monitoring wells, groundwater levels should be monitored semi-annually and sampled annually for groundwater quality analyses. It should be noted that, under the adaptive management approach in the GMMMP, analysis of the data collected may require that the proposed monitoring program be modified for these later year of operation and the post-operational period.
- First post-operations year – the pre-operational monitoring and sampling program recommended above should be implemented during this period of rapid groundwater recovery.
- Years 2-5 post-operations – the monitoring and sampling program implemented in years 2-5 of operations should be implemented during this period of rapid groundwater recovery.
- Subsequent post-operations years - the groundwater monitoring and sampling program proposed in the GMMMP (ESA, 2012b) is acceptable.

To provide baseline data on groundwater conditions throughout the watersheds tributary to the Cadiz Project, it is recommended that the updated monitoring program be initiated at least one year prior to the initiation of pumping at the Cadiz Project.

7.11 Third-Party Wells in Fenner Valley

No potable third party wells have been identified in the Cadiz Project area. However, it is recommended that transducers be installed during the pre-operational period in any third-party non-potable well that could be materially impacted by the proposed pumping at the Cadiz Project (i.e., third-party wells closest to the Cadiz project well-field). The transducers should be maintained in these third-party wells during the first five years of pumping at the Cadiz Project. After this initial operating period, groundwater levels should be measured quarterly at third-party wells during the remainder of the operations period, and annually in the post-operational period. Field water quality parameters should also be monitored at third-party wells on an annual basis during the pre-operational period, operational period, and for five years during the post-operational period.

This data will establish baseline groundwater conditions at the third-party wells, and allow for groundwater level and quality changes to be monitored during the proposed pumping at the Cadiz Project. Higher frequency data will assist in determining whether any observed impact results from the proposed pumping at the Cadiz Project, or other factors such as climatic variability.

To provide baseline data on groundwater conditions at third-party wells, it is recommended that the transducers be installed at least one year prior to the initiation of pumping at the Cadiz Project. It is recognized that consent of the third party is required and this is implicit in the recommendation.

7.12 Saline Migration

There is currently an established transitional interface between saline groundwater in the vicinity of Bristol and Cadiz dry lakes and freshwater moving towards the dry lakes from the Fenner Valley and other up-stream watersheds. The proposed pumping at the Cadiz Project will cause the saline-fresh water interface to migrate away from the dry lakes towards the Cadiz Project well-field. Results of the analysis of saline water movement using the numerical groundwater model (GSSI, 2011; ESA, 2012b) indicate that migration of the saline-fresh water interface induced by the proposed pumping at the Cadiz Project ranges from 6,300 to 10,400 feet.

The GMMMP (ESA, 2012b) proposes the installation of nine cluster wells to monitor saline groundwater conditions and/or the potential migration of the saline–fresh water interface (see **Figure 10**) (ESA, 2012b). The installation of cluster wells proposed in the GMMMP is an appropriate approach to monitoring a saline–fresh water interface. Such wells have been used in other areas experiencing saline intrusion. However, the saline–fresh water interface will not migrate in a uniform regular fashion, either spatially or at depth. The migration will occur along areas of preferentially higher hydraulic conductivity, either spatially or vertically. That is, once the interface begins to migrate, it may do so in an irregular pattern of "saline fingers" as opposed to a uniform "saline front". These fingers will also vary with depth. Such irregular migration may not be detected by just four well clusters (three at Bristol Dry Lake and one at Cadiz Dry Lake).

Given the above, it is recommended that the location of the interface be mapped spatially and at depth using geophysical techniques (areas 3 and 4 on **Figure 13**) prior to the commencement of pumping at the Cadiz Project. Given the relative homogeneity of the alluvial deposits and known groundwater depth, EM techniques will be effective at mapping the mineralization of groundwater (i.e., TDS content). Different EM tools can be used to spatially map groundwater mineralization at various depths. ERT can also be used to map vertical profiles of groundwater mineralization along cross-section lines. The outputs from the spatial EM mapping and ERT can be combined to create a three-dimensional visualization of the saline-fresh water interface. The results of this geophysical mapping can be used to locate the proposed cluster wells, and select the screened depths at each cluster. It is further recommended that the geophysical mapping be repeated every five years after the proposed pumping at the Cadiz Project is initiated. This will allow the migration of the saline-fresh water interface to be mapped in three-dimensions over time. An understanding of the migration of the saline-fresh water interface will allow any potential mitigation actions to be optimized (e.g., recharge of fresh water in areas and depths of preferential migration).

7.13 Subsidence

In the current GMMMP (ESA, 2012b; Section 6.3 and Table 6-1), the proposed land surface monitoring consists of ground-level surveys, InSAR imagery, extensometers, and reviewing this information at various frequencies during pre-operational, operational, and post-operational periods.

The current GMMMP proposes to acquire InSAR imagery once during the pre-operational period, once every five years during the operational period, and twice at five-year intervals during the post operational period. InSAR is a powerful tool that cost-efficiently measures ground surface deformation throughout an area of interest. Therefore, the Panel recommends the following:

- The availability of historical InSAR imagery in the Project area should be investigated and, if available, acquired and processed to obtain a pre-operational assessments of land subsidence

- InSAR imagery should be acquired and processed every year during the first ten years of the operational period
- InSAR imagery should be acquired and processed every five years for years 11 through 50 of the operational period
- InSAR imagery should be acquired and processed every year for years 1 through 5 of the post-operational period
- InSAR imagery should be acquired and processed every five years thereafter during the post-operational period

In the GMMMP (ESA, 2012b), it is proposed that three extensometers be placed in strategic locations with the highest probability of land subsidence proximate to the Cadiz Project well-field (ESA, 2012b). No information is provided on how the extensometers will be constructed (e.g., whether pipe, cable, rods, or how many anchor points will be constructed at each extensometer site). It is recommended that the expected number of anchor points at each extensometer site be defined. A general description of extensometer construction and instrumentation, and a recommended post-operational period measurement rate should also be specified.

It is extremely costly to install extensometers and they only provide point source data. That is, only three measurements of land subsidence would be provided for the entire project area. Therefore, it is recommended that only one extensometer be installed during the pre-operational period. The installation of the two additional extensometers could be deferred until a temporal and more spatially extensive dataset on land subsidence is available (i.e., InSAR data). If the InSAR data indicates that land subsidence is an Undesirable Result, then the additional extensometers would be installed. The InSAR data and lithologic data collected at new production and monitoring wells would be used to help locate these extensometers.

7.14 Groundwater Modeling

Numerical groundwater flow models have already been developed for the Cadiz project (GSSI, 2011; CH2M.Hill, 2011). These numerical models present a reasonable representation of groundwater conditions for most areas of the watersheds tributary to the Cadiz project; however, they were based on a limited data-set and include significant assumptions and hydrogeologic judgement.

In the GMMMP (ESA, 2012b), Annual Monitoring Reports will be prepared and these reports will contain “Updated groundwater flow, transport and variable density model results.” However, it is unclear when, how often, and how these updates will be accomplished. The existing numerical groundwater modeling was a key tool used to evaluate potential Undesirable Results in the GMMMP (ESA, 2012b). It is also anticipated that the Decision-Making Process outlined in the GMMMP (ESA, 2012b) will use any updated numerical modeling to perform ongoing evaluations of Undesirable Results, as well as design and assess the effects of any possible mitigation actions. Therefore, it would be reasonable to better define the scope of model updates.

The Panel recommends that numerical groundwater modeling be updated as follows:

- At least one year prior to the commencement of pumping at the Cadiz Project, an initial update to incorporate recent data and other recommendations by the Panel
- Once new water supply wells have been drilled, installed and tested at the Cadiz Project well-field, an update to incorporate recent data, and a recalibration of the model
- After one year of pumping at the Cadiz Project, an update to incorporate recent data, and a recalibration of the model
- An update to incorporate recent data, and a recalibration of the model, after five years of pumping at the Cadiz Project (this would include data collected on overall groundwater response to pumping, observations of spring flows, brine water conditions beneath the dry lakes, saline-fresh water interface migration, and land subsidence)
- Updates to incorporate recent data every five years thereafter during the operational period

It is recommended that the initial update include the following:

- An expansion of the model domain to include all of Cadiz Dry Lake - this will allow more detailed analysis of the possible Undesirable Results at Cadiz Dry Lake, and will eliminate concerns about drawdown intercepting a current boundary condition at Cadiz Dry Lake
- An expansion of the model domain to include the Clipper Mountains as active cells - this will allow for further analysis of flows at Bonanza Spring
- Update the water budget in consideration of data collected since the prior update.

After this initial update, the numerical groundwater modeling can then be used to further evaluate potential Undesirable Results that may be caused by the proposed pumping at the Cadiz Project. The modeling should also be used to assess the effectiveness of the mitigation actions proposed in the GMMMP (ESA, 2012b). In particular, simulations should examine whether a trigger threshold should be adjusted to account for the time lag between an action and the response at a monitoring point being used to assess Undesirable Results. In addition, the modeling should be used to assess alternative mitigation measures suggested in this report.

It is recommended that the first model recalibration include the following:

- Update the hydraulic property values (i.e., hydraulic conductivity and storativity) based on the aquifer tests and specific capacity tests conducted at the new water supply wells at the Cadiz Project well-field

- Update the discretization of hydraulic properties based on other new hydrogeologic information (e.g., new monitoring well data, geophysical surveys, down-hole geophysical logging, etc.)
- Update the project recharge and discharge terms, and update the recharge sensitivity analysis, based on data collected since the FEIR (ESA, 2012a) was completed
- Use land surveys, geophysical surveys, inter-ferograms created from InSAR imagery, and water quality data to identify groundwater barriers and, if present, incorporate them into the model domain.
- Use the geophysical surveys at the saline-fresh water interface to adjust the TDS baseline condition in the model
- Develop time-series groundwater level hydrographs, land surface deformation graphs, and water quality chemographs to facilitate the calibration
- Recalibrate the model to match the time series data for groundwater levels, land subsidence, and water quality

It is recommended that subsequent updates include data collected since the prior update, and subsequent recalibration follow the steps above in consideration of new data collected prior to the last calibration.

7.15 Mitigation Actions

The County of San Bernardino imposed a requirement under the GMMMP that limited the aquifer drawdown to 80 feet within two miles of the center of the Cadiz Project well-field in the first 15 years of operation and 100 feet over the life of the Project. The most common Corrective Measure in the GMMMP (ESA, 2012b) to prevent or alleviate Undesirable Results is to reduce or modify pumping at the Cadiz Project well-field (e.g., well cycling, individual pump rate adjustments). Such an action, as a stand-alone Corrective Measure, will likely be effective in the long-term; however, it may not alleviate certain impacts in a reasonable timeframe due to the response lag in the hydrologic system (e.g., groundwater levels would continue to decline at locations distant from the well-field for decades after pumping ceased). Therefore, the GMMMP included some Corrective Measures for specific Critical Resources. The following resource-specific measures would either prevent ongoing impact or alleviate impact in a reasonable time frame:

- Bonanza Spring – the installation of a possible horizontal well immediately above Bonanza Spring, as provided in the FEIR (ESA, 2012a)
- Brine Resources – the installation of deeper brine recovery wells at the dry lakes to maintain mineral strip-mining operations, as proposed in the GMMMP (ESA, 2012b)
- Saline Intrusion – the extraction of brackish groundwater or injection of fresh water along the saline-fresh water interface, as proposed in the GMMMP (ESA, 2012b)

More details regarding these resource-specific measures needs to be developed. In addition, additional evaluation of these potential resource-specific measures is recommended, including analysis using an updated numerical groundwater flow model.

In addition to these resource-specific measures, it is recommended that the following additional Corrective Measures be evaluated:

- Bonanza Spring – The injection of water at the edge of the alluvial aquifer in Fenner Valley below Bonanza Spring to "cut-off" the propagation of the cone of depression beyond the injection area
- Bonanza Spring – The injection of water into water-bearing fractures immediately above Bonanza Spring to maintain groundwater levels in the watershed that supports flow at the spring
- Bonanza Spring – the temporary provision of water for flow and habitat maintenance (e.g., a water tank and pipe to the spring head)
- Brine Resources – the injection of water at the saline-fresh water interface to "cut-off" the propagation of the cone of depression beyond the injection area (this could be combined with injection to halt the migration of the saline-fresh water interface – see above)
- Air quality – the spraying of water on areas prone to dust generation

More details regarding these potential alternative mitigation measures needs to be developed. Their feasibility (effectiveness, implementability, and cost) should be evaluated, including analysis using numerical groundwater modeling. Their effectiveness should examine both short-term effectiveness in preventing continued adverse impact, and their long-term effectiveness at alleviating impacts in a reasonable period of time.

It is understood that saline intrusion and mitigation scenarios have been modeled (tele-conference with GSSI on December 17, 2018). The results of this modeling should be included in the GMMMP to provide confidence in the positioning of well clusters and the effectiveness of potential saline intrusion mitigation measures.

8.0 CONCLUSIONS

8.1 General

The GMMMP provides appropriate and sufficient management and monitoring to identify Undesirable Results that could occur in response to proposed pumping as part of the Cadiz Project. After careful review and consideration of the FEIR, GMMMP, and more recent technical reports, the Panel has recommended a number of complementary additions that could be made to the GMMMP, where such additions are feasible (ESA, 2012b) (see **Sections 7.5 through 7.13**). Collectively these recommendations are intended to allay any concerns that opponents to the Cadiz Project may still have, improve public confidence in the Cadiz Project, and are provided in an abundance of caution.

The recommendations are not intended to alter the analysis or findings regarding the environmental impacts of the Cadiz Project described in the FEIR (ESA, 2012a), or contain any significant new information. In addition, none of the recommendations are associated with a failure of the GMMMP to provide sufficient management, monitoring, and mitigation of Undesirable Results; that is, the Panel finds the GMMMP adequate. However, the Panel strongly believes that the recommendations provide helpful direction in the ongoing monitoring, mitigation and management of the Cadiz Project.

The GMMMP provides effective Corrective Measures to address any Undesirable Results in the long-term, although no un-mitigatable Undesirable Results were identified in the FEIR over a 100-year period (ESA, 2012a). For the avoidance of doubt, where the cessation or reduction of pumping at the Cadiz Project will not prevent or alleviate impacts in a reasonable period of time, alternate resource-specific measures have been proposed in the GMMMP and/or FEIR to mitigate impact (see **Section 7.15**). The Panel has also identified some additional measures that should be considered (see **Section 7.15**).

To provide greater confidence in the data collected as part of the Cadiz Project, and provide greater transparency to project stakeholders – including project opponents, the Panel has recommended the development and/or implementation of certain plans and actions (see **Sections 7.1 through 7.4**).

8.2 Aquifer Management

The numerical groundwater modeling performed to date (GSSI, 2011), considering three different recharge scenarios, is a useful tool to evaluate hydrologic conditions in the Cadiz Project area. The numerical groundwater modeling is also a valuable tool for the analysis of potential Undesirable Results and the evaluation of potential Corrective Measures. The numerical groundwater modeling performed to date was appropriate to support the development of the FEIR (ESA, 2012a) and GMMMP (ESA, 2012b).

The FEIR (ESA, 2012a) concluded that there were no Undesirable Results, or Undesirable Results that could not be mitigated, caused by the proposed pumping at the Cadiz Project, regardless of the recharge scenario. However, the GMMMP (ESA, 2012b) proposed monitoring, management actions, and Corrective Measures to identify, evaluate, and mitigate any Undesirable Results, and additional conditions were imposed by the County of San Bernardino.

Given the reliance on numerical groundwater modeling to support the FEIR and GMMMP, the model should be updated and recalibrated in accordance with the recommendations presented in **Section 7.14**.

8.3 Springs

The FEIR concluded (ESA, 2012a), and subsequent analyses concluded (Kenney and TLF, 2018), that no direct hydraulic connection exists between Bonanza Spring and the alluvial aquifer in Fenner Valley below. Kenney and TLF concluded the following, based on field evidence and other supporting data:

- The bedrock watershed that supports Bonanza Spring is fault bounded, which creates a barrier to groundwater outflow and an up-gradient capture zone for recharge from precipitation
- The volume of groundwater in storage in the bedrock watershed is sufficient to maintain the spring through substantial periods, potentially even droughts lasting several decades, but at reduced flows
- The long-term sustainability of Bonanza Spring is dependent on long-term average precipitation, which provides recharge to the watershed that supports Bonanza Spring
- The location of Bonanza Spring has changed over time in response to climatic variability, and such changes may occur in the future
- Bonanza Spring will not be affected by down-gradient conditions in the alluvial aquifer in the Fenner Valley below, including the proposed pumping at the Cadiz Project

Nevertheless, opponents to the Cadiz Project continue to assert that the proposed pumping at the Cadiz Project will impact the springs, and this appears to be their primary reason for why the project should not move forward. This Panel was not tasked specifically with determining whether a hydraulic connection exists between Bonanza Spring and the alluvial aquifer. However, based on our analysis of the GMMMP and other documentation, including the reports cited herein (Zdon, 2016; Zdon et al, 2018; Rose, 2017; Kenney and TLF, 2018; Experts Review, 2018; Kreamer, 2018; Schroth, 2018; Kreamer, 2019), the weight of credible evidence suggests that no direct hydraulic connection exists. Even if such a connection existed, the FEIR concluded

(ESA, 2012a) that the proposed pumping at the Cadiz Project would still have no significant impact at Bonanza Spring.

Irrespective of whether there is a hydraulic connection between Bonanza Spring and the alluvial aquifer, and what numerical modeling predicts the impacts will be even if such a connection exists, for the avoidance of any doubt, the GMMMP proposes a monitoring program to evaluate potential Undesirable Results at Bonanza Spring (ESA, 2012b). The Panel has recommended this program be supplemented as follows (see **Sections 7.5 through 7.10**):

- Geophysical mapping of in the area of Bonanza Spring (**Section 7.5**)
- Additional monitoring wells proximate to Bonanza Spring (**Section 7.6**)
- A weather station (or a rain gauge at a minimum) proximate to Bonanza Spring (**Section 7.7**)
- Higher frequency monitoring of spring flows and spring geochemistry at Bonanza Spring and other background springs (Whiskey and Vontrigger) (**Section 7.8**)
- More defined vegetation monitoring of the riparian habitat immediately down-stream of Bonanza Spring and other springs (Whiskey and Vontrigger) (**Section 7.9**)
- Higher frequency monitoring of groundwater conditions proximate to Bonanza Spring and in other parts of the watersheds tributary to the Cadiz Project (**Section 7.10**)

This enhanced monitoring program will improve the understanding of hydrologic conditions at Bonanza Spring, allow for improved monitoring and evaluation of potential Undesirable Results, and assist in the design and implementation of improved Corrective Measures, if significant impacts are observed.

If Undesirable Results at Bonanza Spring are observed, resource-specific measures are proposed in the GMMMP (ESA, 2012b). The Panel has recommended alternative mitigation actions that should be evaluated to prevent or alleviate the impacts (e.g., injection of water at the edge of the alluvial aquifer immediately below Bonanza Spring) (**Section 7.15**).

8.4 Brine Resources

The results of analyses using numerical groundwater modeling indicate that brine levels beneath the dry lakes will decline in response to the proposed pumping at the Cadiz Project. With such declines, the evaporation and precipitate recovery trenches used by two mineral strip-mining operations could dry out, and brine recovery wells may experience reduced yields. The cessation of pumping at the Cadiz Project is not expected to prevent further impact or alleviate impact in a reasonable time frame, given the response lag time in the hydrologic system.

To effectively mitigate the likely impact to Brine Resources, a mitigation agreement that includes the installation of deeper brine recovery wells could be implemented as provided in the FEIR (ESA, 2012a). Alternatively, as provided in the GMMMP (GMMMP, Section 6.4 and 6.4.4), water could be injected or spread at the saline-fresh water interface to cut-off the propagation of the pumping cone of depression before it causes significant impact to Brine Resources. This alternative mitigation program requires more detailed evaluation (**Section 7.15**).

8.5 Saline Migration

Existing analyses (GSSI, 2011) indicates that the saline-fresh water interface may migrate from 6,300 to 10,400 feet toward the Cadiz Project well-field. The installation of cluster wells to monitor the migration of the interface, as proposed in the GMMMP (ESA, 2012b), is reasonable and appropriate. However, the interface will preferentially migrate along areas and at depths with higher permeability, and the migration will occur along saline fingers rather than along a uniform saline front. The Panel recommends that a geophysical survey be conducted to establish baseline conditions for the saline-fresh water interface (**Section 7.12**) prior to the proposed pumping at the Cadiz project. The survey should also be used to select the locations and screened intervals for the proposed cluster wells. Subsequent surveys in the exact same areas should be conducted every five years to monitor the migration of the interface.

The cessation of pumping at the Cadiz Project will not alleviate significant impacts associated with saline migration in a reasonable period of time. However, resource-specific measures proposed in the FEIR (**Section 7.15**), such as injection of fresh water at the saline-fresh water interface to prevent further migration, should be effective.

8.6 Land Subsidence

The FEIR concluded (ESA, 2012a) that the proposed pumping at the Cadiz Project would not cause Undesirable Results related to land subsidence. However, a detailed subsidence monitoring program was proposed in the GMMMP (ESA, 2012b) to address any uncertainty as to whether significant land subsidence will result from the proposed pumping at the Cadiz Project. The Panel has recommended modifications to this program to improve its scope and efficacy, including the increased use of InSAR data (**Section 7.13**).

8.7 The GMMMP Document

The GMMMP (ESA, 2012b) meets the objectives set out for this Review (see **Sections 1.1 and 8.1**). However, the Panel has made recommendations that will improve the monitoring, management and mitigation programs (**Section 7**). There are also areas of the GMMMP that would benefit from clarification. These have been noted within **Section 6** of this Consensus Report.

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APPENDICES

APPENDIX A BIOGRAPHICAL SKETCHES OF PANEL MEMBERS

Anthony Brown

CEO and Principal Hydrologist

Anthony is the founder, Chief Executive Officer (CEO) and Principal Hydrologist at **aquilogic**. Prior to **aquilogic**, he was the Chief Business Development Officer at exp, Senior Vice-President of Strategy & Development at WorleyParsons, and the global sector leader for their Environment business. He was previously the CEO and one of the founding principals at Komex Environmental, a global environmental consulting company. In December 2005, WorleyParsons acquired Komex.

Anthony received his Master of Science degree in Engineering Hydrology from Imperial College London in 1988.

Anthony has over 25 years of experience in many aspects of infrastructure engineering and environmental consulting, with a focus on hydrologic science, water resources, environmental engineering, and water treatment & supply. He has provided expert testimony in numerous "high-profile" cases involving emerging and recalcitrant chemicals in groundwater. He has also briefed the following on the impact of industrial chemicals on water resources:

- United States Environmental Protection Agency (US EPA) and State regulators;
- White House Officials;
- US, State, and local elected officials; and
- Professional bodies and academic institutions.

Anthony also has extensive experience in strategic development, mergers & acquisitions (M&A), marketing and business development (BD):

- Evaluating the markets, clients, competition, drivers and the company's position in the market;
- Developing a strategic direction and plan for the company;
- Implementing the strategic plan alongside operations;
- Leading all M&A, Joint Venture (JV) and alliance development activity; and
- Leading all BD activity for major clients/projects and emerging markets.

Mark Wildermuth, PE

President, Principal Engineer

Expertise:	Mr. Wildermuth has 42 years of experience in water resources engineering and planning, including: surface and groundwater hydrology; hydraulics and water quality; surface and ground water modeling; groundwater management, including recharge master plans; water resources systems planning, operation, and optimization; water rights; evaluation of receiving water impacts; and flood control facility design. Mr. Wildermuth has extensive expertise in the development of water resource management plans for groundwater basins and watersheds in Southern California, and he has provided expert witness testimony and opinions for litigation support and mediation in several important cases—the most recent being the recalculation of the Chino Basin safe yield and Phase 3 trial in the Antelope Valley groundwater adjudication. Mr. Wildermuth is a recognized expert in the hydrology of the Santa Ana Watershed, having developed groundwater models at some time in his career for all of the groundwater basins in the upper watershed and highly integrated surface and groundwater models for the Santa Ana River and its tributaries and underlying basins. These models are in active use to manage the Chino, Cucamonga, Six Basins, Temescal, and Mammoth Basins. Most notably, his work forms the basis for the estimation of sustainable yield and the development of groundwater storage and recovery programs. Mr. Wildermuth developed the recharge master plan concept, utilizing detailed surface water models and statistical techniques to identify new recharge projects and to determine expected new recharge and cost. Mr. Wildermuth designed and subsequently led the process to develop the salt and nutrient management plans for the Santa Ana River Watershed and subsequent updates. His work has withstood peer review and has been relied on in adjudicated basins, regulatory processes, and project financing. Mr. Wildermuth directs WEI's technology program, which conducts research and development of models, database/visualization tools, methodologies to estimate the sustainable yields of groundwater systems, and methodologies to evaluate the impacts of climate change on surface and ground water resources.
Education:	M.S., Engineering, University of California, Los Angeles, 1976 B.S., Engineering, University of California, Los Angeles, 1975
Licenses:	Professional Engineer, California, No. 32331
Professional History:	WEI – 1990 to Present James M. Montgomery, Consulting Engineers [JMM] (now called MWH) – 1987 to 1990 Camp Dresser & McKee, Inc. (now called CDM/SMITH) – 1980 to 1987 TetraTech – 1976 to 1980

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Dave Romero is President of the firm of Balleau Groundwater, Inc. Dave received his Master's Degree in Hydrology from the University of Arizona with a focus on model analysis of groundwater interaction with surface water. He is a Certified Professional Hydrologist (#1817) by the American Institute of Hydrology (2008) with over 20 years of experience consulting in the hydrologic industry. He specializes in analysis of water budgets for both natural hydrologic conditions and changes induced to the natural system from development of surface water and groundwater. He has advised cities and peer reviewed hydrogeologic analyses for municipal water districts regarding water resources in settings that involve groundwater pumping, artificial aquifer recharge, aquifer recharge from flooding and remediation of groundwater contamination. He has also advised industrial water users, irrigation and conservancy districts, state and federal agencies, Indian tribes, water associations and private water users with matters involving water planning and source water availability. Dave has presented at conferences involving groundwater hydrology and has been invited to publish in a Theme Issue of the peer-reviewed journal *Groundwater* on research related to analysis of groundwater flow.

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CV

Timothy K. Parker, PG, CEG, CHG
Principal Hydrogeologist

Tim Parker is an independent technical consultant working as Principal Hydrogeologist, Parker Groundwater, located in Sacramento California, specializing in integrated water resources and groundwater management, and serving public and private sector water industry clients. He has conducted hydrogeologic evaluations in the Basin Ranges, Central Valley, Coast Ranges, Los Angeles Coastal Plain, Mojave Desert, Modoc Plateau, Sierra Nevada, and Southern Cascades geomorphic regions of California. His current work largely focuses on assisting clients in understanding and meeting the new California Sustainable Groundwater Management Act requirements, while his experience includes water policy analysis, strategic water resources planning, groundwater management plan development and program implementation, regional and project scale groundwater monitoring for quantity and quality, groundwater recharge & storage projects, and litigation support. He formerly worked for Schlumberger Water and Carbon Services bringing sophisticated oil and gas industry geophysical tools and technologies to water industry clients, and prior to that he was with the California Department of Water Services Conjunctive Water Management Program. Tim is a California licensed professional geologist (#5594), certified engineering geologist (#1926), and certified hydrogeologist (#0012).

Tim currently serves the Groundwater Resources Association of California as Director and Legislative Committee Chairman; California Groundwater Coalition as Director; National Ground Water Association as Scientist and Engineer Section Director and NGWA Board Member; and International Association of Hydrogeologists as U.S. National Chapter Director. He has provided technical analysis and testimony to the California State Legislature in the development of groundwater management and recharge policy, was involved in SGMA development and initial roll out, and is involved with federal groundwater policy development through NGWA. Tim is also actively involved with the Association of California Water Agencies Groundwater Committee, SGMA Implementation Subcommittee, and has served on the Public Advisory Committee and co-chaired the Groundwater Caucus for preparation of the California State Water Plan. He is principal author of *Sustainable Groundwater Management Policy Directives,* prepared for the Mexican National Water Commission as an outcome of the 9th International Symposium on Managed Aquifer Recharge (IAH 2016); *Sustainability from the Ground Up, Groundwater Management in California, a Framework* (ACWA 2011); and co-authored the books *Potential Groundwater Quality Impacts Resulting from Geologic Carbon Sequestration* (WRF 2009), and *California Groundwater Management* (GRA 2005).

APPENDIX B CADIZ PROJECT OVERVIEW

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APPENDIX B:
CADIZ PROJECT OVERVIEW
San Bernardino County, California

Prepared for:

Three Valleys Municipal Water District
1021 E. Miramar Avenue
Claremont, CA 91711-2052

Project No.: 052-01

January 2019

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ACRONYMS AND ABBREVIATIONS

>	less than
%	percent
°F	degrees Fahrenheit
AF	acre-feet
AFY	acre-feet per year
ARZC	Arizona and California Railroad
bgs	below ground surface
CEQA	California Environmental Quality Act
cm/d	centimeters per day
DRI	Desert Research Institute
ESA	Environmental Science Associates
feet/day	feet per day
feet/year	feet per year
FEIR	Final Environmental Impact Report
ft^2	square feet
GMMMP	Groundwater Management, Monitoring, and Mitigation Plan
gpm	gallons per minute
LLNL	Lawrence Livermore National Laboratory
MAF	million acre-feet
mg/L	milligrams per liter
mi2	square miles
MSL	mean sea level
OBW	Orange Blossom Wash
SMWD	Santa Margarita Water District
SWP	State Water Project
TDS	total dissolved solids
USGS	United States Geological Survey

1.0 INTRODUCTION

Cadiz Inc. (Cadiz) is a private corporation that owns approximately 34,000 mostly contiguous acres in the Cadiz and Fenner Valleys (Cadiz Property), which are located in the Mojave Desert portion of eastern San Bernardino County, California (see **Figure 1**).

Cadiz, in collaboration with the Santa Margarita Water District (SMWD) and other water providers participating in the Cadiz Project (Project Participants), has developed the Cadiz Project to implement a comprehensive, long-term groundwater management program for the closed groundwater basin underlying its property that would allow for both the beneficial use of some of the groundwater and storage of imported surface water in the groundwater basin (**Figure 2**).

Underlying the Cadiz and Fenner Valleys, and the adjacent Bristol Valley, is a vast groundwater basin that holds an estimated 17 to 34 million acre-feet (MAF) of fresh groundwater. The Cadiz Project area, which would be sited on Cadiz Property, is located at the confluence of the Fenner, Orange Blossom Wash (OBW), Bristol, and Cadiz Watersheds (Watersheds), which span over 2,700 square miles (**Figure 3**).

Within this closed basin system, groundwater percolates and migrates downward from the higher elevations in the Watersheds and eventually flows to Bristol and Cadiz dry lakes (**Figure 4**). The dry lakes represent the low point in the closed watershed basin, meaning that all surface and groundwater within the surrounding Watersheds eventually flows down-gradient to these dry lake areas and not beyond. Once the fresh groundwater reaches the dry lake areas, it evaporates; first mixing with the highly saline groundwater zone under the dry lakes and getting trapped in the salt sink, no longer fresh, suitable, or available to support freshwater beneficial uses. The portion that evaporates is lost from the groundwater basin and is therefore also unable to support beneficial uses.

Figure 1: Location of the Cadiz Project[1]

[1] Aquilogic, Inc. (2013). Review of The Groundwater Hydrology of the Cadiz Project, San Bernardino County, California.

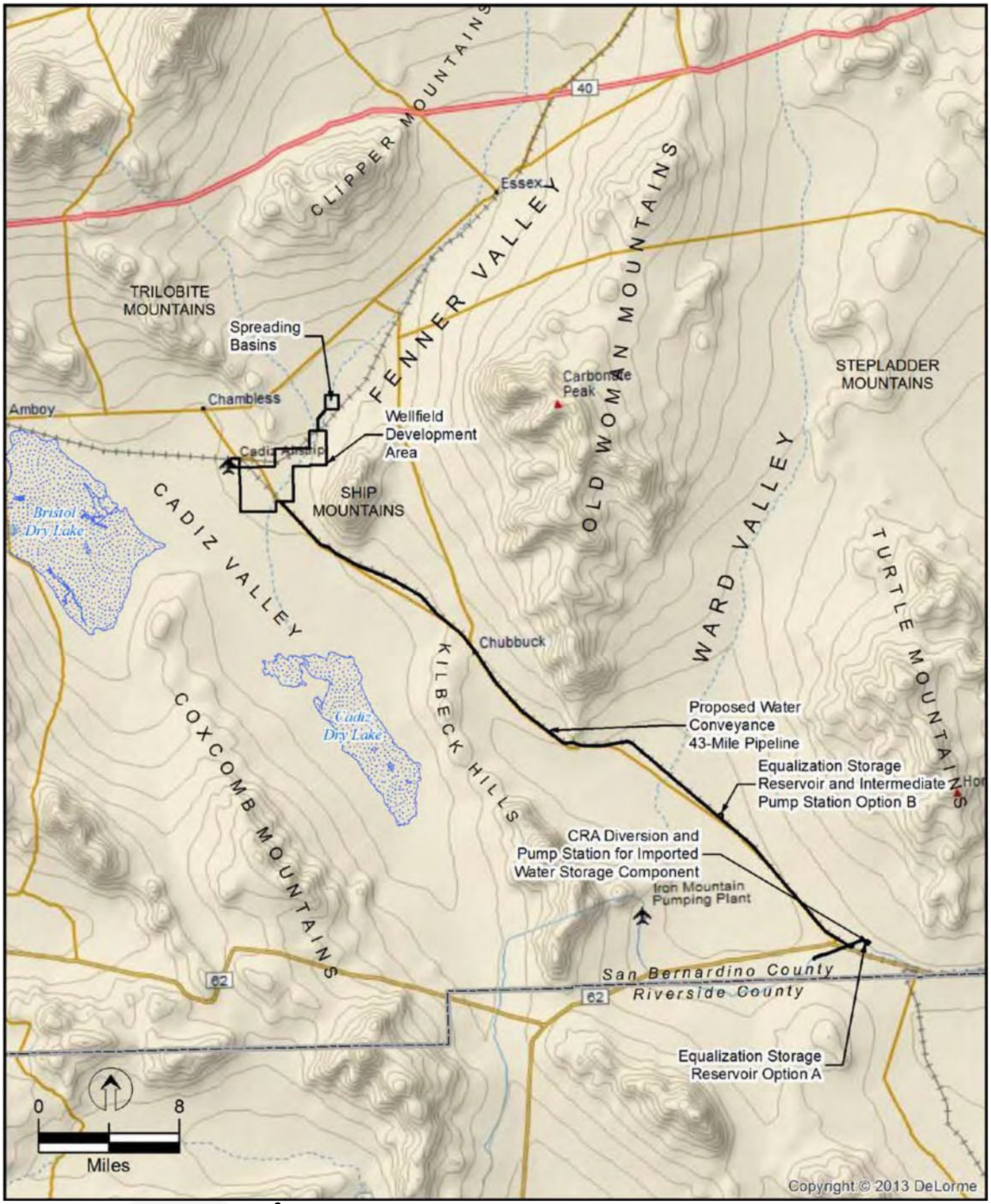

Figure 2: Cadiz Project Area[2]

[2] Aquilogic, Inc. (2013). Review of The Groundwater Hydrology of the Cadiz Project, San Bernardino County, California.

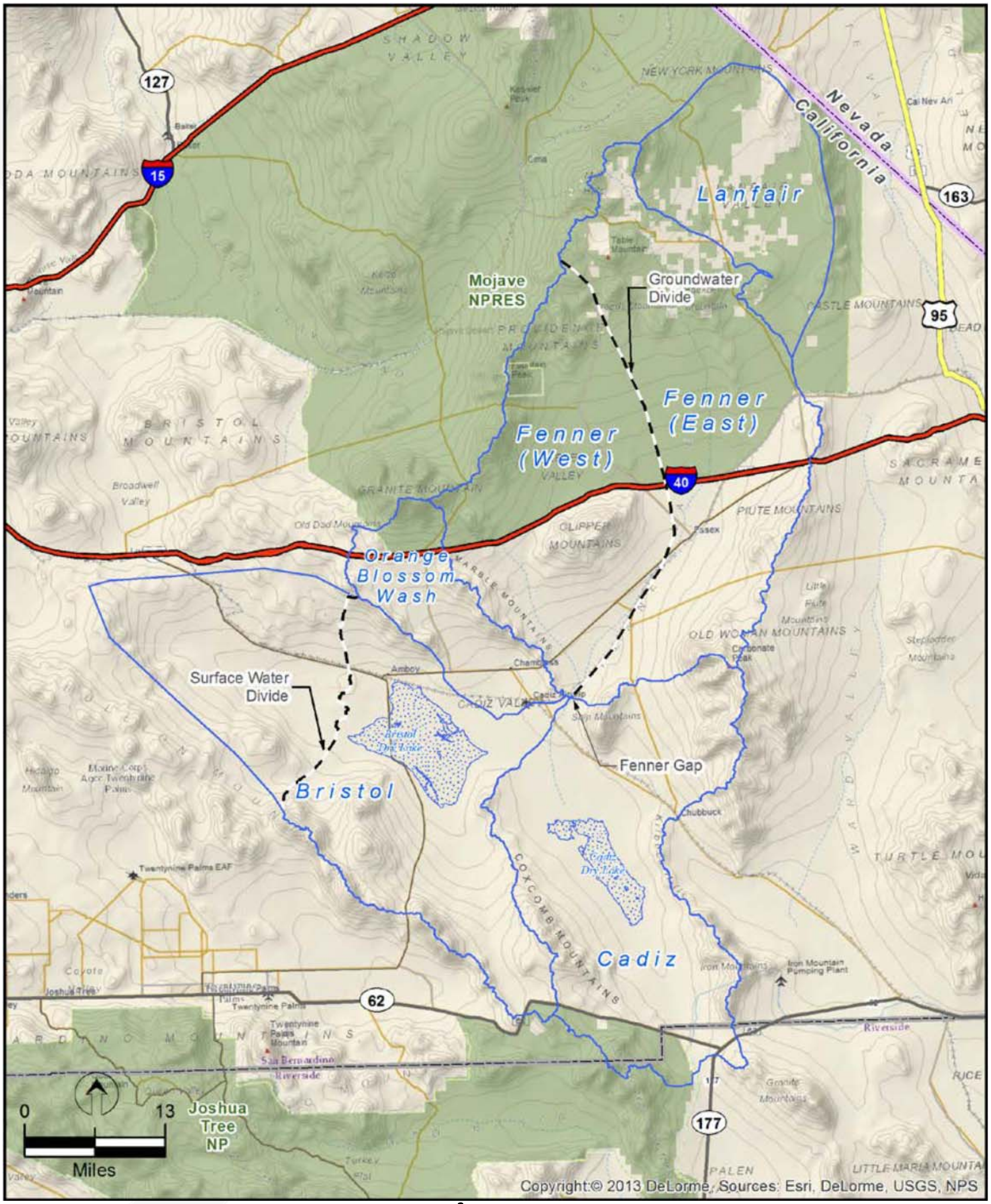

Figure 3: Watersheds in the Cadiz Project Area[3]

[3] Aquilogic, Inc. (2013). Review of The Groundwater Hydrology of the Cadiz Project, San Bernardino County, California.

1.1 Project Purpose

Under Article X, Section 2 of the California Constitution, waters of the state must be put to maximum reasonable and beneficial use and should not be wasted. The fundamental purpose of the Cadiz Project is to save substantial quantities of groundwater that are presently wasted and lost to evaporation by natural processes. In the absence of the Cadiz Project, approximately 3 MAF of groundwater, presently held in storage between the proposed wellfield and the dry lakes, would become saline and evaporate over the next 100 years. By strategically managing groundwater levels, the Cadiz Project would conserve up to 2 MAF of this water, retrieving it from storage before it is lost to evaporation. The conservation opportunity is unique and garners special emphasis. The proposed conservation is not dependent upon future rainfall, snow pack, or the needs and demands of others: the groundwater is already in storage. Moreover, the conservation and resulting water supply augmentation can be achieved independently from the environmental and regulatory conditions that generally constrain the importation of water to Southern California. The geographic isolation of the groundwater makes it non-tributary to the Colorado River system, and therefore eligible for distinctive treatment under federal regulations that may unlock additional complementary storage opportunities, both within the basin and in Lake Mead.

The Cadiz Project makes a reliable water supply available for Project Participants, to supplement or replace existing supplies and enhance dry-year supply reliability. Both the State Water Project (SWP) and Colorado River water supplies are experiencing reductions from historic deliveries. As a result, Southern California water providers are looking for affordable new supplies to replace or augment current supplies and enhance dry-year supply reliability. The Cadiz Project would optimize the reasonable and beneficial use of water within the aquifer system in a sustainable fashion—conserving water that would otherwise be wasted—to create a local water supply alternative for Southern California water providers.

The objectives of the Cadiz Project are as follows:

- Maximize beneficial use of groundwater in the Bristol, Cadiz, and Fenner Valleys by conserving and using water that would otherwise be lost to brine and evaporation.
- Improve water supply reliability for Southern California water providers by developing a long-term source of water that is not significantly affected by drought.
- Reduce dependence on imported water by utilizing a source of water that is not dependent upon surface water resources from the Colorado River or the Sacramento-San Joaquin Delta.
- Enhance dry-year water supply reliability within the service areas of the SMWD and other Southern California water provider Project Participants.
- Enhance water supply opportunities and delivery flexibility for the SMWD and other participating water providers through the provision of carry-over storage and, for Phase 2, imported water storage.

- Support operational water needs of the Arizona and California Railroad (ARZC) in the Project area.
- Create additional water storage capacity in Southern California to enhance water supply reliability.
- Locate, design, and operate the Project in a manner that minimizes significant environmental effects and provides for long-term sustainable operations.

1.2 Project Components

The Cadiz Project includes the following two distinct but related components:

- Groundwater Conservation and Recovery Component
- Imported Water Storage Component

Under the Groundwater Conservation and Recovery Component, an annual average of 50,000 acre-feet (AF) of groundwater would be pumped from the basin over a 50-year period for delivery to Project Participants in accordance with agreements with Cadiz and the Groundwater Management, Monitoring, and Mitigation Plan (GMMMP). The GMMMP has been developed to guide the long-term groundwater management of the basin for the Cadiz Project (ESA, 2012b). The level of groundwater pumping proposed under the Groundwater Conservation and Recovery Component is designed specifically to extract and conserve groundwater that would otherwise migrate to the dry lakes, enter the brine zone, and evaporate. The Groundwater Conservation and Recovery Component is analyzed at a project level in the Final Environmental Impact Report (FEIR) in accordance with California Environmental Quality Act (CEQA) Guidelines' Sections 15161 and 15378(a) (ESA, 2012a).

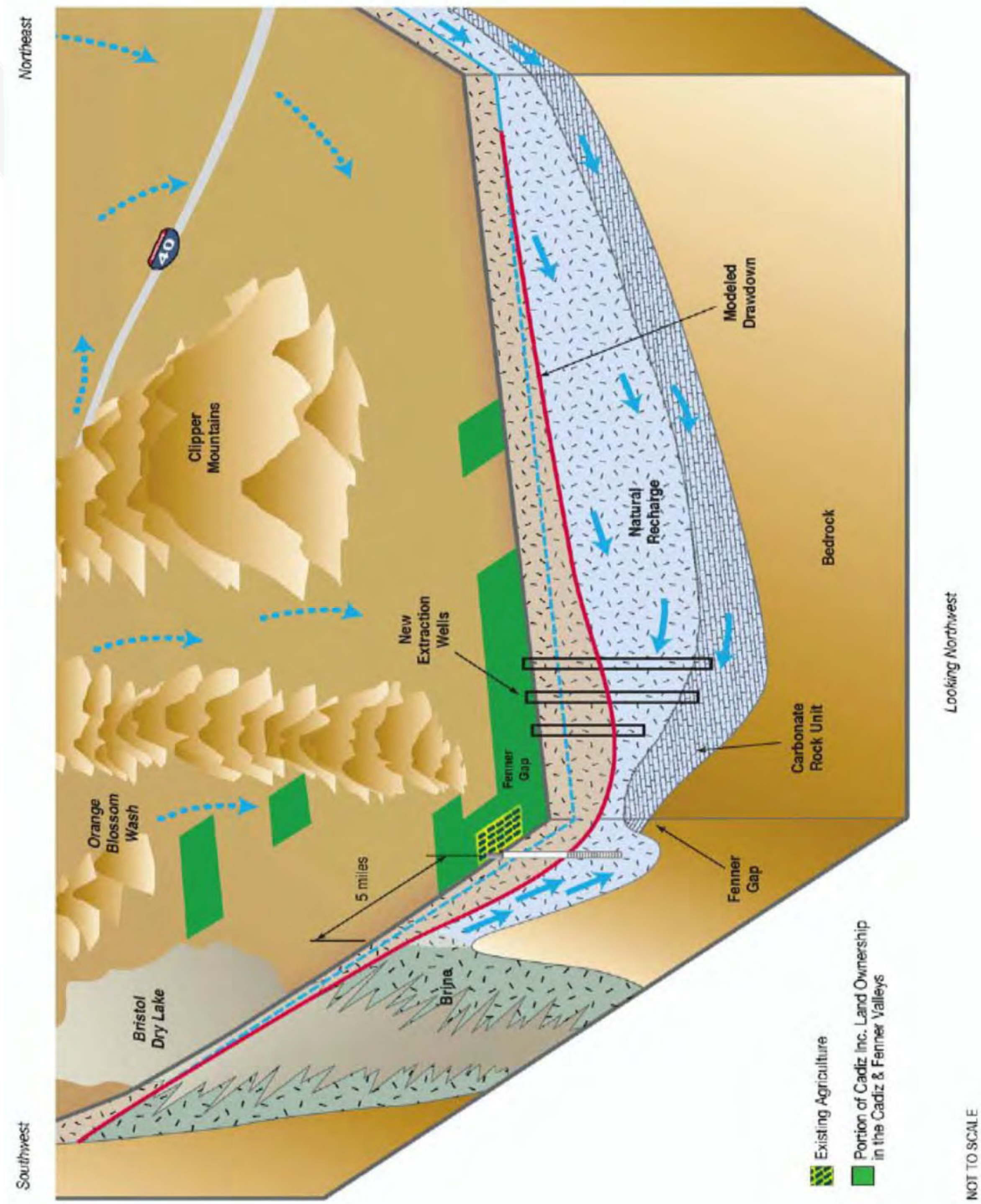

Figure 4: Conceptual Surface and Groundwater Flow. Source: ESA, 2012[4], Figure 3-3a

[4] Environmental Science Associates (ESA). (2012a). Final Environmental Impact Report (FEIR) for the Cadiz Valley Water Conservation, Recovery, and Storage Project, Prepared for Santa Margarita Water District (SMWD). SCH# 2011031002. July.

2.0 SITE SETTING

The following section provides a description of the area that surrounds the Cadiz Project including the Fenner, Lanfair, Bristol, Cadiz, and OBW Watersheds. The following discussions include an overview of the location, topography, surficial geology, structural geology, geologic development, stratigraphy, climate, surface water, land use, and groundwater production. The information is taken directly from **aquilogic** (2013).

2.1 Location

The Cadiz Project is located at the confluence of the Fenner, OBW, Cadiz, and Bristol Watersheds (see **Figure 2**). The Cadiz Project is approximately 17 miles east of Amboy in San Bernardino County, California (see **Figures 1 and 2**).

The watersheds that surround the Cadiz Project are located in the Eastern Mojave Desert, which is a part of the Basin and Range Geomorphic Province of the western United States (see **Figure 3**). Of these watersheds, the Fenner Watershed has the highest mountain elevations and largest surface area. This watershed encompasses approximately 1,100 square miles (mi^2) and is bounded by the Granite, Providence, and New York Mountains on the west and north and the Piute, Ship, and Marble Mountains on the east and south (ESA, 2012a).

The Fenner Gap occurs between the Marble and Ship Mountains near the location of the Cadiz Project. The Fenner Gap is the location of the groundwater outflow of the Fenner Watershed into the Bristol and Cadiz Watersheds. The Clipper Mountains rise from the southern portion of the Fenner watershed, just northwest of Fenner Gap (CH2M Hill, 2010).

2.2 Topography

The Basin and Range Geomorphic Province is characterized by a series of northwest/southeast trending mountain and valleys formed largely by faulting. One of the prominent features of the area is the Bristol Trough, a major structural depression caused by faulting (i.e., a graben). The Bristol Trough encompasses the Bristol and Cadiz Watersheds that together form a relatively low land area that extends from just south of Ludlow, California, on the northwest, to a topographic and surface drainage divide between the Coxcomb and Iron Mountains on the southwest (see **Figure 5**). The Bristol and Cadiz Valleys are bounded on the southwest by the Bullion, Sheep Hole, Calumet, and Coxcomb Mountains and on the northeast by the Bristol, Marble, Ship, Old Woman, and Iron Mountains.

The Cadiz and Bristol Dry Lakes are separated by a low topographic and surface drainage divide (CH2M Hill, 2010). Volcanic eruptions and resultant lava flows from the Amboy cinder cone have created a low topographic ridge that divides the Bristol Watershed into two surface water catchments. Surface water west of the divide does not flow to Bristol Dry Lake, but rather evaporates at a topographic low west of the lava flows; whereas, surface water east of the divide does flow to Bristol Dry Lake.

The New York Mountains, at the northern extent of the Project area, rise to elevations of approximately 7,532 feet above mean sea level (MSL). The Granite and Providence Mountains, to the west and northwest, range from 6,786 feet to 7,178 feet above MSL, respectively. The Piute Mountains located to the northeast, range up to 4,165 feet above MSL. The Clipper Mountains in the center of the Project area rise to an elevation of more than 4,600 feet above MSL. Finally, the Marble and Ship Mountains, located to the southwest and south of the Clipper Mountains in the center of the Project area, range up to 3,842 feet and 3,239 feet above MSL, respectively. Generally, the Fenner Valley slopes southward toward the Fenner Gap, which is the groundwater outlet from the valley, at an elevation of about 900 feet above MSL (CH2M Hill, 2010).

The mountain ranges surrounding the Bristol and Cadiz Watersheds are lower in elevation than those mountain ranges surrounding the Fenner Watershed. Peak elevations for these mountains include the following: Bristol at 3,422 feet above MSL; Iron at 3,296 feet above MSL; Bullion at 4,187 feet above MSL; Sheep Hole at 4,685 feet above MSL; Calumet at 1,751 feet above MSL; and Coxcomb at 4,416 feet above MSL.

The alluvial basins surrounded by these mountain ranges form gently sloping topographic valleys. In the Lanfair Valley, the alluvial surface slopes to the southeast and ranges in elevation from approximately 4,500 to 3,500 feet above MSL. In the Fenner Valley, the alluvial surface slopes generally to the south and ranges in elevation from 3,500 to 1,000 feet above MSL. In the OBW, the alluvial surface slopes to the southeast and ranges in elevation from 2,500 to 100 feet above MSL. In the Bristol and Cadiz Valleys, the alluvial surface slopes radially toward the dry lakes, and ranges in elevation from 1,000 to 600 feet above MSL.

The Bristol and Cadiz Dry Lakes represent the lowest elevations within the watersheds at 595 and 545 feet above MSL, respectively.

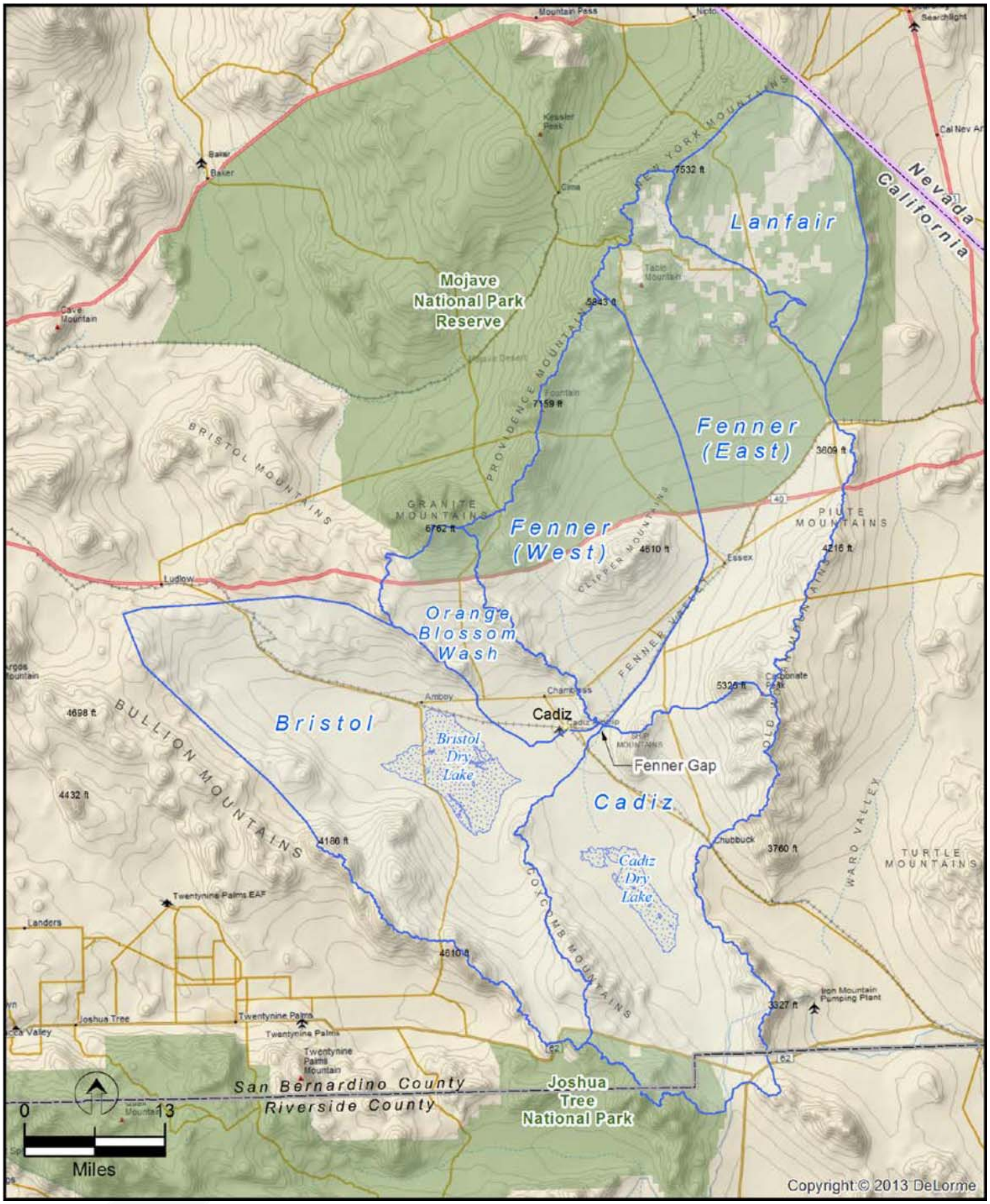

Figure 5: Project Area Topography[5]

[5] Aquilogic, Inc. (2013). Review of The Groundwater Hydrology of the Cadiz Project, San Bernardino County, California.

2.3 Surficial Geology

The surficial geology in the vicinity of the Cadiz Project can be classified into the following three types of cover (see **Figure 6**):

- Bedrock outcrops and mountain exposures
- Hillslope erosional deposits
- Alluvial basins

In general, the bedrock outcrops and exposures in the mountains are either Archean granite, Cambrian shale, dolomitic limestone and quartzite, Permian carbonate limestone, and Jurassic granite, with some Tertiary volcanics. The hillslope deposits are either exposed Miocene fanglomerates or Quaternary colluvium, talus, and landslide deposits, with disaggregated cover over the mountain bedrock. The surficial materials in the alluvial basins are generally coarse-grained Quaternary sediments ranging from fine-sand to cobbles, with some finer-grained Holocene sediment in ephemeral stream channels.

Cadiz and Bristol Dry Lakes are locally bordered by active dunes formed by fine to medium-grained windblown sand. These Holocene deposits overlie older playa deposits of differentiated Quaternary age (CH2M Hill, 2010).

Amboy Crater, located near the western margin of Bristol Dry Lake, is a basaltic cinder cone and lava field believed to be as young as 6,000 years.

2.4 Structural Geology

The larger area of study is located at the eastern margin of the eastern California shear zone, a broad seismically active region dominated by northwest-trending right-lateral strike-slip faulting. Roughly a dozen fault zones showing evidence of Quarternary movement (during the last 1.6 million years) have been identified in, and adjacent to, Bristol, Cadiz, and Fenner Valleys (CH2M Hill, 2010).

Cadiz Valley is underlain by two major northwest-trending faults, inferred on the basis of gravity and magnetic data. These fault zones have strike lengths of at least 25 miles and may merge to the north and northwest with extensions of the Bristol-Granite Mountains and South Bristol Mountains fault zones (CH2M Hill, 2010).

Right-lateral slip of as much as 16 miles along the Cadiz Valley fault zone has been postulated on the basis of correlation of a distinctive Precambrian gneiss unit across the zone. Slickenside surfaces produced by fault movement and steeply dipping sediments recovered from cored drill holes beneath Cadiz Dry Lake suggest the fault zone displaces sediments of Pleistocene age (CH2M Hill, 2010).

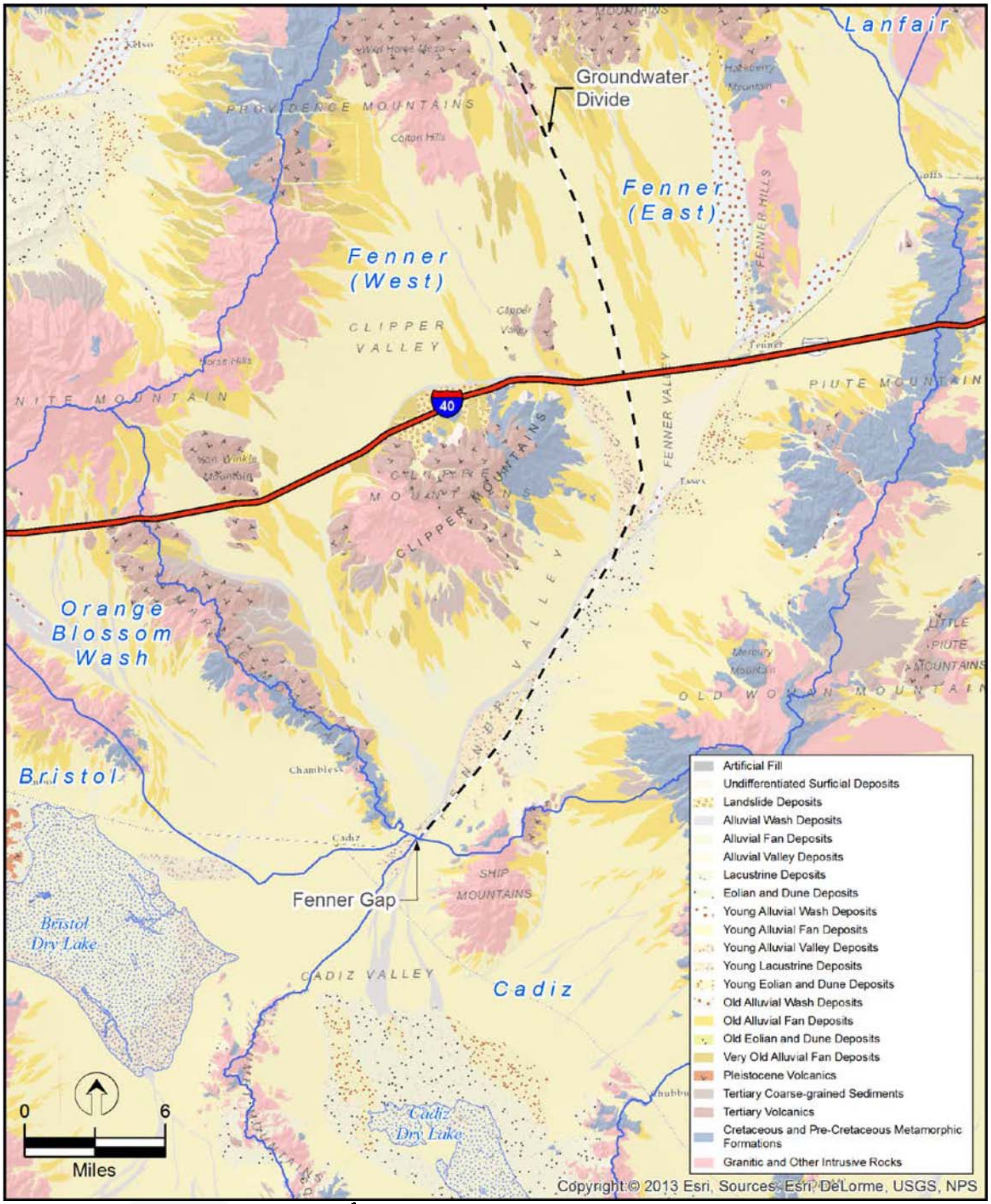

Figure 6: Regional Surficial Geology[6]

[6] Aquilogic, Inc. (2013). Review of The Groundwater Hydrology of the Cadiz Project, San Bernardino County, California.

Bristol Dry Lake is bordered by probable extensions of the Cadiz Valley and South Bristol Mountain fault zones to the east, and by probable extensions of the Broadwell Lake and Dry Lake fault zones to the west. Geophysical data indicate this structural depression (or graben) may exceed 6,000 feet in depth. Geologic cores recovered from drilling at depths of more than 1,000 feet beneath Bristol Dry Lake suggest that subsidence of this basin began by Pliocene time and continues to the present, and therefore may be tectonically active (CH2M Hill, 2010).

Fenner Gap appears to be a structural sub-graben, formed by a system of northeast-trending, northwest-dipping normal faults, some of which are exposed in outcrops of the bedrock that flank the gap. The presence of these northeast-trending faults beneath the alluvial deposits that underlay the gap can be inferred from surface geology mapping, gravity surveys, a seismic reflection survey conducted across the gap, and recent test wells drilled in the Fenner Gap (CH2M Hill, 2010).

The system of normal faults that formed the sub-graben of Fenner Gap displace and tilt volcanic rocks of mid- to late- Tertiary age. However, these faults do not displace Quarternary sediments and are, therefore, not considered to be either active or potentially active (CH2M Hill, 2010).

The mountains that flank the Bristol-Cadiz graben are essentially block mountains (i.e., horsts) that have been uplifted relative to the adjacent graben and sub-grabens.

In addition to tectonic movement, Jurassic plutonic intrusions have affected the structural evolution of the regional geology. In many areas, including the Fenner Watershed, the intrusions created broad anticlinal structures. Subsequently, these structures were partially eroded-away and in-filled with fanglomerates and alluvium.

2.5 Geologic Development of the Cadiz Project Area

The oldest rocks underlying the project area are Archean granites. During the Archean or Cambrian periods, a series of major northwest-southeast fault zones developed. These fault zones include the South Bristol Mountains – Cadiz Valley fault zone, the Broadwell Lake – Calumet – Dry Lake fault zone, and the Ludlow – Sheep Hole fault zone. Over time, the area between these fault zones subsided creating a deep (>6,000 feet) graben structure. During the Cambrian and Permian periods, the Archean granites were overlain by sedimentary units, predominantly dolomite limestone, shale, and carbonate limestone (karst), likely deposited during periods of shallow marine inundation (limestone) and deltaic or continental settings (shales).

During the Jurassic period, plutonic intrusions (likely coupled with movement along the fault zones) uplifted the Cambrian and Permian sediments to the northeast of the Cadiz Valley fault zone into a broad anticline. In addition, ancillary, unnamed faults (mapped by Kenney GeoScience [Kenney], 2012), perpendicular to the main fault zone created “sub-grabens” (e.g., the Fenner Gap, and sub-basins within the Fenner Watershed) and a series of horsts (e.g., Marble Mountains, Ship Mountains). Subsequent to the Jurassic intrusions, the sediments of the anticline were partially eroded away. In the higher-energy mountain environments, only isolated areas of Cambrian and Permian rocks remain on the flanks of the mountains and uplift, and erosion exposed the Jurassic granite plutons at these horsts. Within the sub-grabens, erosion created an unconformity at the top of Cambrian and Permian units formerly folded in a broad anticline. During the Miocene, portions of the sub-grabens were in-filled with fanglomerates, and during the Quaternary period, substantial thicknesses of alluvium accumulated in the sub-grabens and basins. The Quaternary alluvium is present at the surface across most of the basins. However, in areas with ephemeral streams flow, a thin veneer of Holocene alluvium is present. In addition, late Quaternary and Holocene volcanic deposits are present associated with eruptions from the Amboy cinder cone, northwest of the Bristol Dry Lake.

This geological development has resulted in a deep graben (rift-valley) underlying the Bristol and Cadiz Dry Lakes, flanked by a series of horsts (block mountains). Ancillary faults, perpendicular to the main fault zones, have created sub-grabens and broad basins between the horsts. The horsts are primarily Jurassic granite plutons with isolated areas of Cambrian sediments on their flanks, notably dolomites and carbonate limestone (karsts). Within the basins, a thick sequence of quaternary alluvium covers an erosional unconformity (an eroded anticline created by Jurassic plutonic intrusion), and localized dolomite, carbonate, and shale are found beneath the alluvium.

The geologic development has, over time, created a closed hydrologic system. The alluvial basins are flanked by mountains on most sides. Given the arid climate, only brief ephemeral surface water flows occur during major storm events. Surface waters flow down the channels in the alluvium and discharge to the dry lakes, the lowest points in the closed hydrologic system. However, most water enters the system as infiltration in the surrounding mountains (both from rainfall and snow-melt) and, to a much lesser degree, infiltration across the alluvium. This infiltration recharges the groundwater within the basins, and groundwater flows toward the deep graben. Both surface water and groundwater exit the hydrologic system as evaporation at the dry lakes. Over geologic time, this has resulted in a deep saline water body beneath the dry lakes. Given the flow of groundwater into the graben from the surrounding basins, and the density of the saline water, the zone of saline water has been restricted to the graben (i.e., directly beneath the dry lakes), but likely extends to a depth of many thousands of feet.

2.6 Stratigraphy

The stratigraphy and structures observed in the Fenner Gap and adjacent mountains are typical of the geologic history of the Basin and Range Province. The region exhibits Paleozoic sedimentary craton platform deposits overlying pre-Cambrian igneous and metamorphic cratonal rocks. These rocks were then intruded by Mesozoic age igneous plutonic rocks, and then extended in the Miocene during regional extension. Since the Miocene, the region has been relatively tectonically inactive with the exception of relatively minor right-lateral strike-slip faulting due to the San Andreas Fault System. For the most part, since the Miocene, the dominating geologic processes have involved erosion of the local mountains and sediment infilling of the adjacent basins (Geoscience Support Services, Inc. [Geoscience], 2011a).

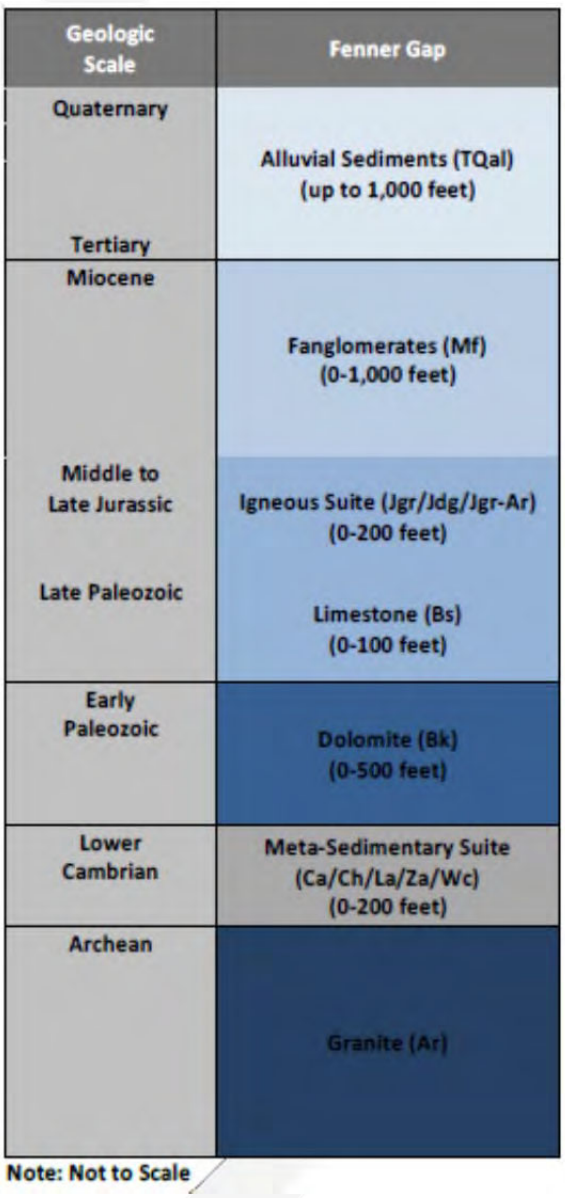

Figure 7: Generalized Stratigraphic Column of the Fenner Gap[7]

[7] Aquilogic, Inc. (2013). Review of The Groundwater Hydrology of the Cadiz Project, San Bernardino County, California.

The lithology within the Fenner Gap is complex due to historic tectonic activity and varies with distance away from the mountains towards the center of the gap. A generalized lithologic column can be seen in **Figure 7** and is based on the geologic interpretation presented by Kenney (2011). Generally, there is up to 1,000 feet of Tertiary to Quaternary alluvial deposits overlying Archean granitic bedrock. However, depending on the location within the Fenner Gap, there may be up to 1,000 feet of Miocene fanglomerates underlying the alluvial sediments. Underlying the fanglomerates, there may be up to 200 feet of a Jurassic igneous suite, including granite and gneiss. Underlying the Jurassic igneous suite, there may be up to 100 feet of limestone (Late Paleozoic), and up to 500 feet of Dolomite (Early Paleozoic). Underlying the dolomite, and overlying the Archean granite, may be up to 200 feet of Lower Cambrian-aged meta-sedimentary deposits, including limestone, shale, siltstone, and quartzite.

2.7 Climate

The eastern Mojave Desert is characterized as an arid desert climate with low annual precipitation, low humidity, and relatively high temperatures. Winters are mild, and summers are hot, with a relatively large range in daily temperatures. Temperature and precipitation vary greatly with altitude, with higher temperatures and lower precipitation at low altitudes, and lower temperatures and higher precipitation at higher altitudes (CH2M Hill, 2010).

2.7.1 Precipitation

Annual average precipitation at Mitchell Caverns, located at an altitude of 4,350 feet above MSL, is 10.47 inches. Amboy is represented by two stations: Amboy – Saltus Number 1, with an elevation of 624 feet above MSL and a long-term annual average precipitation of 3.28 inches (from 1967 through 1988); and, Amboy – Saltus Number 2, with an elevation of 595 feet above MSL and long-term annual average precipitation of 2.71 inches (1972 through 1992) (CH2M Hill, 2010).

Isohyet maps prepared using the PRISM model for the period 1971 through 2000 shows average annual precipitation that varies from about 4 inches in Bristol Valley to more than 12 inches in the New York Mountains. Relatively dry conditions prior to the mid-1970s (overall declining trend in the cumulative departure curve), and relatively wet conditions (overall rising trend in the cumulative departure curve) since the mid-1970s, is typical of much of Southern California (CH2M Hill, 2010).

2.7.2 Temperature

Air temperature in the eastern Mojave Desert reaches highs in the summer and lows in the winter. The average winter temperature is between 50 degrees Fahrenheit (°F) and 55 °F, with average daily maximum near 65 °F and average daily minimum near 40 °F. Average daily temperature in the summer months is over 85 °F, with maximum temperatures near 100 °F and occasionally exceeding 120 °F. Average daily minimum temperatures in the summer are around 70 °F, so the range of daily temperatures may exceed 20 °F to 30 °F (CH2M Hill, 2010).

The two weather stations in the area, Amboy and Mitchell Caverns, record air temperature. The minimum monthly temperature at Amboy is reported to be 50.7 °F in December and the maximum monthly temperature is 94.7 °F in July. The minimum monthly temperature at Mitchell Caverns is reported to be 46.3 °F in January and the maximum monthly temperature is 82.1 °F in July. The average annual temperatures at Amboy and Mitchell Caverns are 71.8 °F and 62.6 °F, respectively (CH2M Hill, 2010).

2.8 Surface Water

2.8.1 Intermittent Streams

The Watersheds form a closed drainage system with no surface outflow; all surface water in the Project area drains to Bristol and Cadiz Dry Lakes. The only outlets for surface water are direct evaporation of surface water, uptake, and transpiration by vegetation, infiltration, and then evaporation of soil moisture from the unsaturated zone, and direct evaporation from the dry lake surfaces (ESA, 2012a).

There are no perennial (year-round) streams in the Watersheds. Intermittent streams are distributed throughout the Watersheds. Ephemeral runoff within the Fenner Watershed flows into the Schulyer Wash, the principal drainage in the Fenner Valley Watershed, and then flows through Fenner Gap to either Bristol or Cadiz Dry Lakes. Ephemeral runoff within the OBW flows into Bristol Dry Lake. Ephemeral flow in the Bristol and Cadiz Watersheds flows into the Bristol or Cadiz Dry Lakes, respectively (ESA, 2012a).

It should be noted that the surface water catchments within the watersheds may not map directly to the underlying groundwater basins. As noted, the Bristol Watershed can be divided into two surface water catchments separated by a low topographic ridge associated with the Amboy volcanics. However, it is likely that all groundwater in the Bristol Watershed flows to the Bristol Dry Lake. The Lanfair Valley is located to the northwest of the Fenner Watershed. Surface water in the Lanfair Valley appears to flow to the southeast, enters the Ward Valley, and eventually drains to the Danby Dry Lake. However, groundwater in the Lanfair Basin likely flows directly south into the eastern portion of the Fenner Watershed, and thence through the Fenner Gap to Cadiz Dry Lake.

2.8.2 Springs

Some naturally-occurring springs and wet-ground that support denser vegetation are present at higher elevations within the mountain ranges that surround the watersheds (see **Figure 8**). No springs, wetlands, or phreatophyte vegetation are present in the lower elevations within the intervening basins and washes because the depth to groundwater in the alluvium is too great.

Many of the "springs" are supported by pipes or tunnels that have been driven into the subsurface to intercept groundwater and create "guzzlers". Many of these guzzlers are used by bunters to lure Big Horn Sheep or were used historically for railroad operations.

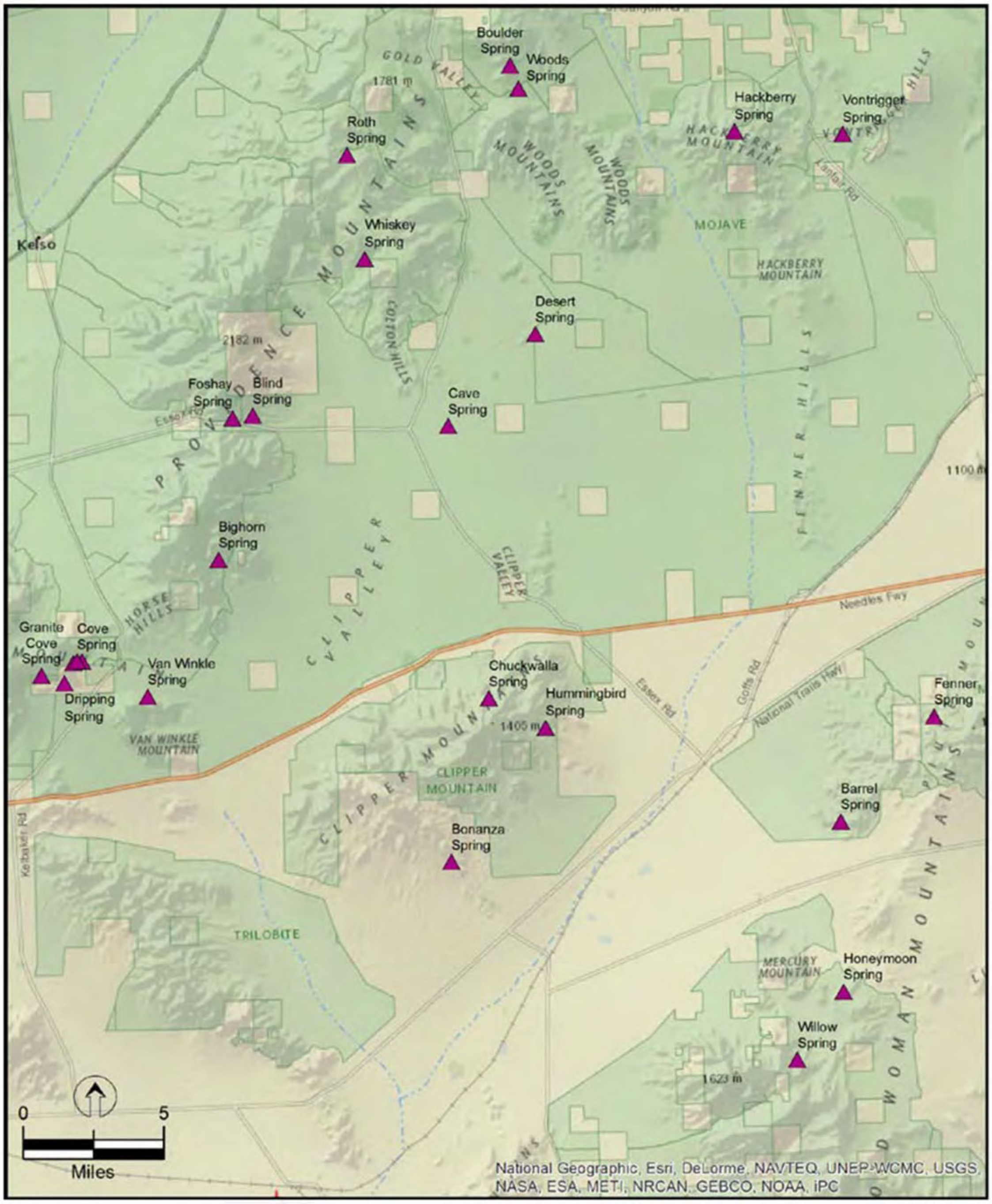

Figure 8: Springs within the Project Area[8]

[8] Aquilogic, Inc. (2013). Review of The Groundwater Hydrology of the Cadiz Project, San Bernardino County, California.

The closest naturally occurring spring to the project area is the Bonanza Spring located more than 11 miles north of Fenner Gap in the Clipper Mountains. Bonanza Spring is at an elevation of about 2,100 feet, substantially above the adjacent Fenner Valley floor at about 1,350 feet. More distant springs are found in the upper elevations of the Granite, Marble, Clipper, and Old Woman Mountains. Recent field mapping of the Marble Mountains has revealed numerous ephemeral pools or tinajas fed exclusively by surface run-off and guzzlers (ESA, 2012a).

It should be noted that these springs are found at elevations well above groundwater in nearby alluvial sediments. Therefore, they are likely sustained by localized, perched groundwater that mounds behind fault scarps or lower-permeability strata. As such, the springs are not in direct hydraulic communication with groundwater in the alluvium.

2.9 Land Use

Land use in the area consists primarily of desert conservation open space. There are isolated areas of agriculture, limited chloride mining of the brine from the dry lakes, and localized mining, military use, recreation, railroad, and electrical, gas, and oil utility corridors (ESA, 2012a).

2.10 Groundwater Production

Cadiz used, on average, 5,000 to 6,000 acre-feet per year (AFY) of groundwater between 1994 and 2007, for its agricultural operations. This annual usage was reduced beginning in 2007 in connection with the removal of approximately 500 acres of vineyard. Based on the current crop mix, the agricultural operations are using approximately 1,800 to 1,900 AFY (ESA, 2012a).

Two existing salt mining operations at the Bristol and Cadiz Dry Lakes involve evaporation of the hyper-saline groundwater from the dry lakes to obtain the remaining salts. One operation uses approximately 500 AFY of the hyper-saline groundwater based upon recorded water extractions, while the other operation uses approximately 250 AFY, for a total of 750 AFY (ESA, 2012a).

Average annual groundwater production for the Cadiz Valley Agricultural Development from 1998 to 2002 was approximately 5,600 AFY; and from 2003 to 2007 approximately 4,390 AFY. Annual average production from 2008 through 2013 was approximately 2,160 AFY. Total production during 2017 decreased slightly to 1,222.82 AF, compared to 1,857.99 AF in 2016 (TLF Consulting, LLC [TLF], 2018). This decrease in extraction is likely associated with increases in irrigation efficiency practices.

3.0 HYDROGEOLOGY OF THE PROJECT AREA

3.1 Hydrologic Inputs

3.1.1 Precipitation

Most of the precipitation in the Eastern Mojave Desert occurs between November and March. In general, the amount of precipitation increases with increasing elevation, and snow can accumulate at higher elevations (greater than 5,000 feet above MSL). Average annual precipitation ranges from approximately three inches on the Cadiz and Bristol Dry Lakes (elevations of 545 to 595 feet above MSL) to over 12 inches in the Providence and New York Mountains (elevations over 7,000 feet above MSL). The table below provides the total volume of precipitation that falls on each of the watersheds:

Table 1: Total Volume of Precipitation by Watershed

Watershed	Area (ft^2)	Precipitation Volume (AFY)
Bristol	22,141,717,000	170,541
OBW	4,736,693,394	46,232
Fenner (West)	13,700,280,036	173,716
Fenner (East)	16,625,535,879	234,753
Lanfair	7,831,938,617	123,806
Cadiz	16,482,012,982	131,042
Total	**81,518,177,907**	**880,090**

Note:
ft^2: square feet

3.1.2 Infiltration

Nearly all of the rainfall that falls on the alluvium enters shallow soil moisture storage or flows as run-off in ephemeral rills and streams, only to infiltrate downstream into unsaturated soils. After the rainfall events, most of this water is lost to the system as evapotranspiration and never recharges groundwater. Most of the recharge into the groundwater basins comes from water that has infiltrated in the surrounding mountains, and thence recharges groundwater as fracture-baseflow from bedrock to alluvium, or infiltration of surface water flows at the mountain bedrock-alluvium contact. Thus, the source of most of the groundwater recharge within the regional watershed occurs in the higher elevations since they receive higher volumes of precipitation.

It should be noted that no direct measurements of infiltration have been made at any locations within the watersheds. Estimates of infiltration, and resulting groundwater recharge, have been based on calculations using other parameter inputs (e.g., rainfall and surface cover).

3.1.3 Recharge

Several estimates of groundwater recharge have been completed for the Cadiz Project area since 1984. More recently, recharge estimates have been presented by Geoscience (1999), United States Geological Survey (USGS) (2000), and Lawrence Livermore National Laboratory (LLNL) (2000).

Geoscience (1999) estimated groundwater recharge based on a watershed model that included variables that affect the daily water balance of the watershed, including precipitation, runoff, vegetation interception, infiltration, evapotranspiration, soil moisture, and percolation. Geoscience estimated the total recoverable groundwater for the entire Project area (Bristol, Cadiz, and Fenner Watersheds) to range between 19,886 and 58,268 AFY. The recharge estimates for the Fenner and OBW Watersheds range from 14,646 to 37,254 AFY and 1,193 to 4,285 AFY, respectively. This provides an estimate for the combined total recoverable groundwater (Fenner and OBW) of 15,839 to 41,539 AFY (CH2M Hill, 2010).

The USGS (2000) estimated groundwater recharge based on a modified Maxey-Eakin model of the Project area (Bristol, Cadiz, and Fenner Watersheds), which was used to estimate groundwater recharge as a percentage of the average annual precipitation within discrete elevation-precipitation-recharge zones. The model estimated a median groundwater recharge rate of 2,550 to 11,800 AFY, of which 2,070 to 10,343 AFY was estimated for the Fenner Watershed alone (CH2M Hill, 2010).

LLNL (2000) reviewed the USGS (2000) Maxey-Eakin groundwater recharge estimates and concluded that they underestimated recharge to the Fenner Watershed. LLNL (2000) developed a separate Maxey-Eakin model of the Fenner Watershed, which estimated a recharge rate between 7,864 and 29,815 AFY, based on local precipitation (CH2M Hill, 2010).

Additionally, an estimated groundwater recharge value of approximately 32,000 AFY was generated by CH2M Hill (2010) using the model INFIL 3.0 for the model period of 1958 to 2007. The average annual groundwater recharge quantities for the Fenner Watershed, OBW Watershed, and in total, were estimated using the INFIL 3.0 model at 30,191 AFY, 2,256 AFY, and 32,447 AFY, respectively (CH2M Hill, 2010).

3.2 Groundwater Flow

In the Bristol and Cadiz Watersheds, groundwater flows radially toward the dry lakes from the surrounding hills and mountains. In the OBW, groundwater flows to the southeast from the Granite Mountains through the wash, and then to the southwest into Bristol Dry Lake. In the Fenner Watershed, groundwater generally flows radially from the surrounding mountains to the center of the valley and thence southward. A groundwater divide exists within the watershed. Recharge from the Providence, Granite, Clipper, and Marble Mountains (the western portion of the watershed) eventually discharges through the Fenner Gap to the Bristol Dry Lake. Recharge from the New York, Old Women, and Ship Mountains (eastern portion) eventually discharges through the Fenner Gap to the Cadiz Dry Lake.

As noted, it is likely that groundwater from the Lanfair Valley flows into the eastern portion of the Fenner Watershed, and eventually discharges to Cadiz Dry Lake.

3.3 Hydrologic Outflow

3.3.1 Groundwater Pumping

Cadiz currently owns and operates seven full-scale irrigation wells in the Cadiz Valley, including Wells 21 South, 21 North, 22, 27 South, 27 North, 28, and 33. During the period from 1986 to 2009, the total annual amount of groundwater pumped by Cadiz ranged from approximately 1,882 AF in 2009 to 6,689 AF in 1990 with an annual average of 4,602 AFY. In addition, a total of 1,118 AF of groundwater was pumped from Well PW-1 to provide a source of water for the pilot infiltration test conducted during the period between March and September 1999 (Geoscience, 1999). Since 2007, with changes in agricultural operations, the pumping rate has been reduced to between 1,800 and 1,900 AFY.

3.3.2 Dry Lakes

The Bristol and Cadiz Dry Lake playas are located at the lowest elevations in the watersheds that surround the Cadiz Project. All of the watersheds in the Cadiz Project area (including the Bristol and Cadiz Watersheds) are closed; that is, neither surface water nor groundwater discharge to adjacent watersheds. Therefore, the only natural outlet for surface and groundwater is evaporation from the dry lakes.

During sudden spring snow thaws and/or late summer thunderstorms of high intensity, surface water flows to the dry lakes and standing water can occur (CH2M Hill, 2010); however, the standing water rapidly evaporates immediately after such flash flooding events.

The dry lake playas consist of a variety of surface types, including salt crust and soft puffy porous surfaces which are largely devoid of vegetation. Clay and silts are the predominant soil types beneath the surface. Puffy surfaces are believed to be formed from upward groundwater movement in the capillary zone causing salts to precipitate and clays to swell on the surface, resulting in a network of polygons and hummocky relief. This puffy surface is reported to cover more than 60 percent (%) of Bristol Dry Lake (CH2M Hill, 2010).

3.3.3 Evapotranspiration

Geoscience (2000) developed a range of estimates of evapotranspiration from Bristol and Cadiz Dry Lakes, using three different methods, which ranged from 11,665 to 105,436 AFY. The upper range of values was based on evapotranspiration estimates at Franklin Dry Lake playa by Czarnecki (1997). An energy-balance, eddy-correlation technique was used to estimate evapotranspiration from the playa lake surface, which resulted in evapotranspiration rates of 0.1 to 0.3 centimeters per day (cm/d) (approximately 1.2 to 3.6 feet per year [feet/yr]) (CH2M Hill, 2010).

The USGS (2001) estimated evapotranspiration for a number of areas in the Death Valley regional flow system, which included estimates for open playas similar to the Bristol and Cadiz Dry Lakes. The USGS estimated evapotranspiration rates from 0.1 to 0.7 feet/year. They adjusted these evapotranspiration rates by the estimated long-term average annual precipitation rate (by subtracting the precipitation rate) to get evapotranspiration rates ranging from 0.15 to 0.21 feet/year. However, the USGS (2001) stated that the contribution of precipitation to evapotranspiration is uncertain. Given the high rate of evaporation in these arid environments, precipitation may not affect the evapotranspiration rates as estimated from micro-meteorological measurements. Using a range of 0.1 to 0.7 feet/year gives a range of evapotranspiration rates of 5,965 to 41,755 AFY for the Bristol and Cadiz Dry Lakes (CH2M Hill, 2010).

Between May and November 2011, Desert Research Institute (DRI) (2012), conducted an investigation on Bristol and Cadiz Dry Lakes to determine project-specific evaporation rates during the dry months when precipitation is absent. The investigation estimated an evaporation rate from Bristol Dry Lake of 7,860 AFY and from Cadiz Dry Lake of 23,730 AFY, for a total evaporation rate of 31,590 AFY (CH2M Hill, 2012). According to CH2M Hill (2012), the evaporation rate estimates were determined by extrapolating the measured data to an area over which evaporation was expected to occur, and for a full year based on expected monthly variations, as observed from pan and measured evaporation rates from Franklin Dry Lake. The estimated annual evaporation rates calculated by DRI (2012), are considered conservative, as they do not consider the additional groundwater losses due to agricultural pumping by Cadiz (4,600 AFY average production) or to the salt-mining operations on the dry lakes (approximately 750 AFY) (CH2M Hill, 2012). It should be noted that the extrapolated evaporation rates are for dry-weather evaporation; that is, groundwater-supported evaporation. They do not include direct evaporation of ponded rainfall or surface water inflows, or evaporation from the resultant shallow soil moisture, immediately after a rainfall event.

3.4 Storage Volume

The volume of groundwater in storage in the alluvium of the Fenner Valley and OBW has been estimated to be between 17 and 34 MAF. However, this storage estimate does not include water contained within the carbonate and fractured portion of the bedrock beneath the alluvium. Recent investigations have determined that these units may also store and conduct large volumes of groundwater. In addition, this storage estimate does not include groundwater within the Lanfair Valley, probably between 3 and 6 MAF that is likely tributary to the Fenner Basin. As such, the estimated volume of groundwater in storage is a conservative estimate, and the actual volume is most likely greater (CH2M Hill, 2010).

3.5 Aquifers

In the Cadiz Project area, the majority of the geologic deposits that store and transmit groundwater (i.e., aquifers) can be divided into the following four units:

- Upper alluvial aquifer
- Lower alluvial aquifer
- Tertiary fanglomerates
- Carbonate bedrock aquifer (consists primarily of Paleozoic limestone)

The alluvial aquifer units and the carbonate bedrock aquifer are in hydraulic continuity with each other. The differentiation is primarily due to stratigraphic differences and the extent of interconnecting secondary porosity with the carbonate unit (Geoscience, 2011a).

3.5.1 Alluvial Aquifer

The alluvial aquifer system is comprised mainly of Quaternary alluvial sediments consisting of stream-deposited sand and gravel with lesser amounts of silt. The thickness of this aquifer in the Project area has been interpreted to range from approximately 200 feet towards the flanks of Fenner Gap, to as much as 800 feet, as depicted Kenney (2011). To the west of Fenner Gap, the upper alluvium aquifer is separated from the lower alluvium aquifer system by discontinuous layers of silt and clay. The upper alluvial aquifer is very permeable in places and can yield 3,000 gallons per minute (gpm) or more with less than 20 feet of drawdown.

The lower alluvial aquifer consists of older sediments, including inter-bedded sand, gravel, silt, and clay of late Tertiary to early Quaternary age. The Cadiz agricultural wells are screened primarily in the lower alluvial aquifer and typically yield 1,000 to 2,000 gpm (Geoscience, 2011a).

3.5.2 Carbonate Aquifer

Carbonate bedrock of Paleozoic age, located beneath the lower alluvial aquifer, contains groundwater and is considered a second main aquifer unit. Groundwater movement and storage in the carbonate bedrock aquifer primarily occurs in secondary porosity. Recent studies performed by CH2M Hill, have shown that portions of the carbonate aquifer, are highly transmissive (e.g., contain karst features). It is also likely that other carbonate units may also exhibit localized areas of highly-transmissive secondary porosity features (Geoscience, 2011a).

3.5.3 Granitic Aquifer

Granitic and metamorphic rock forms the subsurface margins of the aquifer system. These basement rocks are generally impermeable but can have significantly increased permeability along fracture zones which are associated with the numerous faults that cross beneath Fenner Gap. Fracture zones in the hanging wall of the fault zones and along the detachment fault, range in thickness from 150 to 400 feet, and occupy a significant portion of the cross-sectional area in the Fenner Gap (Kenney, 2011).

3.6 Hydraulic Properties

The hydraulic properties of the aquifers obtained from recent pumping tests (Geoscience, 2011b) at the Cadiz property indicate that the aquifers are highly transmissive in the vicinity of the test wells (TW-1 and TW-2).

Hydraulic conductivities for the alluvial aquifer in the vicinity of pumping well TW-2, located in the center of the Fenner Gap, ranged from approximately 37 to 150 feet per day (feet per day). Hydraulic conductivity of the alluvial aquifer system in the vicinity of pumping well PW-1, located in an older alluvial fan northwest of Schulyer Wash was 158 feet/day. Storativities average approximately 0.002, reflecting semi-confined conditions in the alluvial aquifer system (Geoscience, 2011b).

Hydraulic conductivities for the carbonate aquifer in the vicinity of the Project area (TW-1), ranged from 602 to 1,023 feet/day. Storativities were representative of semi-confined (i.e., leaky) aquifer systems. The alluvial aquifer in the vicinity of TW-1 exhibited leakage effects during the pumping tests, suggesting that there may be a hydraulic connection with the overlying alluvial sediments (Geoscience, 2011b).

Hydraulic conductivity of the fractured granite may range from approximately 5 to 20 feet/day at depth in TW-2. Published values for hydraulic conductivity in fractured granitic rock range from 0.1 to 40 feet/day (Geoscience, 2011b).

The hydraulic properties obtained from aquifer testing and used for groundwater modeling are further summarized in **Table 2**.

Table 2: Hydraulic Conductivity Values Used in Groundwater Modeling and Obtained from Pumping Tests

Model Layer	Lithology	Location Relative to Fenner Gap	Modeled Recharge Rate Hydraulic Conductivity (feet/day)			Aquifer Test Hydraulic Conductivity (feet/day)
			32,000 AFY	16,000 AFY	5,000 AFY	
1	Alluvium	Inside and Outside	0.02 - 543	0.1 – 267	0.02 – 84	37 - 150
2	Alluvium	Inside and Outside	0.02 - 543	0.1 – 267	0.02 – 84	37 - 150
3	Alluvium	Inside and Outside	0.7 – 406	0.1 – 200	0.02 - 128	37 - 150
4	Carbonate	Inside and Outside	500 – 1,500	500 – 1,500	150 - 450	602 – 1,023
	Fanglomerate	Inside	60	25	9	0.0031
	Fanglomerate	Outside	2	1	0.3	0.0031
5	Carbonate	Inside and Outside	500 – 1,500	500 – 1,500	150 - 450	602 – 1,023
	Fanglomerate	Inside	60	25	9	0.0031
	Fanglomerate	Outside	2	1	0.3	0.0031
6	Weathered Granitic	Inside	75	50	15	4.6 – 19.7
	Weathered Granitic	Outside	2	1	0.3	4.6 – 19.7

3.7 Geochemistry

The quality of the groundwater in the Cadiz Project area is relatively good, with total dissolved solids (TDS) concentrations typically in the range of 300 to 400 milligrams per liter (mg/L). At Bristol and Cadiz Dry Lakes, surface water and shallow groundwater evaporation concentrates dissolved salts in the water, resulting in TDS concentrations as high as 298,000 mg/L. The freshwater/saline water interface, as defined by TDS concentrations greater than 1,000 mg/L, is located near the margins of the dry lakes (Geoscience, 2011a).

A summary of geochemical data in alluvial and carbonate aquifer units in the project area are further summarized in **Table 3**.

Table 3: Summary of Water Quality Analyses in the Project Area

Parameter	Aquifer Material (mg/L)	
	Alluvium	Carbonate
TDS	260	220
Calcium	26	24
Magnesium	5.2	5.7
Sodium and Potassium	52.9	65.6
Chloride	34	38
Sulfate	11	32
Carbonate	100	130

3.8 Conceptual Hydrogeologic Model

The watersheds that surround the Cadiz Project form a closed hydrologic system, both for surface water and groundwater. The complete watersheds include broad and deep alluvial basins surrounded by predominantly faulted and fractured, granitic bedrock mountains.

The thick sequence of alluvium (greater than 500 feet in many places) is underlain in localized areas by permeable fanglomerates, and highly-permeable carbonate (karts) and dolomitic limestone, overlying relatively impermeable granitic basement rocks. The fanglomerates, limestone, shale, and other rocks also outcrop within the surrounding mountains. The basins and mountains constitute a series of deep grabens, perpendicular sub-grabens, and horsts formed along major fault zones (**Figure 9**). Tectonic uplift and plutonic intrusion once created broad anticlinal structures within the basins; however, these have subsequently been partially eroded away and in-filled with the alluvium (**Figure 10**).

Alluvium, fanglomerates, and limestone make up the groundwater basins within the overall watersheds that surround the Cadiz Project. In addition, some areas outside the topographic surface-water catchments yield groundwater to the groundwater basins (e.g., west of the Amboy volcanics, and to the northwest from the Lanfair Valley). As such, groundwater basins do not exactly correlate with the overlying surface water catchments.

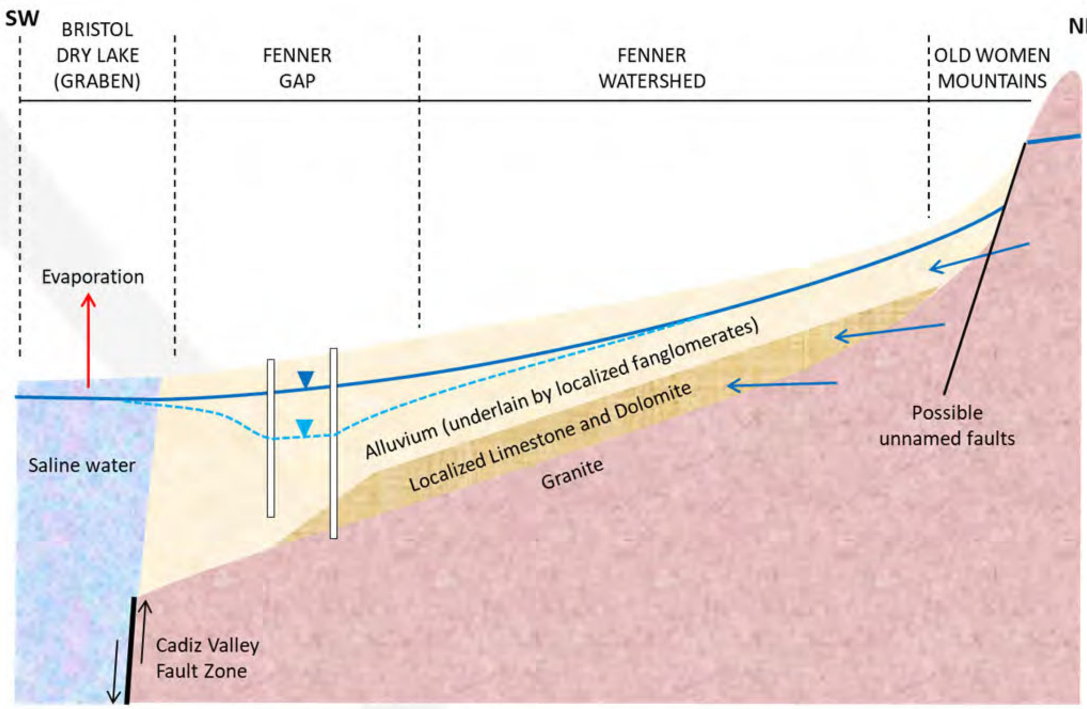

Figure 9: Simplified Hydrogeologic Section up Fenner Valley[9]

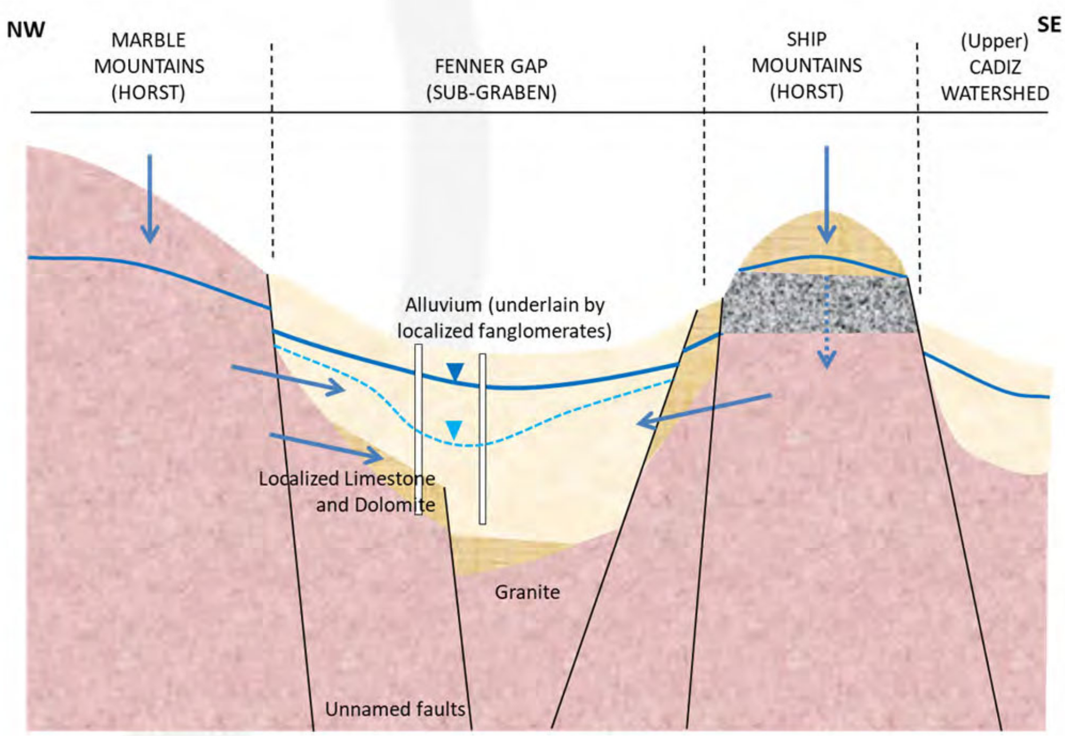

Figure 10: Simplified Hydrogeologic Section across Fenner Gap[9]

[9] Aquilogic, Inc. (2013). Review of The Groundwater Hydrology of the Cadiz Project, San Bernardino County, California.

Precipitation falls across the area, increasing with elevation, and can be present as snow-pack at higher elevations (approximately greater than 5,000 feet above MSL). Nearly all of the rainfall on the alluvium enters shallow soil moisture storage or flows as run-off in ephemeral rills and streams, only to infiltrate downstream into unsaturated soils. After the rainfall events, most of this water is lost to the system as evapotranspiration and never recharges groundwater. Most of the recharge into the groundwater basins comes from water that has infiltrated in the surrounding mountains, and thence recharges groundwater as fracture-baseflow from bedrock to alluvium, or infiltration of surface water flows at the mountain bedrock-alluvium contact.

Throughout most of the alluvial basins, groundwater is found at depths greater than 100 feet below ground surface (bgs). Only at the dry lakes is shallow groundwater encountered. However, at some locations, perched groundwater is present behind fault scarps and above low-permeability strata in the mountains. In these locations, springs can be found or created by drilling or tunneling into saturated rock/sediments. Given their elevation (i.e., more than 500 feet above groundwater in the nearby alluvium) and hydrologic origin, these springs do not appear to be in direct hydraulic communication with the groundwater in the alluvium.

In general, groundwater flows down the alluvial valleys toward the point of lowest hydraulic head within the system – the Bristol and Cadiz Dry Lakes. Groundwater within the Bristol, OBW (a sub-basin of the Bristol), and western portion of the Fenner Watersheds flows to Bristol Dry Lake. Groundwater within the eastern portion of the Fenner Watershed, tributary groundwater that enters the Fenner Valley from the Lanfair Valley, and groundwater in the Cadiz Watershed flows to the Cadiz Dry Lake. Given the storage volume of the alluvial basins and the distances between recharge in the mountains and evaporation in the dry lakes, infiltrating precipitation likely takes many hundreds of years to finally leave the system. No groundwater flows into adjacent basins or discharges to surface water that flows into adjacent watersheds, and all groundwater is eventually lost to the system as evaporation at the dry lakes.

Given the geochemical nature of the rocks within which infiltration and recharge occurs, and the filtering effect of the alluvial sediments through which groundwater flows, the groundwater is generally of high quality with low TDS concentrations. In addition, the permeability of the alluvial sediments and carbonates allows high yields at groundwater pumping wells.

Groundwater within the Fenner Valley, and tributary groundwater that enters the Fenner Valley from the Lanfair Valley, eventually flows through the Fenner Gap between the Marble and Ship Mountains. In addition, groundwater in the OBW flows to the south of the Fenner Gap before flowing to Bristol Dry Lake. All of this groundwater is tributary to the Cadiz Project. It has been estimated that between 17 and 34 MAF of groundwater storage, and between 5,000 and 32,000 AFY of annual recharge, is tributary to the Cadiz Project.

Cadiz plans to pump groundwater at proposed well locations within the Fenner Gap. These wells will essentially capture groundwater that currently flows through the Fenner Gap and OBW to the Bristol and Cadiz Dry Lakes and is lost as evaporation. The proposed pumping rate will exceed the annual groundwater recharge that is tributary to the Cadiz Project, and some water will be removed from long-term aquifer storage. After 50 years, pumping will cease and the aquifers will be allowed to recharge for at least 50 years. In addition, Cadiz has plans to import water for storage in the Fenner Watershed to supplement natural recharge.

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